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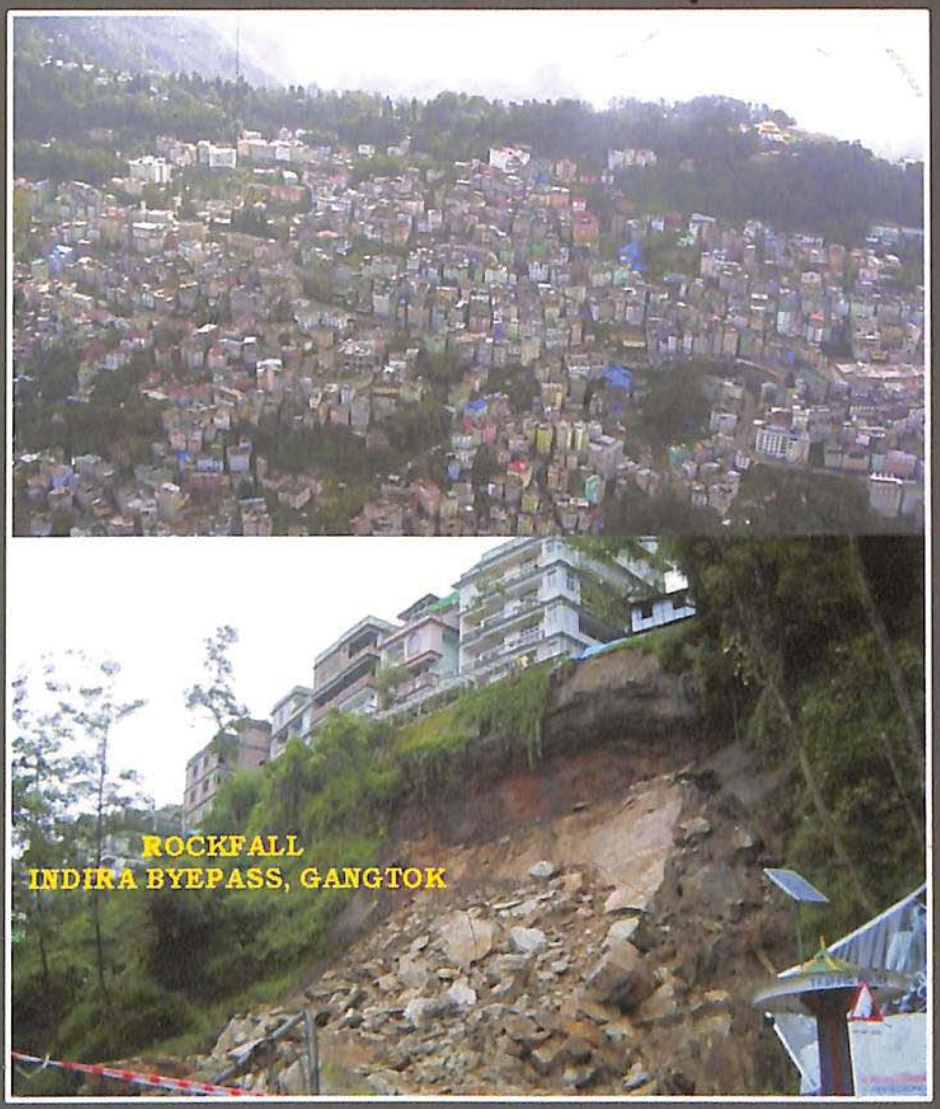
Government of Sikkim

MULTI-HAZARD RISK AND VULNERABILITY ASSESSMENT

OF GANGTOK MUNICIPAL CORPORATION AREA



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NATIONAL DISASTER MANAGEMENT AUTHORITY • INDIA •

Published by
Sikkim State Disaster Management Authority,
Land Revenue & Disaster Management Department
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MESSAGE

Gangtok is the capital of Sikkim where the constructions of infrastructures are on fast increasing mode. With the day by day increase in population, the town has treats from hazards which may poise risk to the life & property of the inhabitants. The recent earthquake of 18th September 2011 has become an eye opener for us.

Sikkim State Disaster Management Authority of Land Revenue and Disaster Management department has at this juncture brought out 'Multi-Hazards Risk Vulnerability Assessment of Gangtok Municipal Corporation Area' by analyzing various hazard components using Geographical Information System. This may, I believe, will be a useful tool for making Gangtok a Disaster Resilient City.

On this occasion, I would like to congratulate Sikkim State Disaster Management Authority of Land Revenue and Disaster Management Department, Govt. of Sikkim and others involved to make this publication come out in the public interest.

D. B. Thapa

GANGTOK MUNICIPAL CORPORATION

K. N. Tobgay (Mayor)
Gangtok Municipal Corporation
Gangtok, East Sikkim

Tel. No.: 03592-280828 (O)

MESSAGE

Gangtok is located over fragile Geo-Environmental condition. Various hazard types threaten the city at number of occasion which poise risk to the life & property of the public. Landslides and Earthquakes have been occurring in this city at number of times. Recent earthquakes of 14th February 2006, 18th September 2011 and the landslide of June 1997 made serious impact over the city.

Under such situation, Sikkim State Disaster Management Authority of Land Revenue & Disaster Management Department, coming out with the publication on **'Multi Hazard Risk Vulnerability Assessment for Gangtok Municipal Area'** using Geographical information System is praise worthy step. This, I believe would be an important scientific document for Disaster Risk Reduction Planning and Mitigation for Gangtok area.

I would like to congratulate the Sikkim State Disaster Management Authority of Land Revenue & Disaster Management Department for bringing out this publication.

K. N. Tobgay
Mayor

LAND REVENUE & DISASTER MANAGEMENT DEPARTMENT
GOVERNMENT OF SIKKIM

FOREWORD

Hazard is potentially damaging physical event, phenomenon or human activity that may cause loss of life or injury, damage to property, social economical disruption and environmental degradation. Natural hazards include latent conditions representing future threats of geological, meteorological or biological origin. Human induced hazards include environmental degradation and technological problems. Hazards may strike as a single event or in tandem.

Gangtok, the capital of Sikkim State, with an area of about 1950 hectares, has a Municipal Corporation comprising fifteen wards. The altitude ranges from 880 mts. to 2350 mts. above mean sea level. A numbers of Nalas and Jhoras cut across the slopes with high discharge of water especially during monsoon period. The geological formations of Gangtok are the sequence comprising of Low to medium grade metamorphic rocks of Daling series.

Under such kind of environment, the potential hazards that may pose threat to Gangtok are earthquakes, landslides, fires, flash floods, hailstorms, active thundering and lightening etc.

Accordingly, these hazards with various sub-components have been assessed using the GIS platform on 1:15000 scale for the Gangtok Municipal Corporation Area. The intent of the Hazard Risk and Vulnerability Assessment of Gangtok is to provide a basis on which the local lanners, politicians and responders can create or update Regional Emergency Plan, allocate resources for Risk Reduction, Mitigation and enhance Community Preparendness.

(Arvind Kumar)
Secretary

GOVERNMENT OF SIKKIM

LAND REVENUE AND DISASTER MANAGEMENT DEPARTMENT

Acknowledgement

This book titled "Multi-Hazard Risk Vulnerability Assessment of Gangtok Municipal Area" is published in interest by Sikkim State Disaster Management Authority (SSDMA) of Land Revenue & Disaster Management Department, Government of Sikkim where different organisations & Individual have Contributed for making this venture sucessful.

I, on behalf of Sikkim State Disaster Management Authority, would like to thank **Shri. Karma Gyastso, IAS**, Chief Secretary-cum-Chairman, State Executive Committee of Sikkim State Disaster Management Authority and **Shri Arvind Kumar, IFS,** Secretary, Land Revenue & Disaster Management Department for encouraging the publication.

I would also like to extend thanks to **United Nations Development Programme**, Government of India and **National Disaster Management Authority**, Ministry of Home Affairs, Government of India for providing funds for the study.

Thanks are also extended to various Governmental & Non-Governmental Organisations of the State and Central Government for providing date and logistic support to bring out the publications in the public interest.

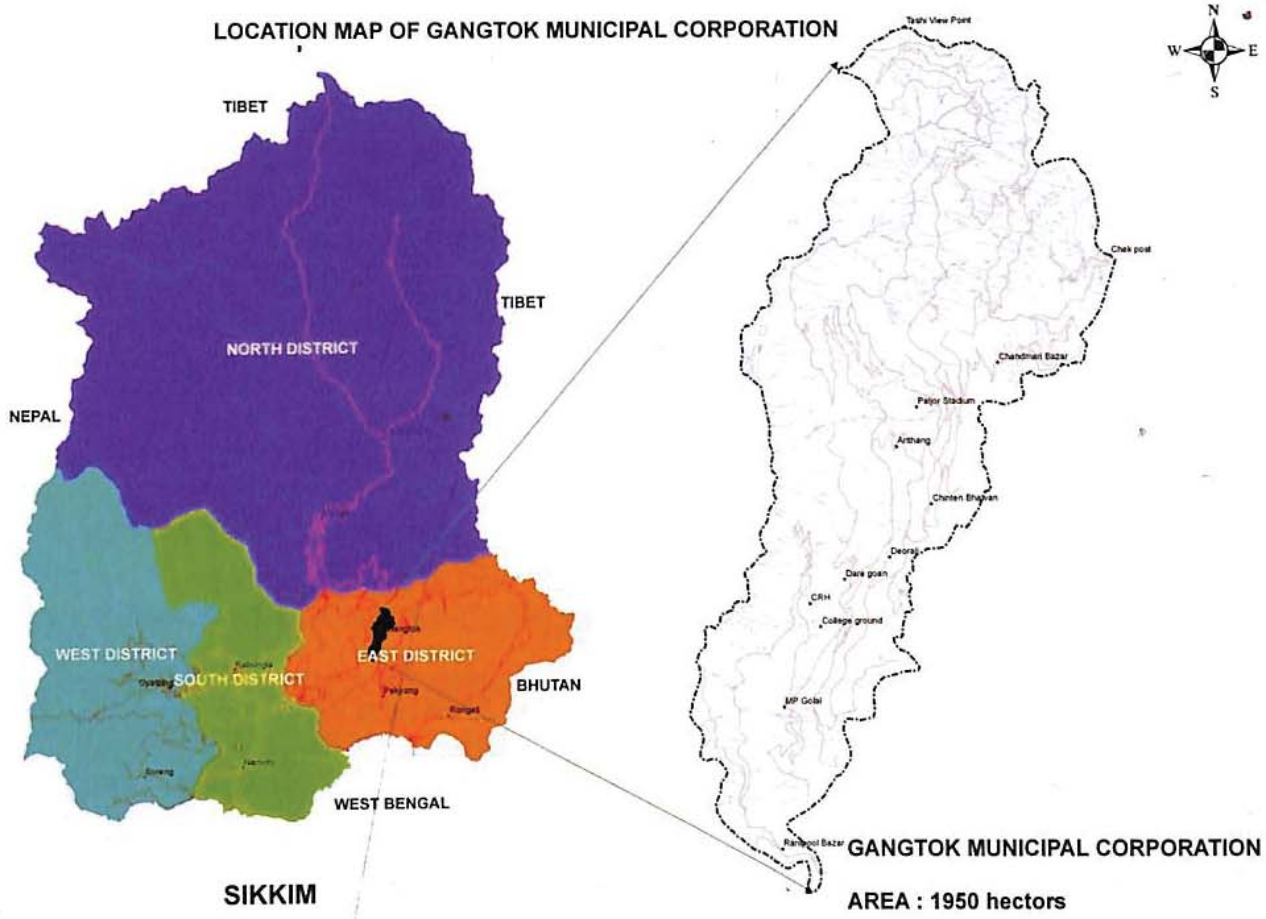
Last but not the least, I would like to thank **Disha Services**, Gangtok for GIS mapping of the Hazard components for Gangtok Municipal Corporation Area.

(G. C. Khanal)
Joint Director

CONTENTS:

INTRODUCTION

The study area comprising of the Municipal Corporation of Gangtok is also the Capital of Sikkim, with an area of about 1950ha. The Gangtok Municipal Corporation divided into fifteen Wards viz. 1. Burtuk 2. Lower Sichey 3. Upper Sichey 4. Chandmari 5. Development Area 6. Diseal Power House 7. Arithang 8. Lower MG Marg 9. Upper MG Marg 10. Tibet Road 11. Deorali 12.Daragoan 13. Tadong,14. Ranipool and 15. Syari/Tathangchen. The outer boundary of Gangtok Municipal Corporation along east runs from Tashi View Point-Himalayan Zoological Park, Bulbuley upto 2nd mile Check Post along JN road. Along South it starts from the Dichiling Jhora follows Roro-chu upto Seti pool steel bridge along Ranipool –Pakyong road. Western boundary lies from the confluence point of Rorrochu with Rani Khola runs along the Rani Khola till Takste Jhora near Penlong. Northern boundary lies from Taktse Jhora to Tashi view point along North Sikkim Highway.



The elevation of the Gangtok Municipal Corporation (GMC) ranges from 880 mts. to 2350 mts. above mean sea level(amsl).Generally maximum of the slope facets are Westerly facing where as few face easterly or southeasterly direction. The average annual rainfall varies from 293 cm to 342.7 cm as recorded from the various weather stations. The establishments along the roadside are more and these areas are thickly populated with high building density. The areas nearing roads are also has medium high building establishment density with little tree cover and the remaining area far from the road side are thickly covered with trees. Number of nalas/jhoras cut across the slope with high discharge of water during monsoon period. Various lineaments in form of shallow or deep seated faults are in existent within different lithological units of Gangtok town. The slopes dip with moderate to high degree with thin, medium thick to thick soil cover over the existing rock units. Lot of surface/sub-surface

water activities are present in the area. These contributing forces in tandem make the slopes vulnerable and result in failures as landslides, which creates the hazard.

GEOLOGICAL SETTING OF GANGTOK AND SUBURB AREAS

GENERAL GEOLOGY

The Darjeeling-Sikkim Himalayas have been divided into several belts each of which is separated by major dislocations. Darjeeling-Sikkim Himalayas has been sub-divided into four districts tectonic belts.

1. Sub-Himalaya Belt.
2. Lesser Himalayan Belt.
3. Higher Himalaya Belt.
4. Tethys Himalayan Belt.

The sub-Himalaya or the foot hill belt comprises of Siwaliks group of rocks falling within Darjeeling Himalayas and which does not occur in the State of Sikkim. Lesser Himalayan belt comprises lower Gondwana sediments, low grade Meta- Sedimantaries of Buxa and Daling group of rocks. The Axial or higher Himalayan belt is characterized by high grade metamorphic rocks viz. high grade gneiss, mica schist, graphite schsit, calcareous gneiss, marble, intrusives etc. is separated from lesser Himalayan belt by Main Central Thrust (MCT). Overlying the Axial belts are the rocks Trans-Axial Belt of Tethyan sequence consisting of fossiliferous sedimentary rocks of North Sikkim Tethyan zone.

GEOLOGICAL AND GEO-TECTONIC SETTING OF THE AREA

The west-east or southerly facing slopes of Gangtok and suburb forms part of inner belt with low, medium grade metamorphic rocks and few areas are covered With Schists and Darjeeling Gneisses.The main Gangtok town stand over the intrusive Lingtse Granite Gneiss. The main litho units of area are gneisses, Lingtse granite gneiss, schistose rocks and medium to low grade meta-sedimentaries.

The lower part of Gangtok from Ranipool area till 5th Mile and Tadong comprise of the rocks of low grade meta-sedimentaries consisting of Phyllites, Quartzite, Quartzitic phyllite and Phyllitic quartzite. The rock shows North Easterly dip, striking NW-SE with low to moderate dip amount. These rocks are at places rotated and attain NW dip (at 5th Mile Tadong area). Quartzite and Phyllitic quartzites in some areas form steeper part of slopes and show high relief.

These low grade meta-sedimentaries are overlain by medium to high grade metamorphic rocks represented by Quartz-Mica Schist and Garnetiferous Mica Schist and mica-schist band. The Garnetiferous mica schist band is locally considered as a marker horizon and is exposed north of STCS complex Deorali and can be traced upto Roro-chhu in North east direction and towards Jhakri Falls in north-west direction. This band is overlain by Mica Schist without garnets and which is overlain by Lintse granite gneiss. Quartz mica schist rocks are exposed in and around Gurudwara complex, north of Accountant General Office. Below National Highway from ICAR Complex to Garage Jhora downslope of Indira Byepass road. Mica schist, Garnetferous Mica Schist, Quartzitic phyllites are the dominant country rock in this area. The rocks at all places show north easterly dip but down-slope of Gurudwara, rocks show North Westerly dip. Similar rocks are expected at variable depth

within the veterinary complex. A fault line present in the area from Deorali to Sokeythang (Marked on the Structural map). These rocks are overlained by Lingtse granite gneiss and the contact between two are suspected to be thrust contact. The contact zone between Mica-Schist band and Lingtse Granite area is shown in the map.

Lingtse Granite Gneiss unit is overlain by Mica Schist followed by high grade metamorphic rocks. As discussed above, mica Schist rocks are expected at variable depth at veterinary complex. The area at Sokethang consists of thick blanket of slope wash material consisting of rock fragments of variable size (derived from Lingtse granite gneiss and mica-Schist of overlying area) followed by sandy & silt cover and fine grained organic soil at the top. Bed rock in this area, similar to rock exposed around 5th Mile Tadong is expected at greater depth.

The Holy Cross School area is subject to instability problems like creep, and subsidence.This is basically because of presence of active fault towards north of school complex. The area below Entel Motors is marked by excessive ground water activity, swampy area and gulley erosion. The seepage of water through fractures, cracks and fissure in slope forming material and rock section is evident in lower part of the area. The Holy Cross-School Complex and the adjoining buildings are facing serious cases of slope instability in form of creep/subsidence due to rock foliations oriented along slope direction, excessive loading, presence of an active fault, vehicular vibrations and so on. Evidence of serious instability around this locality is shown by presence of failure or cracks in buildings, failure of road formations with constant subsidence of the road NH31A.

Similarly there are other such hazard zones effecting the habitation of the capital Town of Gangtok. These are primarily due to effect of one or more types of hazards resulting in loss of human life or property.Sikkim is also placed in zone iv/v in earthquake vulnerability map of India. This is also issue of concern and houses needs to be constructed in resonance with building bye-laws for construction of earthquake resilient structures. Similarly hazards like Fire, Flashfloods, Hailstorms and etc needs to be cared for safe living in Gangtok.

Hazard Risk and Vulnerability assessment

This Hazard Risk and Vulnerability assessment was conducted by SSDMA (Sikkim State Disaster Management Authority) based on the technical data made available by Department of Mines, Minerals and Geology, Government of Sikkim along with other Governmental and Non-governmental central and state government organizations. The GIS mapping was prepared by Disha Services, Gangtok.

Purpose

The purpose of Hazard, risk and vulnerability analysis (HRVA) is to help a community and make risk-based choices to address vulnerabilities, mitigate hazards and prepare for response to and recovery from hazard events. Risk-based means based on informed choices of alternate unwanted outcomes. In other words, communities make risk reduction choices based on the acceptability of consequences and the frequency of hazards.

Hazard Risk and Vulnerability Assessment

Considering **hazards** alone may lead to a skewed set of priorities for action. It is equally important to consider the **severity** of possible impacts from the hazard as well as the frequency or likelihood of a hazard event occurring. The combination of severity and

likelihood is termed the **level of risk**. In determining the severity of a hazard event, a community's vulnerability must be examined. **Vulnerability** is defined as people, property, infrastructure, industry and resources, or environments that are particularly exposed to adverse impact from a hazard event. Hazards reflects the frequency of occurrence for a particular hazard event and can range from rare events occurring every 50 years to more frequent events, which usually have a high number of recorded incidents or anecdotal evidence.

Scope

This HRVA is designed to provide an assessment of the hazards that may present risks to the region of Gangtok Municipal Corporation. The objective of the HRVA is to:

1. Investigate prominent natural and human-caused events.
2. Identify the various hazards affected by that area and hazards likely to occur in Gangtok Municipal Corporation area.
3. Identify any threats that may require a timely and coordinated response to protect lives, property, and to reduce economic losses.
4. Definition of measures to be included in the mitigation plan.
5. Evaluation of the effectiveness of the mitigation and emergency plans and implementation of training activities such as simulation, seminars and workshops.

Components for Assessment of Multi Hazards Risk Vulnerability Assessment (MHRVA)

MHRVA are being undertaken where the following hazards are considered for Gangtok Municipal Corporation in East District of Sikkim located in Lower Himalayan land mass in mountainous state of Sikkim as per IS codes and other requisite data from the field, which is required for Multi Hazards Risk Vulnerability Assessment Study.

a) Earthquake hazards.

b) Landslide hazards.

c) Fire hazards.

d) Flood/ flash floods hazards.

e) Snow Avalanches hazards.

f) Drought hazards.

g) Hailstorm, Thundering and lightening hazards.

h) Riots and stamped.

Vulnerability Assessment

The intent of this Hazard Risk and Vulnerability Assessment is to provide a basis from which local planners, politicians, and responders can create or update the Regional emergency plan, allocate resources for risk mitigation, enhance community preparedness, and prepare budgets for cost-effective, on-going emergency planning. This assessment is based on both primary and secondary sources. Both quantitative and qualitative methods are used to determine hazard ratings for the area of interest.

HRVA Risk Rating Interpretation

These risks are **low**. Implementation of mitigation measures will enhance emergency preparedness but it is of less urgency and highly unlikely to occur in that area than the following hazards.

These risks are **medium low**. Implementation of mitigation measures will enhance emergency preparedness. Hazards are highly unlikely to occur in that area, but are of more urgency than low

These risks are **medium**. These hazards have intermediate levels of frequency and severity. Hazards classified as moderate are more urgent than medium low hazards and are often common place concerns. Given this, moderate level hazards should be addressed with an appropriate level of urgency.

These risks are **medium high**. These hazards warrant review and development of mitigation actions to reduce the risk to an acceptable level. But these hazards require immediate examination and mitigation measures to reduce the risk to an acceptable level.

These risks are **very high**. These hazards are both frequent and are of high severity. These hazards require immediate examination and mitigation measures to reduce the risk to an acceptable level.

Hazards

This HRVA is designed to provide an assessment of the hazards that may present risks to the region of Gangtok Municipal Corporation. However, the following hazards are most likely to occur and may result in significant consequences. Each hazard is examined to assess the relative risks to the community and to highlight opportunities for mitigation and coordinated response. In this analysis, extensive background and historical research was compiled and considered in the context of severity and likelihood to assess the hazard risk.