

Role of Remote Sensing and Geographic Information System (GIS) in Disaster Management in Arunachal Pradesh: a Case Study of Landslides in Itanagar Capital Complex

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ABSTRACT: Remote sensing and Geographical Information System (GIS), has provided enormous scope for geohazard studies and disaster management. In Arunachal Pradesh landslides, flash floods, landslide dam outburst floods (LDOF) and earthquakes are the major geohazards. Itanagar, the capital city witnessed insidious rainfall-triggered landslide incidences in the past decade. Anthropogenic-forcing due to significant rise in population and haphazard urbanization has resulted in accumulation of landslide risk in the capital city. The Landslide Hazard Zonation (LHZ) maps on 1:50K scale are generated under the DMIS project. These maps form very important macro-scale information for all the developmental programmes in the State. Depending on the severity of the landslide hazard zones various actions were suggested like forest conservation, channelization of water flows in the areas affected by existing slides, etc. High resolution topography points to the changes in geomorphic and anthropogenic features that have affected the landscape of the city area therefore Disaster Management and mitigation in Itanagar capital complex demands a holistic way, linking society with the protection of natural ecosystems and appropriate land and water uses. A prospective and compensatory Disaster Management (DM) programme is needed for attaining Disaster resiliency in Itanagar capital complex.

KEYWORDS: Remote Sensing, Geographical Information System (GIS), Landslide Hazard Zonation (LHZ), Itanagar capital complex, Arunachal Pradesh, Disaster Management, Disaster resiliency.

I. INTRODUCTION

Disaster prevention and mitigation are essential part of all development activities. Many areas of the world are at risk from landslides and its damages. The Eastern Himalayan region is having a complex geology and the seismic activities are ascribed due to the juxtaposition of the three mountain belts namely the Himalayan range, Mishmi Hills and Naga Patkoi range (Mohan et.al. 2008). Arunachal Pradesh falls in the very high seismic hazard zone (Zone V) as per Bureau of Indian Standards (BIS, 2002). Co-seismic landslides are also very hazardous as they cause loss of life, property damage and permanent landscape change. (Varnes, 1978). Seismic Hazard Zonation (SHZ) by Mohan et.al. (2008) reveals that Itanagar can experience Peak Ground Acceleration (PGA) of more than 250 cm/sec^2 . Occasional 'cloudbursts' are leading to much higher occurrences of landslides and flash floods affecting larger communities. If susceptibility to natural hazards is identified in the early stages, actions can be introduced to reduce the socio-economic impacts of the impending disasters (OFDA/USAID, 1989).

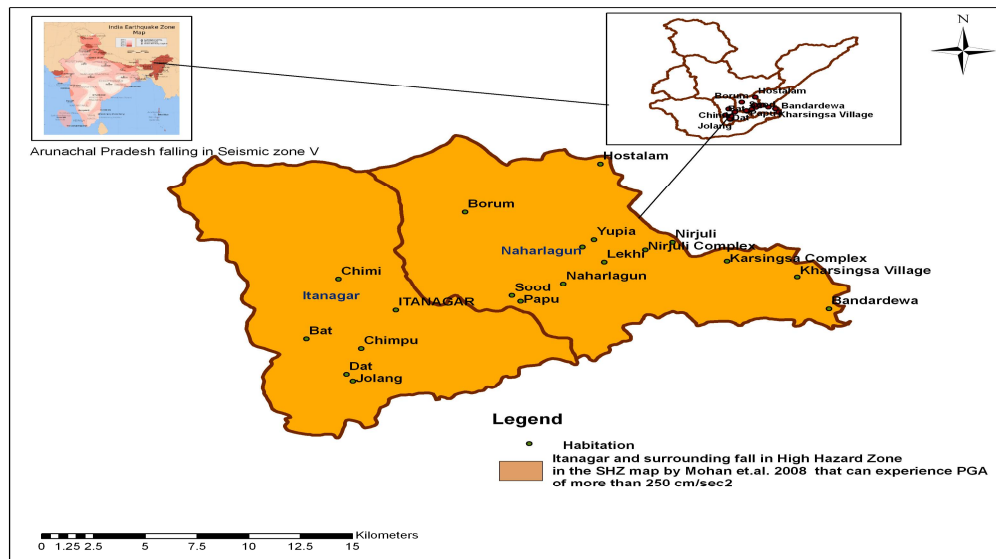


Fig.1: Location Map of Itanagar capital complex and surroundings

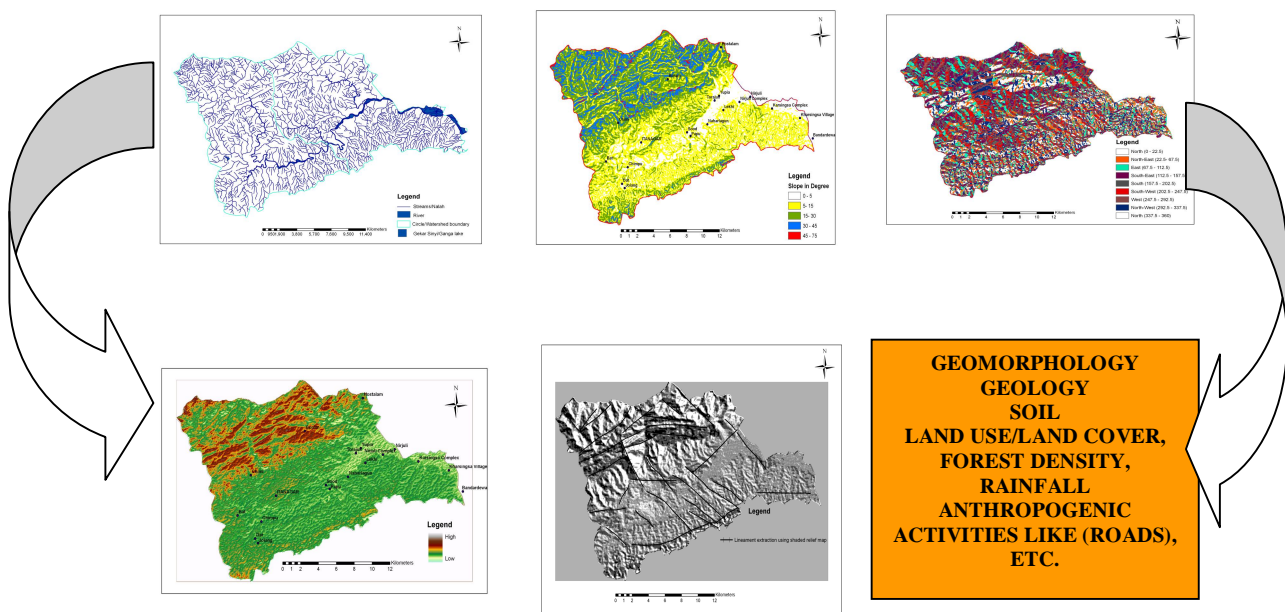
Remote sensing (RS) and Geographic information system (GIS) are recognized as one of the most important tool for disaster management in Arunachal Pradesh. The State consists of large inaccessible areas and the database for these inaccessible areas are created using remote sensing and GIS. RS allows image interpretation & classification, time-series image analysis, hazard susceptibility mapping and mapping & monitoring of land and water resources. The information on habitations, utilities and relief shelters in GIS can be effectively used in the disaster relief phase for search and rescue operations. There is a growing importance of the strategic, economic and decision making benefits of RS and GIS (Westen, 2000). In the present paper we discuss landslide hazard zonation in the Itanagar Capital complex (Fig.1) using remote sensing and GIS.

II. THE URBAN PERIL

In contrast to rural areas, in the urban areas of Arunachal Pradesh has witnessed corresponding changes due to population growth with respect to administrative and political development since attaining statehood. Itanagar capital complex is the focal point of all kinds of development with higher concentration of buildings, public infrastructure like schools, colleges, hospitals, Govt. offices, technological institutions, universities, etc. Developmental activities in the city area are altering the slope form and ground water conditions (Swanson & Dyrness, 1975). The present challenges in the city are its geographic location, repeated occurrence of geohazards, on-going development activities, climate change and haphazard land use pattern. The trepidation is for the habitation in unfavorable conditions like steep slopes and flood prone areas. Rapid urbanization, habitations in sloping lands and increasing population are the powerful drivers in a cycle of disaster risk accumulation (Anderson et.al, 2013). High resolution topography points the changes in geomorphic and anthropogenic features that have affected the landscape of Itanagar capital complex. It is noted that the building and infrastructure that are not being planned to withstand the impact of weather influenced geohazards are the most vulnerable one. Number of occupants in the vulnerable building in the night-time and day-time are the 'at risk' group.

III. LANDSLIDE HAZARD ZONATION (LHZ) AND ITS INSINUATION

Realizing the importance of Remote sensing technology in Disaster management the State Remote Sensing Application Centre, Itanagar (SRSAC), completed Hazard Zonation of Arunachal Pradesh pertaining to landslides, floods and earthquake on 1:50K scale (DMIS, 2008). The term "landslide" refers to the downward and outward movement of slope-forming materials like rocks, soil, sediments, artificial fills or a combination of these (Varnes, 1978). The Landslide Hazard Zonation (LHZ) maps on 1:50K scale is the first attempt by SRSAC to find out the vulnerable zones in Arunachal Pradesh as per the guidelines suggested for landslide hazard zonation in mountainous terrain by the Bureau of Indian Standards (BIS 1998). Major factors that influence the occurrence of landslides are lithology, structure, slope, geomorphology, land use/land cover, forest density, relative relief, anthropogenic reasons and rainfall (Fig.2). Slope facet, which is defined as a part of hill slope having more or less similar characters of slope showing consistent slope direction and inclination is considered as the smallest unit for the study (DMIS, 2008). Cumulative weightages were calculated by adding ratings of individual sub-parameters for each facet. Based on the cumulative weightages the LHZ is classified into five hazard zones such as very high, high, moderate, low and very low (Fig.3). The methodology was validated by overlaying the landslide incidence map over the LHZ map (DMIS, 2008). The LHZ maps are important macro-scale (1:50K) information for all the developmental projects in the state for analyzing and designing the new projects against the possible landslide threat. For that reason the database was shared with all the State Government line departments and to the Govt. of India programme, 'National Database for Emergency Management Mission (NDEM)'. In Figure 3, the high-resolution satellite image shows the active landslide at Karsingsa on National Highway 52A. This landslide falls in the very high hazard zone in the LHZ map. The Karsingsa landslide is active in nature owing to continuous toe cutting by the Dikrong river. The flow of land mass at Karsingsa is termed as static liquefaction by Sharmah and Singh (2011). Several research institutions are engaged in research for management and mitigation of Karsingsa landslide including early warning yet almost every year the community face crisis at Karsingsa.



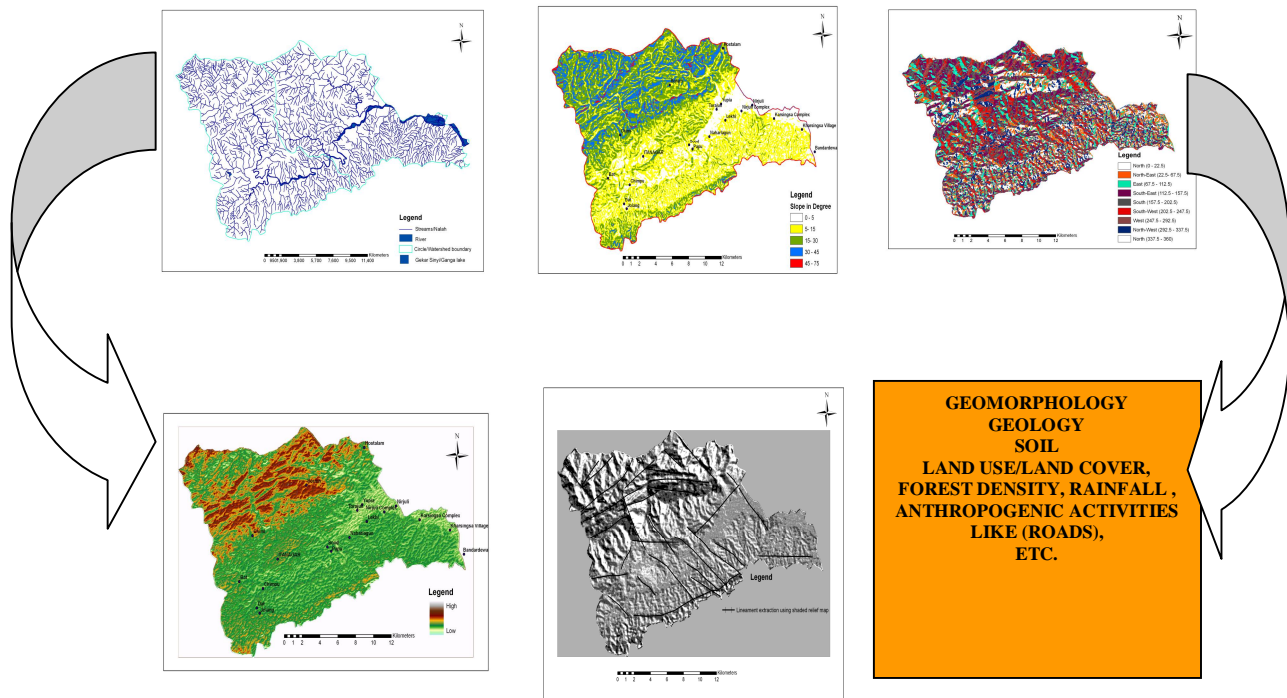
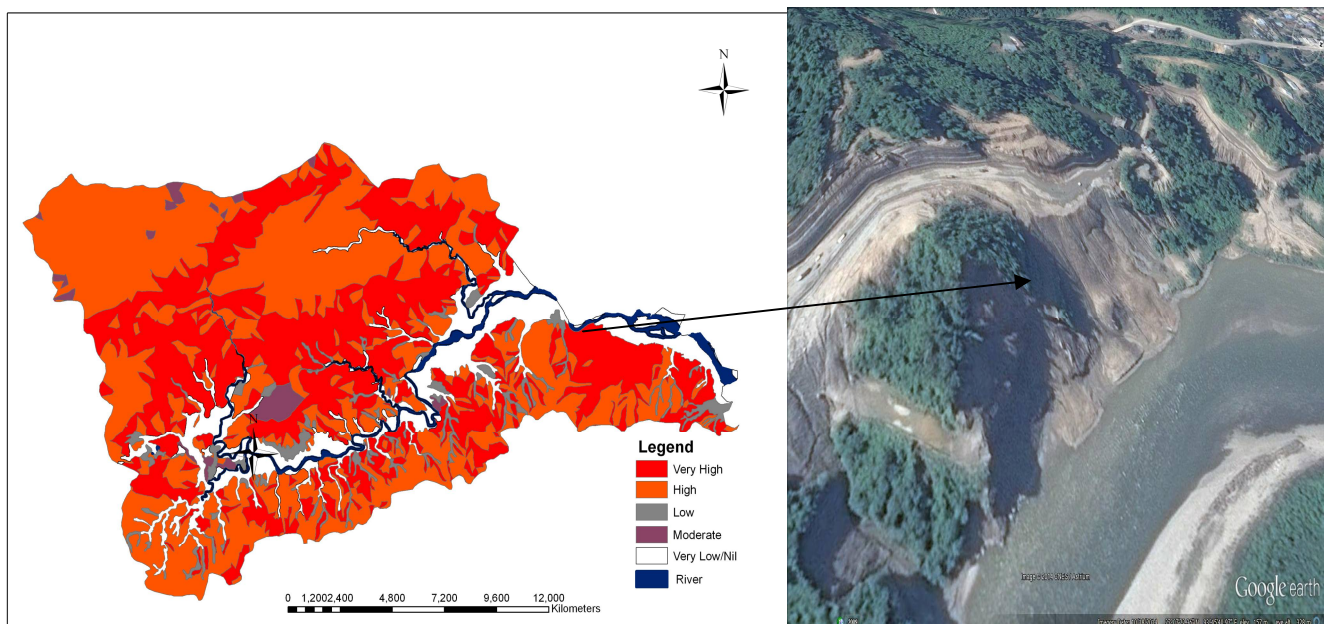


Fig.2. Themes used in LHZ



IV. CONCLUSION

The innovative approaches in remote sensing and GIS are helpful to accelerate sustainable hazard management. The LHZ map of the capital complex and surroundings is shown in Figure 3. The various classes are also delineated in the LHZ map, depending on the severity of the classes following actions were suggested in DMIS. For high, very high and moderate landslide hazard zones, actions suggested are:

1. Forest conservation, Afforestation of barren areas.
 2. Channelization of water flows in the areas affected by existing slides, suitable structural measures for controlling active slides.
 3. Avoidance of anthropogenic activities.
 4. For essential lifeline and utility services like roads, power lines, water supply lines etc., necessary measures like stabilization of slide mass by construction of retaining walls, breast walls, geonet etc.
- For low to very low landslide hazard zones, planned developmental activities are suggested

If we consider the speed of onset of the geohazards, earthquakes, landslides and flash flood give virtually no warning. Thus it is important to categorize each geohazard on the basis of its controllable & uncontrollable nature and also its frequency & severity. The indiscriminate use of the natural resources in the slope alters the topography and augments vulnerability to the slopes. Along with technological intervention, sustainable and effective Disaster management and mitigation demands a holistic approach, linking society with the protection of natural ecosystems and appropriate land and water uses. A comprehensive plan is essential for hazard risk and vulnerability assessment of the slopes, design standards for slope engineering, training and preparedness for slope managers (Pentley, 2009). Management of Slope Stability in Communities (MOSSAIC) is a prospective approach to develop a mitigation mindset for community-based landslide risk reduction (Anderson et al, 2013). Future prospective disaster management programme has to be interlinked with natural resources management and community participation for attaining disaster resiliency. A compensatory disaster management programme should stand alongside development planning and analyze the existing vulnerability that has accumulated through past development practices (Bull-Kamanga et al. 2003).

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