



Jul 13th, 3:50 PM - 4:10 PM

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Kaim, Andrea; Cord, Anna; and Volk, Martin, "Optimal land use?! – A review on optimization techniques used in multi-criteria decision analysis" (2016). *International Congress on Environmental Modelling and Software*. 37.

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Optimal land use?! – A review on optimization techniques used in multi-criteria decision analysis

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Abstract: Agriculture, forest management, conservation planning and other related disciplines have specific land use demands, and thus different perspectives on how land should be used in an “optimal way”. One way to solve arising land use conflicts is employing the ecosystem services concept together with methods from the field of multi-criteria analysis (MCDA). Especially optimization techniques provide the possibility to include socio-economic and ecological aspects as well as the protection of biodiversity. In this study, we give an overview of these methods, focusing especially on their application in agricultural areas. We explore their abilities for the identification of ecosystem service trade-offs since land use planners are particularly interested in minimizing these. The aim of the research is to provide a guideline on which optimization methods can be used given different types of land use problems. For example, the problem’s size and structure determine whether a direct (e.g. Simplex, Branch & Bound) or heuristic algorithm (e.g. Simulated Annealing, Evolutionary Algorithm) should be applied. Furthermore, stakeholder opinions can be included either a priori (before), interactively (during) or a posteriori (after) the optimization process. Interactive approaches are seen as promising because the algorithm steers towards a solution close to the stakeholder’s aspirations which can be adjusted during the optimization process. However, a posteriori approaches are often recommended for trade-off analyses since their solutions provide the whole Pareto frontier – often referred to as “trade-off curve”. All methods are discussed and illustrated with examples of existing applications and case studies. Finally, we provide recommendations for their use in the different facets and perspectives of land and biodiversity management.

Keywords: land use; multi-criteria decision analysis (MCDA); optimization; ecosystem services; trade-offs