

# **A Novel GIS-MCDA and Artificial Intelligence Approach for Optimal Site Selection of CSP Plants with Emphasis on Comprehensive Economic Analyses (Case Study: Bushehr Province)**

**Introduction:** This study presents a novel and comprehensive approach to the optimal site selection of Concentrated Solar Power (CSP) plants in Bushehr Province, Iran, by integrating Geographic Information Systems (GIS), Fuzzy Multi-Criteria Decision Analysis (MCDA), and advanced artificial intelligence techniques. Given the increasing global demand for renewable energy and the pressing need for sustainable energy infrastructure, this research aims to address the complex challenges associated with CSP plant siting by leveraging cutting-edge geospatial and computational methodologies.

**Material and Methods:** The methodological framework involves the processing of Landsat 8 satellite imagery using the FLAASH algorithm for atmospheric corrections, ensuring precise remote sensing data analysis. Key environmental indicators such as the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) were computed, contributing to an accurate classification of land use with an overall classification accuracy of 87%. To establish reliable decision-making criteria, the study employed the Analytic Hierarchy Process (AHP) for criteria weighting, achieving a consistency ratio of 0.093, which signifies a high level of reliability in the pairwise comparison assessments.

**Results and Discussion:** To enhance predictive accuracy in site selection, machine learning algorithms, including Random Forest (RF) and Convolutional Neural Networks (CNN), were integrated into the decision-making process. The application of these AI-driven techniques resulted in a notable 12.7% improvement in model accuracy compared to traditional MCDA methods (Root Mean Square Error [RMSE]: 0.089 vs. 0.102). Subsequently, zonal analysis of the combined AI-Fuzzy MCDA model identified highly suitable zones, covering approximately 5.37% of the total provincial area, as optimal for CSP plant installation. A comprehensive economic assessment was conducted through a Cost-Benefit Analysis (CBA) utilizing Monte Carlo simulation. The economic feasibility of CSP projects was examined, with results indicating an average Internal Rate of Return (IRR) of 13.2% across the identified optimal zones. Sensitivity analysis using the Sobol method demonstrated that the Net Present Value (NPV) of the projects is most sensitive to initial capital costs and electricity selling prices, underscoring the importance of financial viability considerations in renewable energy investments. Additionally, a risk assessment incorporating Value at Risk (VaR) and Conditional Value at Risk (CVaR) at a 95% confidence level provided valuable insights into the economic uncertainties associated with CSP implementation.

**Conclusion:** This research significantly contributes to the field of sustainable energy development by offering an integrated framework that combines spatial analysis, multi-criteria decision-making, and economic modeling. The findings are highly relevant for policymakers, investors, and researchers involved in renewable energy planning and can serve as a replicable model for similar studies in other geographical regions. The integration of GIS, AI, and economic evaluation methodologies ensures a robust decision-support system, facilitating informed decision-making in the transition towards sustainable energy solutions.

**Keywords:** Optimal site selection, Artificial Intelligence, Fuzzy, Concentrated Solar Power, GIS, Economic analysis, Bushehr.