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Assessment of Earthquake Risk on Buildings in Patna Sahib, Bihar

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Abstract. This study is devoted to the risk associated to earthquake of an urban area which is great deal for the local authorities.As India has a relatively high frequency of having great earthquake with low frequency of moderate earthquake so there is need of efficient tool to assess associated with it. Patna sahib which is a Lok Sabha constituency located at Patna District in Bihar which falls under seismically active zone IV, classified as a severe zoneby National Center for seismology. Patna Sahib is well known for the birthplace of Guru Gobind Singh, the tenth guru of Sikhs. The assessment of seismic activity in Patna Sahib is done by RADIUS software, which includes making of Grid mess with the use of software Global Mapper, distribution of region. Assessment of loss of lives, building damage is done by using various datasets such as soil types, number of building, and earthquake scenario. The deterministic analysis is done considering an earthquake of moment magnitude 6.5 using RADIUS software. The result is shown in the form of tables and various thematic maps in the GIS environment.

Keywords: Grid Mess, Earthquake, Risk assessment, Building damage, Global Mapper

1 Introduction

An earthquake is a sudden, rapid shaking of the ground caused by sudden slip of two blocks of earth on a fault plane. The Earthquake event itself (when, where, and how earthquakes occur), the associated ground motions, and the effect on structures are the three aspects of the earthquake problem that should be evaluated. These are still the most important factors to consider when assessing earthquake risk. Earthquakes are the only type of large, naturally occurring disaster that cannot be predicted, so reducing the risk requires knowledge, planning, and resources. According to the “Centre of Research on the Epidemiology of Disaster” (CERD), about 7.8% of all climate-related and geographical disasters are of earthquake type (1998-2017). Climate-related and Geographical disasters included in CERD are Floods, Wildfires Storm, earthquake, Extreme temperatures, Landslides, Drought, Volcanic activity, and Mass movement (dry). Globally, Geographical disasters – primarily greater number of people were killed by earthquake than any other type of natural hazard, with a total death toll of 747,000 fatalities exacerbated by the population's vulnerabilities and lack of preparation between 1998 to 2017. In 1998-2017, an earthquake was second only to storm in terms of economic losses of US$661 billion. Millions of people have died and lost property to this point due to devastating earthquakes worldwide.

1.1 Need of Present Study

- India has a relatively high frequency of great earthquakes and a relatively low frequency of moderate earthquakes. Moderate earthquakes create awareness and lead to improvements in construction at relatively low human costs, which could be very effective in the long run.
- Urbanization is taking place at a faster rate in India and shall continue for the next few decades. The urban population of India is going at a very rapid phase. With the outbreak of rapid urbanization, it has become essential to study vulnerability assessment of these areas.
- As per the National Centre of Seismology (NCS), India Meteorological Department (IMD), the capital city of Bihar is one of the cities that is the most vulnerable to earthquakes. Patna Sahib falls under Zone IV, classified as a severe zone by the NCS.
- The assessment of earthquake risk constitutes the first step to support decisions and actions to reduce potential losses.

1.2 Objective of the study

The primary objective of an earthquake risk assessment is to quantify the loss in terms of building destruction, human life loss, economic loss, or other socio-economic consequences by creating a geo-information database for hazard and risk assessment, which will aid in identifying high-risk areas for micro-urban planning.

In the present study, the assessment of life and property damage due to seismic activity in Patna sahib region has been done by using RADIUS (Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters) software.

2 Literature Review

- **R.M.W. Musson (2000)** used earthquake intensity as a tool for compiling seismic risk Studies. The advantage of using intensity for risk studies is that it bypasses the problems associated with relating damage to physical measures of ground motion. An intensity attenuation equation, when written in a functional form that includes magnitude, is a way of directly describing how damage distributions vary as a function of magnitude and distance.

- **Jean-Pierre.el.at (2000)** carried out a study of seismic risk on Nice City takes into account numerous parameters. First, they have determined the regional hazard that is to say earthquake able to give the maximal acceleration on the site. Then they have estimated the local hazard, in other world site effects and induced phenomena as liquefaction and terrain movement. Then they have evaluated the local hazard, in other world site effects and induced phenomena as liquefaction and terrain movement.

- **F. Meroni and G. Zonno (2000)** developed a computer prototype where a methodology for seismic risk assessment has been implemented. Standard procedural codes, Geographic Information Systems and Artificial Intelligence Techniques, compose the prototype, which permits a seismic risk assessment to be carried out through the necessary steps. Risk is expressed in terms of expected damage, given by the combination of hazard and vulnerability.

- **F. Bendimerad (2001)** Advancement of seismic risk assessment technique has been done in the form of software applications that are accessible by a broad constituency of end-users. These techniques offer a high level of analysis sophistication and enable users to perform various `if-then' scenarios to study the sensitivity of the results, to develop a better understanding of the outcomes and to gain insight on the consequences of the findings and decisions.

3 Study Area

Patna City, popularly known as Patna Saheb or Patna Sahib, is a neighbourhood to Patna district, Bihar, India. The Sikhs in India hold it in the highest regard. Guru Gobind Singh, the tenth Guru of the Sikhs, was born there. One of the five "Takhts," or Sikh places of authority, is the Patna SahebGurudwara, which is regarded as being among the holiest (Figure 1). Although Sikhs respectfully refer to it as Patna Sahib, the location is known by the name HarminderTakht. For Sikhs from all around the world, the renowned Guru Gobind Sahib Gurudwara is a significant shrine.

Figure 1. Takhat Sri Patna Sahib Gurudwara

Figure 2 shows the location of the study area (Patna Sahib). The district is separated into two natural zones, each of which includes a thin strip of moderately high ground,about 8 km wide, running along the southern bank of Ganga River, with extremely fertile soil. In the remaining areas, there are alluvial fertile plains.

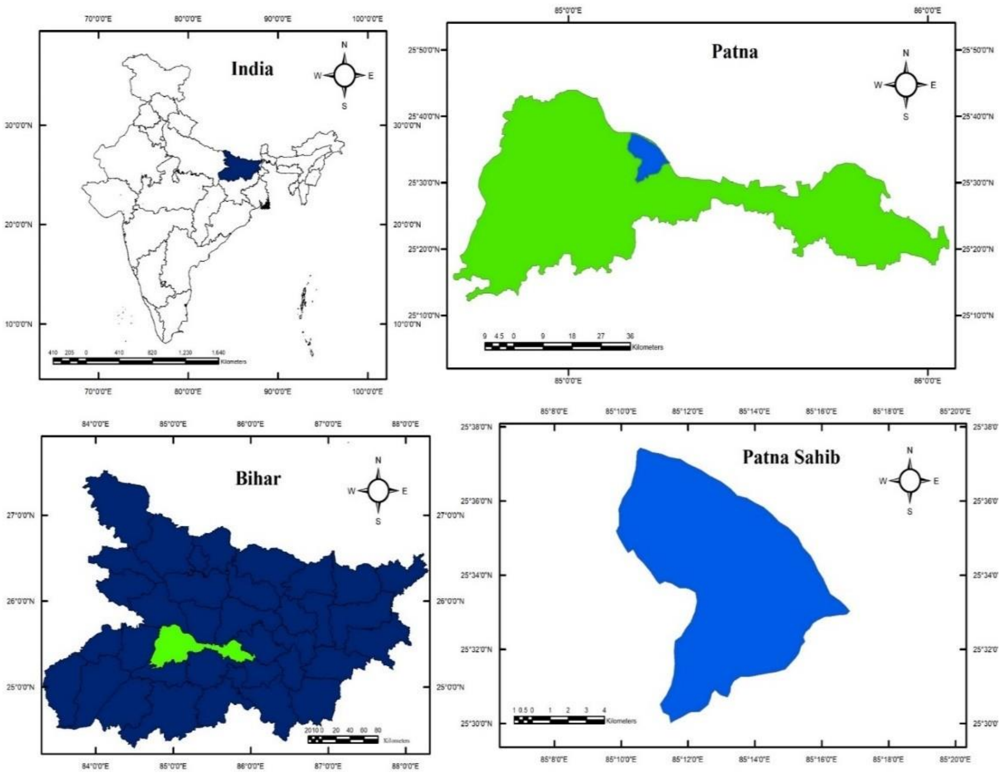
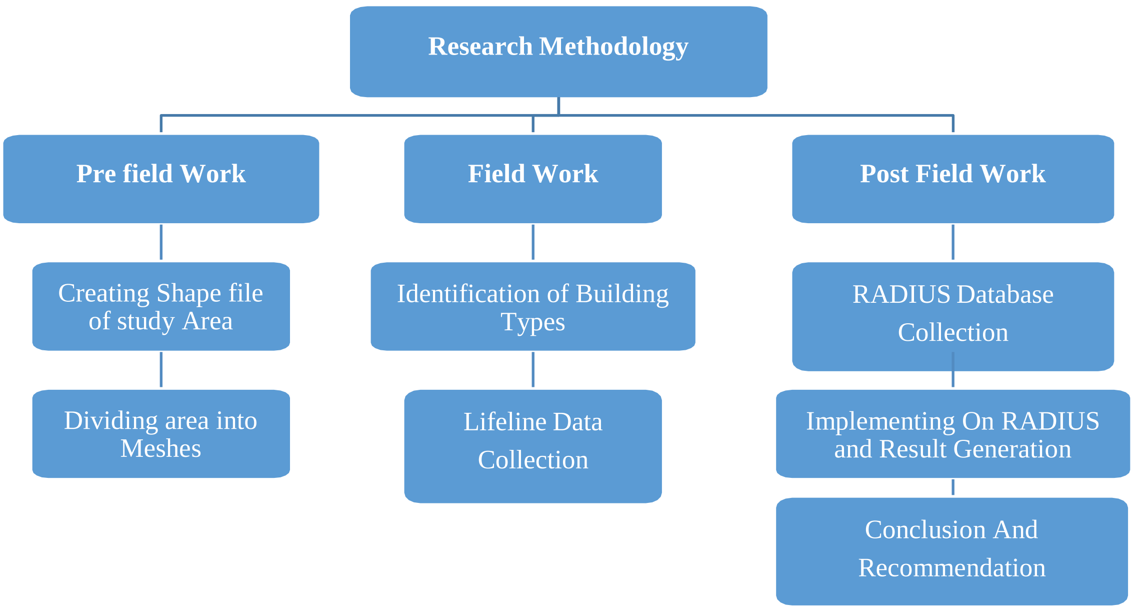


Figure 2. Relative Position of Patna Sahib

4 Methodology



5 Database Preparation / Inputs to the RADIUS tool

I. **Extraction of the map of study area-** The geo-referenced map of Patna Sahib Region has been extracted from the online portal of Google Earth Pro. This region is then divided with grids of size 1*1 sq. km by using Global Mapper. Fig 3 shows the Geo-referenced distribution map of Patna Sahib & Fig 4 shows the Geo-referenced Subdivision Map of Patna Sahib.

II. **Assigning Mesh Weight-** Mesh weight of a grid is defined as the relative density of population and buildings comes under the area of that grid. In the absence of reliable data, the mesh weight has been assigned on the basis of density of building blocks to every grid by observing the high-resolution satellite image of each respective grid. Fig 5 shows the mesh weight map.

III. **Soil Type-**According to Department of Agriculture (Bihar Government), Patna Sahib lies in the river plains of the basin of the river Ganga. It is endowed with fertile alluvial soil ground water resources. The respective soil has been kept under the category of Average Stiff Soil for some part of study area which falls under category 3 as per RADIUS. Since Patna Sahib lies across the bank of river Ganga, the area contains reclaimed landfill soil, which comes under category 4 as per radius. Fig.6.shows the Geo-referenced grid wise soil map of the study area

IV. **Classifiction of Buildings-**Due to the absence of reliable data regarding different classes of buildings as defined by RADIUS software, the following data have been assumed on the basis of field survey, land use map and 3-D satellite image by Google Earth Pro**.**

V. **Lifeline Inventory data-** All the structures and systems like schools, road network, bridges, electric supply lines, water supply lines, petrol pumps and sewage pipes etc. that play a major role in the day-to-day activities of the city are called lifelines of the city. In case of an earthquake, these systems could get damaged and cause a problem during and after the event. Lifeline inventory data is collected from Google Earth Pro, field survey, Patna Authority and various other sources**.**

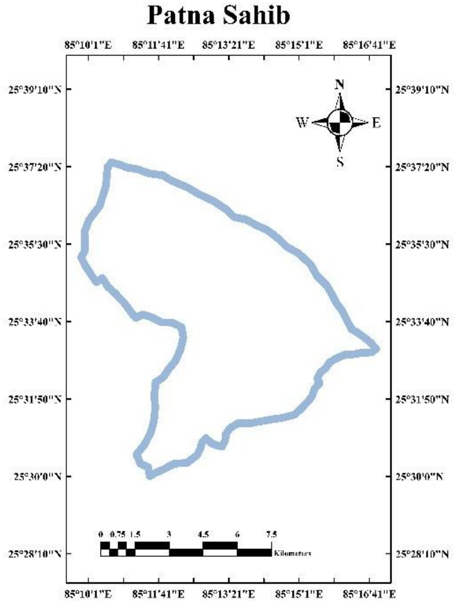


Fig 3.Geo-referenced distribution map of Patna Sahib

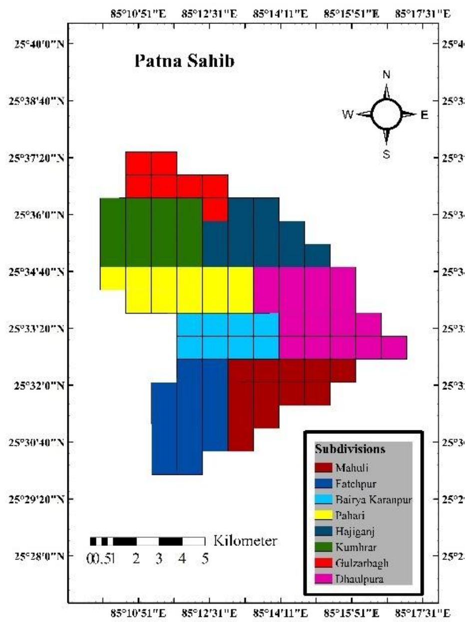


Fig 4.Geo-referenced Subdivision Map of Patna Sahib

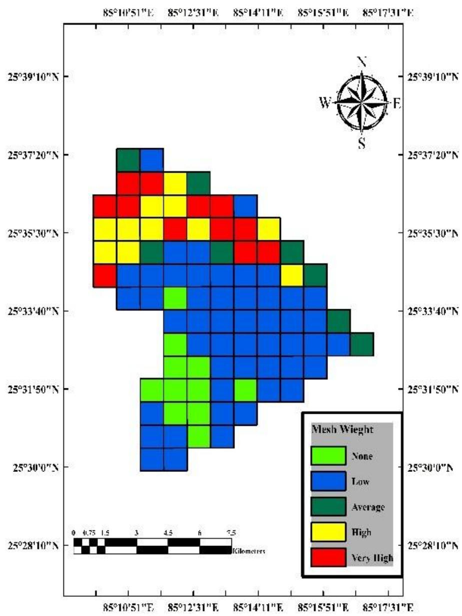


Fig 5.Geo-referenced grid wise map of the study area with their respective mesh weight

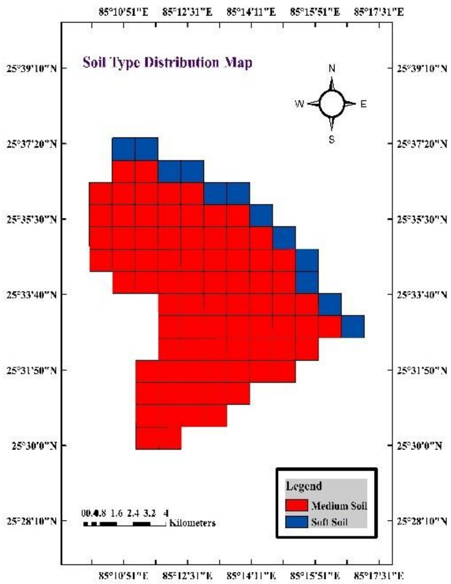


Fig 6.Geo-referenced grid wise soil map of the study area

VI. **Scenario Earthquake -**A user-defined earthquake is considered as input in the RADIUS software with the following details.

a. Name assigned: Bihar earthquake
b. Moment magnitude: 6.5
c. Earthquake depth/focal depth: 15 km
d. Earthquake occurrence time: 23.00 hours
e. Reference mesh number: 60 (Patna Sahib Gurudwara)
f. Earthquake direction relative to reference mesh: Northeast (NE)
g. Earthquake epicentral distance: 30 km
h. Attenuation equation used in the analysis: Fukushima & Tanaka (1990)

6 Results and Analysis

Color-coded thematic maps and tables and have been created as results for criteria like, MMI , the distribution of damaged buildings, injury and death for study area. These diverse thematic maps have been created and presented more efficiently by using GIS platform.

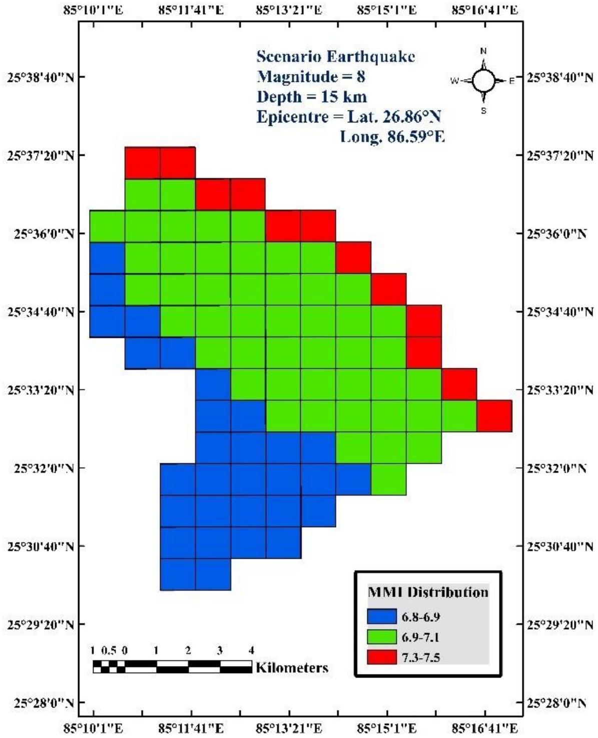


Fig 7. MMI (Modified Mercalli Intensity) map with 0.5×0.5 resolution by using equations of Joyner and Boore (1981) and Trifunac and Brady (1975).

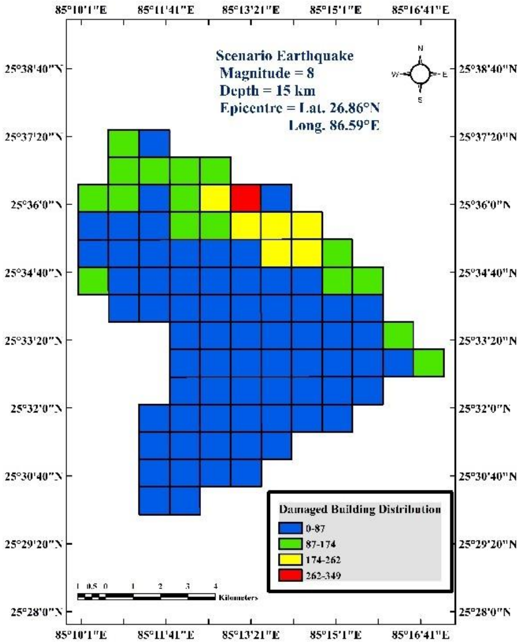


Fig 8. Damaged building distribution map with 1.0×1.0 km resolution

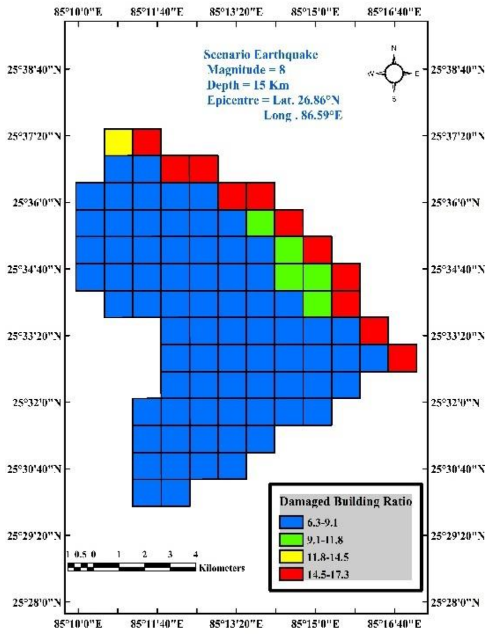


Fig 9. Damaged building ratio map of Patna Sahib with 1.0×1.0 km resolution

Fig 10. Injured distribution map of Patna Sahib with 1.0×1.0 km resolution

Fig 11. Death distribution map of Patna Sahib with 1.0*1.0 km resolution

Building damage summary

The total building count are 62260 and 9.2% damaged					
S. No	Area ID	Area Name	Bldg Counts	Damaged Counts	MDR (%)
1	1	Gulzarbagh	9522	938	9.8
2	2	Kumhrar	15382	1139	7.4
3	3	Hajiganj	15382	1670	10.9
4	4	Pahari	5494	433	7.9
5	5	Dhaulpura	8057	918	11.4
6	6	BairyaKaranpur	2564	196	7.6
7	7	Mahuli	4029	308	7.7
8	8	Fatehpur	1831	118	6.4
Summary Information			62260	5721	9.2

Population and Casualty summary

The total population counts are 373800, 0.048% deaths and 1.59% injured					
Area ID	Area Name	Day Population Counts	Night Population Counts	Death	Injury
1	Gulzarbagh	45415	61883	37	1088
2	Kumhrar	82586	97612	22	1141
3	Hajiganj	80933	89905	66	1807
4	Pahari	25581	29594	8	373
5	Dhaulpura	41348	42148	36	963
6	BairyaKaranpur	13008	14895	3	166
7	Mahuli	17964	26213	6	295
8	Fatehpur	9242	11548	2	99
Summary Information		316078	373800	179	5933

7 Conclusion

Damage assessment leads to the knowledge and awareness of the possible hazards related to some region. It can be used for spreading awareness to people about such disasters and thus improving the preparedness to face such disasters. In the mesh type analysis, based on the various subdivision of the targated city, apart from the damage amount, the weak locations which are most vulnerable, can also be identified.

This helps the government administration to better plan the management of seismic disaster reduction measures.The most critical problem that is associated with this kind of study is non-availability of appropriate data, particularly in the developing countries. The municipal agencies are either not prepared to co-ordinate effectively, or the information available is incomplete or is available in widely different formats.A detailed analysis of the impact of the scenario earthquake has been simulated using RADIUS. The results show that 179 death, 5933 injuries could occur and 5721 buildings could get damaged. The areas of Kumhrar and Hajiganj are more vulnerable to seismic hazard due to higher density of population and higher building density. The state of Bihar shares boundary with Nepal, West Bengal, Jharkhand and Uttar Pradesh, all of which are seismically vulnerable.

8 Scope of Further Research

a) In this study, the identified parameters that were not able to be collected during this limited period of research can be gathered, and the results can then be examined once more for the same study region.

b) If additional research focuses on the systematic collecting of structural data from representative buildings existing in the subdivisions, the results could be more precise.

c) The research should, however, include technical assistance from structure organizations if additional studies are conducted in the future.

d) Different features data like essentiall facilities, transportation lifelines, utility lifelines, high potential loss facilities and human life can lead to better processing and can give better results in terms of hazard and risk mapping for future work**.**

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