Jul 12th, 5:10 PM - 5:30 PM

Using multi-objective optimization to support urban planning

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International Environmental Modelling and Software Society (iEMSs)
8th International Congress on Environmental Modelling and Software
Toulouse, France, Sabine Sauvage, José-Miguel Sánchez-Pérez, Andrea Rizzoli (Eds.)
http://www.iemss.org/society/index.php/iemss-2016-proceedings

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Abstract: Globally urban growth destroys fertile soils and endangers food security. Fertile soils are often located in the vicinity of existing urban areas. Thus, preserving high-quality soils often conflicts with the objective of compact city development. Urban planners have to account for both of these and many other objectives and react to political decisions which put a higher weight on some of them. In addition, urban planners have to deal with uncertain projections on population growth and the demand for housing. We used a multi-objective evolutionary algorithm to show for a case study region in Switzerland how robust urban growth patterns could be and compared them to simulations of Business-As-Usual (BAU) urban growth. We optimized urban growth including two objectives - compact city development and reduction in loss of good quality soils. For simulating BAU urban expansion we have used a land-use model calibrated with the help of remote sensing data. Our analysis included the following steps: First, we optimized urban growth for a specified housing demand and analyzed the resulting set of non-dominated solutions in order to identify areas that were always converted into urban. Second, we analyzed the sets of non-dominated solutions for different scenarios of housing demand and showed that there were again many commonalities in the allocation of urban areas. Third, including simulations of BAU urban growth, we showed that delayed policy action would exponentially increase the gap between optimal and non-optimal urban development. We conclude: Steering urban growth towards common areas in the non-dominated solutions, could help urban planners to reach optimal futures under changing conditions. As immediate policy action is required, it could be a good ad hoc solution to develop common areas across the Pareto-Front before entering the time consuming process of decision-making including stakeholders.

Keywords: multi-objective evolutionary algorithm, urban planning, uncertainty, soil deterioration