Applying integrated modeling of economics and natural resources to a Kenyan watershed.

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Introduction

The Njoro River watershed, located in Kenya, has experienced large-scale land use changes in past two decades primarily from the conversion of upland forests to small-scale agriculture. Watershed residents are concerned with improving their livelihoods; however they also express concern that changes in land use could have adverse impacts on forest, soil and water resources.

In the Njoro watershed land use and management practices are diverse and inextricably linked to the sustainability of natural resources such as water quality, soil productivity, and forest products.

Integrated assessment is an interdisciplinary process of combining, interpreting and communicating knowledge from several scientific disciplines with the goal of synthesizing and evaluating cause-effect interactions of a phenomenon so that useful information can be provided to decision makers (Rotmans and Dowlatabadi 1998). Integrated models have been used in many applications to characterize the complex interactions between the human and bio-physical components of ecosystems and to explore the effects of alternative policies and management practices on the environment.

One challenge of integrated assessment is the comparison of alternate outcomes when different metrics are used to evaluate various objectives. For instance, not all management goals can be measured in monetary terms.

Tradeoff Analysis is a framework for integrated modeling that can be used to quantify the relationships among economic, environmental and human health indicators using the economic principle of opportunity costs (Stoorvogel et al. 2001).

Project Background

Sustainable Management of Watersheds (SUMAWA) is a collaborative initiative for problem model assessment and human capacity building for the rehabilitation of the River Njoro watershed in Kenya. The multidisciplinary team is composed of faculty members from Egerton University, the University of Wyoming, the University of California at Davis, Utah State University and Moi University, as well as partners from other Kenyan institutions such as the Kenya Department of Fisheries and Kenya Wildlife Service.

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Study Area

The Njoro River watershed is located in East Africa, in the Rift Valley of Kenya, just south of the equator (Figure 1). The Njoro River is approximately 50 km in length and drains roughly 270 km^2 (Figure 2). The river originates on the Eastern Mau Escarpment of the Rift Valley at an elevation of over 3000 m and drains into Lake Nakuru, at an elevation of 1759 m.

Figure 1. Location of Njoro watershed in relation to the capital city, Nairobi.

Land uses in the upper watershed include indigenous and plantation forests, small-scale agriculture, rangelands, a university and several settlements.

The lower watershed has more large-scale agriculture, including dairies and wheat farms, and small industries.

The river flows through the outskirts of Kenya's fourth largest city, Nakuru, before reaching its outlet in Lake Nakuru National Park.

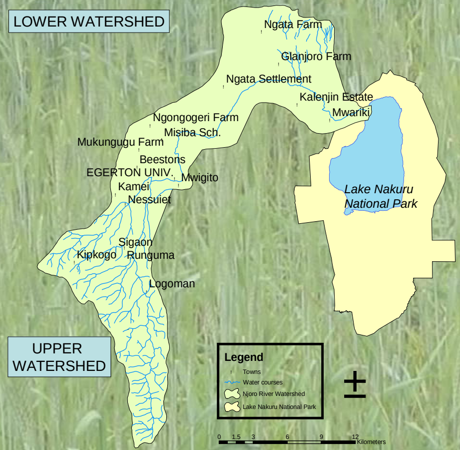


Figure 2. Map of Njoro River watershed.

Tradeoff Analysis

Tradeoff Analysis (TOA) combines spatially explicit econometric and bio-physical simulation models to evaluate the tradeoffs between key economic, biophysical, and health indicators under alternative scenarios.

Possible Indicators
Economic – household income, net income from crops.
Social – human health metrics.
Biophysical/Ecosystem – water quality and quantity measures, soil loss, soil fertility.

Maize and bean intercropping is the mainstay of most family farms in the watershed. Other crops produced include pyrethrum flowers, root crops, and vegetables including the cabbage in the picture to the left.

Intermittent flow during the dry season in a historically perennial river is a sign of changing watershed hydrology.

Evidence of soil erosion in an upper watershed pasture.

Possible Scenarios

- Change in agricultural inputs, technology or management, e.g. – fertilizer application, seed selection, cropping methods, range management.
- Enforcement of existing forest and riparian protection laws.
- Improvement in rural infrastructure, e.g. – roads, community boreholes, off-stream livestock watering sources.
- Forestry projects to develop alternate sources for timber and fuelwood.

TOA Research Implementation Process

Stakeholders | Policy Makers | Scientists

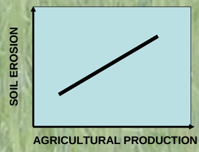
Research Priority Setting
1.) Identify sustainability criteria 2.) Formulate hypotheses as potential tradeoffs 3.) Identify disciplines for research project

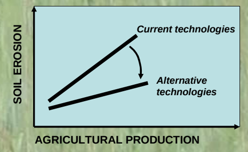
Project Design and Implementation Process
1.) Identify model and data needs, define units of analysis 2.) Collect data and implement disciplinary research 3.) Integrate disciplinary findings, aggregate to policy analysis scale, construct tradeoffs.

Presentation
Present tradeoffs to the public

(Diagram adapted from Stoorvogel et al. 2004)

Examples of hypothesized relationships





Next Steps

- Spatially referenced biophysical, human health, and economic data collection is ongoing.
- Participatory Rural Appraisals are being conducted to identify concerns of watershed stakeholders.
- Indicators will be selected by the multidisciplinary research team.
- The modeling effort is set to begin in mid 2005.

References

Rotmans, J. and Dowlatabadi, H. 1998. Integrated assessment modeling. Pages 291-377 *in* S. Rayner and E.L. Malone, editors. Human Choice and Climate Change, Volume 3. Battelle Press, Columbus, Ohio.

Stoorvogel, J.J., Antle, J.M., Crissman, C.C., and Bowen, W. 2001. The Tradeoff Analysis Model Version 3.1: A Policy Decision Support System for Agriculture. Montana State University, Bozeman, Montana.

Stoorvogel, J.J., Antle, J.M., and Crissman, C.C. 2004. Tradeoff analysis in the Northern Andes to study the dynamics in land use. Journal of Environmental Management 72, 23-33..

Stoorvogel, J.J., Antle, J.M., Crissman, C.C., and Bowen, W. 2004. The tradeoff analysis model: integrated bio-physical and economic modeling of agricultural production systems. Agricultural Systems 80, 43-66.