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Impacts of Gorkha Earthquakes: A Comprehensive Study

Pitri Bhakta Adhikari*, Shanta Nepal, Sapana Dawadi

Department of Physics, Tri-Chandra Multiple Campus, Ghantaghar, Kathmandu 44600, Nepal

*Corresponding Author Email: pbadhikari09@gmail.com

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ABSTRACT

Nepal is highly vulnerable to seismic activity. This review seeks to explore the impact of earthquakes on human populations in terms of casualties and injuries, as well as to pinpoint the risk factors associated with these outcomes. An earthquake measuring 7.8 on the Richter scale struck near Gorkha, Nepal, on April 25, 2015, resulting in the loss of nearly nine thousand lives, extensive property damage, and the destruction of numerous historical and cultural landmarks. Data sourced from the UNDRR, Ministry of Home Affairs, and the United States Geological Survey were analyzed using the ArcGIS software tool. The study offers a comprehensive examination of earthquake-prone regions at regional, national, and global levels. By analyzing recent significant earthquakes along with their associated losses and damages, it underscores the importance of precautionary measures and risk analysis in reducing vulnerability and enhancing preparedness among researchers and stakeholders.

Keywords: disaster, earthquakes, ArcGIS software, precautions

INTRODUCTION

Nepal is a sandwiched country between India and China with latitudes 26°22'N to 30°27'N and longitudes 80°4'E to 88°12'E. Nepal suffered from different disasters which are significant, harmful, and intolerable phenomenon. Different sorts of numerous disasters occur on a regular basis around the world also. Disasters have the potential to kill thousands of people in a short time, as well as leave victims homeless and jobless. Furthermore, it has the power to instantly demolish large-scale infrastructure.

A catastrophe, calamity, tragedy, or significant danger is an incident that negatively affects both life and property. This unforeseen event results in enormous suffering for humans, other living things and also loss significant property [1]. Even there are natural and man-made disasters, the natural disaster is an unplanned incident that has a negative impact on society such as Landslides, Earthquake, Thunderstorm, Fires, Volcanic eruptions, etc. Natural

disasters frequently harm both the environment and the inhabitants. According to Bala Subramanian the environmental degradation, pollution, different types of accidents, etc. are the man-made disaster appearing on the earth. Among all the disasters, an earthquake is a noticeable shaking of the earth's surface and the main effects caused due to earthquakes are: people can lose their lives, injury, damage to property, disruption of lifestyle, loss of livelihood. The world has primarily experienced it as a natural calamity throughout history. An earthquake that may result in 50 fatalities in a matter of minutes is distinguished from automobile accidents by events that are concerned with space and time. The US experiences about 34,000 earthquakes every year [2].

Earthquakes are transient events that are caused by natural forces and phenomena and often occur in the earth’s crust or upper mantle. The earthquakes are unexpected earthlings of the energy stored beneath the earth. These movements of flipping can occasionally be rather large [3]. Earthquakes are the natural disaster and can occur in the atmosphere. Similarly, it can effect on traffic, communication, electricity, etc. People can also be affected by sociological and psychological effects. In the region where the earthquake happens, there can be a shortage of food resources in people [4]. Among all the disasters, an earthquake is a noticeable shaking of the earth's surface; Nepal is also one of the most earthquake-prone countries in the world. Major faults in and around Nepal have caused recent earthquakes and seismic activity, suggesting that faults can trigger at any time. The most recent catastrophic (disaster) earthquake in Nepal occurred on April 25, 2015. About 9000 people were killed, over 22,000 were wounded, and an additional 2 million were displaced. Hall, (2017) explained that earthquake caused unpredictable property losses; many have lost their jobs and lost their homes [5].

Adhikari (2015) explained about the Gorkha earthquakes of Nepal occurred on April 25, 2015, which caused tremendous damage and loss [6]. On the gradually sloping fault plane, the earthquake's rupture moved from west to east and from deep to shallow, causing intense shaking in Kathmandu and the nearby settlements. Thousands of people have died, unpredictable property losses, destroyed a variety of buildings and infrastructure in both urban and rural areas. It causes numerous other disasters such as landslides, it shut down of services such as network connections, transportation, and electricity services. Mavrodiev (2016) concentrated on using earth's geomagnetic and tidal data to forecast approaching seismic activity in the area [7].

Goda, (2015) also observed the major tremors of the Gorkha earthquake [8]. He used a foreshock to describe a fault rupture model of the main shock. Sapkota, (2016) compared the moment magnet between the 2015 Gorkha earthquake and 1934 Bihar – Nepal earthquake [9]. Zhang, (2016) studied the rupture process of Gorkha earthquake 2015 by applying 48 tele seismic stations having good coverage and concluded that future seismic hazard can be appeared due to lack of shallow slip [10]. Joshi (2020) summarized potential factors that increase the likelihood of being associated with social, physical, psychological, economic, socio-economic, poverty and so on during and after the 2015 earthquake [11]. Pasari, (2021) performed research work on quantitative analysis of the most dangerous hazard Earthquake in Nepal [12]. They developed a statistical calculation of natural times and found earthquake

potential scores by taking 24 major cities of Nepal including metropolitan cities also. The main objective of the study is to reduce the impact of the earthquake even it may occurs on every continent. It can't be stopped but the knowledge about its effects can be taken by analyzing the numbers of death of the people, damage and loss of properties due to earthquakes, etc.

METHOD

Data were collected from United Nations Disaster Risk Reduction, (UNDRR, DesInventor) (http://www.disinventor.net) and Disaster Risk Reduction Portal of the Government of Nepal. UNDRR applies prevention against emergencies due to disasters which helps to sustainable future of all over the world. The collected data contains all disasters fatalities, worldwide deadliest earthquakes with magnitude, national and international data for magnitude and fatalities of earthquakes. The descriptive analysis on different attributes each as fatality number, fatality density, affected number, economic losses, and fatality rate was conducted. Geographic Information System (ArcGIS) was used to analyze the data. ArcGIS plays a pivotal role in this research domain by facilitating spatial analysis for mapping purposes. Utilizing GIS-based spatial analysis, it enables the creation of Pie diagrams illustrating fatalities attributed to various disasters across seventy-seven districts of Nepal, as well as their depiction on both the Asian and global maps. The integration of dependable data sources, extensive datasets, descriptive analysis, and GIS-based spatial mapping amplifies the robustness and significance of the study. The data consists of deaths, affected population and economic loss of all 77 districts of Nepal from 1971 to 2022. ArcGIS is helpful for the integration of district locations with attribute data.

RESULT AND DISCUSSION

Different types of disasters during five decades in seventy-seven districts in Nepal

There are lots of disasters, natural or man-made, occur in the world which may affect many peoples, animals and loss of huge property. There are large numbers of disasters appeared in the world by which large numbers of people injured, many are missed from their relatives and large of them are died. These disasters may be both predictable and non-predictable. Some of the examples of disasters are flood, landslides, earthquake, lightning, avalanche, and so on. Nepal is a landlocked country and its geographical structure is more vulnerable to the disasters. The total numbers of peoples died due to different disasters in seventy-seven districts of Nepal during the time period from 1971 to 2021 are shown in TABLE 1. The data about death of peoples due to different disasters in seventy-seven district are represented in diagram by using the ARCGIS mapping tools is shown in FIGURE 1.

A disaster is a sudden accident or a natural catastrophe that causes great damage or loss of human life, animals, buildings and huge properties. Among the disasters, landslides, flood, thunderbolt (lightning), road accident, fire, earthquake, avalanche, are main disaster which affects seriously in Nepal are mentioned in TABLE 2 and the fatality due to different disasters in Nepal are shown in FIGURE 2. The total number of deaths due to landslide is 4658, due to flood is 3538, due to thunderbolt is 1332, due to accident is 1675. Similarly, 1386 from fire,

883 from earthquakes, 822 from cold wave, 256 from avalanche, etc. lost their life is mentioned in the FIGURE 2.

TABLE 1. Number of Fatality in districts due to different type of disasters during the period of 1971 to 2021*.

S. N.	Districts	No. of Fatality	S. N.	Districts	No. of Fatality	S. N.	Districts	No. of Fatality
1	Achham	703	27	Jajarkot	718	53	Parbat	107
2	Arghakhanchi	162	28	Jhapa	678	54	Parsa	300
3	Baglung	456	29	Jumla	429	55	Pyuthan	279
4	Baitadi	391	30	Kailali	1137	56	Ramechhap	286
5	Bajhang	349	31	Kalikot	670	57	Rasuwa	397
6	Bajura	529	32	Kanchanpur	356	58	Rautahat	778
7	Banke	1112	33	Kapilbastu	339	59	Rolpa	270
8	Bara	319	34	Kaski	519	60	Rukum East	311
9	Bardiya	239	35	Kathmandu	519	61	Rukum West	212
10	Bhaktapur	109	36	Kavre	319	62	Rupandehi	564
11	Bhojpur	233	37	Khotang	303	63	Salyan	260
12	Chitawan	455	38	Lalitpur	220	64	Sankhuwasabha	305
13	Dadeldhura	104	39	Lamjung	181	65	Saptari	918
14	Dailekh	580	40	Mahotari	571	66	Sarlahi	1059
15	Dang	584	41	Makwanpur	1043	67	Sindhuli	533
16	Darchula	227	42	Manang	89	68	Sindhupalchok	720
17	Dhading	505	43	Morang	920	69	Siraha	486
18	Dhankuta	256	44	Mugu	365	70	Solukhumbu	194
19	Dhanusa	702	45	Mustang	54	71	Sunsari	648
20	Dolakha	378	46	Myagdi	261	72	Surkhet	134
21	Dolpa	368	47	Nawalpur	198	73	Syangja	428
22	Doti	855	48	Nuwakot	331	74	Tanahu	330
23	Gorkha	495	49	Okhaldhunga	244	75	Taplejung	315
24	Gulmi	320	50	Palpa	357	76	Terhathum	139
25	Humla	447	51	Parasi	139	77	Udayapur	409
26	Ilam	293	52	Panchthar	202		Total	25751

*-Source: (DESINVENTAR, MOHA)

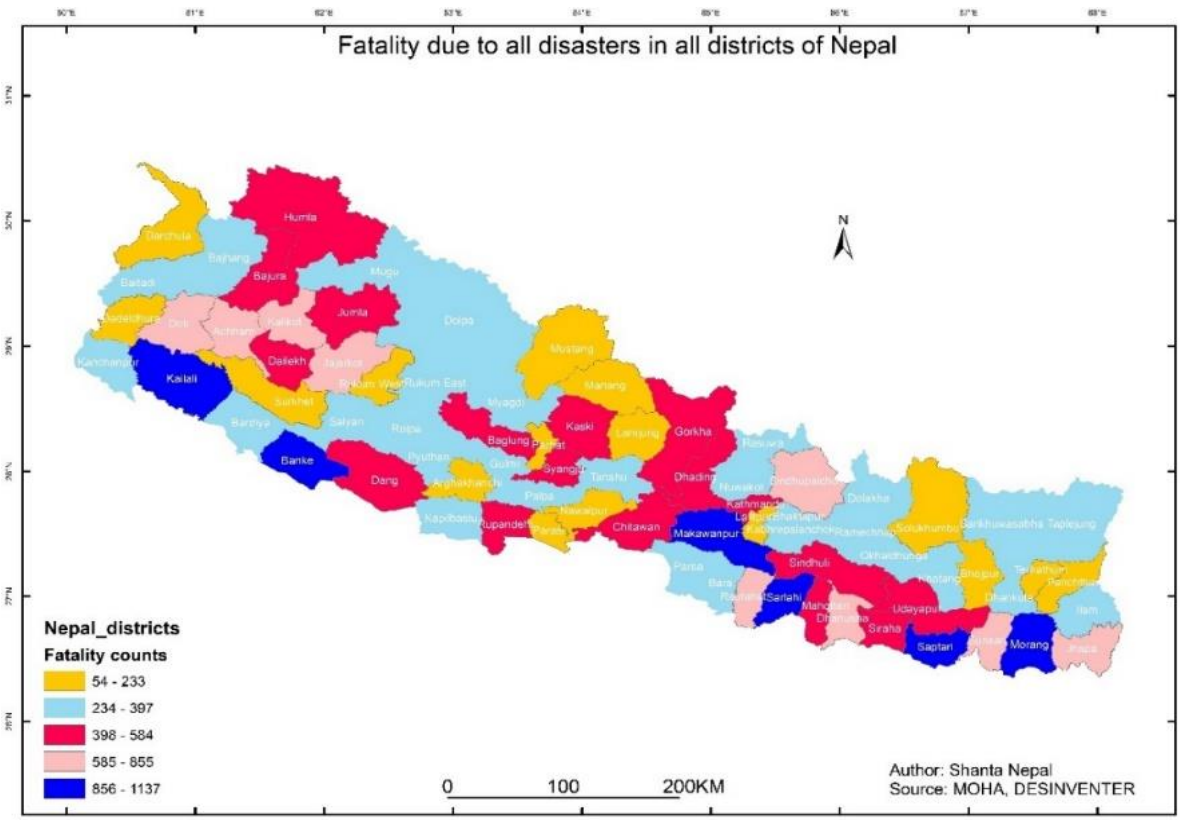

FIGURE 1. Pie diagram of fatality due to all disasters in seventy-seven districts of Nepal.

TABLE 2. Total number of fatalities in Nepal as a consequence of various disasters*.

Disaster Events	Total Deaths	Disaster Events	Total Deaths
Accident	1675	Heat Wave	45
Avalanche	256	Landslide	4658
Biological	0	Leak	0
Boat Capsize	297	Other	77
Cold Wave	822	Panic	89
Drought	0	Plague	11
Earthquake	883	Pollutions	0
Epidemic	16660	Rains	96
Explosion	36	Sedimentation	0
Famine	10	Snow Storm	82
Fire	1386	Storm	52
Flood	3538	Strong Win	184
Forest Fire	71	Structure Collapse	426
Frost	7	Thunderstorm	1332
Hail Storm	65		

*-Source: (DESINVENTAR, MOHA)

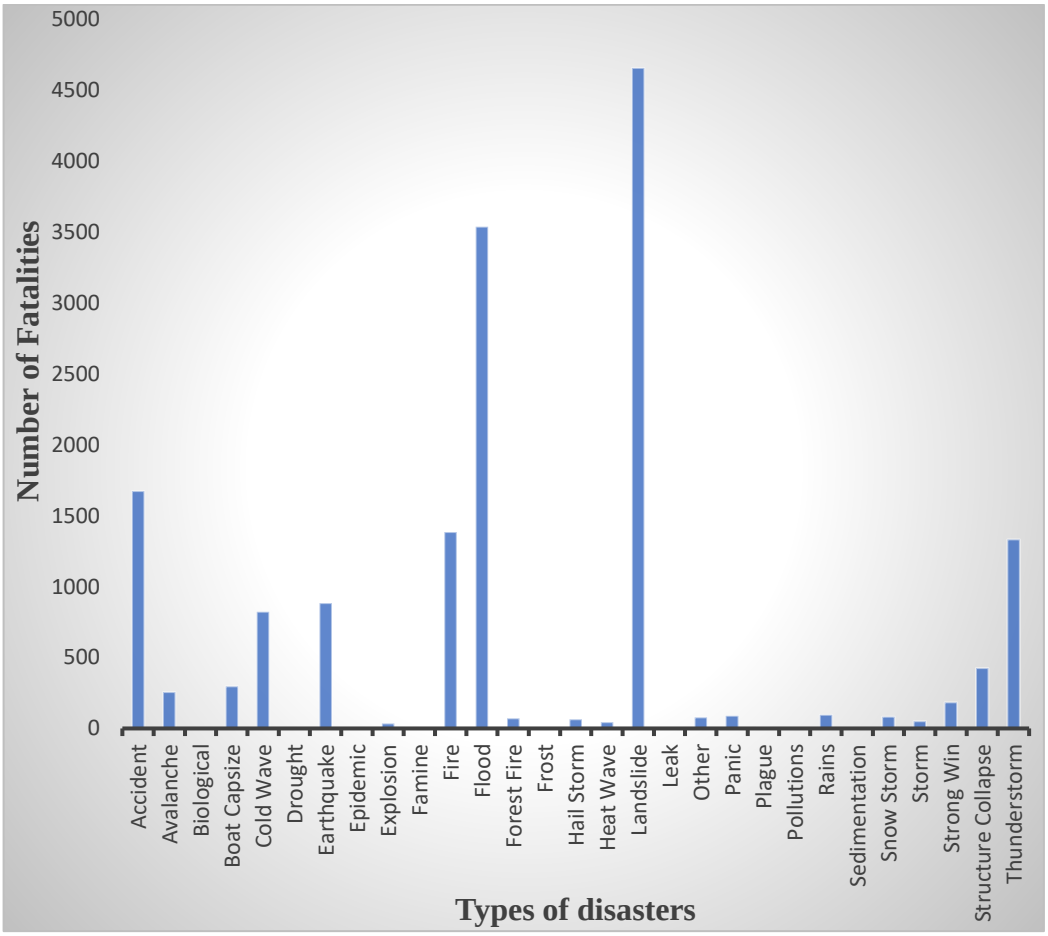

FIGURE 2. Bar diagram of total deaths due to different disasters in Nepal.

Earthquake as a disaster across the world

An earthquake is taken as a disaster, which is a violent and abrupt shaking of the ground. It is caused by movement between tectonic plates along a fault line in the earth's crust. An earthquake is a violent shaking of the ground produced by the sudden movement of rock materials inside the earth or below the earth surface. The earthquakes originate from the tectonic plate boundary. The hypocenter is the focus point inside the earth from where the earthquake started. Epicenter is on the surface of the earth directly above the hypocenter. The magnitude of the earthquake is measured in terms of its energy released. Its unit of measurement is Richter scale.

a. Large seismic earthquake more than seven Richter scale in the world

There are so many numbers of earthquakes occurred in the world. Here on selecting only the high earthquake data during the latest five years. The worldwide data for earthquake having large magnitude more than seven Richter scale with incident place for last five years is presented in the TABLE 3. The data are arranged in ascending order from 2018 to 2022. This data of earthquake having large magnitude of more than seven Richter scale with the duration

for five years (2018-2022) with epicentre are representing in FIGURE 3 by using the ArcGIS mapping tools.

TABLE 3. Large seismic earthquake more than seven Richter scale in the world during five years (2018-2022).

S. N.	Incident Date	Incident Place	Magnitude	S. N	Incident Date	Incident Place	Magnitude
1	26-05-2022	Peru	7.2	30	13-02-2020	Russia	7
2	03-03-2022	New Caledonia	7	31	28-01-2020	Jamaica	7.7
3	16-03-2022	Japan	7.3	32	14-11-2019	Indonesia	7.1
4	29-12-2021	Timor Leste	7.3	33	14-07-2019	Indonesia	7.2
5	14-12-2021	Flores Sea	7.3	34	06-07-2019	2019 Ridgecrest Earthquake Sequence	7.1
6	28-11-2021	Peru	7.5	35	24-06-2019	Banda Sea	7.3
7	02-10-2021	Vanuatu region	7.3	36	15-06-2019	New Zealand	7.3
8	08-09-2021	Mexico	7	37	26-05-2019	Peru	8
9	22-08-2021	South Sandwich Islands region	7.1	38	14-05-2019	Papua New Guinea	7.6
10	14-08-2021	Haiti	7.2	39	06-05-2019	Papua New Guinea	7.1
11	12-08-2021	South Sandwich Islands region	8.1	40	01-03-2019	Peru	7
12	12-08-2021	South Sandwich Islands region	7.5	41	22-02-2019	Ecuador	7.5
13	11-08-2021	Philippines	7.1	42	29-12-2018	Philippines	7
14	29-07-2021	Alaska	8.1	43	20-12-2018	Russia	7.3
15	21-05-2021	China	7.3	44	11-12-2018	South Sandwich Islands region	7.1
16	20-03-2021	Japan	7	45	05-12-2018	New Caledonia	7.5
17	04-03-2021	New Zealand	8.1	46	30-11-2018	Alaska	7.1
18	04-03-2021	New Zealand	7.4	47	10-10-2018	Papua New Guinea	7
19	04-03-2021	New Zealand	7.3	48	28-09-2018	Indonesia	7.5
20	13-02-2021	Japan	7.1	49	06-09-2018	Fiji	7.9
21	10-02-2021	southeast of the Loyalty Islands	7.7	50	29-08-2018	New Caledonia	7.1
22	21-01-2021	Philippines	7	51	24-08-2018	Peru	7.1
23	30-10-2020	Greece	7	52	21-08-2018	Venezuela	7.3
24	19-10-2020	Alaska	7.6	53	19-08-2018	Fiji	8.2
25	22-07-2020	Alaska	7.8	54	25-02-2018	Papua New Guinea	7.5
26	17-07-2020	Papua New Guinea	7	55	16-02-2018	Mexico	7.2
27	23-06-2020	Mexico	7.4	56	23-01-2018	Alaska	7.9
28	18-06-2020	south of the Kermadec Islands	7.4	57	14-01-2018	Peru	7.1
29	25-03-2020	Russia	7.5	58	10-01-2018	Honduras	7.5

*-Source: (USGS)

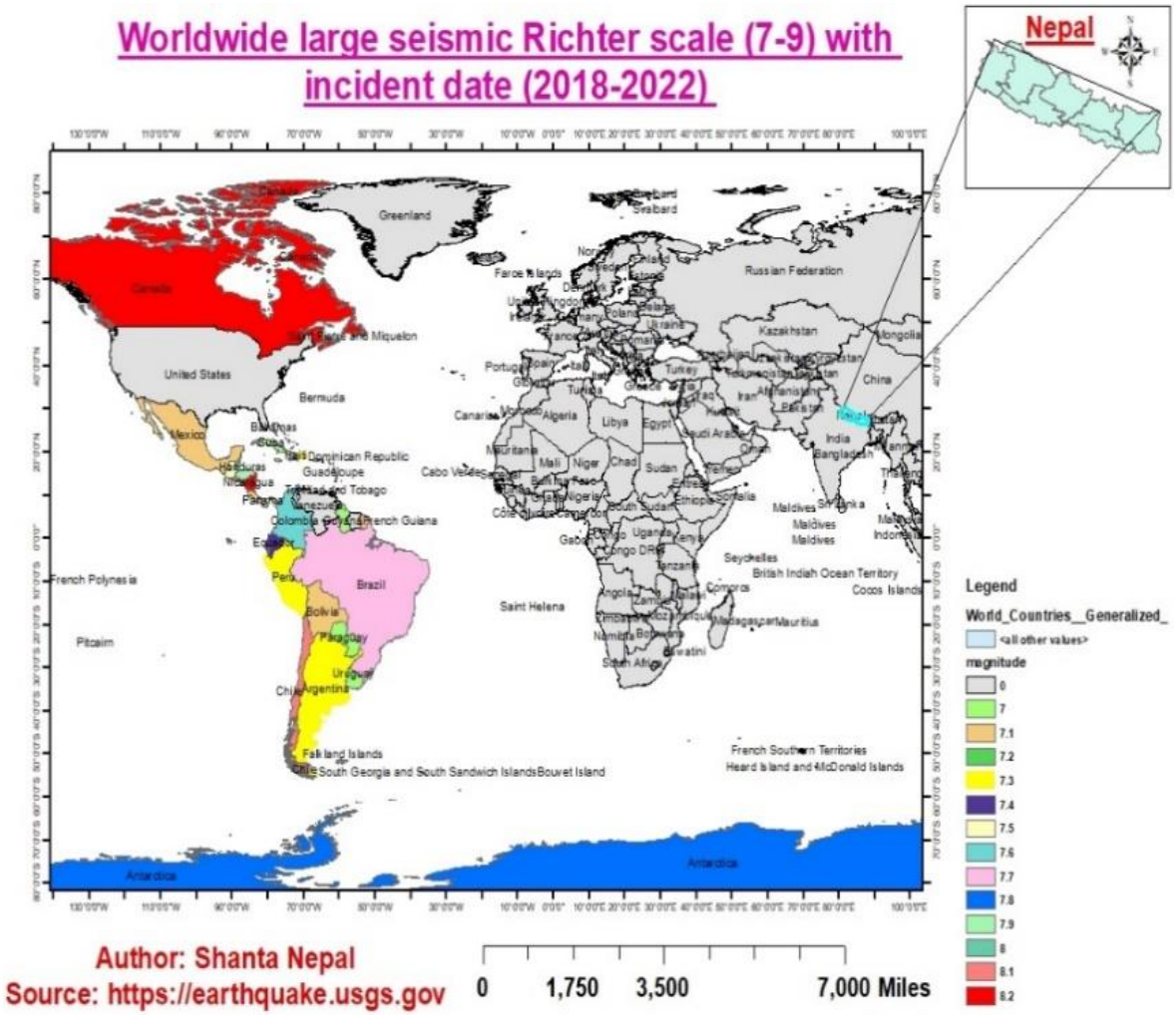

FIGURE 3. Large seismic earthquake more than seven Richter scale in the world latest five years.

b) Large seismic earthquake more than 6.5 Richter scale in the Asia continent

The disaster earthquake having magnitude more 6.5 Richter scale of the largest continent Asia on the earth is describing in TABLE 4 with incident place, date and magnitude. The Asian countries including Nepal, the Himalayan region, were analysed according to earthquake data with the most devastating earthquake having 7.8 Richter scale. In Asia continent, this earthquake of 7.8 Richter scale in Nepal, is the highest one. Similarly, 7.3 Richter scale in Japan, 6.7 Richter scale in Taiwan, and more than 6.5 Richter scale were recorded several times in different parts of Asia such as Japan, Philippines etc. are shown in TABLE 4. The data of earthquake having magnitude more than 6.5 Richter scale in Asia are representing in FIGURE 4.

TABLE 4. Earthquake having magnitude more than 6.5 Richter scale in Asia.

S.N.	Date	Magnitude	Country	S.N.	Date	Magnitude	Country
1	2022-03-22	6.7	Taiwan	26	2017-02-10	6.5	Philippines
2	2022-03-16	7.3	Japan	27	2017-01-10	7.3	Philippines
3	2022-01-07	6.6	China	28	2016-12-06	6.5	Indonesia
4	2021-11-10	6.6	Japan	29	2016-11-25	6.6	Tajikistan
5	2021-08-11	7.1	Philippines	30	2016-11-21	6.9	Japan
6	2021-07-23	6.7	Philippines	31	2016-08-24	6.8	Myanmar
7	2021-05-21	7.3	China	32	2016-04-15	7.0	Japan
8	2021-05-01	6.9	Unknown	33	2016-04-13	6.9	Myanmar
9	2021-03-20	7.0	Japan	34	2016-04-10	6.6	Afghanistan
10	2021-02-13	7.1	Japan	35	2016-01-14	6.7	Japan
11	2021-01-21	7.0	Philippines	36	2016-01-11	6.5	Philippines
12	2021-01-11	6.7	Mongolia	37	2016-01-03	6.7	India
13	2020-08-18	6.6	Philippines	38	2015-12-07	7.2	Tajikistan
14	2020-06-13	6.6	Japan	39	2015-11-13	6.7	Japan
15	2020-04-18	6.6	Japan	40	2015-11-08	6.6	India
16	2019-12-15	6.8	Philippines	41	2015-10-26	7.5	Afghanistan
17	2019-11-14	7.1	Indonesia	42	2015-06-23	6.5	Japan
18	2019-10-31	6.5	Philippines	43	2015-05-30	7.8	Japan
19	2019-10-29	6.6	Philippines	44	2015-05-12	6.8	Japan
20	2019-01-06	6.6	Unknown	45	2015-05-12	7.3	Unknown
21	2018-12-29	7.0	Philippines	46	2015-04-26	6.7	Nepal
22	2018-09-05	6.6	Japan	47	2015-04-25	6.6	Nepal
23	2017-08-08	6.5	China	48	2015-04-25	7.8	Nepal
24	2017-07-06	6.5	Philippines	49	2015-02-16	6.7	Japan
25	2017-04-28	6.9	Philippines				

*-Source: (USGS)

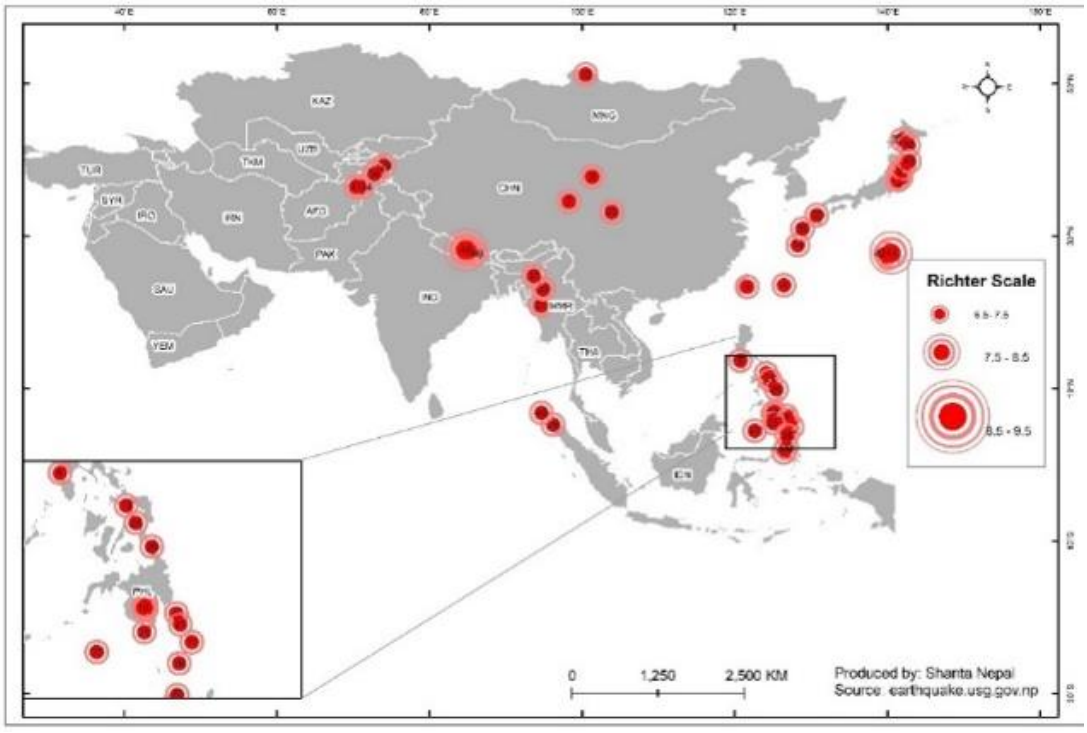

FIGURE 4. Earthquake having magnitude more than 6.5 Richter scale in Asia.

c) Seismic earthquake more than four Richter scale and Gorkha earthquakes in Nepal

The total number of incidents having magnitude more than four Richter scale in Nepal is found to be forty-four events during the latest two years. The different earthquakes having magnitude

more than 4 Richter scale during the latest time period 2020-2022 are mentioned in TABLE 5. The data were taken from the bulletin of National Seismological Centre, Department of Mines and Geology, Kathmandu, Nepal. The presentation of these data by using the ARCGIS mapping tools is shown in FIGURE 5. Here, the data with date, time and epicentre with latitude and longitude are also presented in the same table.

TABLE 5. Latest earthquake incidents with locations and time having magnitude more than 4.0 Richter scale in Nepal.

Date	Epicentre	Latitude	Longitude	Magnitude	Time
2022-05-23	Bajhang	29.58	81.00	4.1	06:03
2022-05-23	Jumla	29.35	82.04	4.1	09:57
2022-05-04	Taplejung	27.31	87.94	4.1	15:00
2022-04-19	Taplejung	27.30	87.73	4.3	09:24
2022-03-23	Taplejung	27.90	87.86	4.2	10:54
2022-02-22	Baitadi	29.70	80.71	4.1	10:07
2022-01-26	Gorkha	27.90	84.57	4.1	11:09
2022-01-21	Sindhupalchok	27.98	85.58	4.1	00:58
2022-01-06	Rukum East	28.68	82.97	4.1	18:29
2022-01-05	Dolakha	27.67	86.32	4.2	10:31
2021-11-09	Sindhupalchok	27.87	85.92	4.1	08:43
2021-10-25	Lamjung	28.29	84.36	4.2	14:45
2021-10-18	Sindhupalchok	27.86	85.82	4.3	09:38
2021-10-18	Sindhupalchok	27.87	85.81	4.2	09:35
2021-10-18	Sindhupalchok	27.92	85.81	4.6	08:11
2021-10-18	Sindhupalchok	27.92	85.8	4.7	08:01
2021-10-16	Gorkha	28.18	84.93	4.2	22:24
2021-10-02	Sindhupalchok	27.91	85.81	6	14:28
2021-10-02	Sindhupalchok	27.92	85.81	4.8	14:13
2021-10-01	Sindhupalchok	27.71	85.92	4.5	07:09
2021-09-25	Sindhupalchok	27.91	85.90	5	06:27
2021-09-20	Kharra, Darchula	29.89	80.59	4.7	10:45
2021-09-12	Dolakha	27.64	86.10	5.3	14:56
2021-08-23	Bajhang	29.61	81.01	4.6	20:38
2021-08-12	Udayapur	26.98	86.69	4.4	04:09
2021-07-23	Khotang	27.28	86.90	4.9	13:12
2021-07-18	Dailekh	28.98	81.47	4.9	15:14
2021-07-07	Lamjung	28.13	84.56	5.3	10:12
2021-07-02	Bajhang/Bajhura	29.79	81.59	4.4	16:17
2021-06-29	Sankhuwasabha	27.30	87.26	5.2	08:35
2021-05-19	Lamjung	28.24	84.41	4.5	16:54
2021-05-19	Lamjung	28.27	84.42	5.6	15:38
2021-05-19	Lamjung	28.27	84.40	5.8	02:41
2021-05-19	Lamjung	28.26	84.36	5	02:32
2021-05-19	Lamjung	28.26	84.35	4.7	02:31
2021-05-19	Lamjung	28.28	84.39	4.7	23:57
2021-03-18	Kavrepalanchok	27.5	85.63	5	04:20
2021-03-03	Dolakha	27.79	86.35	4.2	12:58
2021-02-09	Taplejung	27.89	87.91	4.4	01:50
2021-02-04	Taplejung	27.78	88.15	5	22:13
2021-02-02	Manang	28.78	84.10	4.6	16:14
2021-01-14	Dolakha	27.66	86.18	6	11:40
2021-01-12	Darchula	29.89	80.70	4.5	04:03
2021-01-03	Taplejung	27.66	87.62	4.8	04:59

*-Source: (seismonepal.gov.np)

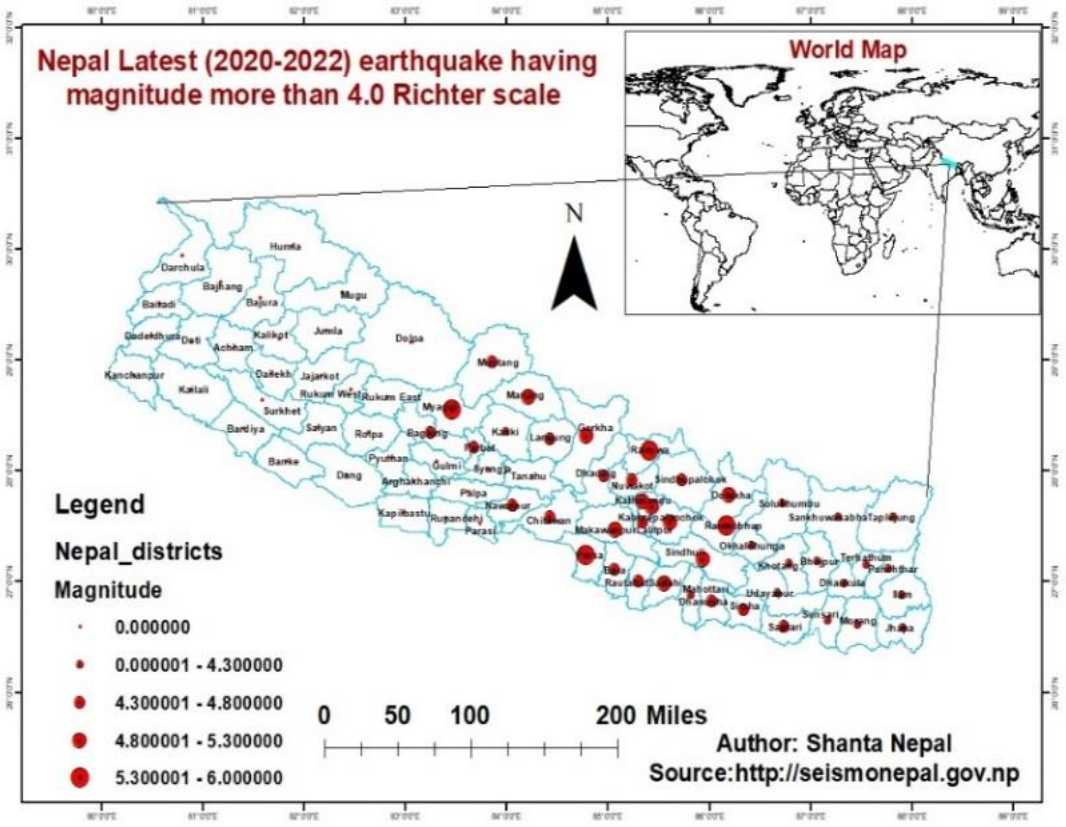

FIGURE 5. Latest earthquake incidents having magnitude more than 4.0 Richter scale.

The large number of casualties due to earthquake and fatality densities were also located during 1971 to 2022 AD has described in the TABLE 6. The pie diagram of the earthquake in all district of Nepal during the time of five decade, from 1971 to 2022 are described in FIGURE 6. The area of district given in square kilometers, average population, and total male and female populations per thousands, number of earthquake-related deaths and injuries and fatality density per square kilometer are shown in the TABLE 6 during this period.

TABLE 6. Fatality density due to Gorkha earthquakes of all 77 districts of Nepal*.

S.N.	District Name	Area	Population (2011) per thousand	Total Male	Total Female	Fatalities caused by earthquake	Fatality density (per Km^2)
1	Achham	1,680	257.48	120.01	137.47	0	0.00
2	Arghakhanchi	1,193	197.63	86.27	111.37	0	0.00
3	Baglung	1,784	268.61	118.00	150.62	2	0.00
4	Baitadi	1,519	250.90	117.41	133.49	0	0.00
5	Bajhang	3,422	195.16	92.79	102.37	0	0.00
6	Bajura	2,188	134.91	65.81	69.11	0	0.00
7	Bara	1,190	687.71	351.24	351.24	0	0.00
8	Bardiya	2,025	426.58	205.08	221.50	2	0.00
9	Banke	2,337	491.31	244.26	247.06	0	0.00
10	Bhaktapur	119	304.65	154.88	149.77	333	2.80
11	Bhojpur	1,507	182.46	86.05	96.41	2	0.00
12	Chitwan	2,218	579.98	279.09	300.90	10	0.00
13	Dadeldhura	1,538	142.09	66.56	75.54	0	0.00
14	Dailekh	1,502	261.77	126.99	134.78	0	0.00
15	Dang	2,955	552.58	261.06	291.52	0	0.00
16	Darchula	2,322	133.27	63.61	69.67	1	0.00
17	Dhading	1,926	336.07	157.83	178.23	680	0.35
18	Dhankuta	892	163.41	76.52	86.90	0	0.00

TABLE 6 (cont.). Fatality density due to Gorkha earthquakes of all 77 districts of Nepal*.

S.N.	District Name	Area	Population (2011) per thousand	Total Male	Total Female	Fatalities caused by earthquake	Fatality density (per Km^2)
19	Dhanusha	1,180	754.78	378.54	378.54	1	0.00
20	Dolakha	2,191	186.56	87.00	99.55	180	0.08
21	Dolpa	7,889	36.70	18.24	18.46	0	0.00
22	Doti	2,025	211.75	97.25	114.49	0	0.00
23	Eastern Rukum	1,161	53.18	24.98	28.20	2	0.00
24	Gorkha	3,610	271.06	121.04	150.02	450	0.12
25	Gulmi	1,149	280.16	121.00	159.17	3	0.00
26	Humla	5,655	50.86	25.83	25.03	0	0.00
27	Ilam	1,703	290.25	141.13	149.13	0	0.00
28	Jajarkot	2,230	171.30	85.54	85.77	0	0.00
29	Jhapa	1,606	812.65	385.10	427.55	1	0.00
30	Jumla	2,531	108.92	54.90	54.02	0	0.00
31	Kailali	3,235	775.71	378.42	397.29	330	0.10
32	Kalikot	1,741	136.95	68.83	68.12	0	0.00
33	Kanchanpur	1,610	451.25	216.04	235.21	0	0.00
34	Kapilbastu	1,738	571.94	285.60	286.34	0	0.00
35	Karvepalanchok	1,396	381.94	182.94	199.00	0	0.00
36	Kaski	2,017	492.10	236.39	255.71	3	0.00
37	Kathmandu	414	1744.24	913.00	831.24	1233	2.98
38	Khotang	1,591	206.31	97.09	109.22	0	0.00
39	Lalitpur	385	468.13	238.08	230.05	185	0.48
40	Lamjung	1,692	167.72	75.91	91.81	5	0.00
41	Mahottari	1,002	627.58	311.02	311.02	4	0.00
42	Makwanpur	2,426	420.48	2,066.84	213.79	33	0.01
43	Manang	2,246	6.54	3.66	2.88	1	0.00
44	Morang	1,855	965.37	466.71	498.66	2	0.00
45	Mugu	3,535	55.29	28.03	27.26	0	0.00
46	Mustang	3,573	13.45	7.09	6.36	0	0.00
47	Myagdi	2,297	113.64	51.40	62.25	3	0.00
48	Nawalparasi	1,043	311.60	303.68	339.83	5	0.00
49	Nuwakot	1,121	277.47	132.79	144.68	1112	0.99
50	Okhaldhunga	1,074	147.98	68.69	79.30	20	0.02
51	Palpa	1,373	261.18	115.84	145.34	1	0.00
52	Panchthar	1,241	191.82	90.19	101.63	0	0.00
53	Parasi	63,488	331.90	160.90	171.01	7	0.00
54	Parbat	494	146.59	65.30	81.29	0	0.00
55	Parsa	1,353	601.02	312.36	312.36	7	0.01
56	Pyuthan	1,309	228.10	100.05	128.05	0	0.00
57	Ramechhap	1,546	202.65	93.39	109.26	42	0.03
58	Rasuwa	1,544	43.30	21.48	21.83	681	0.44
59	Rautahat	1,126	686.72	351.08	351.08	3	0.00
60	Rolpa	1,879	224.51	103.10	121.41	2	0.00
61	Rupandehi	1,360	880.20	432.19	448.00	0	0.00
62	Salyan	1,462	242.44	115.97	126.48	0	0.00
63	Sankhuwasabha	3,480	158.74	75.23	83.52	0	0.00
64	Saptari	1,363	639.28	313.85	313.85	0	0.00
65	Sarlahi	1,259	769.73	389.76	389.76	2	0.00
66	Sindhuli	2,491	296.19	142.12	154.07	15	0.01
67	Sindhupalchok	2,542	287.80	138.35	149.45	3570	1.40
68	Siraha	1,188	637.33	310.10	32.72	1	0.00
69	Solukhumbu	3,312	105.89	51.20	54.69	22	0.01
70	Sunsari	1,257	763.49	371.23	392.26	9	0.01
71	Surkhet	2,451	350.80	169.42	181.38	0	0.00
72	Syangja	1,164	289.15	125.83	163.32	2	0.00
73	Tanahun	1,546	323.29	143.41	179.88	0	0.00
74	Taplegunj	3,646	127.46	60.55	66.91	1	0.00
75	Tehrathum	679	101.58	47.15	54.43	1	0.00
76	Udayapur	2,063	317.53	149.71	167.82	1	0.00
77	Western Rukum	2,877	155.38	74.18	81.20	0	0.00

*-Source: (MOHA, Census 2011)

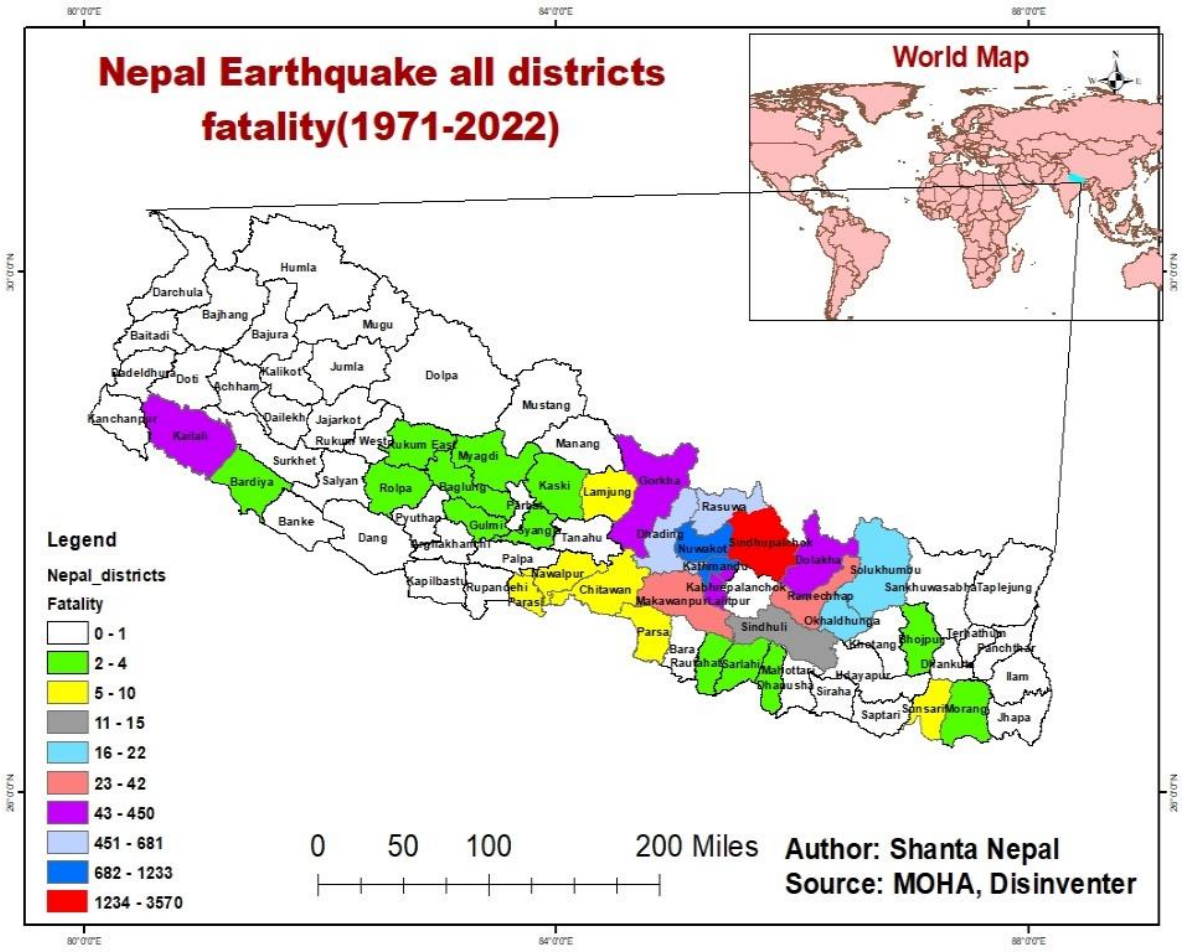

FIGURE 6. Fatality density of all seventy-seven districts of Nepal.

Discussion on the earthquake as a disaster

The earthquake stands out as a devastating hazard capable of impacting both the lives and properties of individuals. Its occurrence often leads to significant loss of life and extensive damage to infrastructure, with unpredictable outcomes. Nepal experienced a catastrophic earthquake measuring 7.8 on the Richter scale on April 25th, 2015, with its epicenter located in Gorkha. This event is commonly referred to as the Gorkha earthquake of 2015. The toll was immense, with 8,790 casualties, 22,300 injuries, and 200 individuals reported missing. Beyond the loss of human life, the earthquake wreaked havoc on various properties, including schools, buildings, monuments, and national heritage sites, many of which suffered damage or complete collapse.

By taking the average population of the census of 2011, total fatalities caused due to seismic activities observed and analysed. The fatality density is calculated from fatality number due to earthquake divided by total average populations and multiplying to area of these districts. Out of the seventy-seven districts, thirty-three districts reported no fatalities, while seven districts recorded only one fatality each. Among these, Sindhupalchok emerges as the most heavily impacted district, with 3,570 fatalities. The fatality density in Sindhupalchok is notably

high at 1.40 per square kilometer, considering its population density of 287.80 per thousand, as per the census data from 2011.

Following Sindhupalchok, Kathmandu emerges as the second most affected district by seismic events. Kathmandu spans an area of 414 square kilometers with a population density of 1,744.24 per thousand. The district witnessed 1,233 fatalities, resulting in a fatality density of 2.98 per square kilometer. Nuwakot ranks third in terms of earthquake-related fatalities, with 1,112 recorded fatalities and a fatality density of 0.99 per kilometer. In twelve districts, a significant number of fatalities were observed, with more than a hundred casualties noted in each due to the Gorkha earthquake. These districts include Sindhupalchok, Kathmandu, Nuwakot, Rasuwa, Lalitpur, Kailali, Gorkha, Bhaktapur, Dhankuta, and Dolakha. The specific number of casualties for each district and their corresponding fatality densities are detailed in the provided table (TABLE 6). The epicenter of the 2015 earthquake, measuring 7.8 on the Richter scale, was located in Gorkha district, resulting in the loss of 450 lives with a fatality density of 0.12.

CONCLUSION

Since 2018, a total of fifty-eight earthquakes registering more than 7 on the Richter scale have been recorded globally, with five of them surpassing a magnitude of 8. The most significant of these earthquakes, measuring 8.2 in magnitude, occurred in Fiji in 2018. The Gorkha earthquake, measuring 7.8 on the Richter scale, struck Nepal on April 25, 2015, making it the most powerful earthquake recorded in the Asian continent. The devastation caused by this earthquake was profound, with widespread loss of life and extensive damage to infrastructure. Additionally, the toll of deaths and injuries resulting from earthquakes in Nepal from 1971 to 2022 has been documented.

The Gorkha earthquake in Nepal claimed the lives of 8,790 people, while 22,300 were injured, and 200 individuals were reported missing. Beyond the human toll, the earthquake also caused extensive damage to properties, monuments, and national heritage sites, highlighting the far-reaching impact of this catastrophic event. Sindhupalchok emerges as the most heavily impacted district, with 3,570 fatalities and a fatality density of 1.40 per square kilometer. Following closely, Kathmandu ranks second, while Nuwakot is third in terms of casualties. Kathmandu experienced a higher number of injuries, whereas Rasuwa reported a significant number of missing individuals. In Gorkha district, 450 fatalities were recorded, resulting in a fatality density of 0.12. The devastation caused by the earthquake extended beyond human casualties, encompassing damage to various properties, schools, buildings, monuments, and national heritage sites.

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