A GIS-based rapid resource assessment and mapping for small-scale hydropower potential: the case of Bohol, Central Philippines

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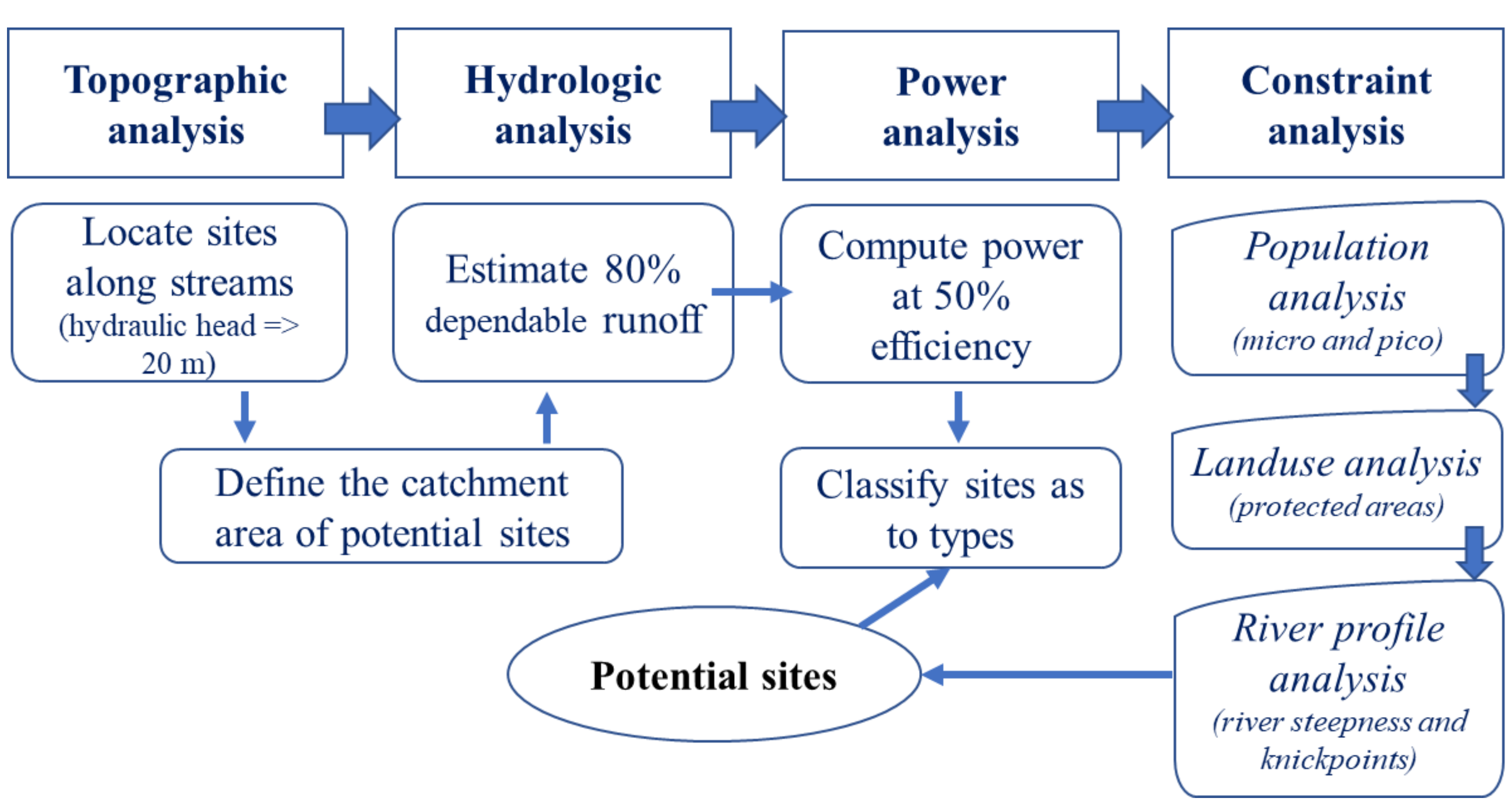
ABSTRACT

The study identifies potential sites for small-scale hydropower projects in Bohol, Central Philippines, using geographic information system, the Curve Number (CN) method, and TopoToolbox to analyze a digital elevation model, hydrologic soil group, landcover information, and other spatial datasets. The assessment includes examining hydraulic head and estimating surface runoff, analyzing population and landuse, and evaluating geomorphic indices – proxies of erosion process and channel stability. The study reveals 94 potential sites with a total power capacity of 9,869 kW. The number reduces to 24 sites after landuse and population constraint analysis, reducing potential power capacity to 3,955 kW. The geomorphic indices classify the remaining potential sites according to the risk level of geological hazards, providing resource managers and planners a priority list for further development. The approach, applicable to other areas constrained with data available to carry the analysis, is limited to the initial assessment stage of project development.

METHODOLOGY



Data used in the study are a 10-m DEM, hydrologic soil group dataset, landcover information, monthly precipitation, and barangay level population data, and barangay polygon. Data processing started with a topographic analysis using ArcGIS 10 defining the streamlines and the required elevation head. Next, using the Curve Number (CN) method, the hydrologic analysis provided an estimate of runoff through each potential site. The hydropower, P [Watts], was computed using the equation, $P = \varepsilon\ \gamma\ H\ Q_{80}$, where ε is the overall efficiency at 50%, γ is the water density [$N{\cdot}m^{-3}$], H is the hydraulic head [m], and Q_{80} is the 80% dependable flow [$m^{3}{\cdot}s^{-1}$]. Then, we considered population and landuse in the constraint analysis. Lastly, the river steepness index, k_{sn}, and the presence of knickpoints in the river profile analysis determined the risk level associated with the erosional process and channel stability. The study used TopoToolbox-Matlab to calculate k_{sn} and determine knickpoints.

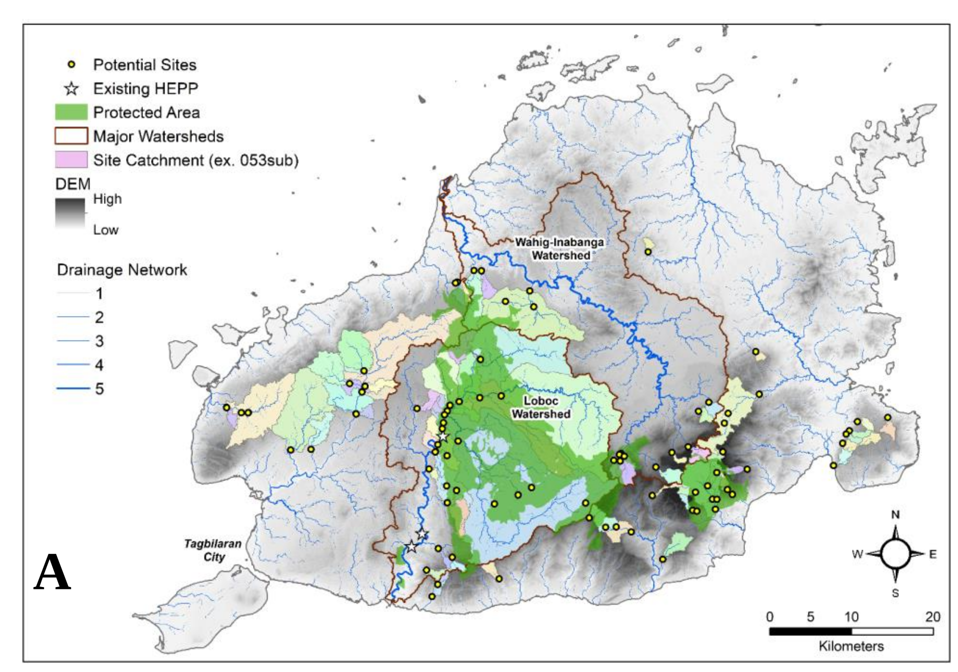
CONCLUSIONS

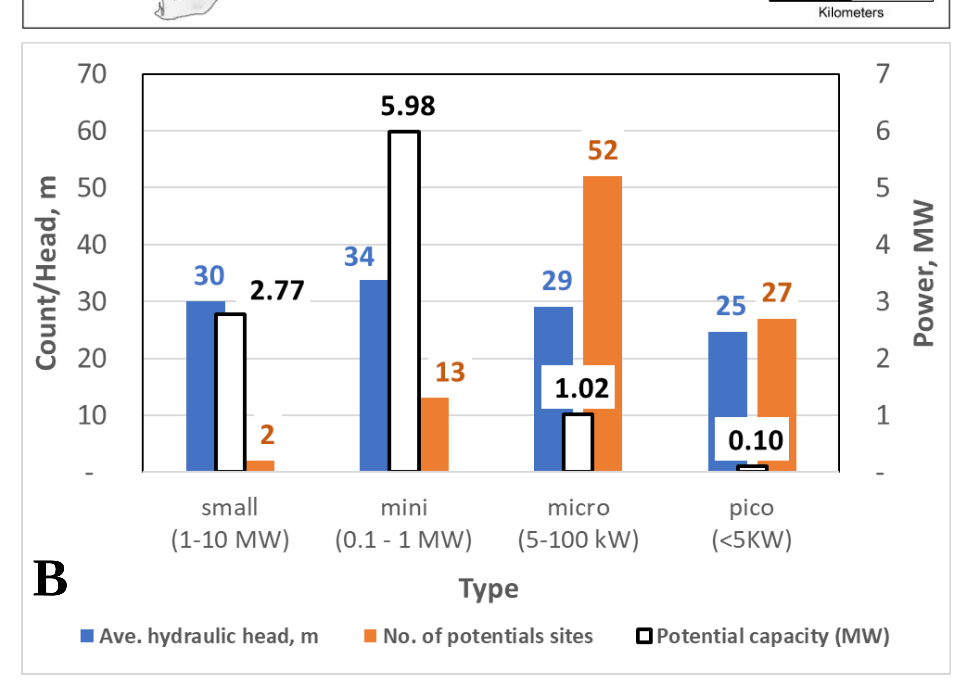
Topographic analysis and hydrologic information identified 94 potential sites, with an estimated hydropower capacity of about 9,869 kW. Analysis of existing landuse policies and population distribution reduced the number to 24. River profile analyses showed that sites were at different risk levels to geologic-related hazards. Field validation is required to establish the reliability of the method. Results of the study could allow decision-makers and energy developers to prioritize sites, reducing the cost and time associated with field surveys.

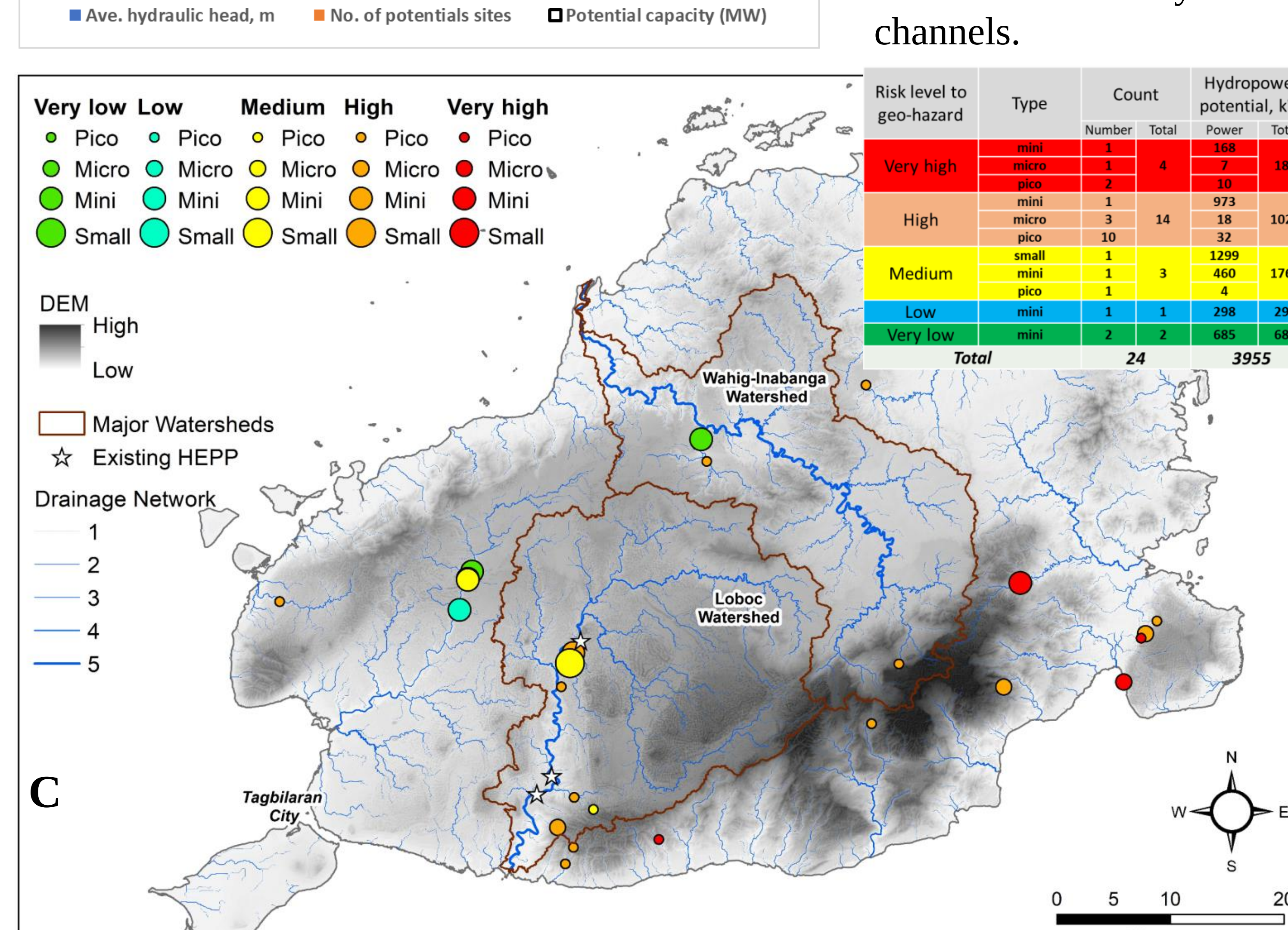
INTRODUCTION

Geographic information systems (GIS) and hydrologic models are the primary tools widely employed to identify potential sites for hydropower development. However, current studies on the initial assessment for potential hydropower sites considered topographic and hydrologic aspects and less attention to geomorphic considerations. Geomorphic factors account for geology-related hazards, given that hydropower infrastructures are located along or adjacent to river channels. The topographic profile of a river system holds useful information of tectonic forcing across a landscape. The study aims to assess land and water resources to identify potential sites for small-scale hydropower projects. Specifically, the study a) analyzes topography and estimates surface runoff, b) examines landuse and population constraints, and c) classifies potential sites' risk level to geologic-related hazards using the geomorphic index. The study is limited to the table assessment phase of hydropower development.

RESULTS AND DISCUSSIONS







Risk level to geo-hazard	Type	Count		Hydropower potential, kW	
		Number	Total	Power	Total
Very high	mini	1	4	168	184
	micro	1		7	
	pico	2		10	
High	mini	1	14	973	1023
	micro	3		18	
	pico	10		32	
Medium	small	1	3	1299	1764
	mini	1		460	
	pico	1		4	
Low	mini	1	1	298	298
Very low	mini	2	2	685	685
Total		*24*		*3955*	

A. Spatial distribution of the 94 potential sites for small-scale hydropower projects with a minimum hydraulic head of 20 m and a total estimated hydropower capacity of 9,869 kW (assuming 80% dependable flow and 50% efficiency).

B. Number of sites per type, the average hydraulic head per type and the hydropower capacity.

C. A decision support map showing the 24 potential sites after considering landuse and population. Sites are classified by level of risk to geo-hazards. Field validation is needed. However, with Google Earth, at least eight sites are found nearby river channels.