Project Summary for the General Public

The project deals with the important issue of the reliability of modeling results in GIS, under the presence of uncertainty in model input data. Specifically, it targets spatial multi-criteria models - a class of normative models widely used in GIS for land use suitability modeling, site selection, and resource allocation. The steps of building a spatial multi-criteria model include the selection of criteria, calculation of criteria values for each mapping unit, elicitation of weights representing the relative importance of criteria, computation of synthetic index value representing the overall worth of each mapping unit and examining the robustness of index with sensitivity analysis. This last step is commonly performed by modelers with a simplified approach examining the consequences of altering model input factors (e.g. weights) one factor at a time, without considering the effects of interactions and simultaneous changes in more than one inputs.

In an effort to develop a more robust approach to spatial multi-criteria model sensitivity analysis, this project offers a unified approach to uncertainty and sensitivity analysis, in which the uncertainty analysis is employed to quantify outcome variability given model input uncertainties, and sensitivity analysis evaluates how much each source of input uncertainty contributes to model output variability. In order to address multiple sources of uncertainty in data stored in GIS, the project will investigate the effects of uncertain criteria weights and criteria values on the variability (uncertainty) of results in GIS-based multi-criteria model of geodiversity. This will be achieved by sampling a large number of plausible weight and criterion values, simulating model results with Monte Carlo method, and mapping the simulation results. The maps will reveal spatial distributions of geodiversity index mean and variance (a proxy of model output uncertainty).

We will then employ a method of calculating the contribution from each input factor to model output variability both; for input factors contributing individually, and in interaction with other factors. Such approach broadens the understanding of the relationships between uncertain model inputs and the reliability of model output. In our approach, information about the influence of input factors on the uncertainty of model output will be mapped in order to visualize and to identify hot spots (influential factors and their spatial pattern) and cold spots (non-influential factors and their locations). Identifying such locations provides important clues for modelers. It can point out mapping units burdened by errors and/or low-quality data. It can also identify non-influential model criteria that, for a given study area, can be removed from the model, thus creating a more parsimonious model version.

The significance of this project comes from investigating the ways of effectively communicating the meaning of uncertainty and sensitivity in environmental analysis and assessment, on the example of geodiversity. Although these concepts are well established in the scientific literature, representing model output uncertainty and sensitivity in a spatially explicit (distributed) manner presents a challenge in understanding and interpreting analysis results. This research will examine thematic maps of sensitivity indicators in an experimental setting involving a broad group of participants with varying knowledge and experience in environmental modeling with GIS and assessment. The results are expected to contribute to finding effective ways of communicating the meaning of sensitivity indicators represented not only by numeric values but also by their spatial distributions. It is expected that effective visualizations coupled with computationally efficient procedures may lead to wider than currently practice of using unified uncertainty and sensitivity analysis in spatial multi-criteria models.