# Water related trade-offs of different crop production schemes for biogas production in a German case study

*Sven Lautenbach[1,2], Martin Volk[2], Michael Strauch[2], Gerald Whittaker[3], Ralf Seppelt[2]*

*[1] University Bonn, Institute for Geodesy and Geoinformation, Nußallee 1, 53115 Bonn, Germany, sven.lautenbach@uni-bonn.de*

*[2] UFZ Helmholtz Centre for Environmental Research, Department of Computational Landscape Ecology, Permoserstr. 15, 04318 Leipzig, Germany*

*[3] USDA, ARS, National Forage Seed Production Research Center, 3450 SW Campus Way, Corvallis, OR 97331-7102*

While increasing biofuel production is worldwide on the political agenda, concerns about the involved trade-offs are on the rise. However, the quantification of these trade-offs is typically based on the comparison of a limited number of plausible alternatives. We extended the analysis by applying a multi-objective genetic algorithm to estimate the set of Pareto optimal solutions which describe the trade-offs between the objectives. The Pareto solutions represent the (estimated) best options given the model and the specified control options. Our analysis studied food and fodder based crop rotations and two alternative biogas crop production schemes: a corn based production scheme and a two-culture production scheme which combines a summer and a winter crop. The integrated river basin model SWAT (Soil Water Assessment Tool) was used to evaluate the effects of the different crop production schemes on bioenergy crop production, food and fodder crop production, water quality and low flow discharge. The analysis took place in a medium sized agricultural watershed (~320km$^2$) in Central Germany. We run the optimization algorithm for combinations of the three sets of crop rotations to identify the trade-offs. The two biogas crop rotation schemes showed significant differences in their trade-offs with water quality and low flow conditions. High corn yields led to increasing nitrate concentrations while high bioenergy crop yields based on the two culture system led to decreases in low flow. But trade-offs depended on the choice of food and fodder crops as well. To assess the robustness of the solutions, we compared trade-offs under current climate conditions with trade-offs under two climate scenarios (A1B and B1 scenarios statistically downscaled by WEREX-IV approach for the time period 2014-2100). The estimated trade-offs differed significantly under the different climate conditions, highlighting thereby that trade-off analysis has to consider changing boundary conditions.