Global Livestock CRSP

Introduction to SEADS: SUMAWA's Spatial Environment and Agricultural Decision Support Tool

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Sustainable Management of Rural Watersheds (SUMAWA) Project

Research Brief 08-03-SUMAWA November 2008

The Global Livestock CRSP Sustainable Management of Rural Watersheds (SUMAWA) project has successfully investigated how land management decisions can be compared across multiple stakeholder groups with competing interests in the River Njoro watershed, Kenya via the use of the Spatial Environment and Agricultural Decision Support tool (SEADS). SEADS not only assists in evaluating an array of land use possibilities, but creates an arena for stakeholders and policy makers to communicate with one another as part of the decision making process. In an area such as the River Njoro watershed, where a long-established human interface has strongly influenced environmental processes, a tool like SEADS can increase the effectiveness of the decision making process at both local stakeholder/community and larger policy levels. SEADS is based on multiple criteria decision analysis (MCDA) methods and supports a number of modeled data including those from the Soil and Water Assessment Tool (SWAT), the Modified Soil Loss Equation (MSLE), and total gross margin for crops and livestock. This brief introduces SEADS and provides an overview of the tools used as part of the spatial decision support system implemented in the River Njoro watershed.

Background

DSS and SDSS. A Decision Support System (DSS) is a computerized system that supports organization decision-making activities. Information may be collected from a number of sources including raw data, interviews, or models and entered into the software-based DSS to help identify and solve problems, compare results, and make decisions. More specifically, a Spatial Decision Support System (SDSS) is a DSS used to provide guidance in making spatial or locational decisions.

As part of the SUMAWA project, the Spatial Environment and Agricultural Decision Support tool (SEADS) was developed to address water resources issues from multiple stakeholder groups in the River Njoro watershed. SEADS is intended to guide policy makers on implementing land management policies that are both environmentally and economically sound, while also acceptable to stakeholders, thereby increasing the likelihood of adoption.

SEADS allows users to integrate spatial and non-spatial data for improved decision-making (Figure 1). These data are generated using models such as the Soil and Water Assessment Tool (SWAT), the Modified Soil Loss Equation (MSLE), and spreadsheet calculations of total gross margin for crops and livestock under potential land use alternatives. All of these data can be generated using a Geographic Information System (GIS) and imported directly into SEADS. Users may also choose to integrate additional data into SEADS from other models or tools. Components currently linked to SEADS are described in the following sections.

SEADS Components

Multiple Criteria Decision Analysis (MCDA). SEADS uses scoring functions and alternative ranking algorithms derived from the Facilitator, which is an open source generic multiple objective decision analysis tool that uses a hierarchical decision making structure (Heilman et al., 2002). Four scoring functions are used in the SEADS model to mathematically transform raw data with varying measurement scales into scores on a zero to one dimensionless scale, which allow criteria to be directly compared (Figure 2; Wymore, 1988; Yakowitz et al., 1992a, 1992b).

SEADS ranks alternatives by calculating the best and worst possible scores for each alternative using all possible weight combinations for criteria, while maintaining the criteria importance order as specified according to stakeholder preferences (Heilman et al., 2002; Yakowitz, 1996; Yakowitz et al., 1993). A significant advantage of this method is that it does not require decision makers to assign numerical weights to the criteria.

Geographic Information System (GIS). SEADS is built to operate on a GIS platform. Geographic Information Systems are information systems used for the capture, storage, manipulation, and visualization - in the form of

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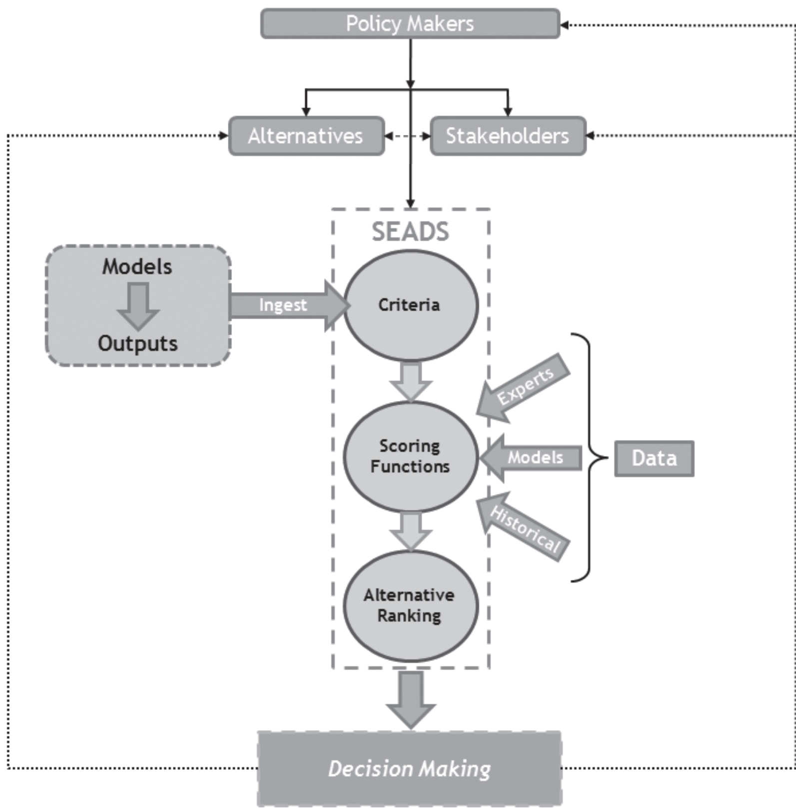
Figure 1. SEADS has the ability to integrate both spatial and non-spatial data, thereby contributing to the decision-making process at the stakeholder and policy levels.



maps, graphs, charts, and reports - of spatially referenced geographic data. GIS can also incorporate and reference non-spatial data through their database capabilities, adding to their popularity as management tools. For example, land use maps generated in a GIS are used in models such as SWAT to generate information about the impact of land use management. This information can then be transferred into a decision support tool, such as SEADS, to aid in the decision making process.

Soil and Water Assessment Tool (SWAT). SWAT is an important part of the SUMAWA project's prototype SDSS, SEADS, as it allows various hydrologic processes to be simulated in a watershed. Originally developed for the USDA Agricultural Research Service (ARS), the SWAT watershed scale model is designed "to predict the impact of land management practices on water, sediment and agricultural chemical yields in complex watersheds with varying soils, land use and management conditions over long periods of time" (Neitsch et al., 2005).

SWAT is physically based, uses readily available inputs, does not require large investments of time or money, and enables users to study long-term impacts of land use change. It has been modified and improved over time to account for changes in agricultural trends and production.

Based on the principle that water balance is the driving force behind everything that happens in the watershed (Neitsch et al., 2005), SWAT has two divisions of simulation that help predict the movement of pesticides and sediments or nutrients: the land phase and the water or routing phase that account for all the movement of water in the hydrologic cycle.

Modified Soil Loss Equation (MSLE). The Modified Soil Loss Equation (MSLE) is used to determine erosion caused by rainfall and runoff and is employed as part of SWAT. It is an empirically based soil erosion model founded on the Universal Soil Loss Equation (USLE); however, it is more versatile in developing nations where land use may not be based on cropping systems because it accounts for Vegetation Management systems (efforts used to mitigate erosion processes). Such systems include rangelands and forests. MSLE may be used at multiple scales from plot level to hill slope scale for predicting average annual soil erosion rates. Like SWAT, MSLE may be used in ungaged catchments where characteristics of the landscape are understood.

Soil erosion prediction is an important aspect of land use management, especially in agricultural areas, for several reasons. Soil losses can result in nutrient depletion and can lead to increased amounts of organic and inorganic matter in water. Such losses can also contribute to alterations in water balance within a watershed through depositional processes. (Neitsch et al., 2005). MSLE can be used to predict how a particular land use decision may impact soil loss, which is an indicator of soil erosion.

Practical Implications

The SUMAWA Spatial Environment and Agricultural Decision Support tool, SEADS, evaluates how well land use alternatives meet stakeholder's preferences using interactive and comprehensive methods to analyze the effects of various land use decisions. It is not designed to select the optimal land use for an area, but it identifies how well land use alternatives address stakeholder concerns. SEADS can guide policy makers on implementing land management policies that are both environmentally and

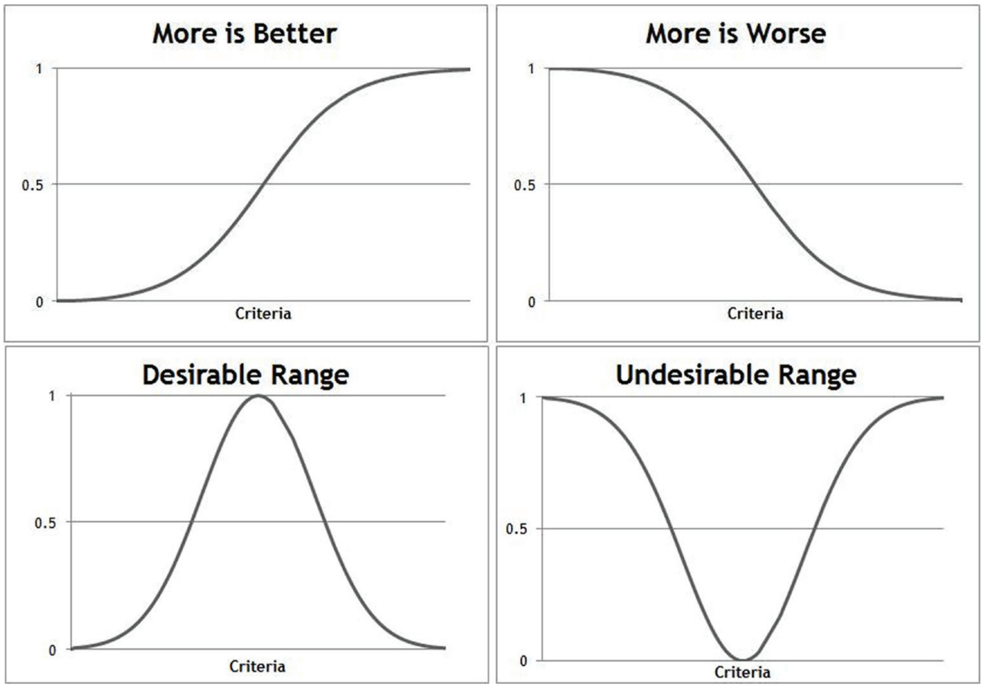


Figure 2. Four basic shapes of scoring functions to be used in the SEADS. Each criterion in SEADS is defined based on one of these four basic functions.

economically sound, while also acceptable to stakeholders, which increases the likelihood of adoption. Information is turned into knowledge by using interlinked and up-to-date models that account for biophysical and economic factors important to any complex watershed.

The SUMAWA prototype Spatial Decsion Support System SEADS has been used in the River Njoro watershed to develop a comparative framework whereby all parties, including local community stakeholders and more regional and national policy makers, can be involved in the decision making processes of future land use in a rapidly changing ecosystem.

Further Reading

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The GL-CRSP Sustainable Management of Rural Watersheds (SUMAWA) project was established in 2003 and is a multidisciplinary research effort focusing on biophysical and human-related factors governing health in the River Njoro watershed in Kenya.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, Central Asia and Latin America.

This publication was made possible through support provided by the Office of Agriculture, Bureau of Economic Growth, Agriculture and Trade, under Grant No. PCE-G-00-98-00036-00 to University of California, Davis. The opinions expressed herein are those of the authors and do not necessarily reflect the views of USAID.

Edited by Franklin Holley & Susan L. Johnson