Rim Slope Instability of Reservoir and Mitigating Approaches

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Abstract: Nepal is mountainous country with high potential of hydropower projects. Hence, steep and geologically complex terrain surrounding the reservoir poses a considerable risk of rim slope instability. This may compromise dam safety, reduce reservoir capacity through sedimentation during operation. The study area is Dudhkoshi Storage Hydroelectric Project in Khotang District. This study investigates the factors contributing to slope instability around the Dudhkoshi reservoir rim, emphasizing the influence of geological structures, seasonal rainfall, fluctuating water levels, and anthropogenic activities such as road construction and deforestation. A combination of geological survey, remote sensing data, and geotechnical analysis was employed to assess the stability of critical slopes. Preliminary results highlight several high-risk zones dominated by weathered rock masses, colluvial deposits, and active landslides and landslides prone areas. These conditions are further exacerbated by monsoonal precipitation and rapid drawdown events, which induce pore pressure changes and slope weakening. This study underscores the critical need for integrated slope management strategies to ensure the long-term stability and sustainability of the Dudhkoshi reservoir. The findings serve as a foundation for hazard mitigation planning and informed decision- making in large-scale hydroelectric infrastructure projects in mountainous regions.

Keywords: ***Reservoir rim stability, Slope instability, Geological structures, Rainfall and drawdown, Geotechnical analysis, Dudhkoshi hydroelectric project.***

Introduction

Nepal, with its steep topography and abundant river systems, possesses immense hydropower potential. However, the mountainous terrain and complex geological settings introduce significant challenges related to slope stability around large reservoir areas. Instability along reservoir rims can threaten dam safety, reduce reservoir capacity due to sedimentation, and endanger nearby communities.

The Dudhkoshi Storage Hydroelectric Project, located in Khotang District, represents one of Nepal's major storage-type hydropower developments. Given the steep slopes and variable geological conditions around the proposed reservoir rim, understanding the mechanisms of slope instability is essential for sustainable project planning and operation. This study aims to identify the key factors influencing slope instability and delineate potential hazard zones through integrated geological, remote sensing, and geotechnical approaches.

Methodology

The study adopted a multi-disciplinary approach combining field investigation, remote sensing analysis, and geotechnical assessment.

Geological and Geomorphological Mapping

Detailed field surveys were conducted to identify lithological units, structural discontinuities, fault zones, and geomorphic features influencing slope behavior.

Geotechnical Evaluation

Laboratory and empirical analyses of representative rock and soil samples were performed to determine shear strength parameters. Stability of critical slopes was assessed using limit equilibrium and kinematic analyses under different reservoir level and rainfall scenarios.

Risk Zonation

Integrated datasets were used to produce a preliminary slope instability hazard map, highlighting zones prone to potential failure during reservoir operation and rapid drawdown events.

Results and Conclusion

The study revealed that the Dudhkoshi reservoir rim comprises several high-risk slope zones, primarily characterized by weathered rock masses, colluvial deposits, and pre-existing landslides. These zones are strongly influenced by geological discontinuities, monsoonal rainfall, and anthropogenic disturbances such as road cutting and deforestation. Moreover, rapid drawdown conditions were found to significantly decrease slope stability due to increased pore pressure and reduced effective stress.

The findings emphasize the necessity for integrated slope management measures, including continuous monitoring, slope drainage improvement, bioengineering stabilization, and controlled land use around the reservoir. The study provides essential inputs for hazard mitigation planning and enhances the resilience and long-term safety of large hydropower projects in Nepal's mountainous terrain.

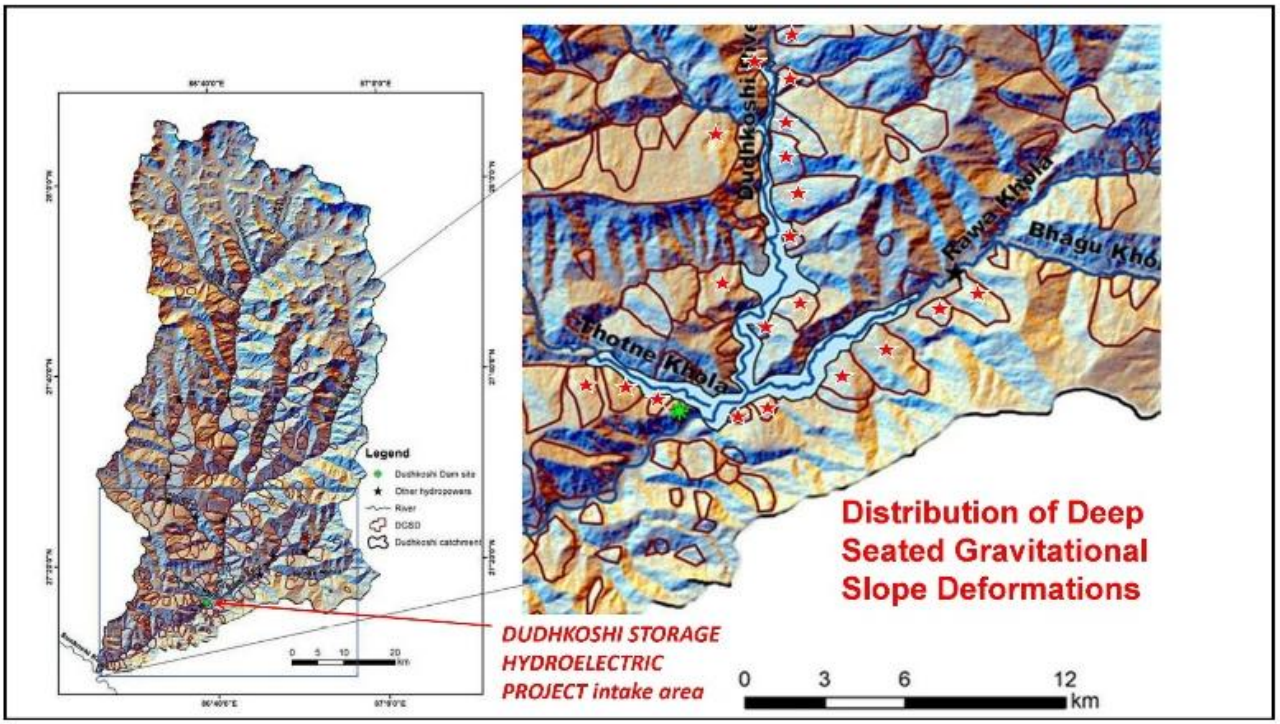

Figure 1, Distribution of Deep-Seated Gravitation Landslide in Dudhkoshi Reservoir (ADB report, 2022).