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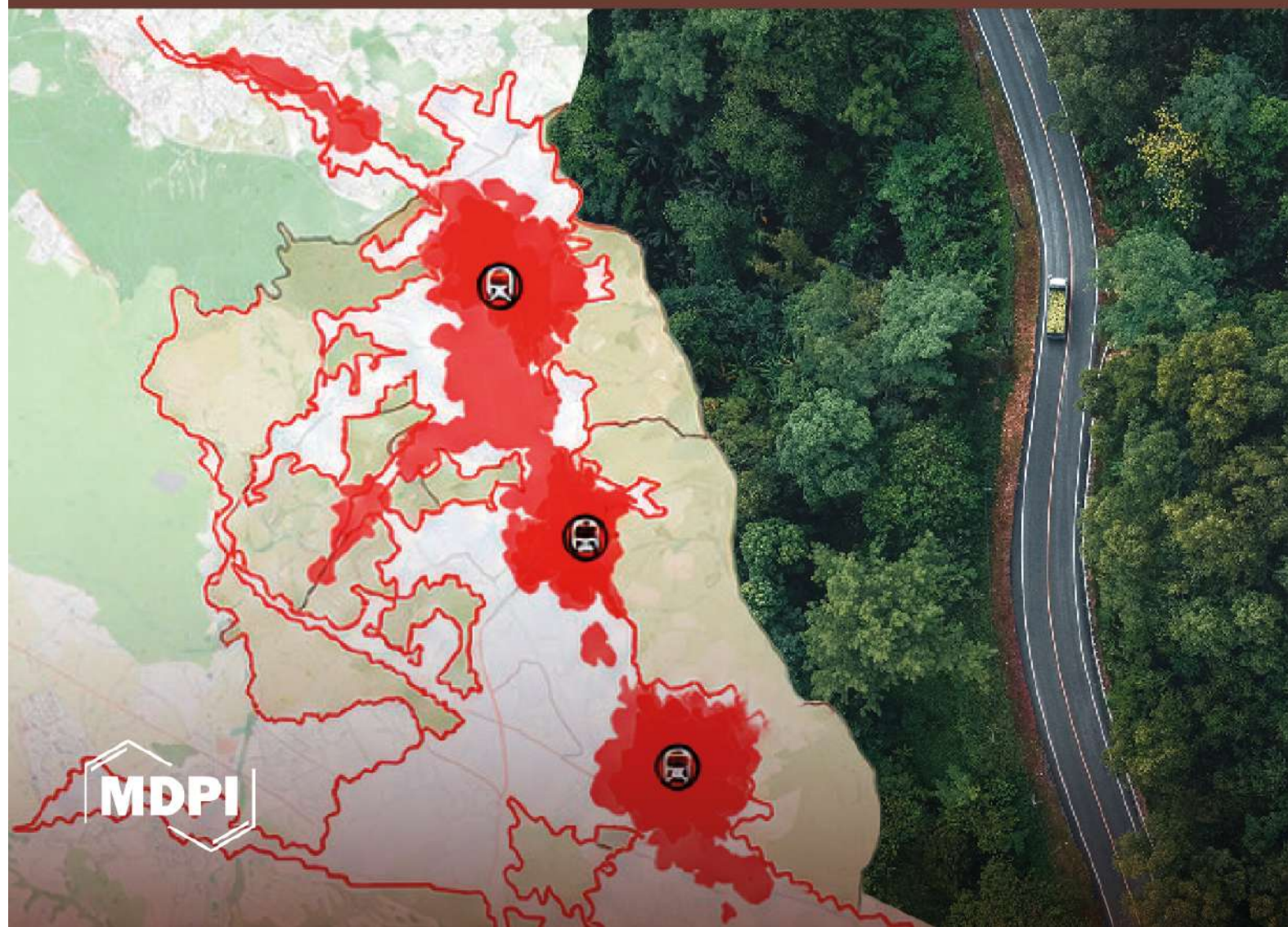
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## Article

# Optimizing Ecological Security Patterns from a Supply–Demand Perspective Using XGBoost and Ecological Network Theory

Wei Feng <sup>1,†</sup>, Jingge Gao <sup>1</sup>, Zhe Zhang <sup>1,†</sup>, Maohua Ma <sup>2</sup>, Jinyu Ye <sup>3</sup>  and Chundi Chen <sup>1,\*</sup> 

<sup>1</sup> Urban and Rural Planning Department, School of Architecture, Southwest Jiaotong University, Chengdu 611756, China

<sup>2</sup> Key Laboratory of Reservoir Aquatic Environment, Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences, Chongqing 400714, China

<sup>3</sup> Zhejiang–Singapore Joint Laboratory for Urban Renewal and Future City, School of Civil Engineering and Architecture, Zhejiang University of Science and Technology, Hangzhou 310023, China

\* Correspondence: chundichen@swjtu.edu.cn

† These authors contributed equally to this work.

## Abstract

Rapid urbanization has intensified ecosystem service supply–demand mismatches, severely constraining regional sustainable development. Ecological security patterns represent a critical strategy to address these challenges, yet existing studies predominantly focus on natural supply while neglecting human ecological demands. This study develops an integrated framework combining XGBoost machine learning and ecological network theory to assess and optimize ecological security patterns from a supply–demand perspective, using the Chengdu–Chongqing Urban Agglomeration in the upper Yangtze River Basin as a case study. Results reveal a distinct spatial pattern of “high supply in peripheries and high demand in urban cores”. Ecological demand sources and corridors have experienced explosive growth, expanding significantly faster than supply components. While the ecological supply–demand network has become more structurally complex with improved structural connectivity overall, the supply–demand balance has progressively deteriorated. Targeted optimization through supplementing key ecological sources and refining network structure enhanced connectivity by 136.46% and improved supply–demand balance by 35.4%. A “three zones, four corridors, six nodes” optimization scheme is proposed. This research provides valuable insights for mitigating ecological conflicts in rapidly urbanizing regions and informs evidence-based decision-making for territorial ecological restoration and public policy design to balance conservation and socioeconomic development.

**Keywords:** ecological supply–demand networks; XGBoost; Chengdu–Chongqing urban agglomeration; ecological security pattern



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## 1. Introduction

Rapid global urbanization drives disordered land use/land cover (LULC) changes, fragmenting landscapes and degrading habitat quality. Interacting with climate change, resource supply pressures, and infrastructure construction, this process increasingly destabilizes the spatial equilibrium between ecological supply and demand, thereby threatening regional ecological security [1]. Ecological Security Patterns (ESP) offer a widely accepted solution to reconcile nature conservation with human development while maintaining the structural and functional integrity of ecosystems [2]. However, existing studies have often prioritized the protection of natural ecological supply, while giving insufficient attention