Sustainable Management of Watersheds: The River Njoro, Kenya

Narrative Summary

This report covers the first year of a multidisciplinary research effort focusing on biophysical and human-related factors governing watershed processes for the purpose of improving long-term sustainability of rural watersheds in Kenya and East Africa. The research area is a critical watershed in the Rift Valley of Kenya that has undergone recent and rapid land use change and population growth with associated negative impacts to water resources, human health, rural livelihoods, and the local economy. The core research focus is on the upland portion of the watershed where livestock and smallholder agriculture are significant components affecting the economic and ecologic health of the watershed system. A multidisciplinary team composed of faculty and partners from U.S. and Kenyan institutions have assembled data regarding the River Njoro watershed. Consultations are ongoing with various stakeholders in the watershed on matters such as water quantity and water quality. The first phase of the project covers a preliminary assessment that will serve as the basis for future research. During the past year, significant improvements have been made in capacity building for the research team members and stakeholders. The focus of the previous year's efforts was on secondary and primary data collection and analysis, participatory rural appraisal, watershed analysis, geographic information system and remote sensing, and the initiation of exchange visits among watershed stakeholders. Interventions and outreach will be developed through the integration of scientific research findings with stakeholder analyses to support local communities and decision-makers in effectively identifying and implementing local solutions to enhance the successful implementation of land management practices for the improvement of environmental condition and people's livelihoods.

Research

A summary of the advances achieved over the previous year is as follows. Significant investments have been made to build team cohesion, physical capacity, and a financial and administrative management structure for the project, achieving a solid foundation for the full project and the establishment of a center of excellence in watershed research at Egerton University. The project has generated interest in the watershed among diverse water actors in Kenya. Senior SUMAWA project researchers have already been solicited for input on various local, regional, and national water management issues at meetings and other decision-making forums. Significant gains have been made in understanding the dynamics governing watershed response within both the biophysical and human-related component of the project. Abundant secondary data has been collected from various governmental organizations, universities, and non-governmental organizations. A program for the collection of primary data (field, remote sensing, modeling) has been initiated. An

initial assessment has been made of livestock trends, practices, and watering sites in the watershed as well as of agricultural farming practices and biophysical conditions in high risk areas recently settled in the upper watershed. Multiple presentations have been delivered with several abstracts, papers, and posters submitted to national and international conferences. The training component of this project is large: to date, 14 students (11 Kenyans, 3 U.S.) have been brought into the project for their graduate training and research. Findings related to specific tasks are discussed in the following section.

Activity One: Watershed Characterization

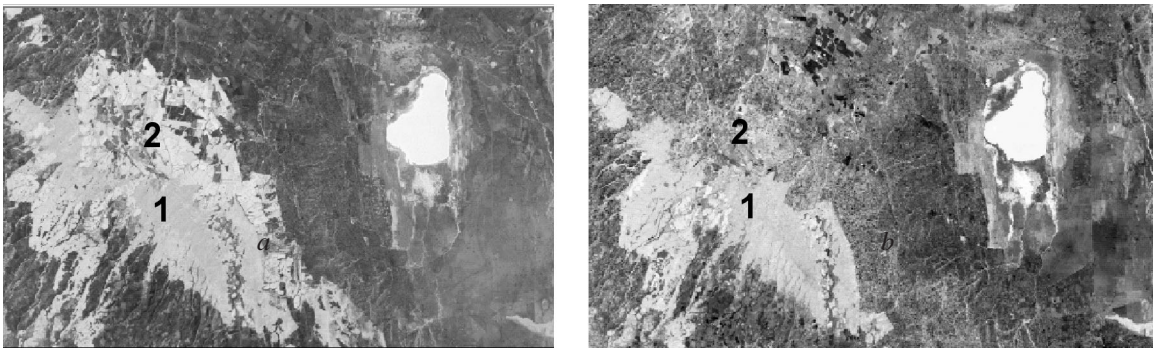
The primary focus of this activity was to collect the necessary secondary and primary data to fully characterize the watershed and establish a baseline for ongoing research efforts.

A geographic information system (GIS) database was designed and implemented that describes and characterizes the physical and social characteristics of the River Njoro watershed. The majority of site locations for biophysical and human research have been located using a global positioning system and are being converted into GIS format. GIS data layers for over 20 spatial characteristics have been either created or imported from existing sources. Important data layers include digital terrain, soils, vegetation, land management, political boundaries, roads, climate, location of precipitation and runoff gauging stations, and community locations. Several images from Landsat platforms have been imported into the Njoro GIS database. These images have been collected on a decadal scale in coordination with the collection of Kenyan national census data (1978, 1989, 1999, 2002). Preliminary watershed characterization has been completed through the integration of field research and GIS. The geospatial characteristics of the watershed, including soils, geology, vegetation, land cover, land use, and other relevant data, have been used to create an atlas of the watershed. This atlas is suitable for use in landscape assessment, identification of problem areas, stakeholder involvement and education, and in the development of statistical and physically-based models. Large- and small-scale maps describing the watershed have been created. These maps are in both digital and hard-copy format and are suitable for use by scientific investigators or as outreach tools for stakeholder education or involvement.

Our problem model relates the explosive growth in population, coupled with the changes in Kenyan governmental policy relating to de-gazetting National Forests in the early 1990s, to significant deleterious effects on the environment, human health, and economic security. The downstream effects associated with land cover change, specifically deforestation, are to be evaluated using fieldwork and hydrologic modeling tools. Remote sensing and image classification techniques were applied in the previous year to determine the extent and intensity of deforestation. Calculations of the precise amounts of loss are ongoing, but preliminary findings clearly show that large tracts of indigenous and plantation forests have been cleared for small-scale agriculture (Figure 1).

Sampling locations for water quantity, water quality, and rainfall have been identified and in most cases established as permanent monitoring stations. The watershed hydrology and ecology team implemented a suite of sampling regimes throughout the upper part of the watershed and in Lake Nakuru. Two historical but abandoned runoff measurement stations were located and revitalized, and data was collected throughout the spring and

Figure 1 - Classified Landsat imagery for 1986 (a) and 2002 (b). The images are classified such that forests show up as bright sections of the image. The numbered locations on the map show the location of indigenous forest (1) and the conversion of forested areas to small-scale agriculture (2).



summer. The Ecology team has instituted sampling protocols for aquatic investigations in the Lake Nakuru National Park (water quality and sediment sampling), along the River Njoro, and for terrestrial ecology investigations.

The sample locations identified above were visited numerous times for the purposes of water quality and quantity characterization. Water quality and quantity were measured on a continuous basis during the dry season (January-March, 2003) and the wet season (April-September, 2003). A large amount of hydrologic runoff data were collected, including twice-daily stream discharge measurements at two gauging stations in the upper-portion of the watershed throughout the sampling periods.

Secondary data for watershed and ecology components were collected from a variety of institutions and published reports in order to establish baseline and trends related to watershed and ecological health. Historical and baseline tabular data were collected for the following:

- Demographic trends in the catchment, 1989-2001.
- Lake Nakuru levels, 1956-2000.
- Lake Nakuru physicochemical parameters (lake water temperature, transparency, dissolved oxygen (DO), pH, conductivity, and orthophosphates), 1994-1998.
- Heavy metal concentrations in sediments of Lake Nakuru, River Njoro mouth, storm water, 1994-1995.
- River Njoro water quality parameters/ physical-chemical habitat characteristics: flow, water temperature, color, total suspended solids (TSS), turbidity, total dissolved solids (TDS), DO, pH, conductivity, salinity, NO_2, NO_3, NH_3, total nitrogen (Tot-N), KN, PO_4, total phosphorous (Tot-P), biochemical oxygen demand (BOD), chemical oxygen demand (COD), heavy metal concentrations, 2000-2002.
- Lake Nakuru Plankton productivity and composition, 2003.
- River Njoro/Lake Nakuru water and sediment quality, 2001-2002.
- Sewage Effluent Quality Data-Town Sewage Treatment Works, 1996-2001.
- Water bird trends, 1990–2003; plus threatened bird species and breeding sites.
- Wildlife trends (numbers and biomass), 1986 – 2000.
- Relative humidity (%) and air temperature from the Kenya Agricultural Research Institute (KARI) Plant Breeding Station, Njoro, 1972-1999.
- Lake Nakuru visitor statistics.

Water-related diseases appear to be widespread in the watershed, and have emerged as a priority problem in all three communities located in the lower and middle portions of the watershed where participatory rural appraisal (PRA) problem analysis discussions have been completed (Barut, and Rumwe and Mwigito sections of Njoro Town). Water-related diseases are ranked second out of four priority problems in Barut, eighth out of ten in Rumwe, and third out of ten in Mwigito. PRA activities in Kaptembwa, Ngata, and Nessuit are incomplete or have not yet started. One underlying cause of the high rates of water-related diseases in the watershed is very poor access to safe water supplies, resulting in consumption of fecally contaminated drinking water and insufficient quantities for basic personal and domestic hygiene. Water supply infrastructure for domestic use is far from adequate in many communities in the watershed where significant sections of the population, mostly the poorest, collect and transport water by hand from the river or from communal boreholes where water charges are relatively high. Evidence from Egerton University indicates that groundwater, the main developed source of domestic water supply in the watershed, may also be contaminated by fecal matter, and if untreated, poses a health risk. Health problems identified in the PRA exercises so far include:

- Typhoid (Barut, Mwigito)
- Diarrhea (Barut, Mwigito)
- Amoebas (Rumwe)
- Eye infections (Rumwe)
- HIV/AIDS (Barut)
- Malaria (Barut, Rumwe, Mwigito)
- Pneumonia and flu (Barut, Rumwe, Mwigito)

Research at Egerton University is underway to identify the patterns of water-related diseases in the watershed, with particular focus on typhoid and diarrhea diseases. Registered cases of typhoid, bacillary dysentery, amoebiasis, and diarrhea diseases over the last five years are being collected and analyzed by Egerton University M.S. student Joseph Kiragu at three locations in the watershed: Nessuit Dispensary (upper zone), Njoro Health Center (middle zone), and Barut Dispensary (lower zone). Disease patterns by age, sex, season, and residency will be analyzed, and the underlying causes evaluated in a thesis prepared for December 2003. Data to analyze the private and public costs of this disease burden in the watershed will also be assembled as part of this research. These results will provide a foundation for subsequent scientific investigations into drinking water quality, water supply, and sanitation and hygiene conditions in the watershed (see Activity Four) and stakeholder discussions on the causes and solutions for improving environmental health conditions at sub-group, community, and watershed scales. Findings will be introduced at stakeholder and community meetings for discussion and evaluation of actions that affect the domestic water supply conditions and community health in the watershed.

Activity Two: Socio-Economic Assessment

Tasks associated with the socio-economic assessment were designed to collect baseline and historical data. These data are used in economic modeling and analysis as well as in the development of intensive household questionnaires and community outreach.

An M.S. student has started collecting case statistics on typhoid and diarrhea diseases treated at clinics and hospitals in the watershed over the last five years to analyze water and sanitation-related disease patterns.

Modifications were made this summer to improve the research proposal and data collection protocol for this M.S. research project. The work should be completed by the end of 2003.

Livestock assessment has been initiated at the household and watershed scale. The determination that intensive and extensive grazing has been occurring at the watershed headwaters is a significant link between grazing pressures, economic utilization, and watershed health.

Copies have been obtained of archival documents and reports from the Njoro Division Agricultural Office that contain useful information on market prices for goods and inputs, livestock diseases, grazing practices, and extension activities.

Fieldwork was conducted this summer to assess agronomic and forestry practices of small farmers recently settled in the upper reaches of the watershed. The goals of this research are to understand how poor rural producers in this keystone position in the watershed relate to larger issues of natural resource management, local ecology, and subsistence strategies, as well as to evaluate opportunities to adapt and develop indigenous resource management strategies, focusing in particular on the use and integration of agroforestry species to improve soil and resource conservation. The research will develop an in-depth understanding of potentially viable production methods, technologies, constraints, and farmer willingness to participate in promising changes and will make recommendations for extension actions and methods to improve agricultural production and farmer livelihoods while simultaneously improving watershed health and resource conservation among this group of producers in the watershed. Included will be a recommended list of appropriate species and agroforestry technologies adapted from farmer conditions and practices in the area.

The study includes 15 small farm households, nearly all having settled in the watershed within the last ten years, with many only three to five years ago. All are located above Nessuit center, between 2,747 and 2,378 meters elevation, on sloped lands in close proximity (<200 m) to first-order streams and springs. Six are headed by females. Farms range in size from two to ten acres, with an average of 5.4 acres. Eight out of the 15 households own cattle, ranging from one to 15 head. Sheep and goats are less common. Only two households have no livestock at all, while four have only chickens. Out of the 15, nine are using chemical fertilizers, and three of these also apply chemical pesticides. Reported application rates for fertilizers vary from about ten to 50 kg./acre.

A variety of types of data and methods are being used in this study, including in-depth interviews, soil analyses, biophysical assessments, agro-economic inputs, yields and income data, perceptions of environmental and resource conditions, inventory of tree species, uses, and forestry and conservation management practices for each of the 15 farm households. These data are being augmented with outside informant interviews, archival research, botanical and ethno-botanical information, geographic analyses and soil erosion risk assessments for each location, economic assessment of production systems, and research literature. The final report in the form of a thesis is expected by September 2004.

Key issues emerging from the study so far indicate varied land tenure status (most have no formal title, some renting) and ethnic divisions and tensions among the three resident groups (Ogiek, Kipsigis, and Tugen) in relation to land access. Differences in knowledge of

resource management strategies, farming experience, and agronomic traditions also widely affect practices and perceptions. For example, Ogieks are traditional hunter-gatherers with extensive knowledge of indigenous tree species and uses, while Kipsigis and Tugen have brought their former agro-pastoral practices with them.

Access to markets is a major constraint on agricultural income and production in this part of the watershed where the road network is very poor or nonexistent. Because yields and farm income are often inadequate, many residents in this part of the watershed try to diversify their income with wood-related products (fuelwood, charcoal, and timber) extracted from the already threatened upland forests, further exacerbating the rapid rate of deforestation underway since the early 1990s. Wood product shortages within the watershed and in Nakuru Town fuel strong demand for these products. The study highlights a major problem for resource management: without alternative sources and with insufficient income from farming, poor rural families often have no choice but to turn to the remaining natural resource base (trees, in this case) to survive.

At each household survey location, soil samples were collected to measure the soil's physical and nutrient qualities. Global positioning systems (GPS) locations will be used to extract topographic and geographic data from available geographic information system (GIS) layers in the analysis phase. Two visits to the International Center for Research in Agroforestry (ICRAF) were made to collect information on agroforestry best management practices. This information will be analyzed and combined to evaluate and propose environmentally sustainable agroforestry practices and improved farming methods that would be appropriate for the biophysical and economic conditions typical of these upper watershed farmers.

The design of the baseline household survey is ongoing, with comments solicited from the other research components and the U.S. Co-PI. A half-day meeting to clarify the goal, objectives, methods, sampling strategy, organizational steps, and tasks for the design and execution of the baseline survey was held during the summer with the U.S. Co-PI. A quantitative economist with survey experience has been identified to help in the design and execution of the survey, and plans are being formulated to recruit a survey team and begin surveying households in the fall.

Activity Three: Stakeholder Involvement

This research project relies heavily on the interaction of physical and social scientists. Our intended goal is to fully embed findings from stakeholder involvement into the development and implementation of biophysical research, and for the research findings to be available to interested stakeholders throughout the term of the project. Towards meeting that goal, members of the stakeholder involvement team initiated participatory meetings at the household and community level at sites throughout the upper portions of the watershed.

Stakeholder workshops (barazas) and interactions in six target communities and a two-day watershed-wide stakeholder workshop were successfully held between December 2002 and April 2003. The project was introduced to stakeholders throughout the upper portion of the watershed. Project goals and issues were discussed, and perspectives on the use of the watershed were shared. Basic information on the communities, stakeholders, and institutions involved in the River Njoro watershed was gathered.

The communities along the Njoro River are composed of sub-groups with diverse livelihood interests and activities dependent on the natural resource base, in particular to water and riparian resources in the public domain in the watershed. The first stage of the stakeholder PRA activities have focused on identifying and understanding these different sub-groups in relation to surface water and river bank conditions in the riparian corridor. Table 1a summarizes some initial results from the participatory assessments in four of the six communities. It shows the involvement of different sub-groups in resource use and decision-making. The findings indicate that women have key responsibility and decision-making roles for domestic water supply from the river and firewood collection along the banks, men for livestock watering and grazing decisions (esp. large livestock such as cattle) and small-scale irrigation, and young men for water extraction, fodder collection, and other resource extraction activities for cash sales or hired work. Men and women both are involved in timber/wood gathering for house building, and in maize cultivation decisions, while men alone are involved in wheat cultivation. Direct

Table 1a - Resource extraction and uses by communities along the Njoro River.

Community	Group	Surface Water Extractions from River							River Bed/Bank Materials			Riparian Trees/Vegetation/Cultivation								
		D	L-L	L-S	SL	IR	BL	C	SD	RK	HS	FW	FDC	FDG	VG	VG-MZ	VG-WT	BM	HB	HY
Barut	Women	*d	*			*	*d		*d			*d			*d			*	*	
Ngata	Women	*?	*	*d											*d	*d			*d	
Rumwe	Women	*d				*d	*d					*d		*					*d	
Mwigito	Women	*d	*d			*				*d		*d								
Barut	Men	*	*d			*?	*d		*d									*d	*d	*d
Ngata	Men	*	*d		*?											*d	*d		*d	*d
Rumwe	Men		*d			*d	*d		*d	*d				*d					*d	
Mwigito	Men	d	*d			*d				*d		*d		*d						
Barut	Youth	*	*		*d	*												*d	*d	
Ngata	Youth	*		*d	*?															
Rumwe	YgMen	*d	*		*d								*d	*						
Mwigito	YgMen[d]																			
Barut	Others[a]		*		*d		*d	*d	*d			*d							*d	
Ngata	Others[a]																			
Rumwe	Others[b]		*d		*d		*d		*d	*d	*d	*d	*d	*d					*d	
Mwigito	Others[c]	*d	*d		*d	*d				*d		*d		*d						

Source: Initial PRA Reports (2002-2003)
Resource extraction and use codes are on the next page.

Notes:

*: use activity carried out by group

d: decisions regarding use made by group

?: likely decision-maker, but unclear from initial report

[a] "Others" refers to people from outside the community and ministers (in case of baptism)

[b] "Others" refers to hired hands and people from other sections of Njoro Town (L-L); other communities in the watershed such as Ngata and Nessuit, as well as outside the watershed (e.g., Lare, Ngecha, elsewhere) (L-L and FDG); traders and construction people from outside the community and watershed (BH, RK); County Council (SN, RK); KARI, forest department, and the Forest Action Network (HS)

[c] "Others" also includes male youth which were not split out in the Mwigito PRA, and people from other communities in the watershed (L-L)

[d] Included in "O" for Mwigito

Table 1b - Resource extractions and uses by institutions, industries, commercial, and other actors along the Njoro River.

Community	Actor	Surface Water Extractions from River							River Bed/ Bank Materials			Riparian Trees/Vegetation/Cultivation									GW	WW
		D	L-L	L-S	SL	IR	BL	C	SD	RK	HS	FW	FDC	FDG	VG	VG-MZ	VG-WT	BM	HB	HY		
Rumwe	Rumwe Society	*	*			*										*	*				*(2)	
Rumwe	Nakuru County Council	*							*	*											*(?)	
Rumwe	FAN										*											
Mwigito	Mwihoti Water Proj.																				*(1)	
Mwigito	Kiragu F. Dairy		*																		*(1)	?
Mwigito	Kiptanui F. Dairy		*																		*(1)	?
Mwigito	Njoro Canning																				*(1)	*
Mwigito	KH Flower Co.	*																			*(1)	?
Mwigito	EU	*	*			*										*	*				*(10+)	*
Mwigito	KARI	*				*					*					*	*				*(3)	?
Mwigito	Tim-Sales Enterprise																				*(1)	
Mwigito	Gikombo Farm	*																				

* : use activity carried out by group

? : likely but unclear from initial PRA report.

(#): number of active boreholes on property adjacent to river

Source: Initial PRA Reports (2002-2003)

Resource extraction and use codes in Tables 1a and 1b:

D: fetching water for domestic use
L-L: watering large livestock at the river
L-S: fetching river water for or watering small livestock at the river
S: fetching water for transport and sale
IR: river withdrawals for irrigation adjacent to river
BL: fetching water for construction and building houses
C: cultural uses, such as baptisms
SD: extracting sand from river for construction
RK: extracting rocks and gravel from river for construction
HS: humus gathering along banks for tree nurseries
FW: gathering fuelwood along banks for domestic uses, for sale, and for charcoal making
FDC: grass fodder collection for sale
FDG: grass fodder livestock grazing along river banks
VG: growing vegetables along the side of the river (e.g., potatoes)
VG-M: growing maize along the side of the river
VG-W: growing wheat along the side of the river for sale
BM: gathering wood, bark, parts of trees for house building materials
HB: gathering herbs and other plant matter for medicinal purposes (roots, barks, leaves)
HY: bee-keeping for eventual sale of honey
GW: groundwater extraction by borehole
WW: wastewater discharge to river

and separate engagement with each of the relevant sub-groups should be built into subsequent PRA activities and stakeholder dialogues when developing and discussing alternative options for improved management of riparian resources. The initial PRA activities were done in mixed groups with relatively poor representation of women and no youths. This should be rectified in future PRA activities, with better representation of women and youths, and organizing separate PRA activities with each sub-group.

The PRA information shows that the exploitation of water, riverbed materials, and vegetation in the riparian zone (medicinal herbs, firewood, and fodder) by people from outside the community is significant, especially in the middle and lower parts of the watershed (see Table 1a). Better identification of, active engagement with, and inclusion of these groups will be necessary in planning and implementing local community actions to improve conditions and conserve riparian resources. The planned tiered workshops offer an opportunity to begin engaging in dialogue to develop cooperative solutions between communities and "outsiders," in cases where outsiders are actually from other communities within the watershed (see Table 1a). Some of these outsiders are in fact institutional, public, or commercial enterprises in the watershed. Table 1b provides an initial list of institutional, commercial, and public actors and their resource extraction activities as identified in the initial PRAs.

Community problems and priorities for resource management along the Njoro River revealed in the PRA activities are listed in Table 2. Water scarcity and water quality problems for human and livestock health, related human diseases, and fuelwood scarcity are top-ranked problems in two of the three communities so far investigated. Water supply problems are less important in Rumwe, the community along the section of the Njoro River that runs through Njoro Town. This may be because it has the best domestic water supply conditions of the three communities, serviced by communal boreholes and piped house connections, although poorer segments of the local population rely on the river as their water supply source.

Future activities with stakeholders will revolve around the policies and legalities governing the management of natural resources in the watershed. As a first step in developing an intervention in this regard, relevant tools for management and assessing individual and environmental rights were located. Copies of the recently enacted Government of Kenya (GOK) Environmental Coordination and Management Act (2002) and other GOK acts and laws governing use, rights, standards, and responsibilities for management of watershed resources were obtained (The Water Act-Chapter 372 of the Laws of Kenya; The Tea (Amendment) Act, 1999; The Kenya Roads Board Act, 1999; The Environmental Management and Coordination Act, 1999). A preliminary extraction and summary of relevant sections was prepared as the basis for further discussions and dialogue with stakeholders on their practical administration, effectiveness, and implementation.

Activity Four: Capacity Building

Numerous capacity building activities were completed to enhance the physical, intellectual, and team capacity for the long- and short-term success of the project.

The management structure of the Kenyan and U.S.-led research teams was optimized, as the research team was altered and divided into four components based on individual skills and the objectives and activities of the

Table 2 - Community problems and priorities for resource management along the Njoro River.
B = Barut; R = Rumwe (Njoro); M = Mwigito (Njoro)

Problem	Perceived Causes & Issues	Ranking		
		B	R	M
Insufficient (river) water	River runs dry periodically (Barut); lack of alternative sources; poor river protection; shallow dams upstream (Barut); drought; irrigation upstream; sand scooping; overstocking of animals; outsiders extracting water for sale, too many users (Barut); obstruction of river flow (Rumwe).	1	7	
Low income	Over-reliance on milk and maize, farm employment, and sawmills employment (which have shut down); reliance on middlemen for marketing; lack of storage facilities for wheat; lack of market for produce.		1	
Water	Poor quality water, not enough- scarcity esp. in January-February dry season; water siltation.			1
Water-borne diseases (consuming polluted river water)	Run-off with dirt including human waste; dirty water from washing of vehicles, laundry, and bathing in river; dirty effluents; lack of latrines; soil erosion; sand extraction makes river dirty; dumping of waste in river (from Kaptembwa in Barut).	2		3
Poor community cooperation	Poor leadership; ignorance about group value.		2	
Fuelwood (scarcity)	Deforestation; failure to plant trees on own shambas; closing down sawmills.		4	2
Polluted river water	Human diseases; no water access points, lack of sewage system, garbage collection.		8	
Sand scooping (extraction from the river)	Related to unemployment; rising demand for sand; laxity in enforcing rules; destroys roads, makes river dirty; causes land slides, deaths, and devaluation of land.	3		
Weak community water institutions	Low income; low level of skills to start income generating project; lack of trust among members; poor leadership; poor project management.		3	
Flooding	Siltation of the river; soil erosion; sand scooping; destruction of vegetation on farms and on river banks increasing run-off to river; bank vegetation removal related to fuel wood gathering, tree felling, and tree dying from root/bark removal.	4		
Electricity	In village but not connected to houses.			4
Weak Nakuru County Council	Lack of sewage system, garbage collection.		5	
Insecurity	Unemployment; drunkenness.			5
Unemployment	No jobs.			5
Lack of riparian management plan	Lack of knowledge; lack of ownership of riparian zone.		6	
Dumping	Attitude.			6
Livestock diseases	Plastic papers; outbreaks; expensive drugs.			7
Lack of extension services (soil erosion)	Extension officers never seen; steep slopes; lack of terraces.			8
Poor roads	Erosion causes pot holes; no bridges, river Njoro blocks access to Egerton University for many residents who work there; lack of culverts.			8
Seasonality of fodder			9	
Inadequate infrastructure	No water access points, inadequate bridges, lack of storage facilities.		10	

Source: Initial PRA Reports (2002-2003)

project. Several team members were dropped from the project due to overlapping abilities, while other scientists were brought into the project when specific needs were identified. A two-day workshop for the entire research team was held in which team members were exposed to the language and objectives of each of the four research components. The budget cut resulted in the cancellation of a planned two-day training to expose the entire research team to PRA and GIS methods and objectives. Consequently, the project team has experienced some difficulty integrating and interlinking research activities and planning across components, especially due to the general lack of experience with GIS, and how it can be used to integrate data sets across scales and disciplines. Further contributing to difficulties integrating components is the lack of skills among project researchers and students in database design, manipulation, and information management, and the absence of a GIS technician to manage the GIS data sets to facilitate access to project data by researchers and students from different components.

Management and budgeting capacity was enhanced through attendance at a three-day management training seminar held in Washington, D.C. following the Global Livestock CRSP Program Conference. The facilitator was the president of Team Technologies, a consulting firm specializing in international development project management and grantsmanship. All team PIs and co-PIs attended. Special attention was given to the use of logframes in grant writing and the conceptualization of projects. The training exercises were crucial in helping the project team leaders to define a common vision of the problem model, develop the long-term goals of the research project, and construct a shared logical framework and tools with which to implement and manage the full three-year project.

To address the physical capacity needs in Kenya, equipment, computers, software, and educational needs were identified. Where possible, these needs were addressed via capacity building in order to ensure project success and to help develop Egerton University into a regional center of excellence in integrated watershed studies. Numerous capital expenditures critical to the short- and long-term success of the project were made. A summary list follows:

- Rental of a secure facility with multiple offices for research staff, project leaders, fiscal manager, and students. Computers, books, and other resources dedicated to the SUMAWA project are maintained in this office suite.
- Acquisition of telephone and internet capability dedicated to the SUMAWA project.
- Delagua Portable Field Kit to test drinking water quality (fecal and total coliform counts), designed for and extensively used in developing countries, was acquired and an initial orientation provided to the Ph.D. student who will be responsible for using the equipment in her research.
- Four desktop personal computers (Egerton).
- Five laptop computers (Egerton, Moi, Fisheries, Wyoming, Davis).
- Two GPS receivers.
- External hardware for computers: scanner, printer (3), multi-function machines (2).
- Two digital cameras.
- Various hydrologic, soil, and ecological sampling equipment.
- Establishment of a project library with over 20 recent books and 200 journal articles.

- Specialized software for project investigations, including initial training orientation: Epi Info 2002, the World Health Organization/Center for Disease Control epidemiological and disease surveillance statistical software package; SYSTAT, a complete statistical software package; ArcView3.2 and ArcGIS, GIS software packages; and Imagine, a remote sensing software package.

Activity Five: Submittal of Long-Term Research Proposal to GL-CRSP and Extension of Research

In this phase of the project, a full proposal for submittal to the GL-CRSP was developed. This proposal is intended to build on the capacity building and preliminary data analysis performed during the current research phase. This proposal is a multi-year (3-5 years) intensive applied research program integrating watershed assessment using cutting-edge research and stakeholder involvement.

A core function of this research group was to develop a scientifically defensible approach to integrated watershed assessment. The submitted proposal was funded by the GL-CRSP for a three-year period. The research within the proposal will build on the capacity building and preliminary data analysis performed during last year's research phase and is a multi-year (3-5 years) and intensive (integrated watershed assessment using cutting-edge research and stakeholder involvement) research program aimed at both understanding the system dynamics governing a complex and evolving watershed and improving people's livelihoods within the watershed.

Several key members of the research team traveled to Washington, D.C. to participate in the GL-CRSP Program Conference. A poster presentation was prepared that details the problem statement, project objectives, scope of work accomplished to date, and proposed research. Each research component team contributed material to the poster. In addition, the Lead PI (S. Miller) gave a presentation on the SUMAWA project, including both long-term project goals and intermediate findings.

Gender

Women in the River Njoro Watershed are centrally responsible for domestic water supplies, family health and hygiene, firewood collection, and they carry out important roles in both farm and non-farm household income production activities that have implications for the sustainability of watershed resources. Furthermore, a larger portion of poorer households in rural and urban areas tends to be headed by women. For this reason, gender analysis is included in the participatory rural appraisal methods being used during the assessment phase with communities in laying the foundation for stakeholder involvement in managing the watershed. PRA exercises identify the roles, responsibilities, and activities of women relative to men, youth, and other actors in the analysis of different benefits provided by local watershed resources community members. This information will allow for organizing subsequent phases of project outreach and dialogue using separate strategies for men, women, and youth, as needed for the resources issues in question. The inclusion of female representatives in the planned exposure visits, tiered workshops, and stakeholder trainings will also be key to ensuring that diverse stakeholder interests, perspectives, and impacts, particularly for poor households, are represented in developing interventions and management plans for the watershed.

Policy

One of the primary research thrusts in this project is stakeholder involvement and outreach. Through the participatory rural appraisal mechanism, we have started to assess the feasibility of possible interventions. The problems inherent to the River Njoro watershed were initiated at the highest levels of government in the form of political favor for support. Thus, the question of public policy involvement is central to understanding the mechanisms controlling land tenure, management, and stewardship. For example, preliminary results indicate that in Nessuit, which includes the most recently settled upper portion of the watershed, sub-communities are based on a mixture of historical and recent settlement patterns, and tribal and land tenure differences. In the much older Ngata area of the watershed, the two sub-communities are geographically divided by the River Njoro, and little to no cross-communication occurs between these sub-communities. Understanding the different local and regional issues is essential to establishing successful linkages among science, policy, and land management since decision-making must account for realities on the ground.

In the long-term (after this year), activities with stakeholders will revolve around the policies and legalities governing the watershed. The Kenyan government has recently issued a series of environmental rulings and legislation which change the historic paradigms of natural resource management. Members of the research team will be responsible for assessing the usefulness and applicability of these laws within the context of the watershed and the potential for empowering local communities and stakeholders for greater control over basin resources. An informational program will be developed that exposes local landowners and managers to these tools for taking control of their local land management. Copies of the recently enacted GOK Environmental Management Act (2002) and other GOK acts and laws governing use, community rights and responsibilities for management of watershed resources have been obtained, which will form the basis for further analysis, discussions, and dialogue with stakeholders on their practical implications and implementation.

Central to the successful implementation of interventions has been the identification of key stakeholders and policymakers that are in positions of authority (whether that be moral, ethical, or managerial) and ensuring that they are committed to the success of the proposed intervention. We have initiated a series of tiered workshops that are taking place longitudinally within the communities of the watershed. Community leaders and policymakers are included in these workshops, the aim of which is to facilitate the transfer of knowledge from the research (biophysical, socio-economic) realm into the applied realm.

Outreach through personal communication and networking is ongoing in Kenya, and the Host Country PI and Co-PIs serve as science ambassadors to land managers, politicians, and policy makers. Long-term efforts are aimed at establishing professional relationships with policymakers beyond those in the watershed, including at the national or international level, NGOs, and the Ministry of Water. Invitations to ministry officials will be extended for regional seminars and conferences, such as the proposed May seminar series and the June WEAP training. It is proposed that research briefs prepared for the GL-CRSP be made available to government ministries.

Outreach

Outreach and stakeholder involvement are the lynchpins of this research effort. There is an equal commitment to biophysical research and the transfer of knowledge and technology back and forth between research and social scientists. One of the benefits of having faculty from Egerton University central to the project is that the university itself is a stakeholder within the watershed. There is a strong commitment on behalf of the university administration and faculty to assume stewardship in order to understand and improve the overall condition of the watershed.

Outreach activities at the community level have occurred in the communities located in the upper portions of the watershed. Stakeholder workshops (barazas) and interactions in six target communities and a two-day watershed-wide stakeholder workshop were successfully held between December 2003 and April 2003. Project goals and issues were discussed, and perspectives on the use of the watershed were shared. Basic information on the communities, stakeholders, and institutions involved in the River Njoro watershed was gathered. These data are being made available to the participants and their input will be encouraged throughout the life of the project.

The primary economic driver in the upper watershed is agriculture, primarily at the smallholder (household) scale. Grazing in the upper portions of the watershed is critical to people's economic security. However, the communities along the Njoro River are composed of sub-groups with diverse livelihood interests and activities dependent on the natural resource base, in particular to water and riparian resources in the public domain in the watershed. The first stage of the stakeholder PRA activities have focused on identifying and understanding these different sub-groups in relation to surface water and river bank conditions in the riparian corridor. This approach will show the linkages among various land management activities and downstream water quality and quantity.

Local involvement and knowledge transfer is integral to several project components. Data collection efforts have been initiated at local schools. In the coming year, meteorological stations will be installed at two local schools who will participate in data collection efforts. Scientists from the research team will interact with students and teachers at these schools to explain key scientific principles and encourage an understanding of the environment and the impact of humans on their surroundings. Pond aquaculture is a promising prospect for improved and diversification economics in the watershed. A demonstration project has been initiated on the Egerton campus. Local citizens will be incorporated into the project in order to encourage the establishment of these ponds. The Kenya Fisheries Department is responsible for identifying interested parties and facilitating their involvement.

Developmental Impact

Environmental impact and relevance. Over the years, degradation of water resources in terms of quantity and quality within the River Njoro watershed has occurred due to poor watershed management. This has resulted in serious degradation of the ecological integrity and hydrologic cycle within the watershed. This is shown by loss of biodiversity, habitats, and interference with the hydrologic processes, i.e., infiltration into groundwater, run-off and interception of raindrops within the watershed. Consequently, the trend has resulted in declining socio-

economic well-being of inhabitants and their livestock, threatening Lake Nakuru and the surrounding national park, which is a major income generating resource through tourism. The long-term goal of improving watershed health will be achieved through incremental improvements and demonstrable successes within the Njoro watershed. These successes will serve as models for transferable practices to other watersheds in the region. Appropriate indicators for watershed and ecological health assessments will be determined during the coming year. These indicators will be determined from secondary, primary, and simulation data and serve as a baseline for interpretation of improvements over the next several years. Instrumentation and monitoring will supplement the interpretation of these indicators. Water resources are of critical importance to the stakeholders, and it has been observed that water quality and quantity, both in the surface and groundwater supplies, has been decreasing over the past decade due to land tenure changes. During the coming year we will plan and begin to implement interventions designed to improve the quantity and quality of water resources (agroforestry, assessment techniques for land managers, and alternative grazing and cropping systems). The stakeholder involvement group is focusing on developing good relations with stakeholders and managers within the watershed, and policymakers who have control over the manner in which the watershed is governed. These foundations of strong stakeholder interaction and outreach will support the short- and long-term success of implementation of interventions and knowledge transfer. Ongoing dialogue with land managers and policymakers will be supportive of this indicator as well. Longitudinal site visits and exposure of stakeholders to empowerment tools, such as environmental legislation and the development and implementation of watershed community action plans are intended to support the improvement of people's health and livelihoods.

Agricultural Sustainability. Given that small- and medium-scale agriculture are the primary economic forces in the watershed, it is critical that principles of sustainability be developed and implemented in the watershed. In the coming year, we will identify appropriate interventions and practices to improve farming, forestry, soil management, income opportunities, water supply conditions, and community watershed awareness and develop proposals to establish demonstration sites, behavioral trials, and other activities to test effectiveness and acceptability jointly with stakeholder and community participation. These interventions will be developed in coordination with members of the socio-economic team to ensure feasibility and practicality of implementation.

In the coming year we will test and demonstrate the feasibility of aquaculture in the watershed. One of the principal hindrances to economic development in the region is the overwhelming dependence on maize production. By introducing other mechanisms for economic and food security we intend to demonstrate the importance of diversification and alternative agricultural practices. The test site will be on the Egerton University campus. An integrated effort, this program will serve a dual scientific and outreach role: the ponds will be managed by scientists from Moi University who are interested in experimental design and maximization of pond aquaculture systems, while team members from the Department of Fisheries will manage a citizen outreach and training component that will draw upon the local population to construct, manage, and track the

economics of the pond project. This year's objective is to establish a functional and economically feasible aquaculture demonstration site that will serve as a site for technology transfer. Other demonstration sites and technology transfer schemes will be implemented in future years.

A pilot project related to strategies for on-farm water management on steep slopes will be developed. Results of the preliminary phase indicate that there is a continuous cultivation without adequate soil conservation measures on the steep slopes of the watershed. Sustainable management of the agricultural lands can be achieved through agroforestry, hedgerows, and grass strips to reduce soil loss and runoff. These simple agroforestry technologies will need to be established on the steep slopes in order to determine the soil losses. This will also assist in assessing their effectiveness and adoption as soil conservation technologies.

Evaluation of the potential for agroforestry and tree nurseries for economic and ecological benefits is an ongoing effort. Data recorded from 13 sites along the River Njoro suggest that five key indigenous tree species occur along the river. These are: *Acacia xanthophloea, Acacia abyssinica, Cussonia holstii, Podocarpus,* and *Olea africana*. The zoning of these trees along the river profile signifies altitude as the major cause of the zoning. Community tree nurseries exist in the watershed, and an assessment of their impacts and usage within the watershed will provide baseline data for the potential to implement larger-scale interventions to improve forest health.

Contributions to U.S. Agriculture. It has long been recognized that water resources and their effective use and management for long-term sustainability are crucial to agricultural stability. This statement applies with equal validity to Kenya and the U.S. The problems facing residents of the Njoro watershed are undoubtedly more critical than those in developed nations such as the U.S., but parallels exist nonetheless. For example, the watershed is comprised of a mixture of stakeholders with a variety of complementary and competing interests, including agriculture, livestock grazing, business, residents, and the environment itself. Land cover and land use are rapidly changing due to population pressures and policy decisions with resultant negative off-site impacts. This research project will provide a demonstrable method for integrating biophysical and human-focused research for sustainable watershed management in an agricultural setting. The overall purpose of the research is to develop tools and techniques that will allow local stakeholders, managers, and policymakers to obtain a clear understanding of the processes governing the system. These tools and technologies will be transferable to other systems, including the U.S.

Contributions to Host Country. In the coming year preliminary tools, such as hydrologic and ecologic models, will be developed that will describe the processes governing watershed health and the response to changes in land management and tenure. These tools will provide a scientific basis to interested parties, such as land managers, policymakers, and local residents interested in understanding their physical environment.

A series of interventions for the improvement of economic stability, ecologic health, and hydrologic resources are planned. These interventions include demonstration plots for pond aquaculture, agroforestry, alternative agricultural practices, and water distribution. It is anticipated that these interventions will have a localized beneficial impact. An outreach component will be

implemented that links local landowners to the planned interventions so as to facilitate their adoption on other regions of the watershed that would have a larger-scale impact on watershed health. A school-based outreach and education component will introduce schoolchildren to land stewardship and environmental awareness.

The Njoro watershed will be established as an experimental watershed with the addition of continuous monitoring stations for rainfall and runoff. Kenya has a sparse network of rain gauges and there is a paucity of useful runoff data. Our team has been unable to uncover any records of event-based runoff in the Rift Valley; this knowledge gap is a serious hindrance to scientific understanding of the fundamental processes that govern hydrologic response as well as water quantity and quality. These monitoring stations will provide a means to use cutting-edge tools and models for scientific assessment and land management.

There is a significant training component for Kenyan students and researchers. Nine Kenyan students will be trained during the upcoming year, many of whom will continue their careers working for ministries and policymaking organizations. The successful training of students in integrated and sustainable research and decision-making will be beneficial to Kenya.

Linkages and Networking. While this project is relatively nascent, there have been significant strides taken towards networking and developing institutional linkages. This project was conceived as a multidisciplinary effort requiring the involvement of multiple educational and institutional partners. Linkages have been established among the following Kenyan institutions: Egerton University, Moi University, Kenya Fisheries Department, and Kenya Wildlife Service. In addition to these more formal partnerships, linkages have been made with a project funded by the Rockefeller Foundation in Kenya, the Kenya Agricultural Research Institute (KARI), the Lake Naivasha Riparian Conservation Committee, and the Friends of Mau Watershed. Linkages are being developed with the USAID Mission in Nairobi, the Rockefeller Foundation, the Macaulay Institute (Aberdeen, Scotland), and the Wyoming GIS Center.

Collaboration with International Research Centers (IARCS) and other CRSPs. Strong collaborative relationships have been developed with the Pond Dynamics/ Aquaculture (PD/A) and the Soil Management (SM) CRSPs. In the year that has just concluded, significant funding and technical leadership was provided by the PD/A CRSP. The formal agreements with Moi University and the Fisheries Department were greatly enhanced by the participation of the PD/A CRSP. In the coming years, we have an agreement to interact with team members of the Trade-Offs project (funded by the Soils CRSP, Lead PI John Antle), which is utilizing a trade-off model for household and agricultural economics. This will be a collaborative effort aimed at utilizing cutting-edge tools that link biophysical and human-related inputs in watershed assessment, planning, and interpretation. Data collection efforts for agricultural economics and problem model development will be coordinated, and data regarding on- and off-site impacts associated with decision-making and economic impacts will be shared between the groups.

Other Contributions

Support For Free Markets and Broad-Based Economic Growth. One of the primary goals of enhancing watershed health

and agricultural sustainability is to foster economic stability and growth. The inability of local smallholders to transport goods and services beyond the local market was identified as a hindrance to development and growth. This barrier may best be surmounted through a policy and legal framework. However, the implementation of local and regional interventions are planned to enhance economic growth. Examples of these economic stimulants include upland grazing practices, pond aquaculture, agroforestry, and sustainable agriculture techniques (especially related to steep slopes). In addition to land management practices directly related to enhanced productivity, the project objectives of improving water quality and human health will directly improve local economics as stress is reduced within the system.

Contributions to and Compliance with Mission Objectives. The research activities directly address three strategic objectives as defined by USAID: building human capacity through education and training, protecting the world's environment for long-term sustainability, and encouraging broad-based economic growth and agricultural development. One of the four Kenyan USAID Mission objectives is to promote natural resources management, and this project directly addresses that critical need in Kenya. Spatial analysis has been widely used in support of decision support for agriculture and land management practices, and several of the team members, including the PI, have extensive experience in those areas. Long-term sustainable development in Kenya will hinge on the successful implementation of emerging scientific tools. This project will provide a mechanism to adequately prepare students and faculty to act as resource managers and utilize emerging technology in their research analyses.

Concern for Individuals. The outreach and stakeholder involvement components of this project are targeted at the community and household level. Central to the successful implementation of interventions is identifying key stakeholders and policymakers that are in positions of authority (whether that be moral, ethical, or managerial) and ensuring that they are committed to the success of the proposed intervention. We have arranged for a series of tiered workshops that will take place longitudinally within the communities of the watershed. Community leaders and policy makers will be included in these workshops, whose aim is to facilitate the transfer of knowledge from the research (biophysical, socio-economic) realm into the applied realm. The concept behind this structure is to ensure that watershed- and community-scale activities are not disconnected from the intended goal of improving the livelihoods of individuals.

Support for Democracy. One of the principles of good governance and successful democratization is the establishment of functioning policies and legalities related to people's livelihoods and environment. As a first step in developing an intervention in this regard, relevant tools for management and assessing individual and environmental rights have been located. We intend to foster pubic participation in the governance of their environment by exposing them to their rights established under the recently enacted GOK Environmental Coordination and Management Act (2002) and other GOK acts and laws governing use, rights, standards, and responsibilities for the management of watershed resources and improvement of economic security. To date, a preliminary extraction and summary of relevant sections has been prepared as the basis for further discussions and dialogue with stakeholders on their practical administration, effectiveness, and implementation.

Humanitarian Assistance. Aside from the short- and long-term objectives of enhancing people's livelihoods, there is no humanitarian component to this research.

Leveraged Funds and Linked Projects

University of Wyoming Global Perspectives Program: $1,500.
University of Wyoming International Travel Grant: $2,000.
University of Wyoming Graduate Student Assistantship.
University of California Graduate Student Assistantship.
Utah State University–Data sharing and project facilitation with the GL-CRSP PARIMA project.
Montana State University – Research linkage with the Trade-Off Analysis Project (Soils CRSP-funded project).
Kenya Wildlife Service–Research and facilitation linkage.
Kenya Agricultural Research Institute–Research and outreach linkage.
Egerton University–Data and information-sharing linkage with Agricultural Research Library (Rockefeller-funded project).
Friends of Mau Watershed–Information and outreach linkage.
Lake Naivasha Riparian Conservation Committee–Information and outreach linkage.

Training

In Progress

Tracy Baldyga, M.S., 2003, Rangeland Ecology & Watershed Management, University of Wyoming.
Stephen Huckett, Ph.D., 2006, Forest, Range, and Wildlife Sciences, Utah State University.
Luke Kessei, M.Sc., 2003, Environmental Science, Egerton University.
Samuel Kibichii, M.Phil., 2003, Fisheries Management, Moi University.
Joseph Kiragu, M.Sc., 2003, Environmental Science, Egerton University.
Timothy Krupnik, M.S., 2003, International Agricultural Development and Resource Management, University of California-Davis.
Charity Munyasya, M.Sc., 2003, Natural Resources, Egerton University.
Elijah Oyoo, M.Phil., 2003, Fisheries Management, Moi University.
Godfrey Ndonye, M.Sc., 2003, Environmental Science, Egerton University.
Peter Muriuki, M.Sc.,2003, Environmental Science, Egerton University.
Henry Sumba, M.Sc., 2003, Environmental Science, Egerton University.

Non-degree

University & research exposure visit to U.S. institutions - William Shivoga, Francis Lelo, Charles Maina-Gichaba. June 23 - July 5, University of Wyoming and Utah State University.
International Rangeland Congress, Durban, South Africa. Stephen Huckett, Utah State University, July 26 - August 1.

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Publications, Abstracts, and Presentations

Shivoga, W.A., F. Lelo, C. Maina-Gichaba, M.W. Jenkins, and S.N. Miller. 2002. Integrated Stakeholder Participation and Watershed Assessment in the River Njoro Watershed, Kenya. Poster Presentation to the Global Livestock Collaborative Research Program Conference, October 9-12, 2002, Washington, D.C.

Miller, S.N., W.A. Shivoga, F. Lelo, C. Maina-Gichaba, M. Muchiri, and M.W. Jenkins. 2002. Multidisciplinary Research for Sustainable Management of Rural Watersheds: the River Njoro, Kenya. Oral Presentation to the Global Livestock Collaborative Research Program Conference, October 9-12, 2002, Washington, D.C.

Huckett, S., D.L. Coppock, W.A. Shivoga, F.K. Lelo, and S.N. Miller. 2003. Comparing processes of stakeholder participation in community-based watershed programs: the Little Bear River, Utah, USA, and River Njoro, Rift Valley Province, Kenya. VII International Rangeland Congress. July 26th – August 1, 2003, Durban, South Africa.

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