From Land Evaluation to Spatio-temporal Decision Support on Afforestation

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LAND EVALUATION

Land evaluation delivers a classification and ranking of land units in an intervention zone according to their observed or modelled performance to produce quantity and quality of a given commodity or service (FAO, 2007). In contemporary land evaluation exercises, the geometric and semantic definition of the land units and their performance attributes are typically stored in a geospatial database. Statistical and geospatial (GIS) tools are then used to assess the land units and to present the results as suitability maps. When current land use and boundary conditions are considered, land evaluation answers the 'What ?' question: 'What is the current performance of a land unit and how does it compare to the other land units in the study area ?'. Rather 'What if ?' questions are at stake when hypothetical or potential use and/or conditions are evaluated.

A TYPOLOGY OF USER-QUESTIONS

The answers provided by land evaluation to the 'What ?' and 'What if ? questions are informative rather than conclusive for further action. To support afforestation also 'How ?' questions ('Which is the recommended tree species to be planted and what management to apply ?'), 'How long ?' questions ('For how long is this recommendation valid given the life cycle of a tree plantation and/or taking climate change into account ?') and 'Where ?' questions ('Where is a given tree species the recommended one ?') are pertinent but not directly dealt with.

The listed types of questions can be expressed in terms of four components:

1. The land unit in its initial condition, characterised by a location, land use type, other site characteristics and the baseline values for the selected performance attributes;
2. The afforestation option encompassing actions taken at the time of planting (tree species selection, level of site preparation) and during tree growth (level of tending);
3. The time lag since afforestation;
4. The land unit after afforestation, described by the state and rate variables resulting from the application of a given afforestation option as a function of time.

A single-component question is one in which three of the four listed components are specified while the answer to the question is the specification of the fourth one. A multi-component question has more than one unknown and hence less than 3 specified components. A further distinction into single- and multi-criteria questions can be made based on the number of land performance aspects which are included in the question. Moreover, for multi-criteria questions, criteria may be independent from one another or interrelated. In the first case, the question can be solved by treating the criteria sequentially. Simultaneous optimisation of the criteria is required in the second case.

Single-component, multi-criteria questions are probably of most interest in afforestation planning. An example of such a 'Where ?' question, without optimization is:

"Which land units will yield a soil carbon stock of at least 100 T ha^{-1} and a cumulative amount of soil lost through erosion lower than 20 T ha^{-1}, 30 years after afforestation according to a given afforestation option ?"

The following is a single component, multi-criteria 'How ?' question encompassing optimization:

"Which afforestation option results in the highest possible carbon stock and the lowest possible cumulated soil loss 30 years after afforestation of a given land unit?"

THE SPATIAL DECISION SUPPORT SYSTEM FORANDEST

To address single- and multi-component, single- and multi-criteria questions without and with optimisation, for supporting decisions on 'Where ?', 'How ?' and 'How long' to afforest in the southern Andes of Ecuador, the FORANDEST-sDSS was developed. GIS-technology is used as the generator of the sDSS (Sprague and Carlson, 1982). The GIS is built upon a geospatial database resulting from the prior land evaluation exercise considering 3 tree species, 4 bio-physical, 1 economic and 1 socio-cultural performance attributes at 0, 10 and 30 years after afforestation. The GIS-engine MapWindow GIS was choosen (Ramsey, 2007). It makes use of a database implemented using PostGreSQL which is an object-relational database management software (Ramsey, 2007). This combination of database and GIS-functions can be regarded as the FORANDEST-GIS. Using the core and plugged in functionalities of the GIS-engine, the database can be queried, viewed, mapped and analysed through a user interface. Sites can be selected based on multi-criteria location analysis techniques like map algebra, topological overlay and proximity analysis. The FORANDEST-sDSS is the result of the further extension of the FORANDEST-GIS with tools for interval goal programming (Charnes and Collomb, 1972) to cope with multi-criteria optimization questions, resulting in 'best' or 'worst' sites, practices or time lags (Malczewski, 1999). A comprehensive schema of the sDSS and its building blocks is given in Figure 1.

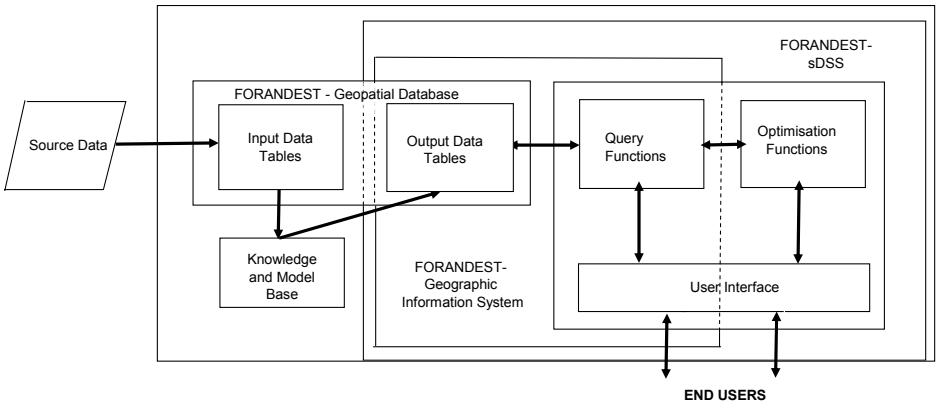

Figure 1: Components of the FORANDEST-sDSS

SPATIAL INTERACTION AND SPATIO-TEMPORALITY

From a survey of user requirements and user experiences we conclude that efforts are needed to extend the FORANDEST-sDSS with spatially integrated performance attributes like sediment delivery to rivers and with performance assessments under changing climate. The latter will result in a true spatio-temporal decision support system since not only the 'How long ?' question can be addressed but also the more general 'When ?' question.

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