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Developing a decision support tool for landscape planning and management to minimize land and water degradation in Volta basin

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Although many soil/water-landscape studies have been published in the last two decades, progress in developing operational tools for supporting landscape planning to minimize land and water degradation in developing regions is still modest. Some of the existing tools are very data demanding and/or too complicated to be useful to data scarce regions. A research group at the Center for Development Research (ZEF), University of Bonn has developed a LAndscape Management and Planning Tool (LAMPT) to facilitate land management decision making and landscape planning by optimization.
Firstly, we used the Revised Universal Soil Loss Equation (RUSLE) and a Distributed Sediment Delivery Model (DSDM) in a GIS environment to estimate the spatial distribution of areas experiencing different levels of soil loss in the White Volta basin. The RUSLE is employed to map the spatial patterns of major sediment source areas based on data calibrated for the study region. As RUSLE only estimates the potential gross erosion of each grid cell, a DSDM is used to estimate the sediment delivery efficiency of each cell using flow distance and velocity along the flow path. The combined models allow a classification of sub-watersheds experiencing different levels of soil loss using a soil tolerance threshold suitable for the study areas (Burkina Faso and Ghana). The result shows that the majority of areas around north-eastern and eastern parts of the White Volta basin (mainly south-eastern Burkina Faso and upper east region of Ghana) are associated with high levels of sediment yield (over 15 t ha-1 yr-1). The main reason could be high population pressure, poor surface cover and relatively high slope of some of the areas in Ghana. On the other hand, the north-western and southern parts of the basin experience low levels of sediment yield (less than 5 t ha-1 yr-1) mainly due to their flat terrain and good surface cover that encourage sediment deposition rather than erosion. We revealed that a GIS-based soil erosion and sediment delivery model can successfully be used for identifying and prioritizing critical sub-watersheds for management purposes. Such a tool can be of significance in developing areas where problems are severe but resources are scarce.
Next, we implemented the RUSLE-DSDM model into NetLogo, an agent-based programming platform, producing a LAMPT's prototype. The operational model was designed in such a way that fast and robust sensitivity analyses can be performed, after users are allowed to (i) select and set different physical parameters, and (ii) choose different sets of land-use management and planning options. The physical parameters choice meets the scientific needs of landscape modelers in their exploration of adequate values of the many parameters in soil/sedimentation models that are often not well-calibrated in developing regions. The latter is expected to meet the needs of practitioners in catchment management and planning. As the tool allows front-end users to handle the selection of management/planning options, and provide a fast and responsive outputs (in terms of both maps and graphs), LAMPT can assist in effective multi-stakeholder negotiations over land-use planning where the minimization the degradation of land/water resources is the ultimate goal. The LAMPT model can be easily coupled with LUDAS, an agent-based land-use change model using the same platform, to comprehensively simulate environment–community loops. During the further development of LAMPT, the research team intends to follow a participatory approach to enhance the relevance of the tool to local community needs. To plausibly calibrate LAMPT at the catchment/community levels in the data scarce environment of West Africa, additional long-term research catchments are essential.