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ECOLOGICAL PROTECTION AND SUSTAINABLE DEVELOPMENT OF AGRICULTURE BASED ON GENETIC ALGORITHM AND AGRICULTURAL ECONOMIC MODEL

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Abstract

To balance agricultural economic development and ecological protection, a two-stage framework integrating the dynamic obstacle degree model and the Non-dominated Sorting Genetic Algorithm (NSGA-II) is proposed. First, a vulnerability assessment index system is constructed for regional water and soil resource system, incorporating 27 indicators across three dimensions: water-soil resources, socio-economic factors, and ecological structure. The obstacle degree model, enhanced by entropy weighting, dynamically diagnoses key vulnerability drivers, revealing that the grey water footprint (nitrogen-based) was the dominant factor, contributing up to 17.35% to regional vulnerability. Second, a multi-objective optimization model is developed using NSGA-II to reconfigure crop planting structures, aiming to maximize economic output, minimize fertilizer usage, and ensure food security within the constraints of resource availability, policy compliance, and ecological thresholds. Empirical analysis in Region X demonstrated that optimized planting structures reduced fertilizer usage by approximately 50,000 tons (12.3% reduction) while maintaining economic stability. The Pareto optimal solutions under four scenarios (baseline, economic development, technological progress, and water conservation) highlighted trade-offs. Water conservation scenarios prioritize ecological benefits, but require policy support for farmers' income, while technological progress maximizes yield at potential ecological costs. Key limitations include the model reliance on nitrogen-focused grey water metrics, excluded pesticide data, and the regional specificity of the results, which may require validation for broader applicability. This interdisciplinary framework provides actionable insights for policymakers to harmonize agricultural productivity with ecological resilience.

Key words: agriculture, ecological protection, genetic algorithm, obstacle degree, sustainable development

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