EXPLORING THE SEISMAL PHENOMENON IN INDIA BETWEEN 1865 TO 1945 - AT A GLANCE.

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ABSTRACT

Earthquakes are extremely dangerous natural hazards. They vary from high to low intensities causing little impact to pernicious upshot. From the year 1865-1945 i.e., in the span of 80 years around 150-200 earthquakes and seismal activities had took place all-round the world. This paper discusses about the local geography of the quake area and the obliteration the earthquake had built up. Geography and the seismic activities have a close associative relationship. This was discussed in this paper through chorography and by representing the epicentrum of the particular Seism. The present paper studies include the earthquakes that had its origin or epicentrum within Indian territory and had occurred between the years 1865-1945. The significance of this paper is to consolidate the paramount details of the earthquakes and to have a meticulous attribute of the topography and geography of the local extent of the influenced area. The main objective is to compare the intensities of the earthquakes and to analyze the decadal frequency of the earthquake occurrence. The output of the paper helps in tackling the earthquakes with the reference of the past occurrences.

Keywords- Epicentrum, Seismic waves, Fault, Tectonic plates, Chorography, Seism, Aftershocks, Liquefaction, Seiches, Mercalli Intensity Scale, Asthenosphere.

INTRODUCTION

An Earthquake is termed as a violent shaking or vibration of the earth's crust. The reason could be the passage of seismic waves from beneath the earth's crust to the surface. These seismic waves are the series of shock waves, coming as a result of release of elastic energy. Though the elastic energy unfettered from the rocks is regarded as the main reason, there are other causes that could be the basis and acts as the underlying principle for the occurrence of the earthquakes.
The underpinning Fundamental essence associated with the Earthquake Phenomenon is the Reid's "**Elastic Rebound Theory**". The name itself indicates that the elastic energy, which may be stored, is bounced back when the source got broken. The stress, built up in the plates or rocks, gets exerted when it is beyond the capacity. The release of energy may be is in the form of heat and elastic waves. Simply, the movement of Tectonic Plates and Volcanism are the causes of earthquakes.
The load at the Fault lines slowly deforms the crust and moves the Lithospheric plates. In addition to this, the magma in the mantle tries to move the tectonic plates due to "**Convection Current**". The convection theory is associated with the circular movement or circulation of magma in the asthenosphere which makes the plates to converge, diverge and transform resulting in the deformation. This abrupt change and residual deformation may result in the stress beneath the earth crust and act as a source for the energy to release.

OBJECTIVES

- To understand the geography and topography of the affected region.
- To sense the seismic cause and impression.
- To figure out the prevalence of the seismicity in India.

EARTHQUAKES IN INDIA (1865 – 1945)

In this paper, we shall discuss about the earthquakes that had occurred in India and has its epicenter in the geographical boundary of the Indian Territory. Here, below are the seismic activities which had occurred in the Indian Lithosphere and had its effect to a greater extent.

CACHAR EARTHQUAKE - 1869

On the 10th January at 17:15 IST the earthquake occurred with a magnitude of 7.5 which is generally considered as a Major Earthquake. The Cachar earthquake falls under the seismic zone of 5. There were 2 deaths reported due to the consequences of the earthquake and caused severe damage to the physical infrastructure.

Areas Affected: -

In the regions of Cherrapunji, Silchar, Sylhet, the earthquake tremors were felt.

Geography-

According to Latitudes and Longitudes, the epicenter falls near Diyung river. The Cachar region in Assam is a heterogenous plain. It comprises low lands and high hills. It is bounded by North Cachar and Jaintia Hills.

Cause-

The fissure below the Jaintia hills caused the massive hazard.

Encapsulating the affected area

Origin Date, Time - 10-01-1869, 17:15 IST

Region Name - Cachar, Assam

Land Type - Heterogenous Plain

Epicenter - Cachar region and Dhubri Area

Latitude - 25.5 N

Longitude - 93.0 E

Magnitude - 7.5

Soil Type - Clayey Loam, Alluvial Soil

Climate - Humid Sub-tropical

Seismic Zone - Zone 5

Elements at Risk during the Hazard

- Human Settlements
- Infrastructure and Institutional elements.

Damage Occurred

A saw-mill was displaced and houses made of wood were toppled.

Figure 1

Figure 1 shows the Geographic location of the Epicenter of the Earthquake

Figure 2

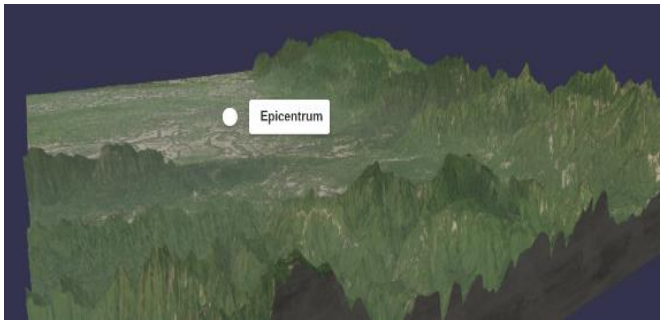


Figure 3

Figure 2 and 3 depicts the Elevation of the quake region.

Figure 4

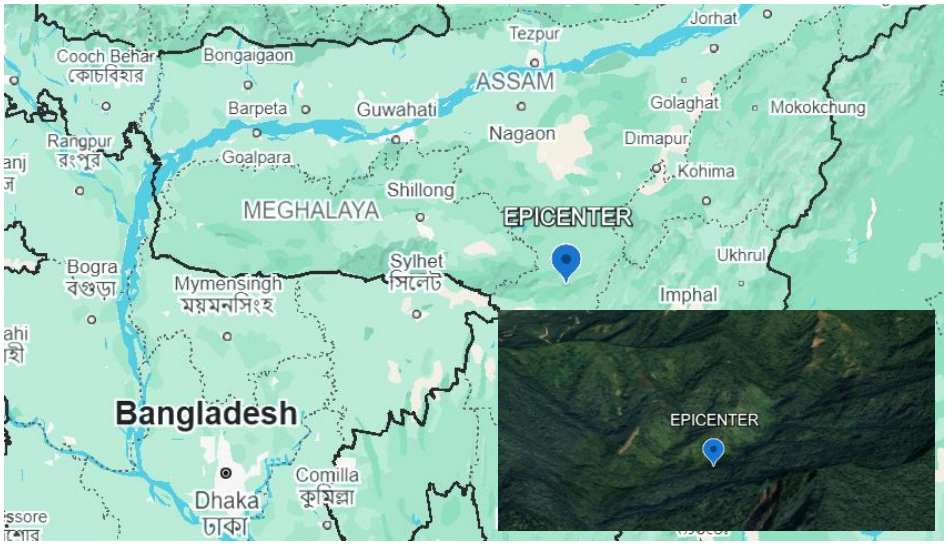


Figure 4 shows the local area of the affected region and also depicts the terrain of the area.

1881 NICOBAR ISLANDS

The 1881 Nicobar Islands is an Earthquake triggered Tsunami, with a magnitude of 7.9. The maximum Tsunami waves is recorded at Nagapattinam of height 4ft. The intensity of earthquake was stretched to even port Blair, Sri Lanka though there are no death casualties recorded, the infrastructure in the port Blair had got affected.

Areas Affected: -

Car Nicobar, port Blair, Burma, Colombo, Sawai, Perka.

Geography-

The seismic waves impact was felt to a stretch of 2 million square miles. The Nicobar Islands comprises the Kamorta and Nan cowry islands. These are also known as Central, North and South Islands respectively. Car Nicobar, the Northern group Islands are relatively flat and have hilly areas. They lie in the Coastal line where the earthquakes occurrence is high.

Cause-

The earthquake may had occurred due to the tectonic movement of Andaman plate and Sunda plate. The earthquake aftermath shocks were noticed and felt in nearby regions and led to the havoc of destruction of plantation and structural damage.

Encapsulating the affected area

Origin Date, Time	-	31-12-1881, 7:19 IST
Region Name	-	Nicobar Islands
Land Type	-	Flat and Hilly areas
Epicenter	-	beneath Car Nicobar
Latitude	-	9.25 N
Longitude	-	92.70 E
Magnitude	-	7.9
Soil Type	-	Sandy, hilly soil, loamy soil
Climate	-	Tropical wet climate
Seismic Zone	-	Zone 5
population (During Hazard)	-	5000

Elements at risk during the Hazard

- Human Settlements
- Local Infrastructure and Ecosystems
- Indigenous Communities, Ethnic groups and livelihood

Damage Occurred

- Cracking of Masonry buildings, Chimney of a factory.
- Destruction of Coconut groves/Shaking of Inland Plantation.
- Caused disturbance to the residential dwellings.
- Upliftment of Car Nicobar Island.

Figure 5

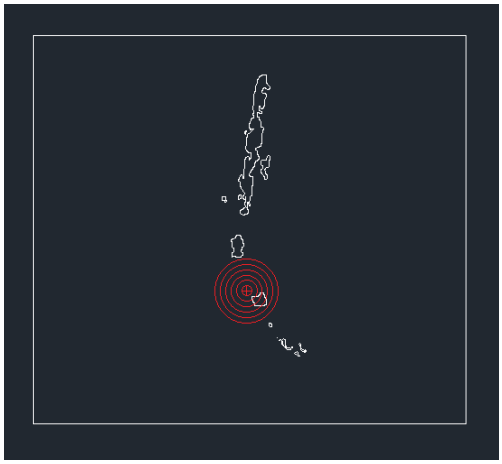


Figure 5 shows the extent of seismic impact on the nearby areas.

Figure 6

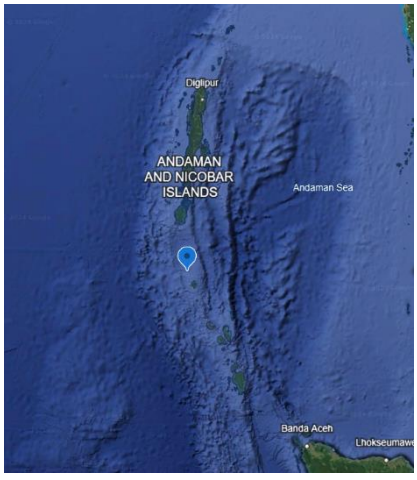


Figure 6 depicts the terrain of the region of epicenter i.e., beneath Car Nicobar.

Figure 7

Figure 7 shows the terrain of the Epicentrum.

Figure 8

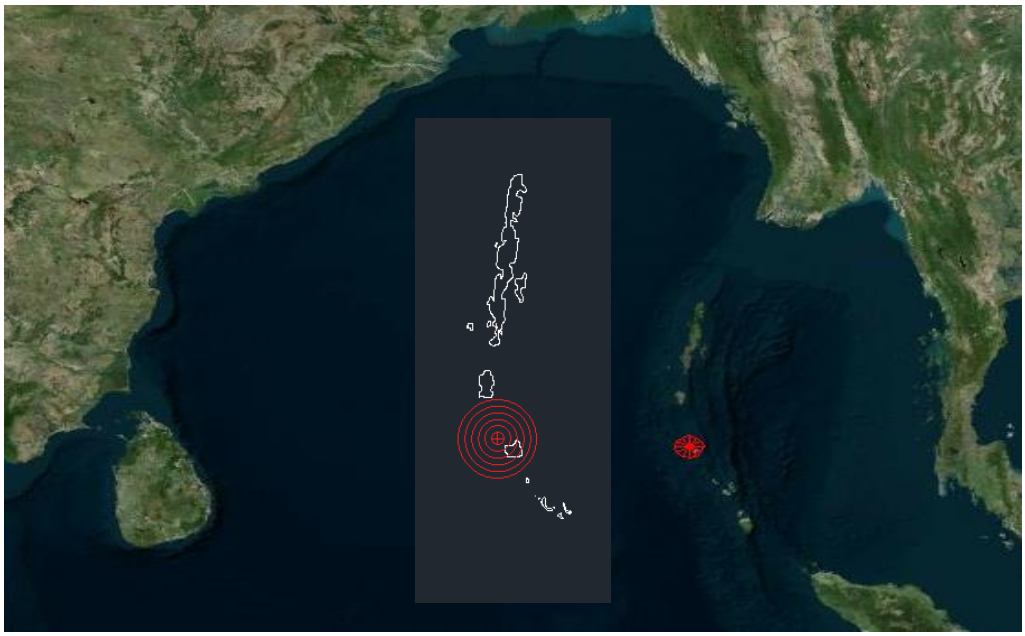


Figure 8 shows the local extent of the seismic consequence.

1885 KASHMIR SRINAGAR EARTHQUAKE/ BARAMULLA EARTHQUAKE

On the dark night of 30-05-1885, the valley of Kashmir, Srinagar had shaken and seen a tremendous vibration of the earth and had experienced an earthquake of magnitude around 6.6 to 6.8 M. It led to large casualties, deaths and damage. Though the damage assessment and analysis are high in numbers, it also seen a land fall or landslide near Laridura. As many as 75000 huts were destroyed and 3500 people died due to the deaths and destruction might be reduced if the earthquake had not occurred before the dawn.

Areas Affected: -

Kashmir, Baramulla, Pattan, Lasipore, Magam, Badgam, Ganderbal, Srinagar.

Geography: -

The expanse of the epicenter is at the hugely populated area where approximately 51000 people resides over there. The earthquake caused a death toll of around 3500 people and casualties resulted in livestock, cattle and also led to a greater destruction of local structures.

It receives an annual snowfall of 580-585mm. the Budgam district comprises both mountains and flat plain areas. The higher elevated areas experience high snowfall and sometimes the low-lying areas are flooded with heavy rainfall.

Tangnor, in Budgam, is boasted with decodar and pine trees and Srinagar has many lakes, swamps and rivers. As these places have many ecological ecosystems, the earthquake (might) had affected these natural bio-habitats and also wrecked some settlements and towns like Sapore, Baramulla of Kashmir. The vegetation in the Baramulla, Budgam, Srinagar (apple orchards, chinar, willows, sago palm) has got disrupted to a large extent and especially in hill-side areas, got typically influenced.

Cause: -

The main cause is due to the ‘Baramula- Loridor Fault’. It was from here; the main earthquake shock has generated. Because of the thrust Fault rupture, the earthquake has occurred.

Encapsulating the affected area

Origin Date, Time - 30-05-1885, 2:24 IST

Region Name - Baramulla, Kashmir

Land Type - Broad Valley and Arable Land

Epicenter - beneath Car Nicobar

Latitude - 34.12 N

Longitude - 74.61 E

Magnitude - 6.6

Soil Type - Alluvial Soil, Loose Soil

Climate - Temperate, Montane climate

Seismic Zone - Zone 5

population - 51000 (Srinagar), 1,32,000 (Kashmir)

(During Hazard)

Elements at Risk during Hazard

- Residential dwellings
- People, cattle
- Environmental balance

Damage Occurred

- The earthquake spreads from epicenter towards east to the Srinagar and west to the Baramulla.
- It caused casualties to 25000 cattle and also damaged livestock and collapse of huts.
- In some areas, sand fissures are observed and the water level of the springs has seen an increase.
- The dwellings of the people have crumpled and enshrouded in the ground.

Figure 9

Figure 9 shows the Geolocation of the Epicenter.

Figure 10

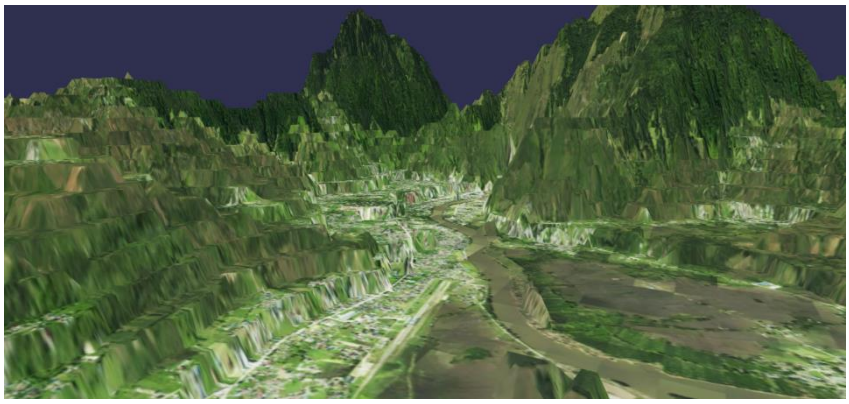


Figure 10 shows the Elevation of the affected region.

Figure 11

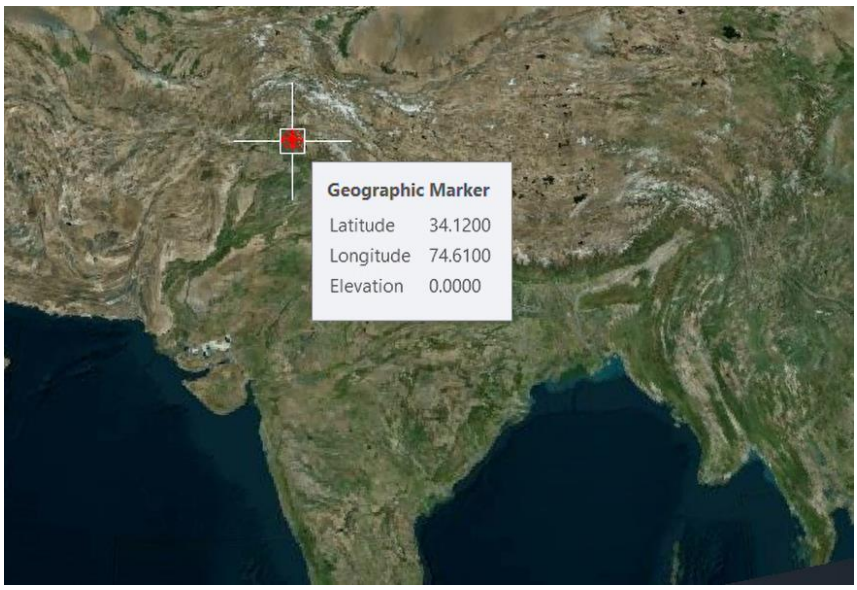


Figure 11 shows the latitude and longitude of the quake generated area on the Indian Map.

Figure 12

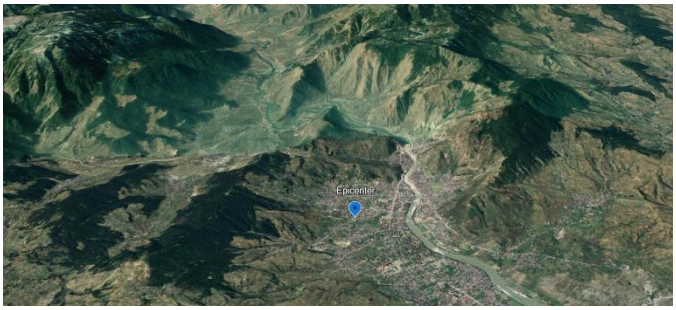


Figure 12 shows the local Terrain of the Baramulla area.

Shillong Earthquake of 1897

The Shillong earthquake 1897 is considered as most massive one where the waves had variable speeds and took distinct paths and ram shackled the areas within reach. The load at the Shillong plateau slowly resulted in the upward thrust and caused this tremendous earthquake. Its consequence not only seen in India but also in Bhutan and Bangladesh. 1897 earthquake had occurred in the rugged topography of salpara, assam. Though its epicenter is at salpara, Goalpara district, the damage had reached to the extents of Ahmedabad, Calcutta, Peshawar.

Areas Affected: -

Bhutan, Bangladesh, India- Shillong, assam, Nalbari, Guwahati, Nagaon, Sylhet, Sunamganj, Dudhnoi, Chirang, Panigoan.

Geography: -

The earthquake waves had carried its impact from the epicenter to the far distant areas like Ahmedabad, it is considered that the trembles have travelled 19.8 miles from the epicenter. When the earthquake has occurred, the region of Goalpara is experiencing the early monsoons. The Goalpara district of assam comprises hills, plains and also the river valleys. The Goalpara district and most parts of the regions near to Salpara are along/ nearby Brahmaputra River. The earthquake resulted in the arose of water waves and resulted in destruction of the nearby areas.

Cause: -

The Shillong plateau (Meghalaya) thrusted upward suddenly approximately about 11 meters. It resulted in fault of the tectonic. This sudden movement resulted in the huge release of energy of around 8.3 magnitude. Along with this, there were some formations of volcanic vents and liquefactions, seiches.

Encapsulating the affected area

Origin Date, Time - 12-06-1897, 11:06 IST

Region Name - Assam

Land Type - Both flat - plain and hilly, rugged Topography

Epicenter - At salpara, Goalpara district, Assam

Latitude - 26.0 N

Longitude - 90.7 E

Magnitude - 8.3

Soil Type - Sandy, hilly soil, loamy soil

Climate - Humid Sub-Tropical
(receives south-west monsoon rainfall)

Seismic Zone - Zone 5

population - 4,46,232
(During Hazard)

Elements at Risk during Hazard

- Forest and Biodiversity Reserves
- Natural lakes, connectivity, people lives.

Damage Occurred

- Detriment of umananda island temple
- The railway connectivity is much important for trade and goods transfer. The earthquake had affected the railway lines especially assam- Bengal railway and this ended up in the death of around 17 deaths.
- The earthquake caused the collapse of buildings and there were some fissures observed in quake hit areas and also sand dykes at kharidhara.

Figure 13

Figure 13 marks the origin of the Earthquake.

Figure 14

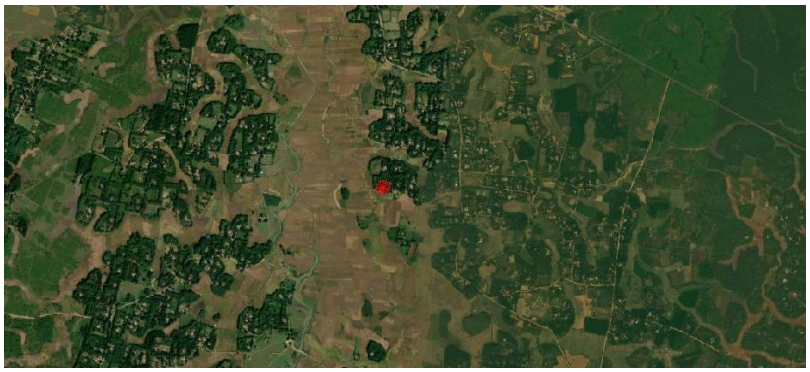


Figure 14 depicts the Epicenter and the local Geography.

Figure 15

Figure 15 shows the extent of the Seismic Impact.

Figure 16

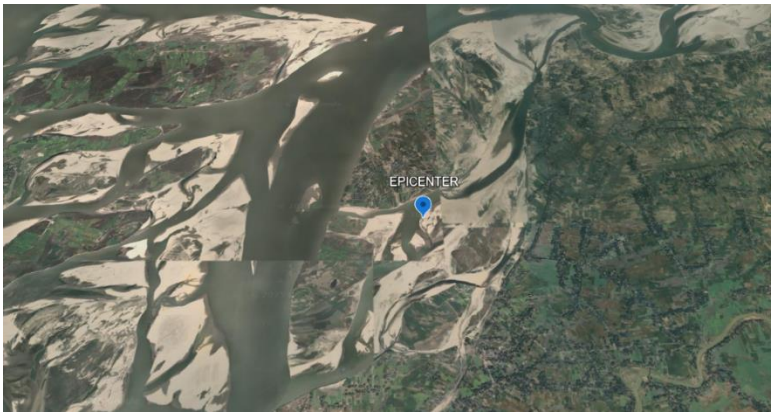


Figure 16 shows the Topography and the Terrain of Salpara.

Figure 17

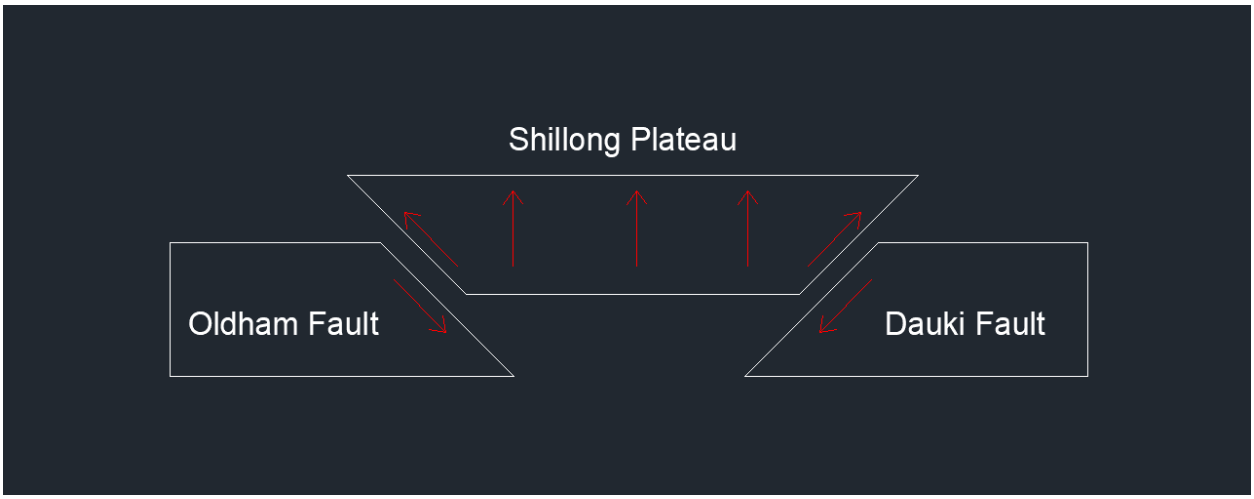


Figure 17 shows the Shillong Plateau and its Transform Boundary Plates.

Figure 18

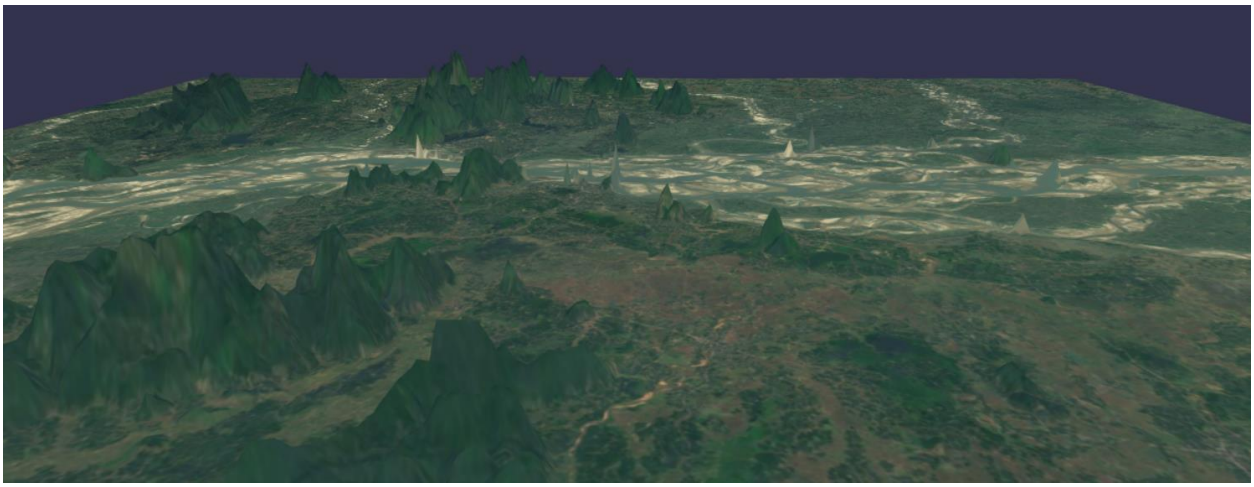


Figure 18 shows the Elevation of Salpara, Goalpara district.

KANGRA EARTHQUAKE OF 1905

Magnitude 7.8 is considered as most disastrous earthquake. 1905 Kangra earthquake had made its impact throughout Kangra valley, Parts of Himachal and Jammu and Kashmir.it caused a massive destruction to nearby areas and casualties to people and livestock and infrastructural damage.

Areas Affected: -

Kangra, Bhalessa, Shahpur, Chamba, Surangani, Dharamshala, Palampur, Kasauli

Geography: -

The major impact of the earthquake is at low area between mountains and hills i.e., at kangra valley. The kangra valley has warm temperate climate, they have long and hot summers. They have dense forests and terrain is of hilly and mountain.

Coming to the epicenter region, Gandoh bhalessa it has non-uniform climate. There were many hill stations and dhars in the affected areas. The affected areas are highly susceptible to seismic activities and has seen many seismic acts and has seen even land elevation and landform changes.

Cause: -

The earthquake has the epicenter at the Himalayan thrust fault. The Himalayan thrust fault is regarded as the mighty continental thrust which is still active.

The load at the thrust fault may had caused the earthquake. People attribute the main cause to be movement of Indian and Eurasian plate, as the epicenter is exactly at the fault.

Encapsulating the affected area

Origin Date, Time - 04-04-1905, 7:19 IST

Region Name - Kangra Valley

Land Type - Valley

Epicenter - At Gandoh, Jammu and Kashmir (near Himalayan Thrust)

Latitude - 33.0 N

Longitude - 76.0 E

Magnitude - 7.8

Soil Type - Loamy Sand to Sandy Loam (brown)

Climate - Humid Sub-Tropical

Seismic Zone - Zone 5

population - 4,70,000

(During Hazard)

Elements at Risk during Hazard

- Religious places
- Mountain ecosystem
- Water supply system

Damage Occurred

- There were many mortalities and casualties happened due to this earthquake.
- Structural damage has occurred to some old temples.
- The earthquake has changed most of the outlook of the infrastructure and landscape.
- Deaths occurred to 19,700 people and 53,000 cattle.
- An estimation of 1lakh buildings had collapsed and destroyed.

Figure 19

Figure 19 shows the latitude and longitude of the source of the quake.

Figure 20

Figure 21

Figure 20, 21 depicts the Terrain of the Earthquake area.

Figure 22

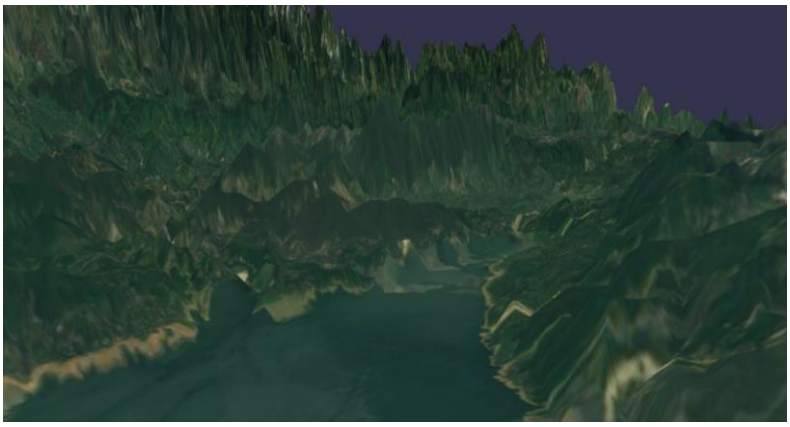


Figure 23

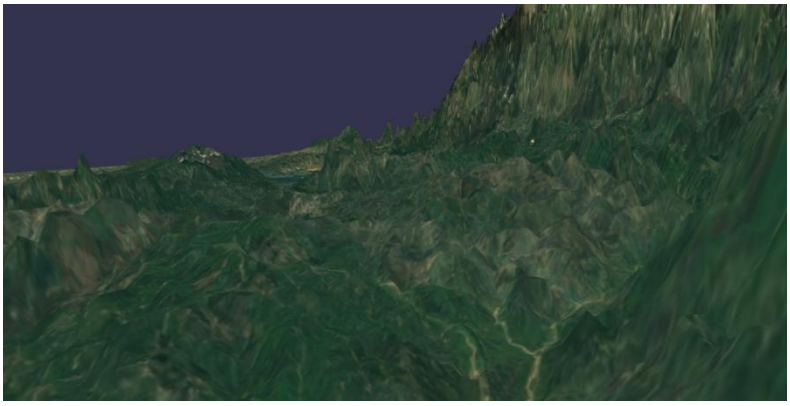


Figure 22,23 shows the Elevation of the quake impacted region.

DHUBRI EARTHQUAKE 1930

The north east India is tremendously susceptible to the natural disasters due to its topography and geographical position. The 1930 Dhubri earthquake has caused a severe damage with Dhubri earthquake has caused a severe damage with a magnitude of 7.1. the earthquake has followed by many aftershocks, it is estimated that around 34-35 aftershock had been observed. The after shocks were somewhere near to the epicentral tract. Some after shocks had continued even after 70 days.

Areas Affected: -

Dhubri, Bagadol, Cherrapunji, Gauhati, Coach Behar, Bux Fort, Garo Hills, Dalsinghpara, Nidanpur, Tura, Areas Near Brahmaputra River In Assam, Manipur, Sikkim, Chittagong, Dibrugarh, Dabigiri, Kurigram-Bangladesh.

Geography: -

The extent of impact of the earthquake from the epicentral area or tract has been to all the surrounding areas including Nidanpur to Dhubri, Bagadol to Garo hills, Tura, Rongkon. It has extended from Dhubri to coach Behar affecting even Bangladesh. Places like Lalmanirhat, Kurigram, Boromani in Bangladesh had felt the shock of the waves.

There were many hills in the Meghalaya. The Jaintia and Khasi hills are of the prominent one. There wee deep gorges and valleys making the way for the rivers to flow down the beneath. It comprises both hilly areas and gradual slopes, plains. The Meghalaya state and Dhubri region experiences a temperate climate due to its geological orientation.

Causes: -

The main cause of north east India's high vulnerability to seismicity is attributed to the Dhubri Fault thrusting or dipping.

It was reported that there is an intensity of 8 and affected the nearby areas and also far extended Manipur, Sikkim and even Bangladesh.

Encapsulating the affected area

Origin Date, Time	-	3-07-1930, 3:23 IST
Region Name	-	Dhubri
Land Type	-	Plateau
Epicenter	-	Near Bagadol
Latitude	-	25.57 N
Longitude	-	90.0 E
Magnitude	-	7.1
Soil Type	-	Loamy to Silty
Climate	-	Humid Sub-Tropical Climate
Seismic Zone	-	Zone 5
population	-	4,80,000 (Meghalaya),
		1,90,000 (Garo Hills)

(During Hazard)

Elements at Risk during Hazard

- Indigenous population
- Infrastructure, Railway Lines
- Residential Structures

Damage Occurred

- It has affected the ‘Eastern Bengal Railway’ line. It is observed that the seismic waves had passed through this Railway Connectivity.
- There was some cracking observed in the buildings due to seismic impact.
- The structural repair and damage assessment had done in the later stages.

Figure 24

Figure 24 shows the Geolocation i.e., the latitudes and longitudes of the quake source.

Figure 25

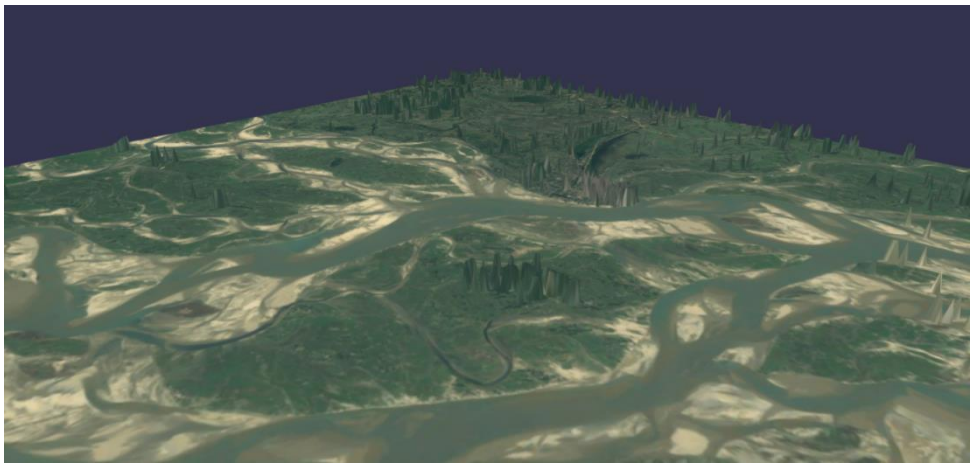


Figure 25 shows the Elevation and Topography of the quake influenced area.

Figure 26

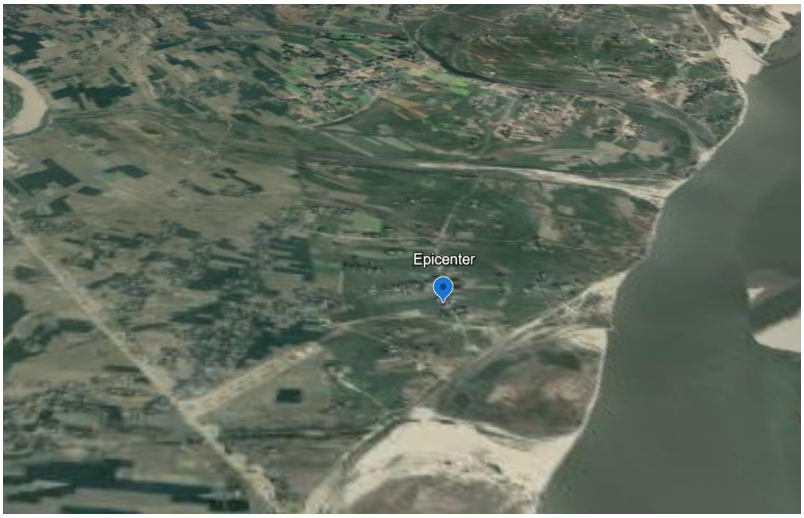


Figure 26 shows the Terrain of the plateau.

ANDAMAN ISLANDS EARTHQUAKE - 1941

1941 Andaman earthquake is the strongest seismic activity in the Bay of Bengal with an intensity of 8. It has a shallow focal depth of 20km. there were many aftershocks on the following day of the earthquake. It had occurred as a consequence of subsidence and subduction of the tectonic plates.

Areas Affected: -

Andaman and Nicobar Islands, broom valley, Anderson Island, Chennai, Kolkata, south Andaman, Sylhet, Sri Lanka, Colombo.

Geography: -

The earthquake had made its effect on many areas. It had its impact on the Barren Island which is the nearby volcano in the closest proximity of the epicenter. There were some islands like core brook, porlob, Interview Island which had abated and subsided inside beneath the crust. The earthquake had annihilated most of the regions, it included not only India but also columbo, Sri Lanka.

Andaman Islands terrain is mostly rugged comprising both valleys, hills, volcanoes. Barren island in Andamans is the only active one in the entire south east Asia. The Andamans have white sand beaches in Radha Nagar. The seismic waves had extended up to south Andaman.

Causes: -

Due to the faulting of tectonic plates the earthquake has occurred. The fault is of around 800 – 850 km. it also triggered and generated a tsunami of wave height around 3ft to 4ft in Bay of Bengal. Though the tsunami has not caused any significant deaths or damage the impact of earthquake has Shaked the most parts of the country.

Encapsulating the affected area

Origin Date, Time - 26-06-1941, 11:52 am IST

Region Name - Andaman and Nicobar Islands

Land Type - Island (Flatland)

Epicenter - Near Yadita

Latitude - 12.50 N

Longitude - 92.57 E

Magnitude - 8.1

Soil Type - Red Loamy and Marine Alluvial Soil

Climate - Tropical Climate

Seismic Zone - Zone 5

population - 33,700

(During Hazard)

Elements at Risk during Hazard

- Infrastructure elements
- Environment, Natural Ecosystems
- Ethnic groups

Damage Occurred

- The repercussions of the earthquake had resulted in damage to many buildings in places like columbo, port Blair.
- The earthquake had extracted and pulled up many trees and caused destruction to roads, embankments.
- There were some marks of fissures, liquefaction and soil vents.
- Many biodiversity and natural ecosystems had got influenced. It was reported the mortality of around 3000 deaths.

Figure 27

Figure 27 shows the origin area of the earthquake.

Figure 28

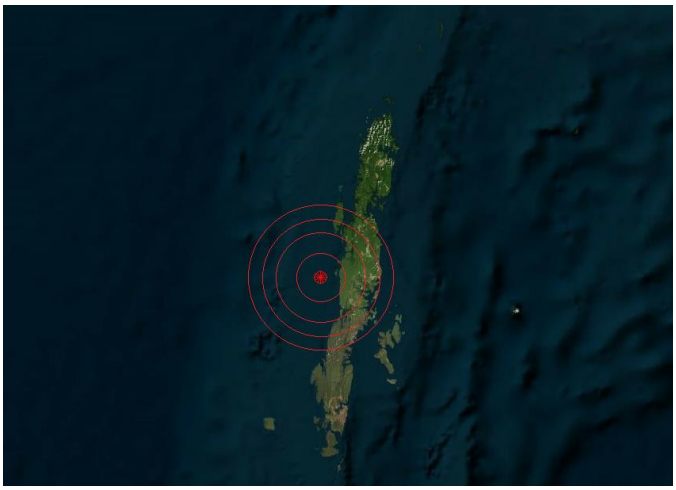


Figure 28 shows the Seismic Impact area.

Figure 29

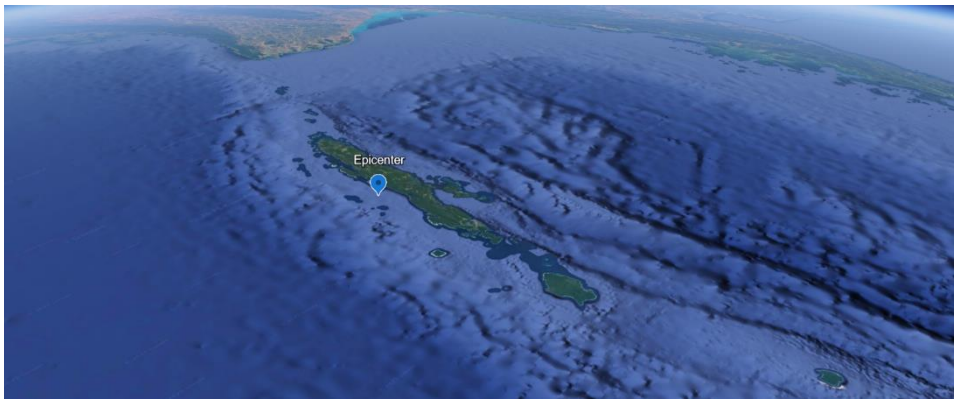


Figure 30

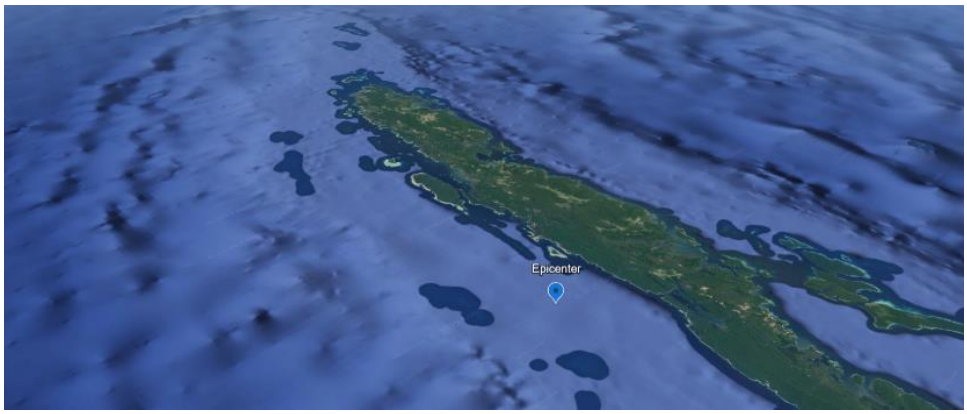


Figure 29, 30 shows the Topography and Terrain from the extended Top-view.

Figure 31

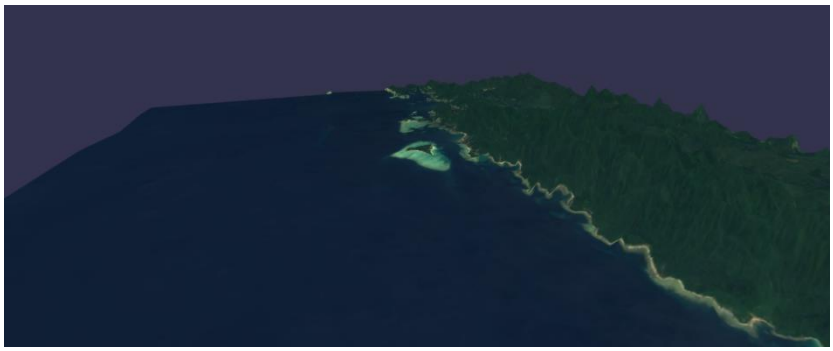


Figure 32

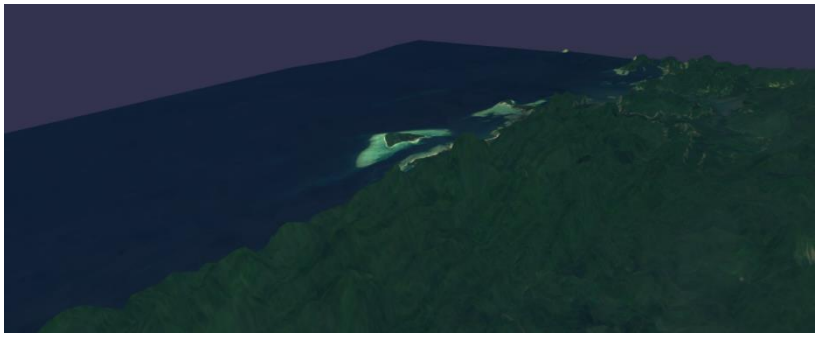


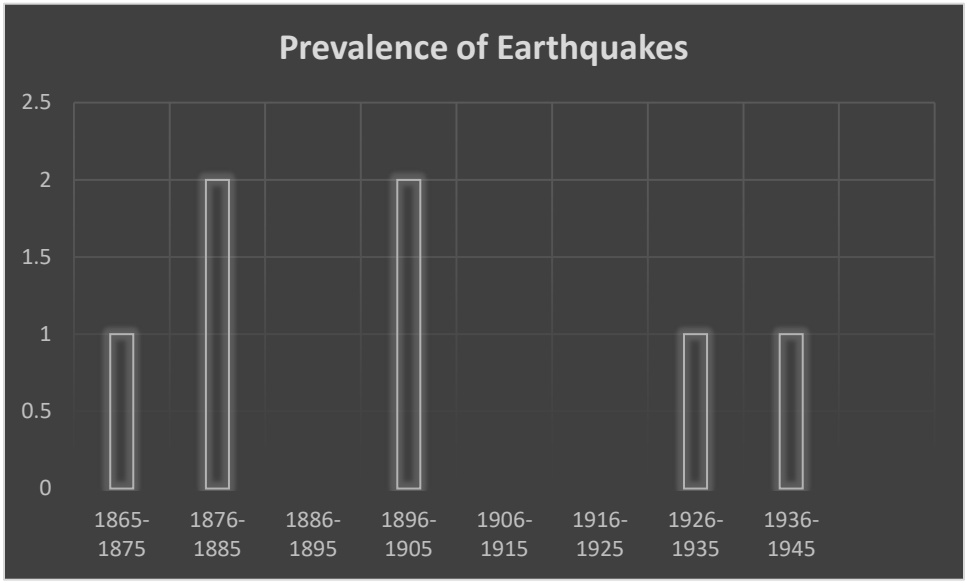
Figure 31, 32 shows the Elevation of the quake affected area.

DISCUSSIONS

The Earthquake management in India had seen and taken a transitional and paradigm shift. It had abandoned the old traditional practices of facing the consequences of the aftermath disaster. It had keenly focused on the preparedness stage and were well prepared for the reduction of the elements that are susceptible to the risk. However, the earthquakes from 1865 to 1945 had caused a disastrous effect and a tremendous negative impact on the people, topography and livelihoods. Though there were no official sources that had reported about these earthquakes, this paper brought out the basic elements that were at risk at that time and it also lime lighted the damage caused due to the earthquakes – it included both infrastructural damage as well as physical, human geological related aspects.

The intensity of the earthquakes is basically measured with Mercalli Scale. The intensity of the earthquake is represented by an integer varying from 1 – 10 with intensity 10 being the most destructive and dangerous. It may even damage the earthquake engineered buildings.

Graph 1 – Chart showing the seismicity Frequency.



Graph 2 – Comparison Chart of Intensities and Magnitudes.

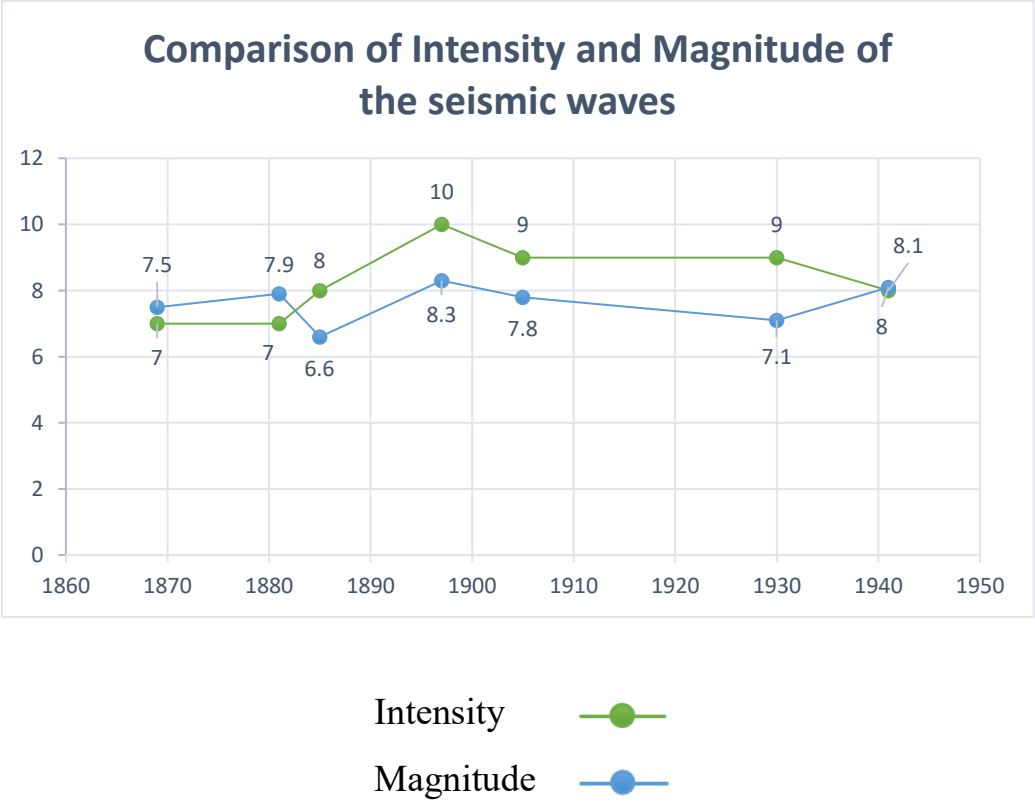


Table 1 – Depiction of Intensity and Seismic Zonation.

Earthquake	Intensity	Seismic Region/Zone
1869 Cachar	7	North-East India
1881 Nicobar Islands	7	Andaman & Nicobar Islands
1885 Baramulla	8	Kashmir & Western Himalayas
1897 Shillong	10	North-East India
1905 Kangra	9	Kashmir & Western Himalayas
1930 Dhubri	9	North-East India
1941 Andaman Islands	8	Andaman & Nicobar Islands

This paper gives an overview of the Earthquakes of 80 years that took place in the present Geographical Territory of India. we can observe from the **Table 1**, that the occurrence of the Earthquake is majorly in the Seismic Zone of 5. On the basis of Comparative analysis, the quakes prevalence is much higher during 1876 – 1895 and 1896 – 1905. In some quakes, though the magnitude is lower, the intensity and the destruction rate were higher which had led to many casualties.

CONCLUSION: -

India is a country where there is no aseismic zone. India has divided into 7 seismic regions and 4 seismic zones. Earthquakes in India are not a new thing, even in the ancient times it had witnessed many earthquakes. But the discussion about their occurrence and impact is very little known. The present paper brings the fact that - the significance of the study of the past quakes in understanding the management and the emergency response and inculcating them into the hazard readiness plans into a big picture. This paper may act as a basic source and dossier to understand the situation and the extent of damage that occurs when there is no precursor draft. Though the earthquake cannot be stopped from its happening and it is inevitable, measures like early warnings, awareness programs, focusing on engineered buildings can help reduce the severe impact of the seismal activity.

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