

Integrated Arable Land Optimization through Portfolio Optimization for Sustainable Agriculture: A Case Study in Uzbekistan

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Abstract

There is a necessity to optimize land allocation to enhance the productivity and sustainability of agricultural activities in areas that have limited land and water supplies, due to the uncertainty factor. The current study suggests two optimization models, taking into account six main crops, and a case study has been conducted in Uzbekistan, where the arable land constitutes less than 10 percent of the total land, and water supply to agriculture is scarce. The models are formulated based on the Markowitz and Kataoka models, which are premised on financial portfolio theory that the expected value of production is the return, and the variability of the yields is the risk. The Markowitz model reallocates arable land by adjusting different risk aversion parameters, whereas the Kataoka model redistributes land based on probabilistic production under a guarantee. The results of the Markowitz model have shown that there exists a risk-return trade-off in that a decrease in risk aversion leads to increasing values of expected production due to reallocation of land between crops, given a fixed total area. Wheat is always regarded as a stabilizing crop, and the higher-return crops increase its land share as the risk aversion is reduced. Although Kataoka's approach focuses on minimum production value, which will result in high land expansion and a less risky crop mix at a given probability. The analysis indicates that the replacement of Markowitz by Kataoka alters land-use decisions, and the interest will be in the redistribution of the available land to the development of more spaces of cultivated land at a predetermined probability. The findings can be used by policymakers in semi-arid areas since they indicate the fluctuation in the outcomes of the various optimization plans.

Keywords

Agricultural land allocation, Optimization, Risk-return trade-off, Sustainable agriculture, Decision support systems

Biographies

Sonia Rashidian is a master's graduate in Industrial Engineering, and her research interests are in optimization, simulation, decision support systems, and using quantitative methods to solve real-world problems. Her master's thesis was on how to use portfolio optimization models, such as Markowitz, to enhance the agricultural land allocation problem in semi-arid regions, considering uncertainty. She is especially eager to apply simulation, machine learning,

risk modeling, and optimization methods to support strategic and operational decision-making in complex systems. Sonia also has some teaching and academic work experience to continue her studies as a doctoral student.

Professor Béla Vizvári is a full professor of operations research and industrial engineering and specializes in the fields of optimization and applied mathematical modeling. His work is on deterministic and stochastic optimization, network flows, portfolio optimization, combinatorial optimization, and decision support systems. He has made contributions in both theoretical and practical studies, where he has applied them in logistics, finance, and resource allocation. Professor Vizvári is the author of many articles published in international peer-reviewed journals and has presented his work at international conferences. He has also mentored many graduate students at the master's and doctoral level guiding research on operations research, optimization, and analytics. Besides his academic assignments, he has worked on interdisciplinary projects with real-world industrial and economic decision-making. He has taught courses such as operations research, optimization methods, mathematical programming, and decision analysis. Professor Vizvári, with his academic and research works, still contributes to the advancement of advanced analytical procedures and their application in complicated decision-making settings.

Professor Zoltán Lakner is a renowned scholar in food economics, agricultural economics, and sustainability, who has extensive experience in research and higher education. He is the head of the department at the Hungarian University of Agriculture and Life Sciences (MATE). His research concerns food systems, agricultural and resource economics, risk and uncertainty in agri-food supply chains, sustainability, and food production and distribution innovation. Professor Lakner is a prolific international peer-reviewed journalist and has participated in a variety of interdisciplinary research undertakings with a focus on food security, sustainable agriculture, and environmental management. He has also been actively participating in international practices and academic networks to facilitate knowledge sharing among all institutions and countries. In his academic and working endeavors, he still makes contributions towards the development of sustainable and resilient food systems.