ABSTRACT

Landslide incidences are common to India as well as to the North Eastern Region. Nearly 14% of India's land area is landslide prone out of which one fifth is located in the North Eastern Region (Raju, 2002). Hazard related to landslides is also a major societal and environmental concern for Guwahati City which is the main centre for economic and industrial activity. Infact, the problem is becoming severe day by day. Officially, the death toll involving landslide victims in Kamrup (Metro) district since 2003 is 22; however, unofficially it might be many times higher, as indicated by those engaged in different public works in the landslide-prone areas of Kamrup (Mishra, 2009). The first reported landslide was in the year 1972 from Nabagraha hill but over the next 35 years it has affected all most all the hills of Guwahati city raising considerably the death toll and property loss. During 80's and 90’s, landslide incidences were reported eight times in each decade. From 2000 onwards till 2008, landslide incidences were reported in total fifteen times. On an average, 5 to 10 people die each year due to landslide in Guwahati City.

Substantial work on the problem of landslide in Guwahati has been carried out by different researchers covering various aspects, but a comprehensive approach taking into consideration the geo-environmental as well as geo-technical aspects was still awaited. The present research work was taken up to study the geo-environmental as well as some relevant geo-technical parameters to address a number of objectives identified for this study.

To fulfill the objectives and test the hypothesis of the study, a methodology has been formulated after conducting a thorough literature survey concerning the subject.
Understanding of landslide problem in an area requires sound knowledge of the terrain condition and its characteristics such as land use/land cover, rock types, landforms, drainage pattern and density etc. Collection of such information over wide areas is a crucial task, but it is an essential requirement for landslide hazard assessment and its zonation. Field techniques, despite being very precise, are usually not sufficient to achieve this goal since they mostly provide point-based measurements. However, with the advent of modern technology certain advancement has taken place in the field of hill slope failure assessment both in the spatial and temporal domain. Geoinformatics is one such tool which combines computer science and geosciences with the ability to answer complex scientific questions. Geoinformatics is the basic tool used for thematic data interpretation, analysis, integration and ground investigation etc. for the present research work.

The different components of the research work can be classified under four broad heads, viz. – (a) Landslide Inventory, (b) Field Work and ground verification, (c) Laboratory Investigations and (d) Interpretation and analysis of data and their integration under GIS environment. The data used can be divided into two categories, (a) Remotely Sensed (spatial) data and (b) Collateral data (spatial and non spatial).

Landslide Hazard Zonation Mapping was carried out following the outline of BIS guidelines as well as the heuristic model. The interpreted thematic information are presented as a series of maps, analysed data are presented in the form of tables and graphs, field observations are presented as figures.

To answer the identified objectives and propositions in the study, the work is divided into different heads and they are described in six different chapters. The first chapter
presents a general introduction to the theme of the research work providing a review of literature, reports etc together with a historical perspective of the landslide scenario in Guwahati city and justification of the proposed research work.

In the second chapter, the objectives identified for the study are formulated and methodology to be adopted for achieving the objectives is discussed and data sources are identified. Details of the methodology and databases are also described in this chapter.

The third chapter deals with the geo-environmental set up of the study area in terms of location, physiography, geology, communication etc. This chapter also gives an idea about 129 years of population scenario of Guwahati city from 1872 to 2001. The city has recorded population growth of 51.36% in the year of 1971, 78.83% in the year of 1981, 29.51% in the year of 1991 and 38.79% in the year of 2001.

The fourth chapter deals with the interpretation and mapping of various thematic layers using remotely sensed data. Detailed field conditions about rock type, geological structure, geomorphology, weathering conditions of rock, soil texture and depth, slope condition, land use land cover etc are explained with field photographs. This chapter also deals with the landslide inventory accomplished partly through the interpretation of high resolution remotely sensed data and partly in the field with the aid of GPS. It was observed that most of the active landslides are of complex type, some are debris slides, a few are rock falls and rock slides. Rock fall and rock slide are common in the hills where porphyritic granite are exposed. Earth falls, debris slides etc. are common in the hills where deeply weathered gneissic rocks are exposed. Rock fall and rock slides are reported from Dispur Kacharibasti, Kahilipara.
Colony Bazar, Odalbakra, Shantipur and Pubsarania, while Debris slide is reported from Noonmati, Nabagraha, Kharguli, Narikalbari, Rupnagar, Birubari, Jutikuchi etc. The fifth chapter describes the procedure of integration and analysis of multilayered thematic data using geoinformatics and preparation of landslide hazard zonation maps using outline of Bureau of Indian Standards (BIS) and Analytical Hierarchy Process (AHP). This chapter explains how the weights and ranks were calculated and assigned to particular class and themes and subsequently a model was developed for the study area adopting AHP. In this chapter comparison of landslide hazard zonation maps was carried out to validate the results. Also zonation map was validated with spatial distribution of active and old landslides as well as with the recent reported landslide events. According to the Landslide Hazard Zonation Map prepared, 0.12%, 4.92%, 7.64%, 14.12% and 5.20% of the Guwahati Municipal Corporation (GMC) area falls under Very Low Hazard Zone, Low Hazard Zone, Moderate Hazard Zone, High Hazard Zone and Very High Hazard Zone respectively, while 68% of GMC area is plain land.

The sixth chapter deals with the geo-technical analysis of representative soil samples collected from various landslide affected areas and their classification following Indian Soil Classification System (ISC). This chapter also deals with the external factors that triggers landslide, namely, anthropogenic factor and rainfall. Precipitation threshold for the initiation of landslides was identified by analyzing rainfall data associated with historical landslide events. The threshold value calculated for Guwahati city is expressed as, \( I = 28.7 D^{0.89} \); where \( I \) is hourly rainfall intensity in millimeters (mm h\(^{-1}\)) and \( D \) is duration in hours. The equation has a coefficient of determination of 0.7174. This shows that compared to the global
threshold identified by Caine (1980), Guwahati needs comparatively less intensity of rainfall to trigger landslide. This chapter also quantifies the change in land use/land cover of Guwahati city over a period of 30 years. Approximately, 47%, 55%, 62%, 83%, 51%, 26%, 47% and 7% increase in settlement on hilltops or on slopes are observed for Sunsali, Nabagraha, Japorigog, Sonaighuli, Narakashur, Nilachal, Fatasil and Jalukbari hills respectively. A sharp increase in frequency of landslide occurrences in these hills were observed when this data was correlated with the number of landslide incidences reported from various hills of Guwahati since 1972. This observation concludes that apart from heavy rainfall, change in land use pattern is one of the most important triggering factors of landslide in Guwahati City. Developmental activities as well as urban sprawl are obvious phenomena for the growth of any city. Guwahati city is also not an exception in this regard and it is also not possible to restrict this growth. Rapid urbanization and migration of people has forced the city to accommodate them in the hill top. The land use changes are a result of the activities that are prerequisite for supporting viable populations. Hence in this chapter management practices were suggested to reduce the impact of future landslide activities. It is expected that the causative and triggering factors identified by the study will strengthen our understanding regarding the landslide hazard to minimize the damage caused in terms of population and property. It is also expected that this piece of work would serve as reference for the researchers in this field of specialization in future work.