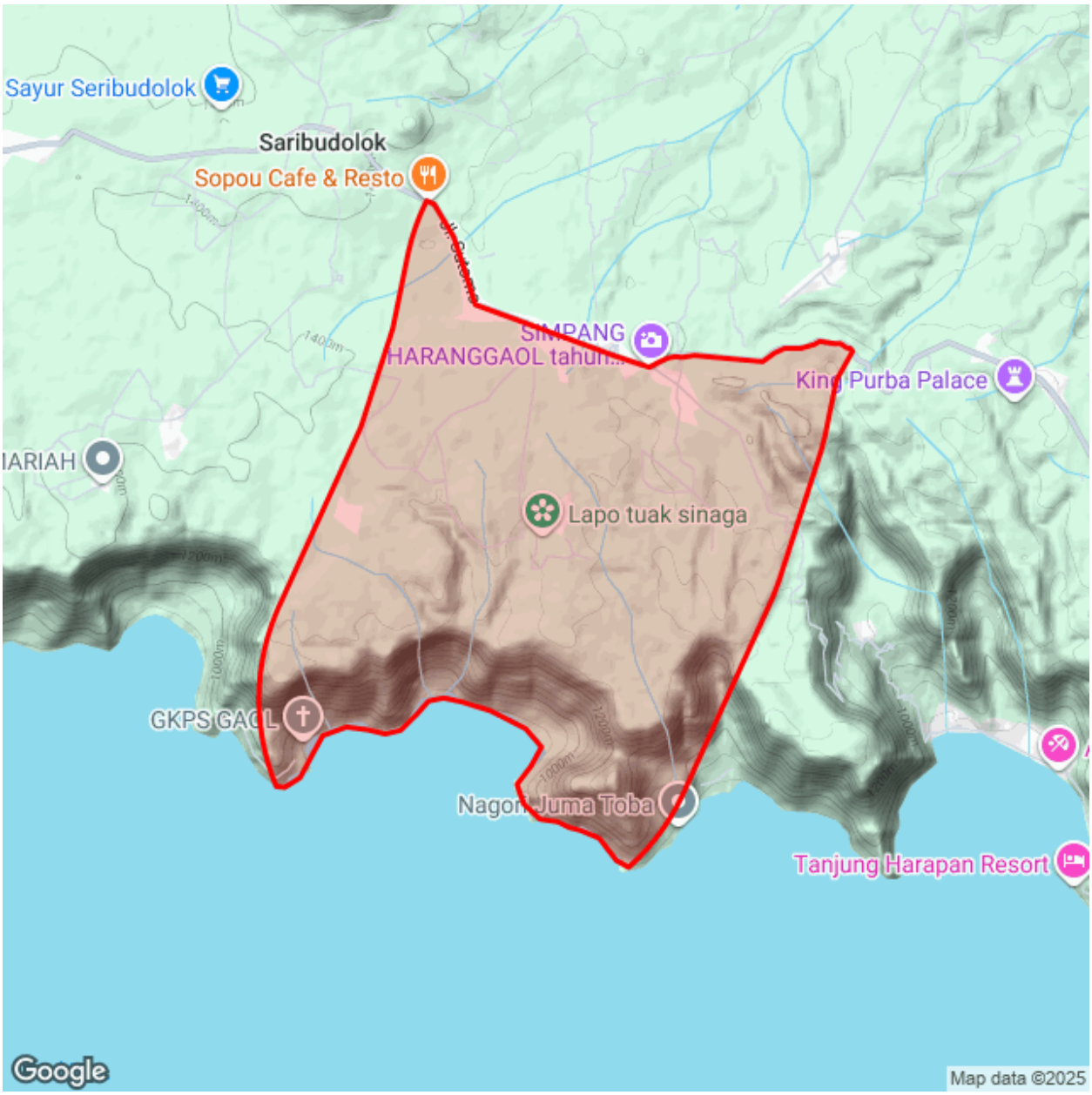
Environmental Baseline Assessment - Landcover & Topography

Lake Toba Pumped Storage Hydropower Project - Haranggaol Horison District

Disclaimer: This report provides baseline environmental information based on remote sensing data analysis. The findings are intended for preliminary assessment purposes only and should not be used for detailed engineering design, which requires comprehensive field investigations, ground-truthing, and site-specific studies.

1.0 Project Location

Location: Haranggaol Horison District



2.0 Assessment Summary

2.1 Executive Summary

The Lake Toba Pumped Storage Hydropower Project site covers a total area of 26.3 km². Elevations across the site range from 901 m to 1425.7 m. Land cover is dominated by grassland and tree cover, accounting for 41.1% and 38.3% respectively. Terrain analysis indicates a mix of slopes, with 36.5% classified as gentle (<5°) and 25.2% as steep (>18°).

2.2 Land Cover Characteristics

The total project area is 26.3 km². Grassland is the most prevalent land cover type, accounting for 41.1% (10.81 km²). Tree cover constitutes 38.3% (10.08 km²) of the area.

Cropland covers 18.9% (4.96 km²), while built-up areas occupy 1.3% (0.34 km²). These human-modified areas collectively represent 20.2% of the total site. Natural vegetation, including grassland and tree cover, comprises 79.8% of the project site.

2.3 Topographic Characteristics

The project site exhibits an elevation range from 901 m to 1425.7 m, with a mean elevation of 1307.1 m. The majority of the area, 73.3% (19.28 km²), lies within the 1321-1426 m elevation zone.

Slope analysis using Young's classification reveals 36.5% of the area to have gentle slopes (<5°). This includes Level (2.0%), Very Gentle (9.6%), and Gentle (24.9%) classes. Moderate slopes (5-10°) cover 23.3% of the site.

Steep slopes (>18°) collectively represent 25.2% of the project area. This comprises Steep (11.3%), Very Steep (12.0%), and Precipitous (1.9%) classifications.

2.4 Key Findings

The project site is predominantly characterized by natural vegetation, with grassland and tree cover comprising 79.8% of the total area. Human-modified land, including cropland and built-up areas, accounts for 20.2%.

A significant portion of the site, 73.3%, is located within the highest elevation zone of 1321-1426 m.

Approximately one-quarter (25.2%) of the project area consists of steep to precipitous slopes (>18°), while over one-third (36.5%) comprises gentle slopes (<5°).

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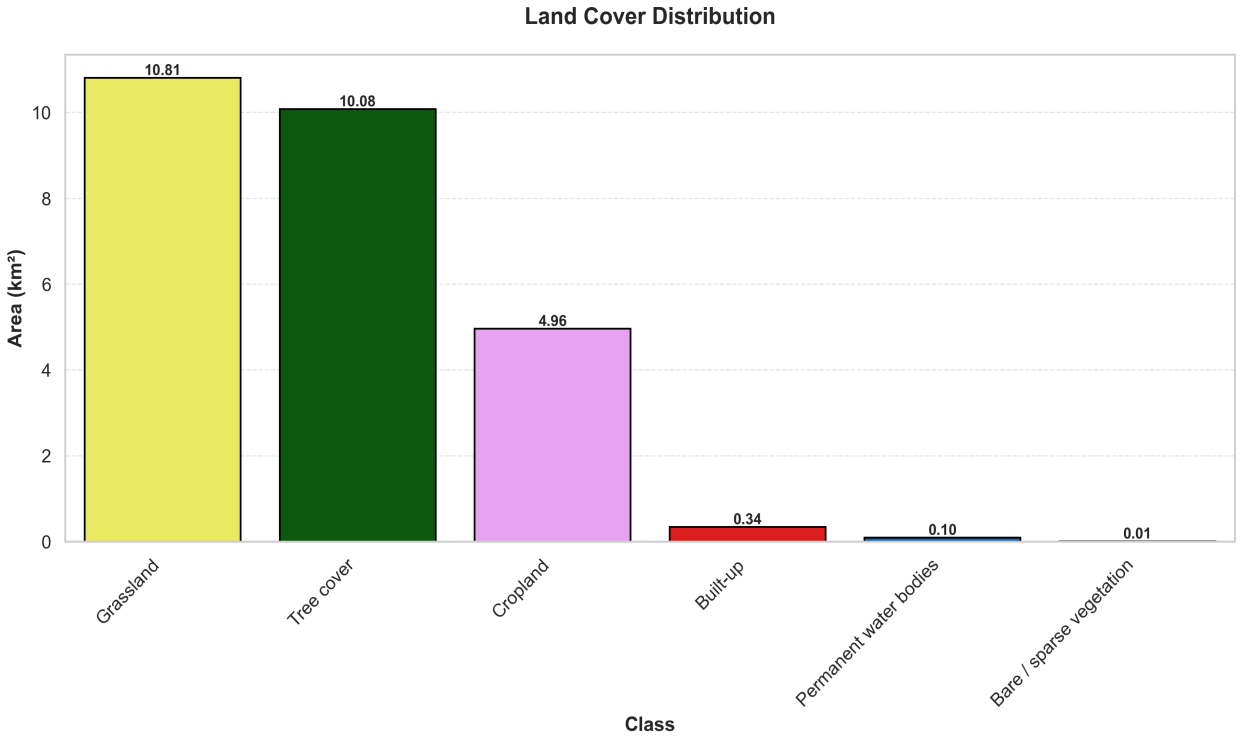
3.0 Land Cover Analysis

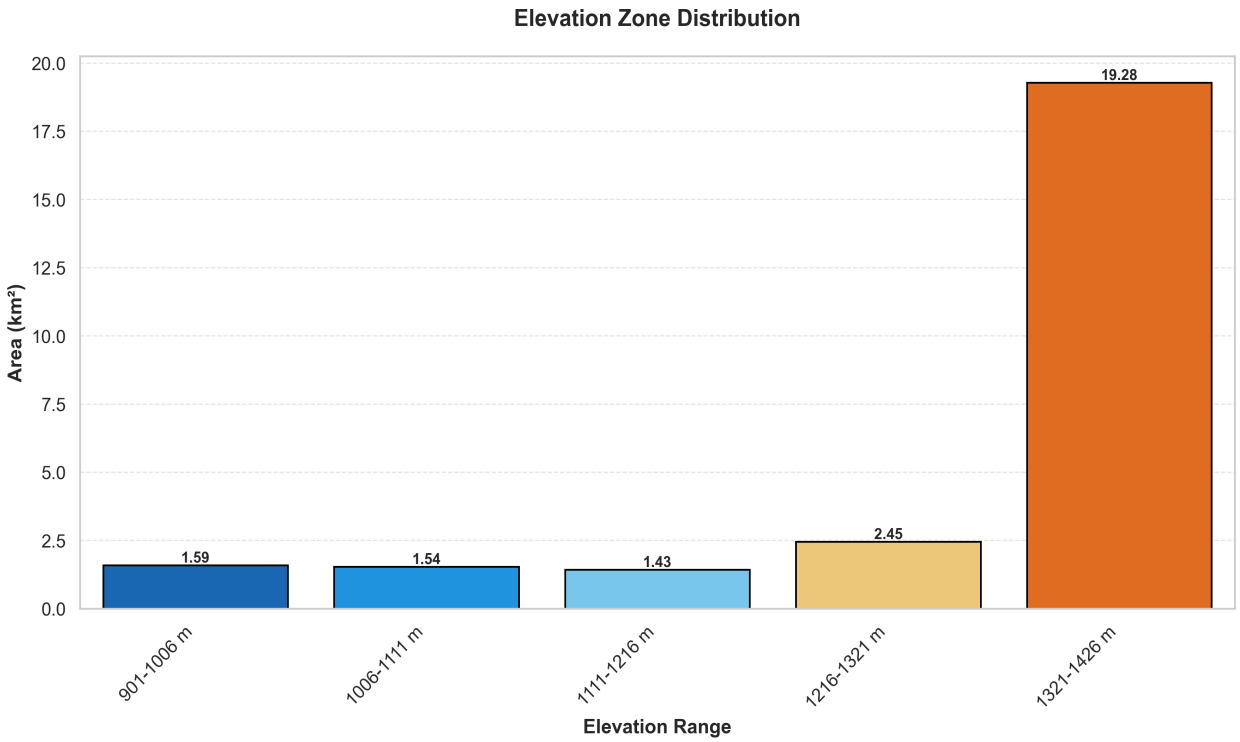


Class	Area (km²)	% Area
Grassland	10.81	41.1%
Tree cover	10.08	38.3%
Cropland	4.96	18.9%
Built-up	0.34	1.3%
Permanent water bodies	0.10	0.4%
Bare / sparse vegetation	0.01	0.0%

4.0 Terrain Analysis

Dataset: Copernicus DEM GLO-30
Min Elevation: 901.0 m
Max Elevation: 1425.7 m
Mean Elevation: 1307.1 m

4.1 Elevation Zone Distribution



Elevation Zone	Area (km²)	% Area
901-1006 m	1.59	6.1%
1006-1111 m	1.54	5.8%
1111-1216 m	1.43	5.5%
1216-1321 m	2.45	9.3%
1321-1426 m	19.28	73.3%

4.2 Slope Classification

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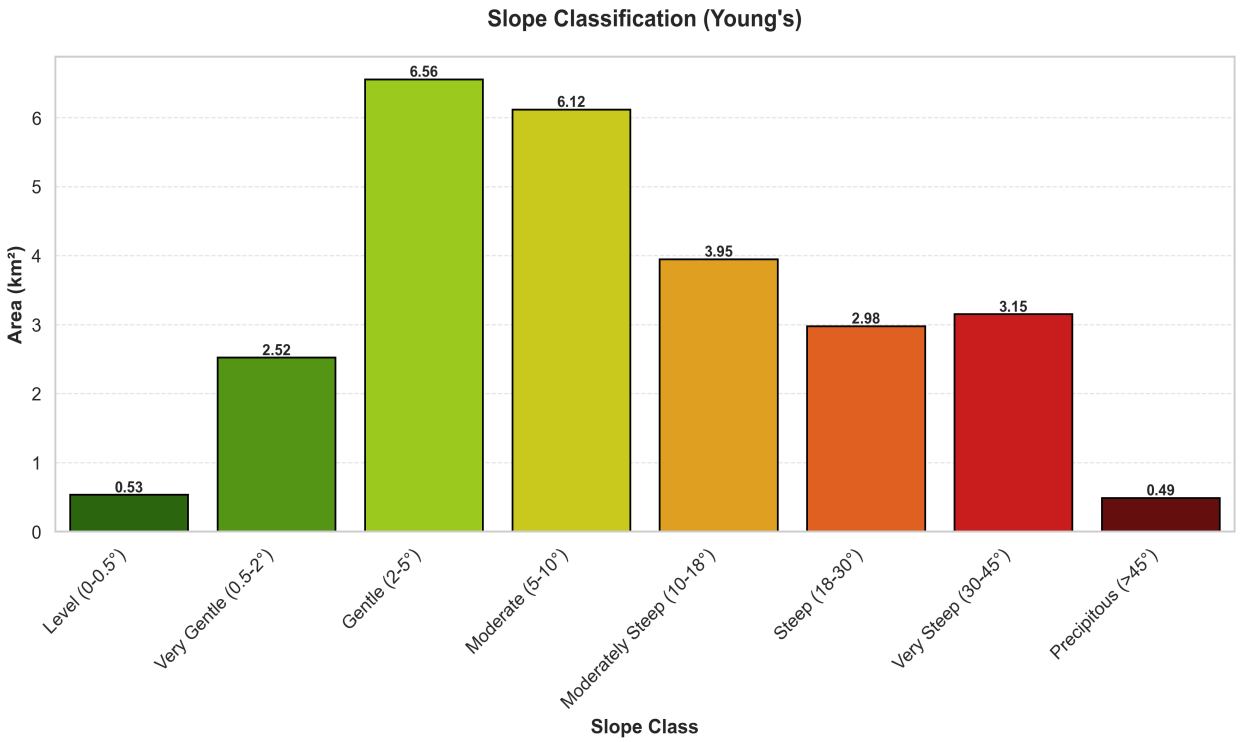

Slope Class (Young's)	Area (km²)	% Area
Level (0-0.5°)	0.53	2.0%
Very Gentle (0.5-2°)	2.52	9.6%
Gentle (2-5°)	6.56	24.9%
Moderate (5-10°)	6.12	23.3%
Moderately Steep (10-18°)	3.95	15.0%
Steep (18-30°)	2.98	11.3%
Very Steep (30-45°)	3.15	12.0%
Precipitous (>45°)	0.49	1.9%

Appendix 1: Data Sources, Analyses, Limitations

Data Sources

ESA WorldCover v200 (2021): Global land cover product at 10m spatial resolution derived from Sentinel-1 and Sentinel-2 satellite imagery. Produced by the European Space Agency. Accuracy: 74.4% overall global accuracy based on validation dataset.

Copernicus DEM GLO-30: Global Digital Elevation Model at 30m spatial resolution. Derived from TanDEM-X mission radar satellite data acquired between December 2010 and January 2015. Vertical accuracy: relative height error less than 2m (slope <20%) and less than 4m (slope >20%).

Analysis Methods

Land cover area calculations were performed using pixel frequency analysis at 10m resolution (100 m² per pixel). Terrain analysis utilized 30m resolution DEM (900 m² per pixel). Slope classification follows Young's geomorphological classification system (8 classes from Level to Precipitous). All spatial analyses were conducted using Google Earth Engine cloud computing platform.

Limitations

Remote sensing data provides synoptic coverage but has inherent limitations. Land cover classification may not capture all ground conditions, particularly in areas with mixed or transitional land cover types. DEM-derived slope analysis represents generalized terrain conditions at 30m resolution and may not identify localized steep slopes or terrain features smaller than the pixel size.

Field validation has not been conducted for this baseline assessment. The analysis represents desktop-level characterization suitable for preliminary environmental assessment. Detailed project planning requires ground-truthing, field surveys, geotechnical investigations, and site-specific data collection.

Generated Outputs: High-resolution GeoTIFF maps (land cover, elevation, slope, elevation zones) have been saved to the data/raw directory for use in GIS applications and detailed spatial analysis.