



Assessment of the Accessibility of Potential Geosites and GIS-Based Design of Optimal Georoutes in Ardahan Province (Türkiye)

Sultan Duran¹ · Mesut Doğan²

Received: 18 October 2025 / Accepted: 5 January 2026
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Abstract

Geotourism development in rural and mountainous regions requires an integrated understanding of how accessibility, scenic visibility, and digital awareness interact to shape visitor potential and spatial feasibility. This study presents a Geographic Information Systems (GIS)-based framework for assessing and optimizing georoutes in Ardahan Province, northeastern Türkiye—a region of outstanding geoheritage richness but limited infrastructural connectivity. Building upon the 2024 Ardahan Geopark Feasibility Report, seventy-three potential geosites were evaluated through spatial modelling that combined terrain impedance, network-based travel-time analysis, viewshed-based scenic visibility modelling, and digital representation metrics derived from Google Maps data. The normalized indicators were integrated into an Integrated Geoheritage Potential Index (IGPI) to quantify the relative significance of each geosite and support data-driven route design. Results reveal a pronounced spatial disparity: while most sites exhibit low to moderate accessibility and minimal digital visibility, a small cluster of geosites achieved high IGPI scores, forming a coherent “Çıldır–Kura Corridor” with strong geotourism potential. Route optimization, implemented through a network-based Traveling Salesman Problem (TSP) model, confirmed the feasibility of efficient one-day circuits linking high-priority sites, with total travel times ranging from 308 to 465 min. Additionally, a dedicated trekking route demonstrated the applicability of terrain-based modelling for adventure-oriented geotourism. The findings highlight that integrating spatial accessibility with scenic and digital visibility provides a powerful analytical tool for aligning geoheritage assessment with sustainable tourism and geopark planning. The proposed framework is replicable, transparent, and compatible with UNESCO Global Geopark principles, offering a transferable methodology for other rural regions seeking to transform dispersed geoheritage assets into connected and economically viable geotourism networks.

Keywords GIS-based modelling · Rural development · Accessibility analysis · Route optimization · UNESCO global geopark

Introduction

Tourism is a significant driver of regional development, yet it can also generate considerable ecological and social pressures if poorly managed (Jackson and Murphy 2006). This underscores the need for planning approaches that balance economic benefits with the conservation of natural

and cultural assets (Lee et al. 2013). Within this context, geotourism has emerged as a sustainable alternative that emphasizes abiotic nature while integrating ecological and cultural values through frameworks such as the ABC (Abiotic, Biotic, Cultural) model (Hose 1995; Dowling 2013; Ólafsdóttir and Dowling 2014; Ólafsdóttir and Tverijonaite 2018). The UNESCO Global Geopark programme (UGGp) further institutionalizes this philosophy by providing a governance framework that promotes geoheritage conservation, education, and community-oriented sustainable development (UNESCO 2016).

Effective geotourism planning increasingly relies on GIS-based tools, which have become indispensable for the inventorying, spatial analysis, and multi-criteria evaluation of geoheritage resources (Bahaire and Elliott-White 1999;

✉ Sultan Duran
sultanbolat@ardahan.edu.tr

¹ Geography Department, Ardahan University, Ardahan, Türkiye

² Geography Department, Istanbul University, Istanbul, Türkiye