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Improved land management in the Lake Victoria Basin: Final report on the TransVic project

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World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

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Abstract

This report addresses the challenges of land management in the Lake Victoria basin of East Africa. In 1999 the World Agroforestry Centre launched a major effort to identify, diagnose and reverse degradation in the Lake Victoria basin, focusing primarily on the Kenyan part of the basin. Dubbed "TransVic," this project was supported by a number of donor agencies and collaborators, with particularly strong support from the Swedish International Development Cooperation Agency (Sida). Field activities in the Kenyan part of the basin were undertaken with Kenya's National Agriculture and Livestock Extension Programme. This report summarizes the major achievements of TransVic from 1999 to the end of 2004. The project greatly improved understanding of land degradation processes, costs and hotspots, the linkages between poverty, degradation and water resource management, and the possibilities for and constraints to solving those problems through various technical and institutional approaches. The research and development agenda for the region is now able to concentrate on the investments in land and water resources that can curtail degradation and help restore these degraded resources.

Keywords:

Lake Victoria, Kenya, land degradation, poverty, sensing soil quality, stages of progress, wetlands, forest conversion, TransVic.

How this report was prepared:

The material presented in this report represents the combined output of many ICRAF staff, students and collaborators over the last several years. In 2005, ICRAF contracted a consultant writer, John Mbaria, to prepare a non-technical summary of the project. To prepare that report, John read many of the project reports and interviewed many of the ICRAF staff involved in the project. He also interviewed farmers and Ministry of Agriculture staff who collaborated in the project activities. Once the draft summary was prepared, the TransVic management group decided that it would be preferable to issue a final technical report, from which less technical publications can be drawn. Brent Swallow took the lead in compiling the report, with extensive assistance from Njeri Okono. Besides the non-technical summary prepared by John Mbaria, material presented in the report is drawn from previous TransVic annual reports, published papers, student theses, as well as some previously unpublished technical material. Several of the staff involved in the project provided maps and synthesis material that was edited and inserted into the relevant chapters and sections of the report. Final technical editing of the report was done by Kris Vanhoutte and Rebecca Selvarajah-Jaffery. Final design and layout was done by John Gikang'a and Kris Vanhoutte.

Acknowledgements:

We must first acknowledge the many development partners and research organizations that contributed financial resources to TransVic. TransVic, a large project undertaken over several years, attracted investments from many donors. Table 1.1 (page 7) of the report lists those donors and their contributions. Here we must make special mention of the Swedish International Development Cooperation Agency who generously supported the project for almost 5 years. Tom Anyonge was instrumental in launching TransVic and steering it during the particularly exciting first years. The Kenyan Ministry of Agriculture and Rural Development (at that time) was the main partner to ICRAF in implementation of TransVic. The list of Ministry staff involved in the project is presented in Annex 2 (Table A 2.4). Japheth Kiara was heavily involved in steering the project from its launching in 1999 to its wrapup in 2004.

TransVic was unusually ambitious in integrating research and development into the same project. The research component benefited from the inputs of many talented students and their university supervisors. The list of students, and their research topics and universities is presented in Annex 2 (Table A 2.2). Sixteen universities from across Kenya, Europe and North America were involved in various components of the project. We have an intellectual debt to them all. On the development side, TransVic benefited from the inputs of a large number of very talented Ministry of Agriculture staff, most of whom are also listed in Annex 2 (Table A 2.4). Given the large number of staff involved, and the wide geographic range of the project, we are not sure that we have included everyone who should be listed. The challenge of effectively integrating research and development was ably taken up by both ICRAF and Ministry of Agriculture staff. David Nyantika and Daniel Bondotich warrant special acknowledgement for the roles that they played in this integration.

The very many Kenyan and international visitors to the TransVic project can attest to the fact that the major inspiration of the project were the farmers working in the 28 focal areas listed in Chapter 6 of this report. We know that the project benefited greatly from their involvement; we only hope that they also benefited. It was particularly inspiring to see how some villages embraced the World Agroforestry Centre motto: Transforming lives and landscapes.

This final report on the TransVic project benefited from the inputs of several current and past ICRAF staff; including, among others, David Nyantika, Keith Shepherd, Alex Awiti, George Aike, Kris Vanhoutte, John Gikang'a and Rebecca Selvarajah-Jaffery. The Relma project, under the leadership of Chin Ong, provided financial support for the printing of this report and for the consultant, John Mbaria, who prepared the first draft of this report.

Acronyms

CAP	Community action plan
CDF	Constituency development fund
CIG	Common interest group
DANIDA	Danish International Development Agency
DFID	Department for International Development, UK
EAC	East African Community
FSAP	Farm-specific action plan
GDP	Gross domestic product
GEF	Global Environmental Facility
GIS	Geographic information systems
GPS	Global positioning system
ICRAF	World Agroforestry Centre
IF	Improved fallow
KARI	Kenya Agricultural Research Institute
LVEMP	Lake Victoria Environmental Management Programme
MoARD	Ministry of Agriculture and Rural Development
NALEP	National Agricultural and Livestock Extension Programme
NDVI	Normalized difference vegetation index
NSWCP	National Soil and Water Conservation Programme
PAPOLD	Participatory analysis of poverty and livelihood dynamics
PM&E	Participatory monitoring and evaluation
PRA	Participatory rural appraisal
RELMA	Regional Land Management Unit
Sida	Swedish International Development Cooperation Agency
SWCB	Soil and Water Conservation Branch

List of maps (see Annex 3)

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Executive summary

The Lake Victoria basin covers an area of 184,200 km^2 across Kenya, Tanzania, Uganda, Rwanda and Burundi, and supports about 28 million of the poorest rural inhabitants in the world. Poverty rates in the basin are 50% or more, and are especially high in the lakeshore areas of Kenya, where the situation is further compounded by a high incidence of HIV/AIDS and water-associated diseases along waterways. The World Agroforestry Centre (ICRAF) has been working with national partners around the Lake Victoria basin (in Kenya, Uganda, Tanzania and Rwanda) for many years, and has developed agroforestry techniques that have been shown to improve the farm resource base and the food security of poor farmers. While thousands of farmers of both genders and all wealth groups have now adopted these techniques, little was known about the applicability of the techniques for the wider population of farmers in the lake basin, or for redressing the daunting environmental problems experienced in the lake basin.

Lake Victoria, with a surface area of 68,000km^2, is the world's second-largest fresh water lake and is a main source of the River Nile. Accelerated soil erosion and nutrient runoff, urban and industrial pollution, and atmospheric deposition have induced a rapid rise in nutrient levels in the lake, which has in turn led to changes in the lake ecology and prolific growth of aquatic weeds - led by the invasive water hyacinth. As a result, the fishery industry — the direct economic mainstay (through fishing and fish processing) for half a million persons in the lake basin, is in decline.

The aim of the TransVic project was to provide extension providers, policy makers and researchers with information, methods, technologies and approaches for improving land productivity while enhancing the local and regional environments in the Lake Victoria basin. While the project's main geographical focus was Kenya, the approaches are relevant to the entire Lake Victoria basin in Uganda, Tanzania, Rwanda and Burundi.

When the TransVic project was initiated in 1999, very little was known about the magnitude of sediment load (from the catchment area) into the lake, the key sources of that sediment, or the links between sedimentation and land degradation "hotspots." Agroforestry practices, such as improved fallows, biomass transfer and rotational woodlots, had been shown to be appropriate for limited areas, but had not been widely tested across the region. ICRAF's comparative advantages for leading research on diagnosing land management problems and testing solutions to those problems lay in its long experience with developing land management options with farmers in the three lakeshore countries. This includes its innovative use of reflectance spectroscopy to map erosion risk and soil nutrient deficiency, its extensive network of partnerships, and its ability to integrate a wide array of disciplinary perspectives.

Between 1999 and 2004, the project covered three river basins in the Kenyan portion of the Lake Victoria basin, with emphasis on the highly-degraded and impoverished Nyando river basin. Work was undertaken in the Sondu-Miriu and Yala basins. The project approach integrated across scales and disciplines and developed new approaches for research, extension and institutional development.

River monitoring and sediment core analysis were used to quantify sediment loads in the major rivers of Kenya, and to relate sediment levels to the continued eutrophication[1] of Lake Victoria. Spectral reflectance, remote sensing and advanced analytical methods were developed for interpolating soil properties across large parts of Western Kenya from a library of soil samples from the region. The "snowflake" research design was developed for the integrated collection and analysis of socioeconomic and biophysical data at scales from small plot to 100-square-kilometer blocks.

[1] super-saturation of nutrients in the lake

Farm and community trials with new techniques and approaches were designed in response to community priorities. These trials were implemented with farmers, and were integrated into the main extension approach of the Ministry of Agriculture. The project worked closely with agricultural extension staff to improve targeting and efficiency, and also to ensure extension that would be more sustainable and more attuned to the needs of poor farmers. Joint impact assessments were conducted. Extension staff were trained in participatory analysis of poverty and livelihood dynamics (PAPOLD), geographic information systems (GIS), and participatory monitoring and evaluation (PM&E). PM&E and PAPOLD have since been integrated into the Ministry's extension planning and assessment approaches. A series of PAPOLD pilot and training activities were undertaken in 2004/5 and 2005/6 and by 2006/7 the PAPOLD method will be fully integrated into the NALEP participatory rural appraisal method and used throughout the country. Extension staff now use PM&E to evaluate community implementation rates and impacts. Households surveyed for socioeconomic analyses are georeferenced to link socioeconomic and spatial data.

The project also demonstrated the magnitude of the land degradation and poverty problems in the basin, and the links between land degradation, river pollution levels, and the historical deposition of sediment into Lake Victoria. Maps showing various soil attributes — phosphorus deficiency, rates of soil erosion and deposition, areas formerly forested — have been produced for the 3,500km^2 Nyando river basin (see Annex 3).

In particular, the research showed that the Nyando basin is a major source of sediment into Lake Victoria with 61% of the basin of 3,500 km sq constituting a source area with average erosion rates of >40 t/ha/yr. Since 1963, the total soil loss to the lake has averaged 3.2 million metric tons per year. Disproportionately high sediment losses have occurred during years with high annual rainfall.

Changes in the Nyando basin have increased the rate of sedimentation of the Winam Gulf of Lake Victoria by three to four times over the last 100 years.

Conversion of forest to grass and cropland over the last century has been a major factor contributing to declines in soil fertility and soil physical condition, and increased soil erosion. Compared to forest and bushland areas dominated by grass and crops are 16 times more likely to be affected by severe erosion. By combining biophysical and socioeconomic assessment methods, the project team was able to show the production effects of land degradation. Compared to stable reference soils, crops grown on eroded soils had an 8 percent higher chance of crop failure and a 30-40 percent reduction in crop yields. Depositional areas had lower risk of crop failure and higher yields compared to reference soils. Fertilizers were only used on highly degraded lands. Subsequent studies suggest that the spatial pattern of degradation and poverty is related to land tenure and settlement patterns in the basin.

A key contributor to soil degradation is the loss of ground cover. Re-establishment of trees and contact ground cover are needed to control soil erosion in fast eroding areas, and to prevent soil erosion in slowly eroding areas. There is also a need to restore and protect sink areas such as wetlands and riverine areas.

Trials of agroforestry techniques, water management and grazing exclusion have been conducted with farmers in a number of land management "hotspot" areas — and some promising results obtained. Over 5,800 farms in 28 focal areas have adopted some new innovations with 59% of target farmers adopting at least one new farming practice. Nonetheless, it has become clear that both the land management and human development problems are deep-rooted, and will require large-scale investments and real commitment at the policy level. A number of government agencies, non-governmental organizations, and local civic organizations have committed their energies to redressing the problems of the region.

The World Agroforestry Centre (ICRAF) implemented the project jointly with the National Agriculture and Livestock Extension Programme (NALEP) of the Kenya Ministry of Agriculture and various partners in research and extension. The ICRAF–NALEP collaboration focused on identifying problems, refining extension approaches, and testing with farmers promising techniques for agroforestry, water management and land management.

Research collaborators included the Kenya Ministry for Water Resources, the Kenya Agricultural Research Institute (KARI), the Kenya Forestry Research Institute (KEFRI), Survey of Kenya, the Regional Land Management Unit (Relma), the African Centre for Technology Studies (ACTS), and the universities of Bonn, Egerton, Florida, Maseno, Moi, Nairobi, Kenyatta, Southampton, Stockholm, Utrecht and Uppsala.

Key collaborators in extension and development included the Consortium for Scaling up Options for increasing Farm Productivity (COSOFAP), which brings together over 40 research and development organizations in Western Kenya, AIC Diguna, The Tinderet Tea Factory and Vi Agroforestry.

Funding was provided by the Swedish International Development Cooperation Agency (Sida), the Kenyan Ministry of Agriculture, the European Union, the Rockefeller Foundation, Danish International Development Agency (Danida) and the World Agroforestry Centre (ICRAF).

Organizations involved in policy aspects were County Councils of the Ministry of Local Government, the National Environment Management Authority (NEMA) of Kenya, and the Ministry of Agriculture.

Chapter 1. Introduction[2]

1.1 Background

Lake Victoria, with a surface area of 68 000 km^2 and an adjoining catchment of 184 200 km^2 is the world's second largest fresh water lake and the largest in the tropics. Lake Victoria is the source of the Victoria Nile, and as such the hydrologic lifeline for much of Uganda, the Sudan and Egypt. Lake Victoria is located 1100 meters above sea level and is shared between the three East African countries of Kenya (6%), Uganda (43%) and Tanzania (51%).

Since the 1930s, Lake Victoria and its basin have undergone enormous ecological changes. Its human population has doubled every 22 years; the introduction of Nile perch (*Lates niloticus*) in the early 1950s led to the extinction of many of the 400 endemic species of fish; pollution from terrestrial, point source and atmospheric sources led to phosphorus levels increasing 2-3 times over the last 50 years; algal concentrations are 3-5 times higher than they were during the 1960s, and much of the lake bottom now experiences periods of prolonged anoxia that were uncommon 40 years ago. The water hyacinth that was introduced in the late 1980s had profound impacts on the fish industry, with up to 80% of the fish landing sites blocked at the zenith of the problem around the year 2000. At its peak, a floating mass of the water hyacinth had enveloped about 680 square kilometers of the lake and at one time was estimated to be growing at a rate of 3 hectares per day. Besides contributing to eutrophication, water hyacinth prevents the penetration of light into the lake's waters thus hampering the growth of fish food (that is, phytoplankton). In Uganda, water hyacinth damaged bridges and dams, necessitating large operational costs to keep the Owen Falls hydroelectric power plant operational.

The human welfare problems of the Lake Victoria basin are also compelling. The incidence of consumption poverty ranges between 40 and 70 percent in the districts around Lake Victoria; agricultural productivity is low (particularly in the Kenyan part of the basin); there are high levels of HIV/AIDS prevalence, especially among the Luo ethnic group of Kenya, and most agricultural subsectors have been in decline since the 1980s. Indeed, the Lake Victoria basin is now deemed to be one of Africa's most severe hunger hotspots (Inter-Academy Council, 2004).

Fortunately, governments in the three East African countries — Kenya, Uganda and Tanzania have come to recognize the serious and deteriorating conditions of the lake and its immediate neighbourhoods. Under the auspices of the East African Community, the three countries have been undertaking a joint development programme for the lake region since 1994. This led to the formation of a number of bodies and programmes, including the Lake Victoria Fisheries Organization and the Lake Victoria Environment Management Programme (LVEMP), funded by the World Bank and the Global Environmental Facility (GEF) to the tune of US$77.7 million. The LVEMP began operations in 1997 with the principal goal of restoring the lake to a healthy, productive ecosystem that is inherently stable and that can sustainably support the many human activities within the lake and the outlying areas. The first phase of LVEMP ended in 2004. A second phase of the LVEMP was still under development as of mid-2006.

The Government of Sweden and the East African Community have provided leadership in institutionalizing the transnational management of the Lake Victoria basin. Key to Sweden's support was the more than 30 years of cooperation with the three East African States and its participation in the successful programme to restore the environment within and surrounding the Baltic Sea. The Swedish International Development Cooperation Agency (Sida) began to develop a coherent strategy on Lake Victoria in 1998

[2] This introduction draws primarily upon material originally presented in the annual reports of the TransVic project. Keith Shepherd and Brent Swallow prepared much of the material used in the background section.

and 1999, punctuated by its support for the TransVic Project through the National Agricultural and Livestock Extension Programme (NALEP). In March 2000, the Swedish Government authorized Sida to "embark on a long-term commitment to support sustainable development in the Lake Victoria basin in East Africa."

1.2 The Kenya Ministry of Agriculture and Rural Development in Kenya's Lake Victoria basin

Kenya's Ministry of Agriculture provides extensive support to soil and water conservation among the farming community. The country has deployed conservation officers in every division and extension providers in every administrative location. Between 1974 and 2000, the Soil and Water Conservation Branch (SWCB) of the Ministry of Agriculture implemented the National Soil and Water Conservation Programme (NSWCP) with support from the Swedish International Development Cooperation Agency (Sida). NSWCP activities were based in selected catchments or focal areas with average size of 150 to 200 hectares. Technical assistants from the ministry worked closely with locally-elected catchment committees for one year before moving to new catchments as frontline extension providers were responsible for providing followup support. This approach was widely credited for successfully reaching large numbers of farmers, mobilizing investments in soil and water conservation, and stemming land degradation. ICRAF's TransVic project began in July 1999 as a component of the NSWCP.

In July 2000, the NSWCP was superseded by another Sida-sponsored programme, the National Agriculture and Livestock Extension Programme (NALEP). Among other things, NALEP was designed to bridge the gap between research and extension and to contribute to poverty alleviation and social development of Kenyan farmers. The NALEP project was designed to be consistent with the policy of pluralistic extension: encouraging and coordinating the inputs of a variety of extension providers, government, private and non-governmental - to meet farmers' needs. NALEP extended the catchment approach of NSWCP into a focal area approach, facilitating the formation of focal area development committees, community and farm-specific action plans, common interest groups, and linking community groups with external agencies and markets. A new phase of NALEP began in 2005, with some changes in approach to supporting focal area development.

1.3 The World Agroforestry Centre and the Lake Victoria basin

The World Agroforestry Centre (ICRAF)[3] has been working in locations around the Lake Victoria basin since the early 1990s. As of 1998, ICRAF has conducted work around research sites in the densely populated highlands of Western Kenya, the lakeshore area around Jinja in Uganda, the Kigezi highlands in Southwest Uganda, and the Shinyanga area of Western Tanzania. For instance, the Centre has been working with the Kenya Agricultural Research Institute (KARI) and the Kenya Forestry Research Institute (KEFRI) since 1995 on short-duration improved fallows and biomass transfer systems in Western Kenya. There, and elsewhere in the world, ICRAF and its partners have developed various agroforestry technologies such as vegetative strips, contour hedgerows and improved fallows to protect fragile sloping lands from erosion (Young, 1997). Such systems have the capacity to minimize soil erosion and to increase food production without imposing additional labour and financial inputs (Sanchez, 1995).

In 1998–1999, ICRAF decided to concentrate its watershed work for East Africa in the Lake Victoria basin, which was chosen for three reasons: (1) the centre had long-term presence and experience at several locations around the basin; (2) the magnitude and importance of the environmental and human welfare problems in the basin; and (3) the scientific advances that ICRAF was making in detecting and diagnosing large-scale land degradation problems. While developing and testing those methods for a study site in Western Kenya, ICRAF scientists identified and characterized a large plume of sediment extending into Lake Victoria from the Nyando river (See Map 1). This

[3] The World Agroforestry Centre is legally known as the International Centre for Research in Agroforestry and is popularly known by the acronym, ICRAF.

scientific finding was widely reported in the international press, including the online version of *Science*.

"… the water hyacinth remains one of the most aggressive invaders on the continent. Now, researchers are getting a clearer picture of why the South American native is flourishing in the world's second-largest lake, Victoria. A satellite image released this month by the International Center for Research in Agroforestry in Nairobi, Kenya, shows three feeder rivers injecting an immense, nutrient-rich plume of sediment far into Lake Victoria, where the weeds now choke most of the shoreline shared by Uganda, Kenya, and Tanzania. Besides making life miserable for fishing boats, the vegetation mats threaten native species. The new plume portrait will help scientists track the nutrients back to their sources and pinpoint which regions should step up tree-planting and other erosion-control measures," Science 26 November 1999: Vol. 286. no. 5445, p. 1675.

Thereafter ICRAF scientists quickly linked up with representatives of Sida and the Kenya Ministry of Agriculture to develop an activity for the Kenya part of the Lake Victoria basin. Senior staff from ICRAF and the Ministry of Agriculture engaged in an intense process of field visits, brainstorming and participatory rural appraisal with the aim of developing a proposal for the TransVic Project[4]. 1999 -2000 was designed to produce tangible results of immediate benefit to the Conservation Branch and develop methods that could be applied throughout Kenya and the rest of the Lake Victoria basin. After the startup year, Sida approved a three-year project as part of its support to NALEP. The first phase of NALEP was extended for another year, and the TransVic project was granted a further six-month extension, formally ending on December 31st, 2004. NALEP allocated a large portion of its discretionary funds (Appropriation-in-Aid) to strengthen the extension component of the TransVic project.

Besides ICRAF and NALEP staff, the project involved a large number of graduate students from Kenya, Europe and North America. Participating too were many other stakeholders who contributed at different levels and in different ways, including national research institutes, universities and a host of community-based groups. Sida funding catalyzed investments in the project by other donors, including the European Union, Danida, the Rockefeller Foundation, the Comprehensive Assessment of Water Management in Agriculture, and the UK Department for International Development. Table 1.1 lists the major investors in the project and activities financed by those investments.

1.4 Purpose, objectives and approach of the TransVic project

The purpose of the TransVic project was to provide extension providers, policy makers and researchers with information, methods, technologies and approaches for improving land productivity while enhancing local and regional environments.

The project had four main objectives:

1. Identify land degradation hotspots in the Lake Victoria basin and identify intervention points for preventing or mitigating those hotspots.
2. Identify and evaluate technologies, institutional arrangements and policies for alleviating poverty while protecting the local and regional environmental of the Lake Victoria basin.
3. Quantify the actual and potential impacts of promising land management interventions on human welfare (food security, income, gender and equality) and the environment (soil quality, water quality and hydrologic function.
4. To strengthen research–extension links to solve high-priority problems in collaboration with farmers.

It was perceived that achieving these objectives would support the outcomes of: farmers planting more trees that generate both income and ecosystem services; local governments and community groups instituting more effective natural resource management; and government and development agencies undertaking more effective investments and policies. Those outcomes were in turn expected to generate the desirable impacts of improved farmer welfare; conservation and improvement of local resources; and reduction of negative impacts on water quality in the Lake Victoria water system.

[4] ICRAF coined the short title, TransVic, for the project formally titled, "Improved Land Management in the Lake Victoria basin." TransVic is meant to evoke the sense of transformation of lives and landscapes, following the World Agroforestry Centre tagline - "Transforming lives and landscapes." TransVic is also meant to evoke the sense of a project that spans throughout or across the Lake Victoria Basin.

Table 1.1. Investors and other partners in the TransVic project

Donor/investor/partner	Activities supported
Swedish International Development Cooperation Agency	All activities and outputs, through the NSWCP and NALEP projects
Kenya Ministry of Agriculture and Rural Development	Strong partner for all activities and outputs, with many field staff involved in strengthening links between research and extension (Obj 4)
Kenya Agricultural Research Institute and Kenya Forestry Research Institute	Technical inputs, germplasm and assignment of staff for work on agroforestry technologies (Obj 2)
Kenya public universities (Jomo Kenyatta University of Agriculture and Technology, Kenyatta University, University of Nairobi, Egerton University, Maseno University)	Faculty supervision for graduate students working on project (Obj 1,2 and 3)
The Rockefeller Foundation	Major support to the development and application of the use of reflectance spectroscopy for large-scale assessment of land degradation hotspots (Obj 1)
Comprehensive Assessment of Water Management in Agriculture	Support for the Safeguard project – assessing the links between land management institutions and poverty in the Nyando basin (Obj 1); developing new diagnostic techniques for extension to target the poor (Obj 4)
Department for International Development, UK	Assessing information sources used by the poor to improve livestock and agroforestry (Obj 4)
European Union, funds earmarked for ICRAF's policy research in Africa	Supporting outreach to policy processes (Obj 2)
Universities in USA, Sweden, The Netherlands, Germany, UK	Support for a number of graduate students working on various research components of the project (mostly Obj 1 and 2)
Danish International Development Agency (DANIDA), funds earmarked for ICRAF's policy research	Support for an assessment of the NSWCP project (Obj 2)
Regional land management unit (RELMA) (Sida funded)	Support for an assessment of the basin-level effects of widespread adoption of conservation agriculture (Obj 3)
British Council	Support for a Masters student working on the impacts of water point management (Obj 2)

The TransVic project adopted an Integrated Natural Resource Management approach, involving problem diagnosis, the design and evaluation of innovations for solving those problems, assessing the impacts of problems and interventions on welfare, and guidance on interventions that can improve welfare while simultaneously improving the environment (See Figure 1.1). For more information about the approach is provided in the book chapter by Swallow et al., 2003).

1.5 Geographic focus of the TransVic project

During the startup year of 1999–2000, considerable effort was put into regional level assessment of land degradation and poverty throughout the Lake Victoria basin. Digital elevation models and stream networks were used to delineate 11 major river basins flowing into Lake Victoria from the drainage area in Kenya, Uganda, Tanzania, Rwanda and Burundi (see Map 2). Two of these basins are transnational: the Mara, which drains parts of Kenya and Tanzania, and the Kagera which drains much of Burundi, Rwanda and parts of Uganda and Tanzania. A smaller basin, the Malaba-Malakisi, drains parts of Uganda and Kenya. In Kenya, the project focused on four priority basins—Nyando, Yala, Sondu-Miriu and Nzoia. Water quality monitoring was conducted for these four rivers. Most of the early land degradation analysis focused on the Nyando and parts of the Yala basins (See Map 1). Focal area development activities were undertaken in the Nyando, Sondu-Miriu, and Yala basins.

Beginning in the year 2000, ICRAF staff began to explore possibilities for expanding the project focus to priority parts of the lake basin beyond Kenya. Field visits and consultations were conducted in Uganda and Tanzania. In early June 2002, a stakeholders' workshop was held in Mbale, Uganda, co-hosted by ICRAF, the Regional Land Management Unit (RELMA, then an independent collaboration with ICRAF), and the Uganda Department for Water Development. Later in June 2002, a similar workshop was held in Mwanza, Tanzania, co-hosted by RELMA, ICRAF and various offices of the Government of Tanzania. In 2003, ICRAF, RELMA and the East African Community (EAC) co-hosted a travelling workshop on improved land management in the Lake Victoria basin, culminating in the signing of a Memorandum of Understanding between the three organizations. Discussions with the EAC have been continuing since 2003. ICRAF still aspires to expand the geographical scope of this project beyond Kenya.

1.6 Publication and dissemination of results

The project had a multi-faceted approach to information dissemination. First, all research results were presented at the semi-annual NSWCP and NALEP review and planning meetings. Second, results were presented in three series of publications: TransVic Newsletters, project working papers, and annual reports. Third, a project website was established on the ICRAF web site (www.worldagroforestrycentre.org/sites/transvic/index.htm.) Fourth, a number of graduate student theses, book chapters and journal articles were published. Fifth, several high-profile workshops were convened for presentation and review of results, discussion, and formulation of action plans. In addition, the project attracted a considerable amount of media attention from the local and international press. Scientific findings on the sediment plume extending into Lake Victoria from the Nyando River attracted attention from several North American and international news agencies, including the Associated Press, *Science*, Canadian Broadcasting Corporation National News, and BBC World Service Radio. The project was also covered by National Geographic Television and the Public Broadcasting Service. Two articles were published in the regional environmental journal, *EcoForum*, and several articles were carried in the Kenya national newspapers. A list of publications produced by the project is included in Annex 1.

1.7 Personnel involved and project management

Up to 15 ICRAF scientists, including seven senior scientists, were involved in the TransVic Project in the field and at ICRAF's Nairobi headquarters. Among them were soil scientists, ecologists, economists,

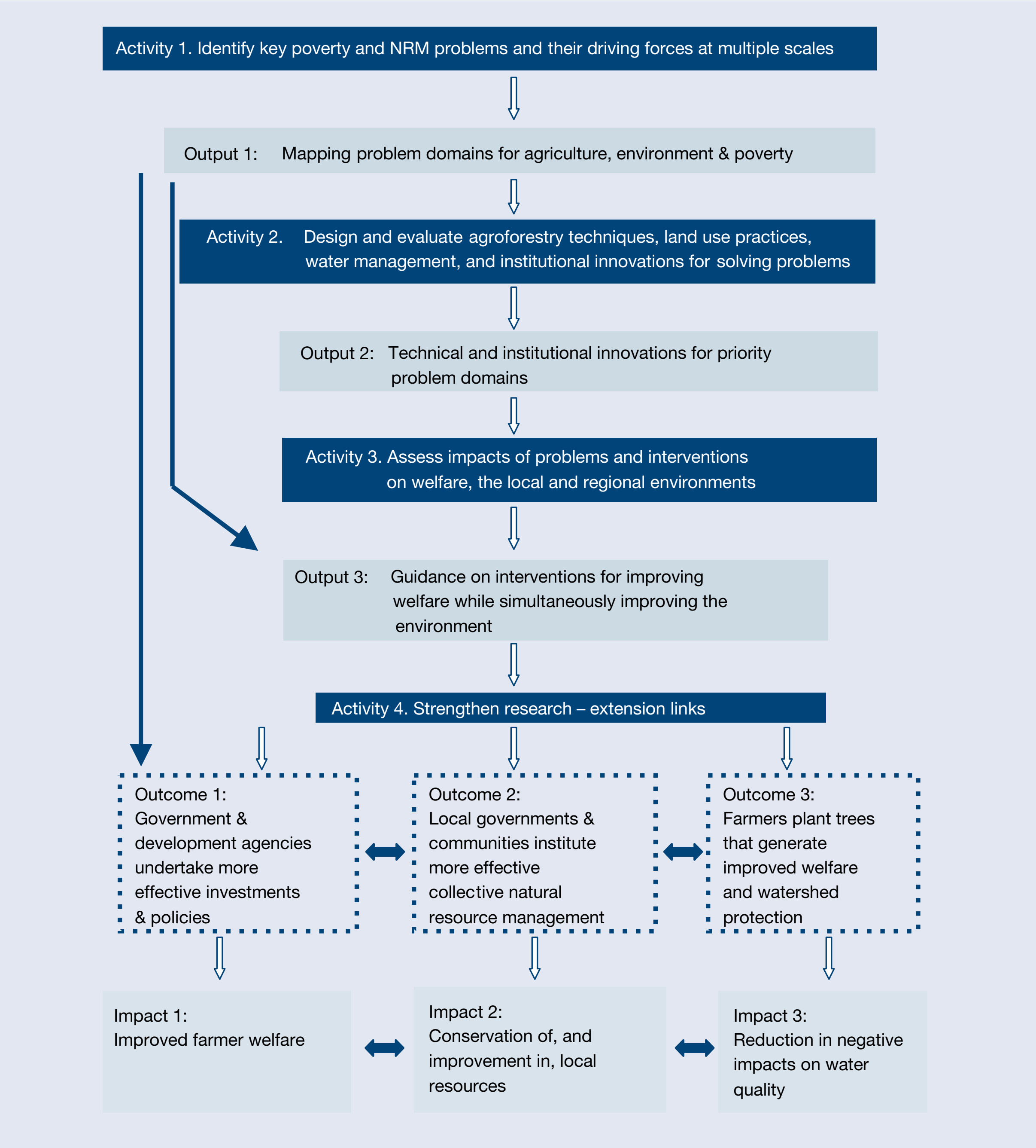


Figure 1.1. TransVic overall project approach (Source: Swallow et al., 2003)

geographers, anthropologists and hydrologists, who also supervised postgraduate students working on the project. The project extensively used GIS for analysis and training in Nairobi and Western Kenya. Soil and water samples were also analysed in Nairobi.

The core project team in Kisumu comprised about 14 full-time and part-time staff: part-time staff were also working on other complementary activities. Twenty-five students undertook their research under the TransVic Project, supervised by ICRAF scientists. At least 67 Ministry of Agriculture and Rural Development staff from all levels (headquarters, provincial, district, division, frontline) were involved in various project activities, especially working on the research and development activities undertaken in the focal areas .
A full list of personnel involved in the project is included as Annex 2.

Project management was through a two-track approach:

1. Engaging with Ministry staff for review and planning meetings for NALEP's programmes—meetings whose outcomes were shared with advocacy groups.
2. Periodic meetings of the Project Management Group, primarily for co-ordination and for ensuring the inputs of Nairobi-based scientists into the project's four thematic areas.

1.8 Overview, outline and objectives of this report

This report presents the main achievements of the TransVic project, from its startup year in 1999-2000, through to its conclusion at the end of 2004. It draws heavily on the annual reports that were prepared for the first four years of the project, plus additional summary material prepared by a number of those involved in the project. Chapters 2, 3, 4 and 5 present the main research achievements of TransVic. Chapter 2 identifies land degradation hotspots and restoration intervention points. Chapter 3 presents results on potential interventions for dealing with those land degradation problems. Chapter 4 is concerned with the human problems of the Lake Victoria basin, particularly the deep-seated problems of poverty and human health. Chapter 5 presents an assessment of the opportunities and constraints of development options for coping with the development and poverty problems. Chapter 6 describes the project's achievements in strengthening research - extension linkages. Finally, Chapter 7 presents a description of the project achievements in influencing development and policy approaches to the Lake Victoria basin. Annexes present, publications, personnel, and details of maps.

Chapter 2. Identifying land management hotspots and intervention points[5]

2.1 Methods for land degradation and water quality assessment

The TransVic project has developed, applied and refined a number of innovative methods for assessing land degradation, and applied more standard methods for assessing and monitoring sedimentation and contamination of rivers. This broad focus on assessment was particularly important given the lack of consistent data from other sources.

Water quality assessment.

Detailed monitoring of the Nyando and Sondu-Miriu Rivers began in early 2000 in order to assess the relative changes in water quality from the headwaters to the river mouths. Later in 2000, monitoring was extended to the Yala and Nzoia rivers. Water samples were examined for nitrogen and phosphorus levels and turbidity. Turbidity values are expressed as Normalized Turbidity Units (NTU). (http://h2osparc.wq.ncsu.edu/info/turbid.html).

Sediment monitoring and coring.

When the TransVic project began, there was very little systematic collection of data on water quantity or quality in the Kenyan portion of the Lake Victoria Basin. Remote sensing studies conducted by ICRAF scientists in 1998 had led to the observation of a major plume of sediment extending into Lake Victoria from the outlet of the Nyando river (published in *Science* online, see introduction). By routinely monitoring the sediment and nutrient load in the Nyando, Nzoia, Yala and Sondu-Miriu rivers from 1999, the project documented the magnitude of the problem and compared the Nyando to the other Kenyan rivers draining into Lake Victoria.

Sediment coring.

Radionuclide measurements performed on sediment cores collected in the Nyando estuary show that sedimentation rates of the basin have increased three- to four-fold over the last 100 years and have been punctuated by "big events" coinciding with known pluvial periods in the region.

Reflectance spectroscopy and large-scale land assessment.

Perhaps the most important research breakthrough of the project was the development and application of powerful new tools for detecting, quantifying and understanding soil erosion, soil degradation and sedimentation in selected river basins within the Lake Victoria basin. These tools combine methods of reflectance spectroscopy, remote sensing, Geographic Information Systems, ground truthing, stable isotope analysis, and advanced quantitative methods. Project scientists are now applying those tools in other parts of the world, including West and Southern Africa and India. Refinement and application of those methods has been noted as one of ICRAF's major scientific achievements of the past decade and was featured as the CGIAR "Story of the Month" for February 2006 (http://www.cgiar.org/monthlystory/feb2006.html). The project maintains a web site with a full description, list of applications, and list of publications (http://www.worldagroforestry.org/sensingsoil/index.html).

The Snowflake protocol.

What has been dubbed the 'snowflake protocol' is used to integrate the collection and analysis of multi-scale socioeconomic and biophysical data. The snowflake is the spatial pattern that results from the spatial sampling approach. At the finest resolution, ground observations and soil samples were taken from 30-meter by 30-meter plots that were exactly matched to the pixels of Landsat TM images through the use of survey-grade GPS units. The landowner or tenant-farmer at that time was quizzed about the current and historical land use and investment on the plot.

[5] This chapter is based on the work of Markus Walsh, Keith Shepherd, Chin Ong, Alex Awiti, Matthew Cohen, and Christian Omuto. A more complete list of the relevant publications is presented in (http://www.worldagroforestry.org/sensingsoil/index.html).

Twenty pixels were located in a snowflake pattern across a one-square-kilometer area and group interviews held with local elders to assess the overall pattern of settlement, land use and investment for the "sub-block." Twelve sub-blocks were located across a 100-square-kilometer block and a range of stakeholder consultations made to establish the pattern of settlement, land use and investment in the block. During the 2000/2001 project year, over 1,000 sites in the Awach, Nyando and Yala basins were surveyed while 300 sites in Awach were selected for monitoring soil erosion.

Soil erosion and sediment budget calculations:

Atmospherically delivered Cesium-137 (137Cs, t½ = 30.2 years) has been widely used for measuring soil redistribution rates. 137Cs accumulation in East African soils is the result of nuclear bomb testing conducted during the 1960s and 1970s. Deposition of wet and dry fallout occurred after adsorption to aerosols, and regional fallout rates are broadly related to rainfall rates and patterns. Fallout peaked in 1963, and there has been no significant additional fallout since 1976. Upon deposition, 137Cs is rapidly and strongly adsorbed by clay particles in the soil surface – by far the most dominant factors involved in the horizontal redistribution of 137Cs in watersheds are erosion by wind, water and gravity. Depositional soils (sinks) may be distinguished from eroded soils (sources) based on measurement of the sample deviation from a "stable" reference location. In the context of this study, characterization of 137Cs activities of soil samples was carried out using reflectance library principles outlined by Shepherd and Walsh (2002).

Plot studies of the effects of land use and farming practice on soil properties:

Coarse resolution studies were complemented by studies of the effects of land use and agroforestry technologies on soil erosion, infiltration, hydraulic conductivity and runoff in particular plots. Plots were established on farmers' fields to first assess the effects of land use, then to determine the effects of agroforestry and other land-use interventions. Plot-level measurements were aggregated at catchment scale through spatially-based hydrological models.

Emergy analysis.

An emergy analysis was undertaken in order to quantify the costs of soil loss in the Nyando basin in relation to the whole district economy. Emergy analysis enumerates the value of soil based on the environmental work required to produce it, integrating all flows within a system of coupled economic and environmental work in common biophysical units (embodied solar energy or solar emjoules—sej).

2.2 Predictions of erosion hotspots across the Lake Victoria Basin

Map 3 shows the spatial distribution of erosion potential in the Lake Victoria drainage basin. Areas with high indices have highest potential for soil erosion.

Average values for sediment transport capacity index, slope, and Fournier index were computed for each of the basins. The Nyando and Kagera river basins stand out as distinctly different from the others. Nyando basin recorded the highest average sediment transport capacity (0.3) and average slope (5%) in addition to a relatively high Fournier Index (31). The Kagera had an average sediment transport capacity index of 0.24, average slope of 3% and a Fournier Index of 31.

2.3 Sediment and pollution loads in four Kenya rivers draining into Lake Victoria

The four Kenya rivers that were monitored over a four-year period showed considerable difference in turbidity levels, with the Nyando river consistently having the highest levels, the Sondu-Miriu the lowest levels, and the Nzoia and and Yala rivers having similar intermediate levels. All of these pollution levels are indicative of very low water quality– water that should not be consumed; that should not be used for industrial purposes; that may harbour bacteria, viruses and protozoa; and that is associated with high levels of blue-green algae and low populations of fish. Turbidity was highest in 2001, when it rose to as high as 3000 Normalized Turbidity Units (NTU) in the Nyando and 800 NTU in the Yala. While average turbidity levels decreased in 2002 for the other rivers, they remained high for the Nyando, perhaps indicating a loss of buffering capacity in the Nyando. Subsequent surveys undertaken by the Water Quality Component of the Lake Victoria Environmental Management Programme suggest that turbidity levels in the Nyando have not returned to their 2001 levels (See Figure 2.1).

2.4 Quantifying land degradation in the Awach basin

The intrinsic value of soil to national, regional and local agroecological and economic productivity in sub-Saharan Africa is not adequately manifest in financial planning and decision making, challenging long-term sustainability as that resource degrades. While efforts to internalize the external costs of soil erosion in monetary units are available in the literature, an alternative approach is offered based on emergy synthesis, which enumerates the value of soil based on the environmental work required to produce it rather than based on surveys or derived pricing techniques. Emergy synthesis integrates all flows within a system of coupled economic and environmental work in common biophysical units (embodied solar energy or solar emjoules—sej), facilitating direct comparisons

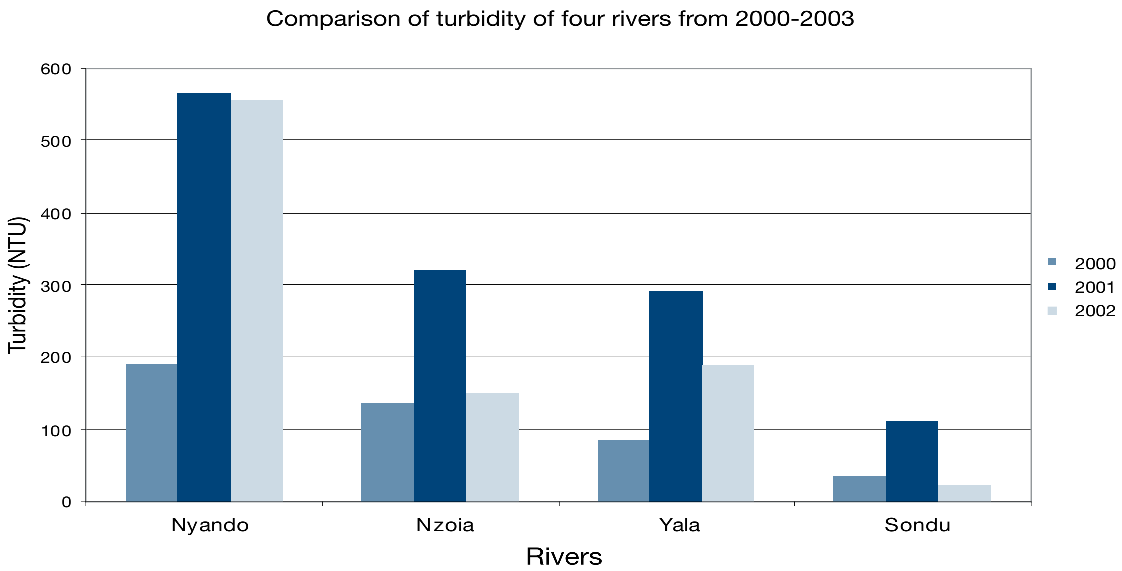


Figure 2.1 Comparison of turbidity of four rivers over four successive years, 2000-2003
Source: Data compiled and analysed by Chin Ong. Previously reported in TransVic Annual report for 2002-3.

between natural and financial capital. Insight into long-term sustainability of human economic production and its basis in natural capital stocks is achieved via a suite of emergy-based indices. The objective was to provide context for the magnitude of soil erosion losses within the larger resource basis of the Kenyan economy at three scales.

The results (Cohen et al., 2006) suggest that erosion losses at the national scale (4.5E21 sej/yr) are equal in magnitude to national electricity production or agricultural exports (equivalent to USD 390 million annually or 3.8% of GDP). This significant hidden, long-term cost is magnified in the selected district economies.

In the densely populated Nyando District (Map 4), it is estimated that soil erosion represents over 14% of total emergy flows. Annual soil erosion in the district is equivalent to total district crop production or 50% of all imports of fuel, goods and services to the district. The soil intensity of agriculture (SIA = agricultural yield/soil loss, both in emergy units) of Nyando (2.25) illustrates a severely marginalized agricultural sector in comparison with the nation as a whole (Kenya, 7.56) or other nations (USA, 81.9; Brazil, 15.6).

Soil loss measurements across land uses typical in Western Kenya allowed emergy evaluation of differential costs and benefits; soil loss represented between 12% and 62% of total emergy use (subsistence agriculture SIA, 8.13, communal rangeland SIA, 1.62). By quantifying the ecological costs of soil erosion in units directly comparable with flows in other sectors of the economic system, this provides a baseline measure of sustainability against which appropriate investment (that is, scaled to problem magnitude, targeted to hotspots) in soil conservation may be evaluated.

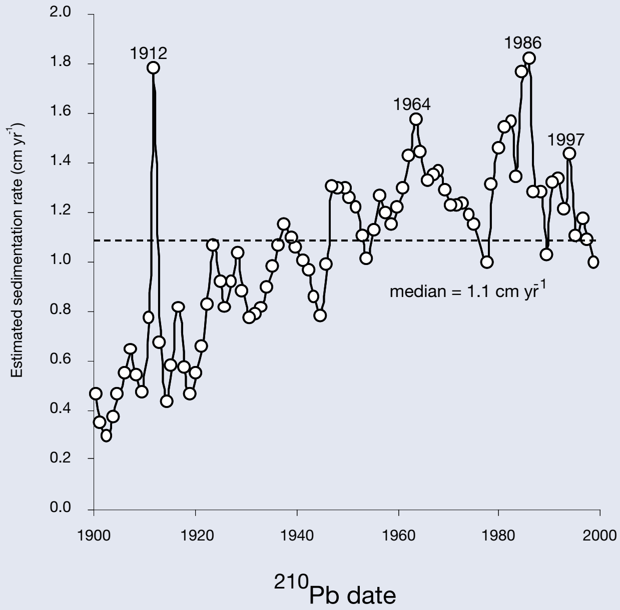
2.5 Land degradation in the Nyando basin

The radionuclide analysis of sediment cores extracted from the Winam Gulf at the mouth of the Nyando River shows that sedimentation at the mouth of the Nyando has increased by between three and four times over the last 100 years. Sedimentation rates peaked during years of major rainfall events associated with the El Niño southern oscillation. These trends suggest that the problems of soil erosion and soil degradation have continually worsened over the last 100 years, while at the same time the land has become more susceptible to large rainfall events (Figure 2.2).

Using Cesium-137 measurements, a preliminary sediment budget (Table 2.1) indicates that sediment source areas currently occupy >60% of the basin, and that rates of soil loss in source areas have not been offset by sediment accretion in sink areas of the basin. This has led to an estimated export of 3.2 x 106 Mg yr^{-1} of sediment to the Nyando River since 1963, severely compromising water quality in the Nyando River compared to other river systems in Western Kenya. Map 5 illustrates the sediment source potential of the Nyando basin and a wider area of western Kenya that drains into Lake Victoria.

Land degradation of this magnitude greatly reduces soil fertility leading to poor crop performance. Soils in source areas of the basin are all depleted of major soil nutrients (nitrogen, phosphorus, potassium) and exchangeable cations rendering them largely unsuitable for conventional agricultural land uses. Similarly, erosion compromises soil physical properties such as soil texture, bulk density, and soil organic carbon significantly decreasing topsoil infiltration capacities of the eroded soils. Figure 2.3 shows soil organic carbon levels for sediment source, reference and sink soils.

Researchers identified, as the most critical hotspot areas, forest margins, the escarpment areas descending on to the Kano Plains, as well as the Nyando basin's wetlands and riparian areas. These areas are either under severe degradation or at a big risk of being degraded due to soil erosion and conversion to cultivation. Map 6 shows the results of an erosion risk assessment for the Nyando basin.



Source: Data compiled and analysed by Markus Walsh. Previously reported in TransVic Annual Report for 2002-3.

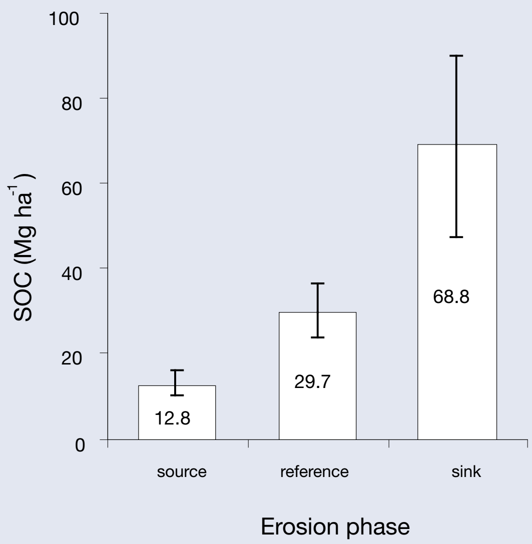
Figure 2.2 Estimated 100-year sedimentation rates of the Nyando River Basin based on Lead-210 (210Pb) chronology. Major peaks correspond to known El Nino periods.

Table 2.1 Sediment budget estimates for the Nyando River Basin (1963 – 2000) with 95% confidence limits

	Average	**Range***
Sources:		
Erosion rate (Mg ha-^{1} yr-^{1})	43.5	40.7 – 69.5
% of basin	61.1	58.3 – 62.4
Sinks:		
Accretion rate (Mg ha-^{1} yr-^{1})	45.5	37.5 – 61.3
% of samples	38.9	36.4 – 41.1
Net erosion rate (Mg ha-^{1} yr-^{1})	8.83	3.81 – 27.5
Total soil loss (Mg x 10^{6} yr^{-1})	3.17	1.36 – 9.86
Sediment delivery ratio (%)	20.1	8.43 – 39.5

* Based on 50 Monte Carlo simulations.

Source: Data compiled and analysed by Markus Walsh, Keith Shepherd and Alex Awiti. Previously reported in TransVic Annual report 2002-3.



Source: Data compiled and analysed by Markus Walsh, Keith Shepherd and Alex Awiti

Figure 2.3. Estimated soil organic carbon stocks for sediment source, sink and reference (stable) phases of soils in the Nyando River Basin. Stocks are expressed on a top-soil (0-20 cm) basis.

2.6 Loss of forest cover and impacts on soil functional capacity

It has long been suspected that deforestation and land cover conversion are a major driving force behind land degradation in the lake basin. Such degradation is manifested by declining soil fertility, accelerated soil erosion, declining in water quality, negative hydrological and atmospheric changes and reduction in land- and water-based biodiversity.

Researchers studied the conversion of the Tinderet, Mau, Nandi and Kakamega Forests into smallholder farming, settlement schemes and into government-sanctioned excisions to create, for instance, the Nyayo Tea Zones. A detailed study of the impacts of forest conversion was undertaken on the forest – cropland chronosequence on the margins of the Kakamega forest (Awiti, 2006). That chronosequence represents the dynamic border areas between undisturbed forest on the one hand and areas used solely for agriculture on the other. The aim of the study was to provide a comprehensive understanding of the extent of deforestation between 1986 and 2000; to identify factors influencing land-use change around the forest and to quantify how changes in land use have affected soil chemical properties and soil fertility. Sites were selected that had been converted for less than 20 years, about 50 years, and about 130 years.

The study found that about 7900 ha (~15.7%) of forest land was converted to subsistence agriculture between 1986 and 2000. This translates to an average annual loss of 1%. Attempts to establish plantation forest through non-resident cultivators (an arrangement commonly known as 'shamba' system) have met with little success. This is mainly because non-resident cultivators, who currently cultivate nutrient-depleted unproductive farms, willfully destroy tree seedlings to extend tenancy and cultivation of these fertile sites for raising subsistence crops. Between 1990 and 2003, farmers cultivating shamba zones contiguous to Kakamega and South Nandi Forests had extended their farmland by about 30 metres into the forest (Map 7).

The study showed that the proportion of tree-derived carbon in whole topsoil samples will have declined to 50% after 37 years of cultivation following the conversion from forest to farmland. Thirty-seven years mark a critical inflection point where the carbon decline switches from a non-linear slow decline phase to a linear rapid decline phase. These findings are consistent with anecdotal accounts by farmers who indicated that loss of fertility (based on maize yield decline) occurred after about 35 years following forest conversion. The implication is that first-generation cultivators after forest conversion will not experience most of the effects of deteriorating soil condition and hence will have the least motivation to adopt sustainable land-use practices. The main effects will be felt one or two generations later. Table 2.2 shows the pathway of decline in soil fertility over the 130-year period.

Table 2.2 Estimates of the decline in soil fertility following conversion from forest to farmland in areas surrounding the Kakamega Forest, Western Kenya

Time Period Since Conversion	Decline in Crop Growth
0 to 20 years	20 percent
Over 50 years	60 percent
After 130 years	92 percent

Source: Alex Awiti, personal communication, based on analysis presented in Awiti, 2006.

The input of soil carbon under subsistence maize was 0.029 kg of carbon per square meter per year (kg C m-^{2}). Conversely, the loss of tree derived carbon was estimated at 0.193 kg C m-^{2} annually over the same period. This indicates that the rate of decay of tree-derived carbon was seven times higher than the rate of accretion of derived carbon from agricultural crops (predominantly maize-based) (See Figure 2.4).

In soils with distinct aggregate structure such as those considered in this study, cultivation leads to a decline in the proportion of soil macroaggregates and an increase in the proportion of soil microaggregates. This has effects on infiltration and water retention. The study showed that available water storage capacity declined by between 25% and 63% in cultivated soils relative to forest soils.

2.7 Land cover conversion and land degradation

Over the last 150 years the most important land cover conversion pathways in the Nyando basin have been characterized by substitutions of vegetation dominated by trees (characterized by a C3 photosynthetic pathway) to vegetation dominated by grasses and annual crops (characterized by a C4 photosynthetic pathway). Evidence from stable carbon isotope (that is, ^{13}C) studies, that preserve the signatures of these past conversions, suggest that historically, grass- and cereal crop- based land-use types are strongly associated with elevated soil erosion risk in this environment.

Another major finding was that areas dominated by crops and grasses are approximately 16 times more likely to be affected by severe sheet, rill or gully erosion than areas dominated by trees.

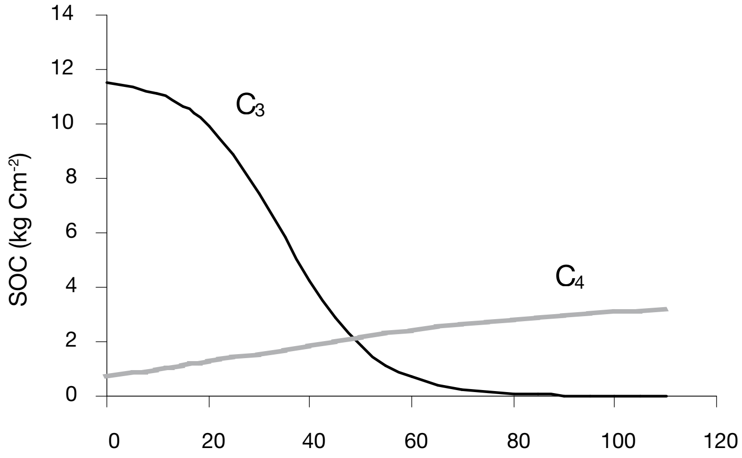
In an effort to establish the historical cumulative relationship between land cover, erosion and soil fertility decline, scientists established that land cover conversion from forests and bush lands to grasslands and croplands may have been 6.7 times more prevalent than the other way round. Secondly, they found that tree cover may have been two to three times greater in Western Kenya 60 years ago than it is today. This massive conversion has had a major impact on increasing soil erosion and reducing soil fertility in the basin.

Soils dominated by trees also have richer nutrient stocks. In places where the top soil (from 0 to 20 cm) is dominated by crops and grasses, soil organic carbon lies between 3.5 to 4.1 mg ha-^{1} while those dominated by trees have between 10.3 and 11.9 mg ha-^{1}. Differences of similar magnitude were observed for soil nitrogen content. Further analysis showed that more than 60% of the changes in current soil organic carbon and nitrogen content could be explained by historical land cover and erosion effects.

These findings suggest the need to maintain tree-based systems in the lake basin as they might be able to prevent soil erosion, maintain soil fertility and sequester more carbon and nitrogen than crop-based systems. Overall, the results show that it takes about 30 years for soil nutrients to be depleted to a productivity level about half of the pre-conversion level.

2.8 The need for large-scale land restoration programmes in the Nyando

The implications of these findings are that a sustained, large-scale rehabilitative effort would be required to reduce non-point source pollution loads and restore primary production capacity of the Nyando basin to pre-20th century levels. Self-reinforcing interactions between soil erosion, fertility depletion, loss of infiltration capacity and woody vegetation cover decline preclude the possibility of spontaneous recovery of this area. The lower portion (<1400 masl) of the basin, and a large area located between the northern boundary of the Mau and the southern boundary of the Tinderet forests may now be particularly vulnerable to the return of a big rainfall event (for example, El Niño). Spatially targeted measures are needed to protect these areas from further mass wasting, and basin-wide emphasis should be placed on re-establishment of woody vegetation cover in currently agriculturally “unproductive” source areas. The major



Source: Awiti, 2006

Figure 2.4. Model of decay and accretion patterns of Forest (C3) and Maize (C4) derived soil organic carbon relative to time since conversion

challenge therefore, is how to maximize the off-take of above-ground carbon (harvest of vegetation as crops, forage and wood) while maintaining sufficient vegetation cover to minimize adverse consequences of soil erosion, nutrient depletion, and eutrophication of Lake Victoria.

The type of management priorities in each watershed area are (Walsh, 2002; Awiti, Walsh and Omuto, 2002):

Sink areas: Management priorities are to protect these areas from further encroachment and to restore their buffer function. Controlled use of the wetland and diversion of the river into many small channels could help to restore the utility efficacy of the wetland.

Fast erosion areas: The key management objective on this type of land is to prevent soil hardsetting and the initiation of gully formation. Maintenance of adequate vegetation cover is important (60% permanent vegetation cover rule). Key objectives will be to shift management practices away from annual cropping towards management systems that ensure more permanent vegetation cover. Priority is to be given to fragile areas nearest to water courses.

Slow erosion areas: These areas are suited for cropping, but require more intensive nutrient and organic matter management and soil conservation to rebuild soil structure, to restore soil tilth and to raise yields. Priority will be given to activities that provide incremental improvement of production capacity through conservation agriculture (P additions, improved fallows, biomass transfer, diversification of production including tree products and fruits, etc.). Reintroduction of woody species, where historically appropriate, is recommended.

The project has achieved greatly improved understanding of how differences in vegetation cover affect erosion and infiltration properties. Experiments involving the erection and monitoring of "erosion pins" showed that vegetation that was in direct contact with the soil surface – termed contact cover[1] — was extremely effective in preventing erosion. This implies that if a dense contact cover can be maintained in the degraded areas of the lake basin, then much of the erosion problems would be done away with. These experiments allow scientists to provide better advice to farmers, extension workers and the government on the particular areas within the basin that need urgent protection and restoration.

Chapter 3. Assessing interventions for countering land degradation and enhancing welfare[6]

3.1 Participatory research with farmers, groups and communities

Participatory research on interventions for countering land degradation problems was undertaken through the extension activities of National Agriculture and Livestock Extension Programme (NALEP). NALEP employs a shifting focal area (FA) approach to extension, in which a team of extension workers work intensively with a group of between 200 and 400 farm households over a 12-month period, then moves on to a new area in the following year. Between 2000 and 2004, the TransVic Project engaged with the NALEP project in 28 focal areas spread across seven districts (Kericho, Kisii, Nandi, Nyamira, Nyando, Vihiga and Siaya) and a variety of land management problem domains (uplands, escarpments, lakeshore, wetlands). Engagement in these focal areas provided the project with easy access to over 10,000 farm-families, providing researchers with ample opportunities to understand farmer problems, evaluate techniques with them, and assess the impacts of research and extension. Trials with new technical interventions were undertaken in the context of the focal area activities.

3.2 Agroforestry options for degraded cultivated lands

Participatory agroforestry trials were undertaken with almost 400 farmers in six of these focal areas in the lower Nyando basin. These trials focused on the effectiveness of different improved fallow species, mixtures and management options on striga (*Striga hermonthica*) infestation and maize yield in different soil types and focal areas in the Nyando basin. Striga is a prolific parasitic weed that is widespread in the low-rainfall high-temperature areas of the Lake Victoria basin. Fallowing with selected nitrogen-fixing shrubs can improve soil fertility while biologically controlling striga. Improved fallow species that have been proven to be well-suited to the higher rainfall areas of Western Kenya, *Cajanus cajan* (pigeon peas), *Sesbania sesban*, *Grilicidia sepium* and *Desmodium distortum* were planted as fallow mixtures with the herbaceous legumes *Desmodium unicinatum* (silver leaf desmodium) or *Macroptilium atropurpuren* (siratro). The management strategy involved continuous harvesting of the herbaceous legume or leaving it to grow until the end of the fallow period. *Crotalaria grahamiana* and *Tephrosia candida* were also grown as short-duration fallow mixtures.

ICRAF typically undertakes three types of agroforestry trials on farmers' land. Type I trials are planned and managed by researchers; farmers are compensated for the use of their land and are involved in discussions and demonstrations of the results. Type II trials are planned by researchers, but managed by farmers. Type III trials are planned and managed by farmers. Type I and type III trials were undertaken as part of the project.

Type 1 trials. Type I trials were undertaken with 130 farmers in the Katuk-Odeyo, Kobong'o, Chebitet, and Burkamach focal areas. Kobong'o is located along the Nyando river, in the Kano plains. With one exception, *Tephrosia candida* produced the highest amount of foliar biomass in all of the sites, followed by *Crotalaria grahamiana*. Although not as productive as tephrosia, sesbania and *Cajanus cajan* did well in all sites except for the cases of livestock damage in some sites. Maize yield increased following the improved fallows in Kobong'o and Burkamach but not in Katuk-Odeyo and Chebitet. The greatest yield increase in Kobong'o was associated with a mixture of *Crotalaria grahamiana* and *Tephrosia candida*. In Chebitet, even though the improved fallow productivity was high, the crop following the improved fallow was affected by drought and performed poorly. In Katuk-Odeyo maize yield was consistently low due to the high level of striga infestation. Reduced striga infestation was

[6] This chapter is based on the work of Eva Gacheru, Qureish Noordin, Mwangi Hai, Chin Ong, Duncan Onyango, Kelebogile Mfundisi, Robert Zomer, Lou Verchot, Thuita Thenya, and Simon Oyasi.

observed after the improved fallows in Kobong'o and Burkamach, especially following *Sesbania sesban* and in plots where the herbaceuous legume was left intact (Figure 3.1).

Type III trials. The improved fallow technology was also tested with farmers in type III trials. These trials were conducted in six focal areas, with inputs from ICRAF, NALEP and KARI staff. The objective of the type III trials was to avail improved fallow techniques to farmers in the drier and more degraded parts of the Nyando basin and to determine their performance under farmer management. A total of 247 farmers participated in those trials.

Across the focal areas, *Tephrosia candida* and *Crotalaria grahamiana* yielded the highest biomass. The highest biomass yield was observed in Jaber, Ombaka and Kipsiwo producing 3.56, 3.83 and 2.98 t ha^{-1} of foliage manure respectively. In Burkamach and Chebitet, foliage production was 1.39 and 1.15 t ha^{-1} respectively, while in Katuk-Odeyo the trees failed to establish. Fuel wood production was more than twice the foliage biomass in most cases. The number of farmers experimenting with the improved fallow systems was highest in Burkamach and Jaber. The type I and type III trials produced similar results: *Tephrosia candida*, *Crotolaria grahamiana*, *Crotolaria paulina* and *Cajanus cajan* produced the highest amount of green manure, yielding 3.22, 3.00, 2.00 and 2.28 t ha^{-1} of foliage. Species preferred for repeated planting or expanding in acreage were *Crotalaria grahamiana*, *Cajanus cajan*, *Tephrosia candida* and *Crotalaria paulina* in order of preference. Species preference was based on ease of establishment and unpalatibility by livestock.

Generally, these results have illustrated that the improved fallow technologies that have been proven to be effective in the high-potential highlands of Western Kenya cannot be simply transferred to the degraded lowlands in the Nyando basin. While some fallows have generated two to three times higher crop yields than control yields, such results are by no means assured. The results suggest that the performance of the fallows is very sensitive to the date of planting relative to the date of the rains.

Another agroforestry option that may have greater potential in the medium term is hedge-row intercropping with *Gliricidia sepium*. Type I trials with gliricidia were initiated in the latter years of the project, but had not been fully tested at the time field studies ended in 2004. It has become apparent that a more sustained and more patient approach will be needed to identify and test new agroforestry options for the systemic land degradation problems of the Nyando river basin.

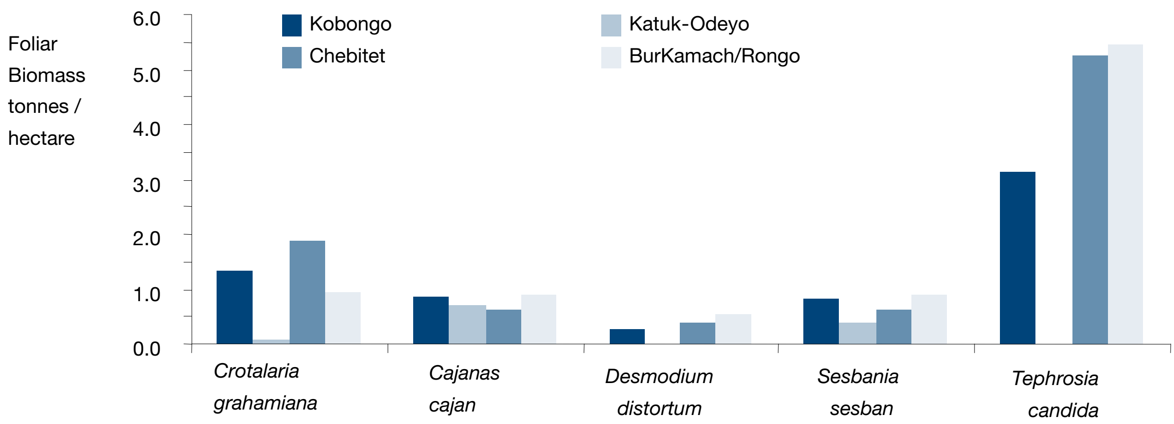


Figure 3.1. Improved fallow productivity (Foliar biomass /green manure) 2001

Trials with dozens of indigenous tree species were also initiated in the latter years of the project.

3.3 Impacts of land use and interventions on runoff and erosion in the lower Nyando basin

A senior staff member from the Kenya Ministry of Agriculture, Mwangi Hai, led a study of runoff and erosion in badly degraded parts of the lower Nyando basin, with the objective of better understanding the link between upstream land use and downstream degradation. Detailed monitoring was conducted at Burkamach, a 54-hectare catchment in the watershed. Research during the first years focused on assessing the runoff and soil loss associated with different land-use types, while research in the latter years focused on assessing the effects of different interventions.

Table 3.1 shows the mean runoff, soil loss, and nutrient loss measured for 46 rainfall events in 2001/2002. Although occupying small fractions of the total landscape, badly degraded grazing lands and footpaths contribute the most runoff, soil loss and nutrient loss. It is somewhat surprising that soil loss from degraded grazing lands suffers three times more soil loss than footpaths, which normally record by far the highest rates of runoff and soil loss. Bushlands, on the other hand, have surprisingly low rates of runoff, soil loss and nutrient loss, while cultivated fields have intermediate levels of runoff and soil loss. These results imply that restoring degraded grazing lands and maintaining bushland should be high priorities in this area.

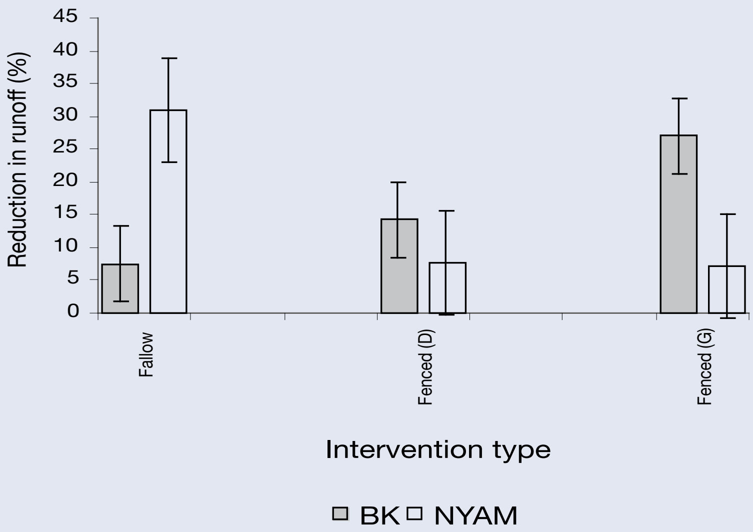
Two types of interventions were established in two sub-catchments of the Ragen catchment, Burkamach and Nyamarimba. Degraded and normal grazing plots were fenced off to allow natural regeneration to take place. On crop plots, a short season fallow of *Tephrosia candida* was relay-planted with maize. After one year, all of the interventions reduced runoff, although by relatively small amounts ranging between 5% and 30% (see Figure 3.2).

Table 3.1 Mean runoff, soil and nutrient loss for plots in the Ragen catchment

Land use type	Runoff (%)	Soil loss (T/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)
Footpaths	26.5	14.9	9.9	2.1
Cultivated fields	13.5	17.2	4.3	0.9
Normal grazing	19.0	6.6	4.1	1.1
Degraded grazing	36.4	45.4	5.7	0.8
Bushlands	1.0	0.1	0.2	0.0

(n=46 rainfall events for runoff and n =11 events for sediment and nutrient analysis)

Source: Hai and Ong, reported in TransVic 2001/2002 annual report, Swallow et al, 2002)



BK is the Burkamach sub-catchment, NYAM is the Nyamarimba sub-catchment. Fallow is a short-duration fallow of *Tephrosia candida.* Fenced (D) is a degraded grazing area. Fenced (G) is a normal grazing area.

Figure 3.2. Indications of effectiveness of interventions based on comparison of late 2000 and late 2001 plot runoff in the Ragen catchment.

3.4 Agroforestry options for riverbank stabilization

A study of the causes, patterns and magnitudes of soil erosion along the lower portion of the Nyando river was undertaken by Duncan Odiwuor Onyango and Chin Ong. The study was conducted at Kobong'o village of Nyando District on an area of 2 x 2 km^2 straddling the river (one of the villages involved in the participatory agroforestry trials described in the previous section on agroforestry options). Specifically the study determined historical land use changes and river dynamics in the study area, quantified and compared runoff, sediment and nutrient (nitrogen and phosphorus) loss from different land uses, and determined intervention points and appropriate agroforestry techniques that attract farmer participation for riparian buffer zone management. Land-use patterns were monitored from 1948 to 2000 by use of aerial photographs. Participatory Rural Appraisal techniques were used to capture local opinions on riparian management. Four different land-use systems were studied and compared for runoff loads by use of a pipe sampler: sites under cultivation (farms); bushland; paths and cattle tracks; and grassland. A general slope of 1% was considered when placing the enclosures to ensure flow to the outlet. Selected runoff events were combined for each land use.

The mean land-use area by types are summarised in Table 3.2. In 1948, bushland covered an estimated 3.7% of the Kobong'o area. By 1967 this had reduced to a mere 0.5% and by 2000 it had risen to 2.1%. Riparian deforestation is obviously not a recent event. Grasslands halved from 70.3% to 36.8% from 1948 to 2000, while farmlands doubled from 23.4% to 54.9% of the area. There is an increasing tendency to concentrate farms along the riverbank. Within 20 meters of the riverbank, cultivation has increased from 0.2% in 1948 to 12% in 2000.

Table 3.2 Area under specified land uses in the Kobong'o study area, 1948 to 2000

YEAR	Units	Farmland	Bush land	Homesteads	Grasslands	River	Total area
1948	Hectares	93.6	14.8	2.4	281.2	8.0	400.0
	% of area	23.4%	3.7%	0.6%	70.3%	2.0%	100.0
1963	Hectares	111.4	12.0	4.7	259.4	12.5	400.0
	% of area	27.9%	3.0%	1.2%	64.9%	3.1%	100.0
1967	Hectares	264.5	1.8	2.2	119.1	12.3	400.0
	% of area	66.1%	0.5%	0.6%	29.8%	3.1%	100.0
1979	Hectares	183.3	6.0	13.8	186.6	10.3	400.0
	% of area	45.8%	1.5%	3.4%	46.6%	2.6%	100.0
2000	Hectares	219.5	8.4	12.5	147.0	12.6	400.0
	% of area	54.9%	2.1%	3.1%	36.8%	3.1%	100.0

Source: Onyango, 2003, p. 36.

Runoff, soil and nutrient loss from different land-use types is given in Table 3.3. The collected runoff volumes were compared as mean amount generated per rainfall event from $100m^2$-land use type enclosure. The results show that runoff and soil loss were highest on paths and cultivated plots. Grasslands were the most protective form of land use. Nitrogen loss per mm of runoff was roughly equal across the four land-use types, while phosphorus runoff per mm of runoff was considerably higher on bushland and farms than on grasslands and paths.

Local community perceptions of riparian areas: The area was previously referred to as *thim* (Luo for a heavily forested area inhabited by wildlife) and was settled in the early 1900s. The area was forested with trees about 25 meters tall with an approximate diameter at breast height of between 60 and 90 centimeters. Significant changes began to occur in the 1940s, including loss of forest area and disappearance of wild animals. The causes of the stated change are extensive clearing for cultivation, settlement, clearing for fuelwood and charcoal, destruction by cattle,

Table 3.3 Mean Runoff per event, soil and nutrient loss from different land use types.

	Paths	**Farms**	**Bushland**	**Grassland**
Mean Runoff per rainfall event (mm)	1.95	1.07	0.90	0.65
Soil loss Kg/ha/mm of runoff	6.2	0.40	0.30	0.10
Nutrient loss N (g/ha/mm of runoff)	0.36	0.52	0.55	0.55
P (g/ha/mm of runoff)	0.04	0.10	0.12	0.05

domestic constructions and climatic change resulting in drought and flooding.

Observable land degradation began to occur in the 1960s. This included riverbank collapse, gully formation, widening of riverbed and change in river course. Gully formation and bank breakage resulting in flooding are recent developments originating in the late 1980s. They are jointly caused by concentration of runoff on paths, deforestation, livestock trampling and increased rainfall volumes. Few control measures have been put into place.

These results indicate that degradation within the riverbank area in Kobong'o is due to three causes: (1) Conversion of most of the riparian land areas into farms and or pastures, due to land pressure and a lack of enforcement of laws on the use of riparian areas; (2) Poor methods of land exploitation resulting in much runoff generation, soil and nutrient loss originating from the exploited land areas; and (3) Lack of awareness on the long-term importance of good riparian management practices.

3.5 Wise use of wetlands

Two long-term studies of the Yala wetland were undertaken through a collaboration between ICRAF and the ZEF at the University of Bonn. Kelebogile Mfundisi (a national of Botswana) studied carbon pools in the Yala Swamp while Thuita Thenya (a national of Kenya) studied utilization of wetland resources. The Yala wetland was chosen for this study because large amounts of the wetland was still intact at the beginning of the study, though under threat of large-scale conversion to commercial-scale irrigation.

Soil and biomass carbon pools in the Yala Swamp of Western Kenya were analyzed using principles of landscape ecology through remote sensing and GIS techniques. Two Landsat images are used to estimate land-use and land-cover change over the swamp between 1984 and 2001. It is found that 6,333 ha of the swamp were drained for agricultural production during that period.

The impact of human activities on the carbon pools, carbon dioxide emissions, and nitrogen content were estimated using soil samples from the 0-20 cm topsoil layer. Soil samples collected from relatively undisturbed wetland and drained wetland areas were analyzed for soil organic content and total nitrogen. It was found that natural wetland areas contain higher soil organic content and total nitrogen than adjacent drained areas. The average soil organic content in natural wetland topsoil (0-20 cm) was 5.63 ± 4.9%, while that for drained areas was 2.31± 1.61%. The total nitrogen values for intact and drained wetland areas were 0.40 ± 0.3% and 0.22 ± 0.1%, respectively. Soil organic content and total nitrogen were found to be highly correlated for both natural wetland and drained areas. A comparison with the Nyando Swamp shows that the carbon stocks found in the two swamps are similar. Covering 15,267 hectares, the Yala Swamp stores 1.2 million tons of carbon in the top 20 cm alone. For the sum of all swamps around Lake Victoria, this amounts to 1.8 million tons of carbon.

In addition to its effect on climate change, destruction of the carbon pools affects ecosystem productivity, the various functions of wetlands for biodiversity, and the regional carbon cycle. For the 6,333 ha converted to date, 104,494.5 tons of carbon were lost from the top 20 cm of the soil. Unlimited access by farmers to the swamps around Lake Victoria for drainage and conversion to agricultural land could release 1.87 million tons of carbon to the atmosphere. Meeting the human need for food in the area, while sustaining the integrity of its biogeochemical cycles and swamp ecosystems is a challenge to farmers and policy makers alike.

Thuita Thenya undertook a study of the utilization of wetland resources in the Yala basin with particular reference to the impacts human activities have had on the Yala swamp. The overall aim of this study was to assess sustainable strategies of wetland resource utilisation as well as the human impact on the Yala swamp ecosystem. The study involved a number of complementary approaches, namely (i) socioeconomic survey measurements on macrophyte growth dynamics, (iii) plant, soil and water analysis, (iv) remote sensing and (v) geographical information systems. Land-cover changes and resource use interactions were analysed retrospectively to delineate: (i) principal drivers and trends of the trajectories of future land-use change on the local communities, and, (ii) field dynamics.

Wetland resource utilization in the whole of Yala swamp was investigated using a structured questionnaire. The socio-economic results indicated that Yala swamp provides a wide range of support and products to the local communities (see Table 3.4). These include mats, papyrus ropes, thatch material, fish, vegetables, forage and firewood. Other uses include small-scale farming, grazing, sand and soil harvesting for brick making, and water withdrawal. Approximately 70% of the wetland products are used at the domestic level with the rest being used to generate modest incomes. Alternative sources of income are rare, especially during the extended dry season. Marketing of wetland products is ineffective, resulting in low profit margins, which again discourage sustainable wetland use. Nevertheless, farming is an important activity, which engages 90% of the farm holdings in the swamp and supplies about 70% of the domestic food requirements. It is no surprise that with respect to future development, most of those questioned preferred to convert swamp into farmland.

The field measurements encompassed harvesting biomass and post-harvest growth rates of *Cyperus papyrus*, *Phragmites mauritianus*, *C dives, C distans*, *Echinchloa haploclada* and *Typha domingensis*. In addition, plant materials were analyzed for nitrogen and phosphorous calorimetrically after Kjeldahl digestion. Macrophyte post-harvest growth characteristic results indicated a high mean growth rate in the first four weeks ranging from 5 to 300%. This was followed by a lower growth rate averaging 1-30% in the next ten weeks. The less disturbed sites recorded higher mean growth rate after the first four weeks of between 10 and 30% compared to the highly disturbed sites, which had growth of 1% to 15%. The growth rate after the 14th week was highly diminished in all the species. Comparative data on macrophyte that were not harvested showed insignificant gain in height after the 14th week. Even during the dry season, fast growth was restricted to the first 14 weeks, but with overall reduction in average height gain, growth rate and biomass in all the eco-types. This variability was attributed to seasonal ecological dynamics and not to the effect of repeated harvesting. The average biomass was about 1050 grams dry weight per m^2, similar to other tropical papyrus wetlands. In addition, there was a 50% change between the wet and dry season. Macrophyte nutrient content was high both in the flooded and swamp edge species with an N:P ratio ranging between 6.0 and 3.5, which was above ecological limiting levels. These results indicate that the macrophyte can be sustainably harvested at an interval of 14 weeks if the natural ecological setup is maintained.

Table 3.4 Average Monthly Household Income from Swamp Products (in USD)

Village	vegetables	Soil for brick making	Fishing in the swamp	thatch	Crafts items material	Wood fuel	sand	Harvesting forage	poles
South	20.82	0.07	27.86	8.88	15.57	10.28	17.04	rare	4.63
North	25.99	19.47	16.53	23.08	22.53	12.14	10.12	7.89	5.26

Source: Thenya 2006.

Ecological dynamics in the wetland were assessed through analysis of selected soil and water parameters. Laboratory analysis encompassed the following techniques: total nitrogen (N) (Kjeldahl method), total phosphorus (P) (Mehlich's double acid method), soil exchangeable potassium (K) (flame photometer after extraction), soil pH (extraction made to a ratio of 1:2.5 with water pH), water soluble carbon (Walkley-Black method), soil cation exchange capacity (measured total cations in the leacheates), electrical conductivity (through electrode) and soil bulk density (using standard disc on natural sites).

Macrophyte growth patterns indicated pronounced temporal and spatial trends, which correlated well with the variability in ecological dynamics in both water and soil. Ecological conditions were more favourable for macrophyte growth during the wet season (as compared to the dry season) and in the less disturbed eco-types (as compared to the highly disturbed eco-types). While soil parameters were significantly influenced by the eco-type, but only varied marginally among seasons. In contrast to the soil, the water chemistry was influenced more by the seasons relative to eco-types. Both soil total N (0.25 -0.3%) and P (0.07- 0.06%) and water P (0.03 - 0.14 mg/l) and N (3.72- 2.01mg/l) were above ecological limiting levels.

Land-cover analysis was done using Landsat satellite images taken in the dry season (February 5, 1973, MSS and February 2, 2001 ETM). In the identified seven land-cover classes, the most prominent change was noted in over three-fold increase in the agricultural area from 1564 ha in 1973 (corresponding. to 7 % of the total wetland) to 5939 ha in 2001 (corresponding to 28% of the total wetland). However, these changes excluded temporary land use during other seasons. Based on field survey, two vegetation communities were identified, namely the bushes-sesbania community (2359.96 ha) and sedge-latifolia community (3435.64 ha), which are periodically converted. Most of the land conversion was located along the swamp edges and in particular on the northern and eastern side of the swamp, where accessibility was good. The satellite images also allowed identification of siltation area, which had increased, along the Lake Victoria shoreline. The overall classification accuracy was high at 75% with Kappa statistics at 70%. The NDVI showed a high reduction of the positives values, i.e. from +0.909 in 1973 to +0.405 in 2001, which was mainly due to the reduction in the vegetation cover. These changes were attributed to anthropogenic activities, mainly farming, in the swamp.

Land-use change assessment involved integration of household and census data with the processed images. The scale of integration was at the administrative level of 'Location'. The main driving factors for land use changes in the Yala swamp were identified as (i) household numbers, (ii) household and population densities and (iii) the wetland accessibility (combining swamp coverage and terrain suitability). Areas with high swamp coverage and suitable terrain had higher conversion rates. These drivers act as proxy for a whole range of factors, in particular the demand for farming land.

In conclusion, it can be stated that under the current utilization scenario, swamp conversion is expected to increase as a function of the household densities. However, the big challenge is to balance between increasing swamp farming and sustainable ecosystem utilization like macrophyte-based water filtering. Hence, there is need to reinvest in the resource-use strategies, wetland products marketing systems and ecosystem level management to stem resource degradation and increase benefits to the local communities.

3.6 Water point management

As the TransVic project unfolded, improved water point management emerged as an area that generates good returns to farmers and significant development and environmental benefits. Most people in the Nyando basin rely on unprotected and unsafe water supplies, even where there are relatively simple technical innovations that could be put in place to better harvest available water. Yet, many communities rate better water supplies as one of their top priorities. At the broader basin level, water point management can also contribute to better watershed management through reduced mobility of livestock, reduced sheet and gully erosion, and conservation of biodiversity around spring heads. Research conducted to date indicates that there are a few key reasons for this discrepancy between need and action: (1) high cost of private water sources compared to more collective approaches; (2) difficulties with initiating and sustaining local social organization around water management; (3) under-investment in land resources which are privately owned, but publicly used; (4) gender roles that separate responsibility for water point development from responsibility for household water provision; and (5) land tenure arrangements that restrict group investment on private land.

Under the TransVic Project, a Masters student supported by the British Council conducted a preliminary study of the impacts of community-level water management activities in the Kipsiwo focal area in the upper Nyando basin of Nandi District and in the Ragen focal area in the lower Nyando basin of Nyando District. A qualitative impact assessment study undertaken in 2002 showed large improvements in human health, better school attendance, time savings for women and children, and increased production of tea and other tree seedlings (Abraham, 2002).

Studies of water management in the Nyando basin have continued since early 2004, largely implemented by graduate students and collaborators from Maseno University and the NGO, Sustainable Aid Network for Africa (SANA), and financed through a number of donor agencies and projects. These projects have advanced the following four general objectives: 1. I*nventory*—to quantify the importance of different types of water sources across the Nyando basin. 2. *Water governance* —to understand the community processes involved in organizing improved water supply and ultimately, to clarify the critical factors in successful water governance. 3. *Water–livelihood connections*—to improve knowledge of the relationship between lack of access to safe water and poverty and to better understand the how improved access to water can lead to improved livelihoods. 4. *Water rights and gender and equity* —to illuminate the relationships between water rights, land rights, access to and use of water.

Results generated since mid-2004 include: quantification and mapping of the importance of different water sources in the upper and lower parts of the Nyando basin; the challenges that community groups face in attempting to organize improved water management, particularly the challenges associated with gender responsibilities and roles; the strong potential for successful collective action that fortunately does exist in many villages, particularly those that are relatively homogenous and relatively prosperous; the large welfare improvements that can result from easier access to moderate amounts of safe water for domestic consumption and small-scale productive use; and the impediments to community water management that are implicit in Kenya's 2002 Water Act.

Table 3.5 illustrates just one of these points: the mix of domestic uses and small-scale productive uses by people in one village when small amounts of water became available at water points in their compounds due to successful collective action for spring protection and piping.

Table 3.5 Average daily water consumption for households with and without piped water.

Household use of water	Average liters used per day reported by households with piped water	% of water by use reported by households with piped water	Average liters used per day in households without piped water	% of water by use reported by households without piped water	Average higher consumption in households with piped water	% higher consumption in households with piped water
Livestock consumption	94.0	28.1	64.4	35.5	29.6	46
Kitchen garden irrigation	45.7	13.7	15.7	8.7	29.9	190
Bathing	41.8	12.5	15.1	8.3	26.8	178
Washing clothes	37.8	11.3	3.6	2.0	34.2	937
Tea seedlings irrigation	37.0	11.1	22.4	12.3	14.6	65
Washing utensils	32.8	9.8	20.6	11.4	12.2	59
Cooking	26.7	8.0	21.2	11.7	5.5	26
Human consumption	15.8	4.7	15.1	8.3	0.8	5
Resurfacing floor	2.6	0.8	3.4	1.8	-0.8	-24
Total	334.2		181.4		152.8	84

Source: Were, Swallow and Roy (2006). Calculations based on household surveys of 30 women using water from protected and piped sources and 39 women using water from unprotected springs

3.7 Institutional innovations for watershed management

When the TransVic Project began in 1999, there was very little discussion or policy support for collective action in watershed management in Kenya. Experiences from India, The Philippines and elsewhere in the developing world indicated that effective collective action is necessary at two levels: 1) at the level of community or village groups who collectively manage micro-catchment areas, village territories, and/or particular water resources; and, 2) at the level of public authorities and formalized resource users groups that collectively manage catchments and the water resources of rivers or large water bodies.

In 1999/2000, a study of the potential and constraints for village and inter-village level watershed management was undertaken in the Katuk-Odeyo and Chebitet area, an extreme environmental "hotspot" in the Asawo and Awach sub-basins of the Nyando river basin. The study area is inhabited by two ethnic groups, the Luo and the Kalenjin who inhabit the lower and upper parts of the basin respectively. It is ravaged by severe gully erosion and ravines, which develop into badlands – arid and barren landscapes characterized by erosion of the soft surface strata. The study drew on a variety of secondary information on the area, including catchment maps and PRA reports by the National Soil and Water Conservation Programme, among other sources. Field research was conducted using participatory monitoring tools which included mapping exercises, extensive transect walks, historical trend lines, historical resource analysis, resource flow maps, institutional analysis, focus and key information discussions, and informal discussion sessions with groups and individuals (Map 8).

The results showed the similarities and contrasts between the two groups. While both communities were polygamous, male-headed polygamous households among the Luo were more than double those of the Kalenjin (17% and 8% respectively for the Luo and the Kalenjin). Clan affiliation is of great importance among the Luo, but less important to the Kalenjin. In both communities, religious institutions play strong development roles and common-use areas such as cattle dips, schools, gullies and riverine strips are located on individually-registered land, a disincentive for community rehabilitation and maintenance. Luo people in the lower part of the catchment frequently lease land in the upper part of the catchment from Kalenjin people for crop production and grazing. Leased lands tend to be badly degraded since tenants have little incentive to invest in soil conservation for land they do not own, and there are no strict rules governing the use of leased land. While there are several external government and non-government development agencies active in Katuk-Odeyo, their activities are neither co-coordinated nor collaborative. Residents feel that most of these agencies "ignore the people".

At the same time, a study of the legal foundations of watershed management was undertaken through a contract with the African Center for Technology Studies (ACTS). The review concluded that the appearance of community groups in the environmental field has upset the dominant institutional actors in resource management (notably the central government, NGOs, and private sector). Community groups carry considerable weight in their areas of operation, although their activities, size, official status and finances are severely constrained by a lack of sound legal and institutional capacity. There is urgent need to nurture these groups to enable them to grow and to find their role in the social sectors where they are born and where they operate. As of the year 2000, none of the legal associations available in Kenya were specifically designed for registration of groups for the management of water or land resources. Some of them are, however, suitable for adoption by groups with such interests. For small ventures in the management of watershed resources the best form of organizations appear to be registration of self-help groups under the Ministry of Social Services. Larger groups that can bear the costs of registration should consider forming cooperative societies.

These two studies were reviewed and considered in a series of three one-day workshops on the institutional foundations of watershed management convened in April and May 2001. The workshops involved approximately 80–100 people, representing the Ministry of Agriculture and Rural Development, other government agencies, non-governmental organizations, donor agencies, research organizations, universities, community groups and provincial administration. The first workshop focused on "design principles for watershed management institutions" related the situation in Western Kenya to the international experience with community-based natural resource management and watershed management. The proceedings document lists a number of design principles (Wangila and Swallow, 2001). The second workshop focused more specifically on the situation in the Lake Victoria, considering basin-level management issues, as well as issues related more to specific parts of the basin (eg wetlands, farmlands) (Muriithi, Okono and Swallow, 2006a). The third workshop involved a smaller number of participants and concentrated on the development of an action plan for the Katuk-Odeyo and Chebitet areas (Muriithi, Okono and Swallow, 2006b).

One of the recommendations of the third workshop held in May 2001 was the establishment of an "umbrella committee" to link the Focal Area Development Committees of the Katuk-Odeyo and Chebitet focal areas. This committee was indeed established in 2001 and was still in existence four years later. The umbrella committee has played a key role in coordinating collective action for water management and gully rehabilitation across the two areas. This institutional innovation addresses the "missing middle" of watershed management—initiatives that link adjacent community groups to address shared or common problems.

In 2002/2003, ICRAF co-hosted a major workshop on 'Reversing environmental and agricultural decline in the Nyando river basin' (proceedings published as Mungai et al, 2004). This workshop sought to address watershed management issues at the scale of the entire 3517 km^2 river basin, bridging across the three districts, various government ministries, and the greater group of stakeholders with interests in water management in the basin. The co-conveners of the workshop were the National Environmental Management Authority (NEMA), the Ministry of Agriculture and Rural Development (MoARD), the Water Quality Component of the Lake Victoria Environmental Management Programme (LVEMP)—Kenya, and the World Agroforestry Centre (ICRAF). The workshop was attended by approximately 100 persons, including representatives of the co-convening agencies, provincial and district authorities responsible for administration, agriculture, environment, health and water, non-governmental organizations active in the basin, universities and research institutes, donor agencies and farmers. After reviewing evidence on the nature of the problems, potential solutions, the workshop agreed upon the following action plan for reversing environmental and agricultural decline in the Nyando.

1. Strengthen support to farm management, enterprise development and conservation

a. Promote agroforestry, soil fertility management and soil conservation techniques on farmers' fields. Improved fallows should be widely promoted in the upper part of the basin; natural regeneration should be widely promoted in the lower basin. More research should be conducted to identify best-bet approaches for degraded lands in the lower part of the basin.
b. Promote drought-tolerant trees and crops in the drier parts of the basin.
c. Promote energy-efficient stoves and water harvesting throughout the basin, especially with women.
d. Continue and expand the focal area approach to agricultural extension, possibly modifying it to create more opportunity for addressing the water and health issues prioritised by the village residents.
e. Conduct participatory research, market development and community mobilization in order to provide farmers and community groups with more diverse sources of income and livelihood security.
f. Devote special resources to women, resource-poor families, and those most vulnerable to environmental variation.

Continued ⏩

2. Environmental management and protection

a. Enforce existing and new regulations to protect degraded hillsides, springheads, the collection areas of first-order streams, and riverine areas from cultivation, livestock grazing and fuelwood collection.
b. Re-examine the 1980 Nyando River Flood Control Master Plan, identify priority investments within the plan, conduct environmental impact assessments for those investments, and mobilise resources for community support for priority investments.
c. Implement District Environment Committee action plans and support the committees through effective collaboration between relevant stakeholders at district level.
d. Re-assess laws and regulations constraining market-oriented tree production (eg. production and movement of charcoal).
e. Protect and harness water from springs, possibly through environmental easements under the Environment Management and Coordination Act.
f. Continue to collect, analyse and interpret data on water quality and land degradation in the catchment.
g. Afforestation and reforestation of critical parts of the landscape, particularly springheads, riverine areas, and headwaters.

3. Enhance health, water and sanitation services

a. Strengthen water users' groups.
b. Support community water resource development.
c. Develop and support basic health treatment facilities.
d. Promote primary health care.
e. Promote good hygiene and sanitation.

4. Promote networking and public awareness of water–environment–health interconnections

a. The districts of the Nyando basin, including Nyando, Nandi, Kericho and Kisumu, should continue to exchange information and harmonise approaches to environmental management.
b. Exploit mass communication methods to promote soil and water conservation among farmers throughout the basin.
c. Raise awareness of all residents, including town dwellers and school children, on the environmental challenges of the Nyando and how they can provide solutions.
d. Improve systems for warning and preparing people in the Kano plains for floods. This could include rainwater harvesting and improved sanitation methods.
e. Enhance awareness of the links between water management and health through workshops, 'barazas', print and electronic media, schools and organised community groups.

Chapter 4. Assessing poverty problems and development priorities in the Lake Victoria basin[7]

A set of research activities were undertaken under the TransVic Project that were focused on objective 3: quantify the actual and potential impacts of promising land management interventions on human welfare (food security, income, gender and equality) and the environment (soil quality, water quality and hydrologic function).

The research outputs produced through these activities can be classified into three groups: (1) better understanding the problems and priorities facing the populations of the Lake Victoria basin who are dependent upon agriculture and the environment for their livelihoods; (2) identifying opportunities and constraints of various options for reaching those populations with new technologies, public services, and management options that can improve people's livelihoods while conserving and restoring the resource base; and (3) decision support systems that can aid development planners working in the basin.

Chapter 4 of this report summarises results on problems and priorities; Chapter 5 summarises results on development opportunities and decision support systems.

4.1 Research methods

Participatory rural appraisal and community planning. The NALEP programme had adapted and institutionalised a standard methodology of participatory rural appraisal (PRA) for collectively identifying community problems, priorities for intervention, and areas of emphasis and composition for common interest groups.

While working with NALEP in the 28 villages, ICRAF staff supported and built upon these methods. Two major innovations were added in the later years of the project. First, information from individual focal areas was collected, aggregated, analysed and used to obtain a broader perspective of community priorities across Western Kenya. This analysis led to an important critique of the Poverty Reduction Strategy Paper (PRSP) planning process in Kenya, particularly the district level consultative process. Second, a new tool for participatory analysis of poverty and livelihood dynamics (PAPOLD) was introduced to the NALEP officers and adopted into the standard NALEP approach. Using the PAPOLD method, a representative community group develops its own notions of poverty and prosperity, identifies the 'stages of progress' that characterise movements into and out of poverty in the community, identifies major livelihood strategies that households employ in the community, and characterises every household according to their current and past stages of process and livelihood strategies. Combined with the other PRA tools used by NALEP, this provides an opportunity for extension workers to deliberately target the poor, and to identify and promote enterprises that fit their circumstances in the local village context (See Chapter 6 for more detail on PAPOLD).

Baseline and followup surveys to assess impact. Baseline surveys are necessary for assessing the direction and magnitude of project impacts. During the course of the TransVic Project, the project team learned a great deal about the potentials and pitfalls of baseline surveys. In 2000/2001, a baseline survey was undertaken in nine focal areas in order to assess the impacts of subsequent focal area activities. Three sets of focal areas were selected, one set of three focal areas in each of Nandi, Kericho and Nyando Districts. Each set of three areas included a NALEP focal areas in which ICRAF was not involved, a NALEP focal area where ICRAF was involved, and a nearby non-intervention area. Baseline data was collected through a household survey and a community survey. A total of 522 households were included in the household survey and a total of nine villages in the community

[7] Chapter 4 is primarily based on the work of Brent Swallow, Fridah Mugo, Samuel Muriithi, Leah Onyango, Frank Place, Leah Cohen and Seth Ooko.

survey. The survey data proved to be fairly difficult to manage and analyse, and a full report on the analysis was ultimately delayed for over a year. A second baseline survey was designed and implemented in six more focal areas in 2002/2003, with data collected from 50 households in each focal area. While following a more parsimonious design than the first baseline survey, compilation and analysis of the data were still delayed by over a year. No followup survey work was conducted in the course of the project. This followup survey could be conducted in subsequent work[8].

Combining household surveys and group techniques in studies of the effects of ill health and women's land tenure on natural resource management. During the course of the TransVic project, postgraduate research was undertaken by Leah Cohen, Leah Onyango, and Seth Ooko Onyango to better understand the effects of ill health and women's land tenure on natural resource management in sites in the Lake Victoria basin. These studies, reported below, combined information from household surveys, interviews with district officials and non-governmental organisations, focus group discussions, and household case studies.

Study of the costs of land degradation. An inter-disciplinary set of methods were assembled for assessing the economic costs of land degradation. The methods included a geographically-based method for sampling plots, extrapolated land quality indices for measuring land degradation, a household survey to collect demographic and resource information, a recurrent survey to quantify inputs, and a yield survey. Layered on top of the land degradation study was a study of the impacts of prolonged illness and death in the same households.

4.2 Poverty and livelihood profile of the Lake Victoria basin

Poverty—measured by national statistics and local perceptions—has increased rapidly in the last ten years, particularly in communities in the lower part of the basin that were previously involved in irrigation schemes owned by the National Irrigation Board (Map 9). Figure 4.1 shows results from the Safeguard Project which used the PAPOLD method to generate community self-assessments of the incidence of poverty 25 years ago, 10 years ago and now for 14 villages scattered across the Nyando basin (Swallow et al. 2006). The parts of the Nyando basin characterised by the highest levels of resource degradation are associated with particular forms of land tenure and settlement history. Degraded areas in the lower part of the basin are former native reserve lands, where the African population was clustered on small parcels of relatively poor land. Most of the degraded areas in the upper part of the basin are located on former European-owned commercial farms that were purchased and subdivided into small plots after independence in the mid-1960s.

4.3 Demographic profile of villages in the Nyando basin

Table 4.1 presents data collected from local chiefs and sub-chiefs on the demographic structure of the nine communities included in the 2000/1 baseline survey. These data were collected prior to the household survey so that a stratified random sample of households could be interviewed. The aggregate data show large differences in demographic structure across the areas.

[8] As a tool for assessing project success, we must admit that the baseline survey was ineffective. The surveys we designed were too demanding of the respondents, data entry was inefficient and time-consuming, there were no clear links between the focal area activities and the impact indicators, and our personnel were too occupied with other tasks that were given higher priority. For the future, we would advise that the impact assessment process: (1) be more tightly integrated into the participatory appraisal process; (2) be more tightly integrated into project monitoring and evaluation; (3) focus on a small number of robust and sensitive indicators of participant behaviour and welfare; (4) have the questionnaire and data entry format prepared at the same time; and (5) be contracted to an outside consultant who can focus on the job and produce a report and database.

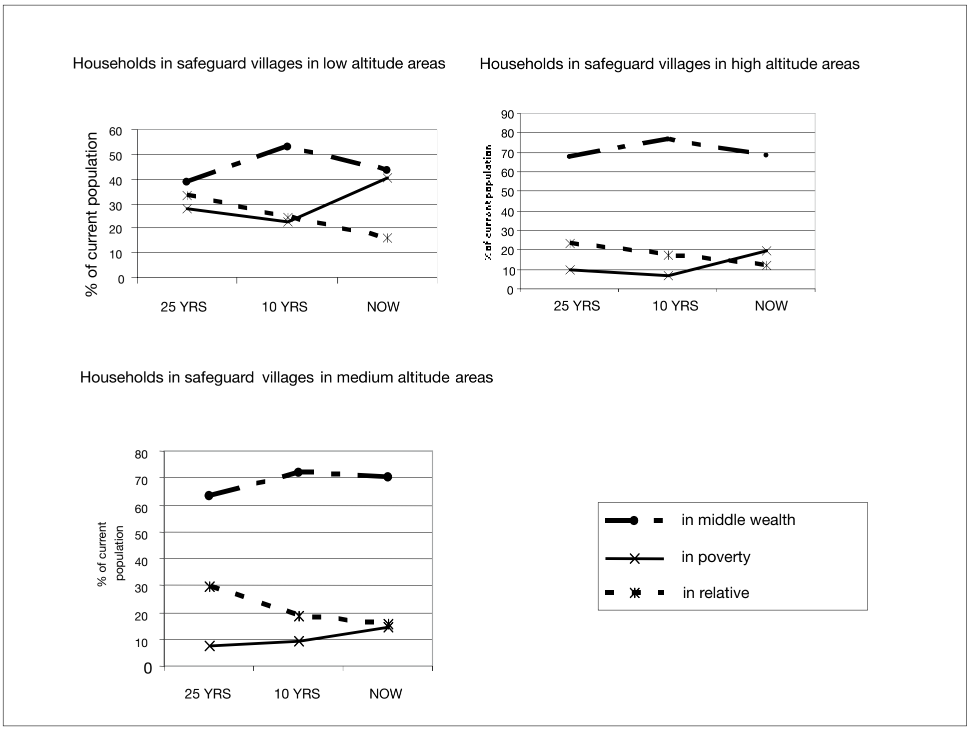


Figure 4.1. Welfare trends in the Nyando river basin by altitude.

Table 4.1 Demographic structure of the 9 areas included in the 2000/2001 baseline survey.

Focal area (Total HH) / Type of village.	Child-headed	Single Female-headed	Female-headed widow	Female-headed husband away	Male-headed single or widower	Male-headed polygamous	Male-headed monogamous
Katuk-Odeyo (621) —ICRAF/NALEP	6.3%	-	28.3%	8.4%	3.2%	15.6%	38.2%
Olwalo- Nyabola (165) —`NALEP	3.6%	-	32.1%	13.3%	6.7%	12.7%	31.5%
Nyalunya (297) —non-intervention	8.1%	-	15.8%	13.5%	2.7%	9.4%	50.5%
Chebetit —ICRAF/ NALEP (133)	0%	0%	18%	0.8%	2.3%	6.8%	72.2%
Chemrusoi —NALEP (207)	0%	1%	10.6%	1.4%	2.4%	4.8%	79.7%
Musaria - (301) —Non-Intervention	0%	0%	17.6%	6.0%	1.0%	8.0%	67.4%
Kipsiwo (165) —ICRAF/ NALEP	0%	4.2%	7.2%	0%	1.2%	17.0%	70.0%
Kamelil (NALEP) (287)	0.3%	3.8%	9.4%	1.4%	2.4%	14.6%	67.9%
Got Ne-Lel (235) —Non Intervention	0.8%	5.5%	6.0%	3.8%	5.1%	8.1%	74.9%

Source: Data provided by sub-chiefs for each area.

Particularly striking is the prevalence of child-headed households in the Lower Nyakach areas (4 to 8 percent) and the prevalence of widow-headed households in all areas, but particularly in Nyando District (between 16% and 31%). The Katuk-Odeyo area, subject of the intensive study described above, is a particularly striking case: 6% of households headed by children, 28 percent headed by widows and 16% headed by polygamous husbands.

4.4 Sociocultural constraints and opportunities for women's agroforestry

A study of women's participation in agroforestry was undertaken in two contrasting locations within Nyando District. The purpose of the study was to examine how women now participate in agroforestry, the sociocultural factors that constrain that participation, and the specific opportunities for women to engage in agroforestry in the 'orundu'(home garden). Intensive field studies were undertaken in two locations in Nyando District: Koru Location in Muhoroni Division and Northeast Nyakach location in Lower Nyakach Division.

'Orundu' is a term used by the Luo-speaking community of Nyanza Province of Kenya to refer to a small garden just behind the house within the family homestead. Orundu gardens are cultivated by women to produce small amounts of important subsistence foods. In a monogamous home, it is located behind the house and on the periphery of the homestead. In a polygamous home every wife cultivates the area behind of her house. Activities in the orundu are determined and controlled by the women.

Data for the study were collected through a household questionnaire, interviews with district officials and representatives of non-governmental organisations, two focus group discussions and 10 household case studies in each location. In each area, focus group discussions were held with women only, and with a mixed group of men and women. Interviews were held with 57 households in Koru and 43 in Northeast Nyakach. Six household case studies were undertaken in Koru and four in Northeast Nyakach.

The results show several contrasts between the two areas Koru is a settlement area that is predominately populated by Luo people from different clans as well as small numbers of people from other ethnic groups. Northeast Nyakach is solely populated by the Luo, who live in tight clusters with people of the same clan and sub-clan. In Koru, every women belongs to at least one women's group, people are already engaged in tree planting for commercial timber production and fruit production. All homes have orundu where they plant vegetables and fruit trees. Men expect women to ask permission to plant trees, but will generally give such permission. A large percentage of the women are widows.

In Northeast Nyakach, in contrast, far fewer women belong to women's groups and very few women engage in tree planting. Women are not allowed to grow several types of trees including trees traditionally used for marking boundaries, trees which produce dangerous sap, trees associated with bad luck and ill health, and trees associated with traditional healers. All homes have orundu where they plant vegetables, some food crops, and a few fruit trees. People still adhere to cultural restrictions on when women can plant orundu, for example, junior wives must wait for senior wives to plant.

4.5 Land tenure patterns and dynamics in the Nyando basin[9]

Land in the Nyando river basin is held under different tenure systems in different parts of the basin, with each system changing over time. In pre-colonial Kenya all natural resources were owned communally and claims were determined by clans. In the colonial era, the Crown Lands Ordinance of 1902 gave authority to the Crown to alienate land. Any land not physically occupied by local people was considered wasteland (free land) and free for alienation to the European settlers. Local people's rights to land were defined by occupancy, while settlers were given free hold titles by the Crown. Two parallel land-holding systems

9 This study of land tenure was undertaken as part of the Safeguard project, which was a collaboration of ICRAF, the International Food Policy Research Institute and Maseno University. The Safeguard project was financed by the Comprehensive Assessment of Water Management in Agriculture and the European Union. These results are drawn from the paper by Onyango et al. (forthcoming).

thus developed, with one set of laws to govern native lands and another set to govern crown land. Even after independence both sets of law were still in force, which in part explains the current state of confusion in land administration in Kenya. Figure 4.2 is an attempt to illustrate the evolution of land tenure in the Nyando river basin (Onyango et al., forthcoming).

This study identified seven ways in which land is currently held in the Nyando basin: 1) Trust land – not titled; 2) Government land – not titled; 3) Adjudicated land – freehold titles on completion of adjudication; 4) Settlement schemes – freehold titles on discharge from the Settlement Fund Trustee (SFT); 5) Large-scale farms with lease hold titles; 6) Land buying companies – freehold title on subdivision to small units; and 7) Forest land – reserved on gazettement. The land holding types in 3,4,5,6 and 7 all fall under the category labeled as "private land" in the chapter by Mumma (this volume). This study has generated a map of land tenure in 1964 (Map 9,10) when the country got independence and one of land tenure in 2004 (Map 11) for purposes of analyzing changes in land tenure. Using the two maps it is possible to examine the changes that have occurred in the last 40 years and how these changes explain contemporary water rights and gender relations.

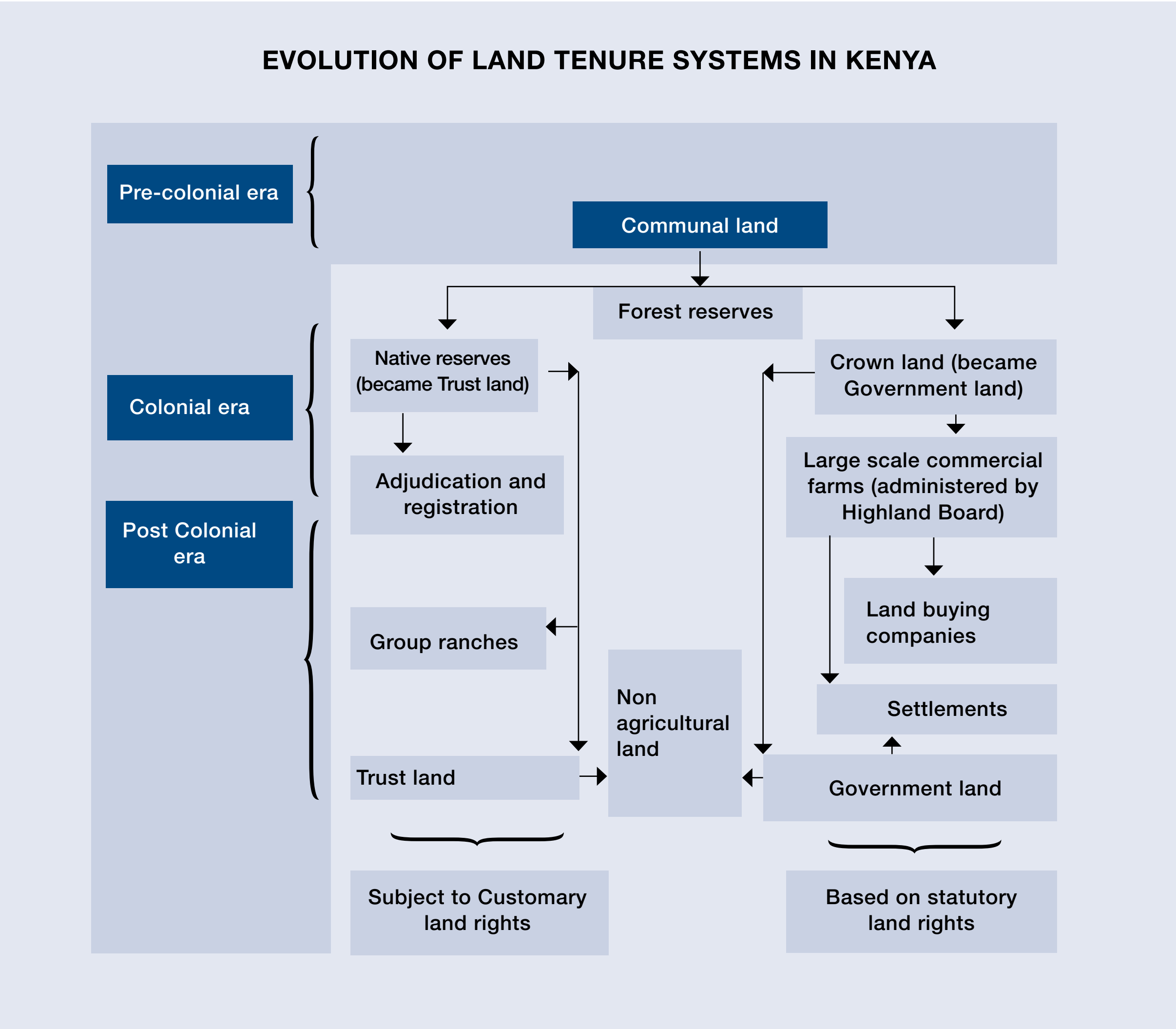


Figure 4.2 Evolution of land tenure in the Nyando river basin
Source: Onyango et al. (forthcoming)

4.6 Production effects of land degradation[10]

A study of the production effects of land degradation was undertaken in a 100 km2 block in the Katuk-Odeyo area of the lower Nyando basin for which a Quick-Bird satellite image was available. Ground-measurements in the 100 km2 block was carried out using a spatially clustered sampling plan. Sub-blocks of 64 hectares were selected at spatially stratified, randomly located grid intersections across the block. All households falling within a 920 meter diameter circle from the centre of the middle plot in the block were identified and included in the household survey. About 260 households fell on the clusters. Since the main objective of the study was to investigate the impact of soil fertility on land productivity, intensive household survey was carried out in 120 plots which were agricultural field. Three types of surveys were carried out in this study: soil survey, household survey, and plot-level survey of inputs and yield. Farm input and yield data were collected during 5 visits over a full cropping season, while the household and soils surveys were collected during single-visit surveys.

One of the unique aspects of this study was the combination of advanced soils analysis with the household survey data. A categorical variable called the Spectral Erosion Index (SEI) was constructed for each of the 120 plots. The SEI variable was constructed by relating the spectral properties of the sampled soils to the properties of soils showing visual signs of erosion (e), reference soils (r) and depositional soils (s). Each plot was thus assigned an SEI of e, r or s.

Results from the survey show that the farming systems are considerable different in the areas farmed by the Kipsigis community in the upper part of the area and the Luo community in the lower part of the area. Household demography is different, with 35 percent of households in Luo-dominated area headed by widows, and 6 percent of households in the Kipsigis area headed by widows. Slightly above half of the Luo households and over 80% of the Kipchigis households grow maize. Other crops had either been abandoned or had reduced in importance for a number of reasons. For instance, due to infrequency of payments and lack of markets, very few farmers now grow cotton. Secondly, farmers had abandoned such other crops like millet and cassava owing to low productivity associated with decline in soil fertility. It was also established that droughts, low and erratic rainfall pattern, massive striga infestation were the most recurrent problems affecting crop production while malaria, typhoid, and tuberculosis were the most common ailments afflicting the residents.

Soil conservation measures had low levels of adoption in the Luo areas where none of the sampled households used chemical fertilizers, while only 35 and 22 percent, respectively, used manure (mostly in kitchen gardens) or left crop residues in the farms. In the Kipsigis area, 35% of the farmers use fertilizers and 85% leave crop residues on the farm. However, only 14% of farmers in the Kipsigis area had constructed soil and water conservation structures on their farms even though much of the farming is done on steep slopes.

The statistical results show strong surprisingly strong relationships between crop production and soil fertility status. First, fertilizer use was highly dependent upon soil fertility status, with a very small percentage of farmers (approximately 12%) using fertilizers on d class soils, an intermediate percentage of farmers (approximately 38%) using fertilizers on s class soils, and over 50% using fertilizers on e class soils. Surprisingly, therefore, it appears that only farmers cultivating the most degraded plots give serious consideration to the use of fertilizers. Soil mining, as observed by Awiti around the Kakamega forest in Vihiga District, appears to be common in the Kenyan part of the Lake Victoria basin. A statistical analysis of factors affecting fertilizer use found that the probability of chemical fertilizer use was negatively related to the number of livestock and distance to an all-weather road, and to ethnicity.

Further statistical analysis shows that soil erosion status is also related to the probability of a crop failure

[10]Research on the production effects of land degradation was led by Samuel Muriithi, environmental economist working with the project between 2000 and 2004. Brent Swallow and Frank Place provided guidance on the economic components of the research. The erosion phase analysis was conducted by Markus Walsh, with inputs from Keith Shepherd. The results presented here have not yet been published.

and crop yield. Of the 108 farmers who planted maize, 42 farmers experienced complete crop failure. Using a Generalized linear mixed model analysis, we estimated that farmers growing maize on eroded soils had a 44% probability of crop failure, farmers on the reference soils had a 36% probability of crop failure, and farmers on stable soils had a 26% probability of crop failure.

For farmers that did obtain a positive maize yield, yield was found to be significantly related to erosion status and fertilizer use. Plots receiving inputs of chemical fertilizer produced average yields of 1.05 tonnes of maize per hectare on eroded soils, 1.39 tonnes per hectare on reference soils, and 1.85 tonnes per hectare on depositional soils. Without fertilizer inputs, average maize yields were 0.32 tonnes per hectare on eroded soils, 0.54 tonnes per hectare on stable soils, and 0.84 tonnes per hectare on depositional soils (Figure 4.3). Relative to the reference soils, therefore, we can conclude that soil erosion processes led to a 30-40% decline in yields in erosion areas, but a similar percentage increase in yield in the depositional areas. A statistical analysis of the factors affecting crop yield showed that maize yield was also positively related to rainfall. Overall, the results indicate that the majority of farmers cultivating eroded soils offset their lower expected yields by applying fertilizer, while few farmers cultivating depositional soils took advantage of the higher potential of their soils for increased production through the use of fertilizer.

4.7 Production effects of prolonged illness and death

Besides land degradation, mortality and chronic illness are also having major impacts on households and communities in the lower part of the basin. Ooko (2006) undertook an intensive study of the production effects of prolonged illness and death in the Katuk-Odeyo and Chebitet focal areas in the Awach basin. The household survey indicated that about one-third of the 107 households included in the survey had lost a family member in the five years preceding the study, one-third of households had a chronically-ill member

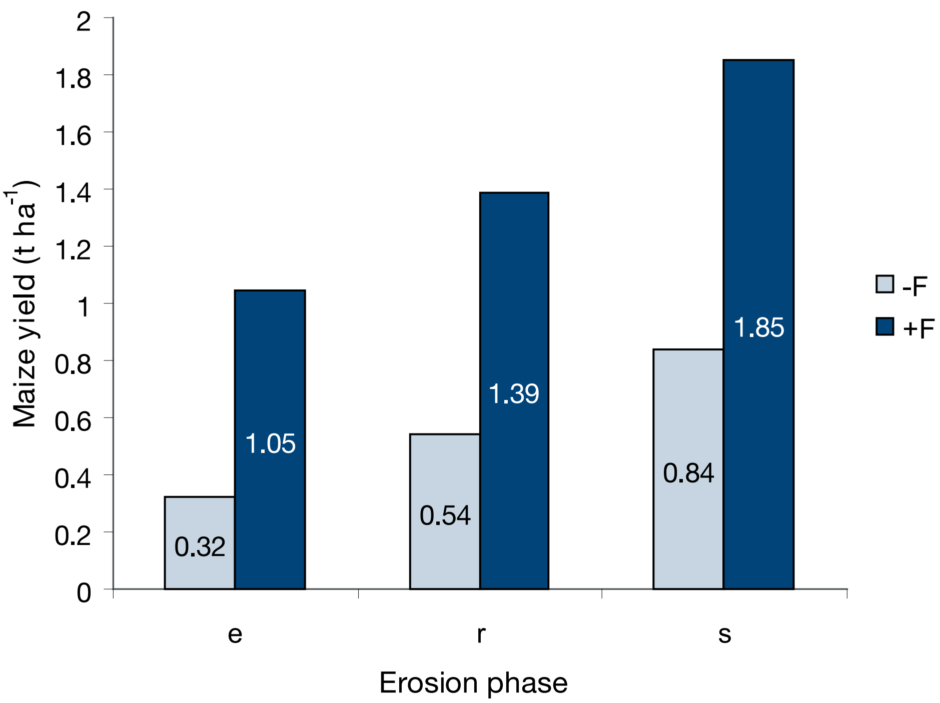


Figure 4.3 Average maize crop yields related to erosion phase and the presence / absence of fertilizer in the Katuk-Odeyo block of the lower Nyando basin

in the previous year, and only one-third had no such loss. Households suffering these health problems bore large costs, due to lost time and increased increases, with an average cost of over 17,000 Ksh per year. Compared to households with no loss, households suffering prolonged illness and recent death cultivated less land, used far less purchased inputs, and had far lower productivity of labour and land. Similar to other studies in Kenya, Ooko found that the gender of the deceased member of the household was very important. Male deaths have much greater negative adverse effects than female deaths while adult deaths and illnesses have more negative effects on purchased input application than child deaths or illnesses. Agricultural labour input applied by households varies with gender but not age of the victim.

4.8 Relationship between agriculture, environment and human health

A study of the effects of human illness on the availability of labour was motivated by the observation that many farmers are distracted from farming activities by illness and death—time lost due to their own illness, time spent caring for others who are sick, time spent attending funerals, and time spent attending to other death-related activities. Besides showing how much labour time is diverted from agriculture, the (preliminary) results also show the high prevalence of diseases that are directly or indirectly related to the environment.

The study was undertaken in two Luo communities in the Lake Victoria Basin: (1) Yala Township location in Yala division, Siaya District, an uplands area where ICRAF has long been active; and (2) West Yimbo Location of Usigu Division, Bondo District, a lakeshore area where ICRAF has never been active. Fieldwork for the study was conducted between April and August 2001. Questionnaires were developed for three subgroups; healthcare facilities, group meetings of villagers, and household heads, both male and female. The study design and questionnaires went through the rigorous human subjects ethnics review at the University of Florida.

The results show:

- Malaria and respiratory diseases were considered to be the most common diseases in both sites.
- Water-related diseases—dysentery, diarrhoea and typhoid—were considered to be important disease in both sites. Dysentery was especially emphasised in the lakeshore area in Bondo District.
- Almost everyone was aware of the presence of HIV/AIDS, although they differed significantly on its importance. People were surprisingly willing to discuss HIV/AIDS and other sexually transmitted diseases.
- People in both of the study sites have many different healthcare options available to them. In fact, people often use more than one option for each illness episode. This can lead to impatience in waiting for treatments to work and therefore situations where patients do not give each treatment option enough time to work, leading to more serious conditions.

[3] Research on the production effects of prolonged illness and death was led by Seth Ooko Onyango as an MSc thesis in agricultural economics at Egerton University. At the time that the data collection was undertaken, Seth was on study leave from the Ministry of Livestock Development. His work was co-supervised by Brent Swallow and Sabine Mukoya-Wangia.

Chapter 5: Assessing the opportunities and constraints of development approaches[11]

5.1 Assessing the NSWCP

In 1988 the Soil and Water Conservation Branch (SWCB) of the Kenya Ministry of Agriculture introduced the 'catchment approach' to soil conservation and land management. In the SWCB approach, the term 'catchment' is not used in the hydrological sense, but refers to an area covering one or two villages. In this study the 'catchment areas' are called focal areas. With this approach, resources and efforts are concentrated in a specific focal area for a limited time period with the aim at initiating conservation measures at all the farms in the specific area.

The catchment approach is a participatory approach where local communities are involved in the identification of problems and solutions. The community also acts in conjunction with the local soil conservation staff in planning interventions. Ultimately, each division is supposed to work in two focal areas each year. Between 1988 and 2000, the SWCB has reached 1.6 million farmers, mostly in areas with medium to high agricultural potential. Less information was available on the impacts of the approach on soil conservation within the focal areas; and still less was known about the household-level impacts of the catchment approach in the Nyando basin or the overall impacts of the NSWCP at the basin scale.

Consequently, two studies were undertaken in 1999–2000 to evaluate the effectiveness of the approach in areas of high erosion potential in the Nyando basin. One study focused on household-level impacts in a particular catchment in the lower part of the basin. The second study provided a basin level assessment of the effectiveness of the catchment approach in targeting areas of high erosion potential in the Nyando basin.

5.2 Household factors affecting adoption of soil conservation practices in the Dirubi Catchment (reported in Shepherd et al, 2000 TransVic Project Annual Report, 1999–2000)

In February and March of 2000, the project undertook a study of household-level adoption of soil conservation structures in the Dirubi catchment of Nyando District, in the Sondu-Miriu river basin. The objectives of the study were to: (1) Relate the adoption of different soil conservation practices to key household characteristics, especially farm size, livestock holdings, labour, gender and education levels. (2) Assess the stepwise adoption of soil conservation and agroforestry practices. (3) Relate adoption of soil conservation and agroforestry to the activities of soil and water conservation branch and catchment committees. Dirubi catchment was purposively chosen because it was reported as having the highest adoption rates (over 80%) in Upper Nyakach Division. A census of all households in the catchment was conducted, full data available for 95 households.

The results show that a total of 14 soil-conserving technologies were adopted in Dirubi catchment. In order of the percentage adoption, the adopted technologies were: grass strips (52%), 'fanya-juu' (50%), unploughed strip (45%), hedge strip (34%), woodlot (25%), banana strip (22%), sisal strip (22%), stone wall (22%), euphrobia strip (6%), cut-off drain (6%), roof catchment (6%), 'fanya-chini' (4%), retention ditch (2%), and water pond (2%). A total of 30 kilometers of filter strips were measured on the 95 farms, for an average of 300 meters per farm. Household factors affecting adoption of the soil conservation techniques were farm size (statistically significant for 'fanya-juu', grass strips, and stone walls) and gender of household head. In fact, among the 29% of households

[11] Chapter 5 is based on the work of Fridah Mugo, Frank Place, Tina Svan Hansen, Markus Walsh, Alex Awiti, Brent Swallow and Antonia Njeri Okono.

that were headed by women, there was very little adoption of any of the soil conservation technologies (See Figure 5.1). These results show a very clear bias against women in the Dirubi catchment. The project was not able to explore how consistent this bias was in other NSWCP focal areas.

Farmers' source of information on the soil conservation technologies adopted was examined and the survey revealed that information from each technology reached the farmers in different ways. For example, information on fanya juu, grass strips and unploughed strips was mainly obtained through the soil conservation extension officers. Information on hedge strips, sisal strips, woodlots and banana strips was mainly from other farmers. A reasonable proportion of information about grass strips, unploughed strips and banana strips information was also transmitted from farmer to farmer. The catchment committee and other agencies provided very little information. These results clearly show the importance of extension officers and the need for them to target specific areas with specific beneficial technologies.

5.3 Basin-level impacts in the Nyando basin (reported in Shepherd et al 2000, TransVic Annual Report 1999-2000)

The study used GIS analysis and remote sensing to produce a map of erosion risk, and a census of all focal areas conducted in the Nyando basin between 1988 and 1999 to ascertain the geographic coverage and effectiveness of the NSWCB in changing farmers' behaviour. The results showed that between 1988 and 1999 the Kenyan Soil and Water Conservation Branch (SWCB) worked in 177 focal areas in the hydrological upland of river Nyando, covering 17% of the 3517 km^2 of the basin (Map 10). Approximately 10,600 households adopted one or more of the recommendations for improved land management, with their farms occupying about 7.7% of the entire upland region of the basin. There was a high concentration of focal areas in regions with relatively high population density, and a low concentration of focal areas in zones with relatively high erosion risk. The implementation rate by farmers was more than double in areas with greater than 4% slope (mostly mid-altitude and higher altitude areas) compared to areas with less than 4% slope

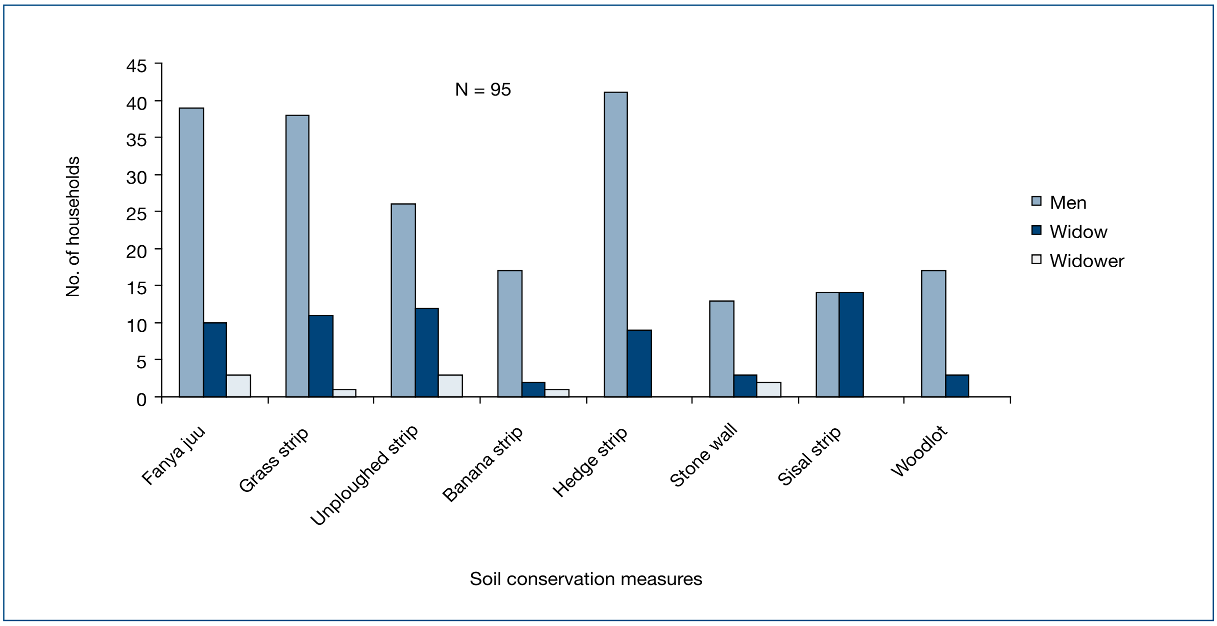


Figure 5.1. Adoption of soil conservation measures by gender of household head.

(mostly areas in the lowland plain area). Overall, therefore, it was concluded that NSWCP did have some significant effects on resource conservation in many upland villages, but that those effects were unlikely to have a significant aggregate effect at the level of the Nyando river basin.

5.4 Information sources used by the poor in the Lake Victoria Basin

The work from Durubi catchment showed the importance of extension workers as sources of information about soil conservation technologies. This led to a greatly expanded study of the information sources used by poor smallholder farmers in the Lake Victoria basin, particularly information about livestock production and health. Funds for this study were provided by the Livestock Production Programme of DFID, then managed by the Natural Resources Institute, NRI. The study of information sources of the poor was undertaken around Lake Victoria in Kenya, Tanzania and Uganda, utilizing a nested approach to select districts, study sites, and households. Qualitative and quantitative techniques were combined for application in the study.

The results of the Kenya study are particularly illuminating for showing the sources of information used by poor livestock keepers. Results presented in Table 5.1 show great diversity in main information sources from district to district. In Migori, about half of all households said that agricultural extension officers were their main source of information, while only 1% said that they relied on neighbours or village elders. The main local source of information in Migori were family members (14%). In Bondo, two-thirds of households said that they relied on veterinary officers and 6% relied on family members. By comparison, farmers in Vihiga District reported a greater diversity of sources, with about 20% of households reliant on agricultural extension officers, veterinary officers and neighbours. Results presented in Table 5.2 show the different sources of information used by female and male headed households: male-headed households were more likely to obtain information from veterinary

Table 5.1 Sources of information for livestock management in the Kenyan part of the Lake Victoria Basin.

Information source	Vihiga	Bondo	Migori	Overall
% of households indicating each information source				
None	14	21	6	12
Agricultural extension officer	21	3	53	31
Family member	8	6	14	10
Veterinary officer	15	67	12	20
Experience	17	3	14	14
Neighbours/other farmers	18		1	9
Village elders	5			2
Livestock traders	1		1	1

Table 5.2 Gender and livestock information sources in Vihiga District.

Type of household	None/own experience	Family	Neighbours	Elders	Agric. extension officer	Vet. Officer	Traders
	% of households indicating each information source						
Male-headed household	16	8	19	4	21	17	7
Female-headed household	7	14	14	14	21	0	0

(Source: Analysis of household data collected by the Safeguard study team)

officers and their neighbours, while female-headed households were more likely to obtain information from family members and elders.

5.5 Factors affecting adoption of technologies

Data from the baseline survey were analyzed in order to identify the types of land management investments made by farmers and in the Nyando basin and to understand the main factors that motivate such investments. The results will be useful in helping to shape intervention strategies by NALEP, especially for attempting to reach disadvantaged households. To understand the processes, obtain information on inputs necessary for making these investments, and to establish a baseline of household data that can be used later to assess the NALEP impacts that ICRAF helps to implement in Western Kenya, data were collected in a baseline survey of 522 households conducted in 2001 in nine locations in the Nyando River basin.

Descriptive analysis of the data shows that the percentage of farmers making different investments was 35% for inorganic fertilizers, 10% for green manure, 46% for animal manure, and 30% for crop rotation in 2001. For long-term investments, on average farmers had 505 trees on-farm, 1.5 soil conservation structures and a single water-harvesting technique.

Econometric analyses show that the factors that are usually considered to influence farmers' investment behaviour – gender of household head, wealth, household size, farm size, number of organizations the household belongs to—have relatively little impact on farmers' investments in soil fertility and soil conservation. The more important underlying factors are those related to quality and sources of information, incentives and culture. Adoption of organic methods for soil management—green manure, animal manure and crop rotation, and soil conservation and water harvesting—appear to be primarily constrained by lack of knowledge, while adoption of inorganic fertilizers appears to be primarily constrained by lack of purchasing power. Culture does play a role, with polygamous households and households in the Nandi ethnic area making fewer of all types of investments (Swallow and Wangila, 2002).

5.6 Using the NALEP focal area priorities for poverty reduction planning

An analysis was conducted to determine how closely Kenya's Poverty Reduction Strategy Paper (PRSP) (Revised in 2001) matched with the problems and priorities articulated by residents of 80 rural communities in 10 districts of Western Kenya. The results suggest that there was a relatively good match between national PRSP priorities and priorities gener-

Table 5.3. Priority problems across the 80 focal areas, grouped according to major sub-sectors of the Kenyan PRSP document.

Sub-sector	Frequency (number of focal areas in which problem area was identified as priority) (n=80)	Total score (sum of scores across 80 focal areas)	Possible percent of effort matched to scores in 80 focal areas
Crop production	101	899	17.9
Livestock disease and production	66	505	10.1
Water and sanitation	53	500	10.0
Human disease and health care	52	479	9.6
Soil degradation	46	444	8.9
Poverty and income	38	346	6.9
Transport and communication	39	276	5.5
Agricultural knowledge & extension	23	224	4.5
Trees and agroforestry	33	213	4.3
Culture, norms and community organization	30	203	4.1
Resources and environmental management	32	191	3.8
Product marketing	27	184	3.7
Livestock inputs and services	21	165	3.3
Inputs into crop agriculture	23	159	3.2
Insecurity	14	107	2.1
Education services & facilities	12	92	1.8
General government services	4	23	0.4

Source: Swallow et al. 2005

ated from the 80 rural communities, but poor matches between district-level PRSP priorities and community priorities, and between national PRSP priorities and the national PRSP implementation plan. Environmental issues were far less visible in the district and national PRSP documents than they were in the focal area priorities. Water was the third-highest priority across the 80 focal areas, especially in the focal areas of Kisii, Migori, Bondo and Nyamira Districts, but was generally given low priority in the district PRSP documents and the national implementation plan. While water is mentioned in most of the district documents, the solution is most often framed in terms of public investments in large-scale irrigation or large-scale domestic water supplies. Soil degradation is a high priority across the 80 focal areas, especially in Vihiga and Migori Districts, but was only mentioned as a low priority issue in some of the district documents. None of the district documents mention the problem of shortage of fuelwood and tree products, although this was given 4.3% of the total score in the focal areas, and was a moderately high priority in the focal areas in Nyando and Vihiga Districts (Table 5.3 Swallow, 2005).

Chapter 6. Enhancing research–extension links for improved land management [12]

The fourth objective of the TransVic project was to strengthen research–extension links for purposes of solving high-priority problems in collaboration with farmers. Work toward this objective began with a modest set of activities in 2000/2001, intensified in 2001/2002 with the appointment of a full-time Research-Extension Liaison Officer (David Nyantika), and continued through to the end of the project in December 2004. Some of the innovations developed by the project have been embraced into the new phase of NALEP. Particularly important in this regard is the consortium approach to the promotion of new innovations, the two-year rolling approach to extension, and the 'PAPOLD' approach for systematically targeting resource poor households and providing support appropriate to their needs and aspirations.

The approach taken in this component of TransVic was to frame all of the work within Kenya's national agriculture and livestock extension policy and the National Agricultural and Livestock Extension Programme (NALEP). The extension policy, agreed in the year 2000, has the following key elements: 1) pluralistic extension – the Ministry of Agriculture and Livestock Development is the focal point for agricultural extension, providing extension support itself, but also encouraging other extension providers (eg non-governmental organizations, research institutions, private sector, faith-based organizations) to work together in a coherent framework for extension; and 2) decentralized participatory planning —extension planning should be sensitive to ecological, social and economic conditions and be based on the needs and aspirations of intended beneficiaries. Within that policy framework, the NALEP programme was implemented in most of the high-potential agricultural areas of Kenya, including all of the areas draining into Lake Victoria. The NALEP extension approach was based on the shifting focal area approach: extension efforts in each division are concentrated on particular focal areas of 200-300 households for periods of one year, with the focal area shifting from one fiscal year to the next fiscal year. Within that fiscal year, the NALEP programme provides for the development of community action plans, farm-specific action plans for every farm household (farm layout and business plans), initiation and support to common interest groups, enterprise development and links to market opportunities.

6.1 Participation in target focal areas[13]

Over the course of the project, ICRAF worked closely with Ministry of Agriculture staff in 28 focal areas in seven districts, covering portions of the Nyando, Yala and Sondu-Miriu river basins. Those 28 focal areas represented contrasting problem situations across the basin: lowland areas subject to flooding; highly degraded hillside areas; areas along the main channel of the Nyando River; and areas adjacent to protected forests (Table 6.1, Map 13).

A total of 10,186 farms were resident in those 28 areas; by July 2004 approximately 5,863 of those farms had implemented elements of the farm-specific action plans that they developed with ICRAF and Ministry of Agriculture staff. Implementation rates varied from as low as 28.7% to as high as 88.4% across the 28 focal areas, for an overall implementation rate of 57.6%. This level of implementation compares favourably with the NALEP experience in parts of Kenya known to have much higher agricultural potential.

Participation in common interest groups increased as the ICRAF–NALEP team gained experience with different approaches to promotion of common interest groups (CIGs), reaching maximum participation in 2002/2003. In 2001/2002, there were 68 CIGs involving 1240 farmers in 11 focal areas, for

[12] This study of the links between agriculture, environment and health was undertaken by Leah Cohen as an MA thesis at the University of Florida (Cohen, 2005).

[13] This section was prepared by David Nyantika and Brent Swallow on the basis of the annual reports prepared by David for the TransVic project. The map was prepared by George Aike.

an average of 6.2 groups and 113 household participants per focal area. In 2002/2003, there were 150 groups involving 2301 farmers in 10 focal areas, for an average of 15 groups and 230 households participating per focal area. And in 2003/2004, there were 140 groups involving 1905 farmers in 11 focal areas, for an average of 13 groups and 173 households participating per focal area. Common interest groups focused on a wide range of enterprises and collective investment, from a wide range of common interests.

Links established between service providers have been important for sustainability. For instance, in Upper Nyakach focal area, local people have linked up with the Kusa Community where the Regional Land Management Unit (RELMA) had initiated an effective system of water harvesting and management at the village level. Secondly, the trade exhibitions in which local Members of Parliament (MPs) participate had been converted into forums for policy dialogue. For instance, they have given farmers the opportunity to impress upon their MPs the need to investing the Constituency Development Fund (CDF) money in agricultural projects. (CDF are funds disbursed from Kenya's national treasury to each of the country's 210 constituencies. The scheme, which begun two years ago, is meant to help achieve equitable development in various parts of the country. However, in most cases, CDF funds are used for putting up physical infrastructures such as bridges, improving roads or schools.

6.2 Enterprise development[14]

Tree nursery survey

During the PRAs in the course of the start-up phase, farmers reported that they could not plant trees because they did not have adequate and reliable sources of seedlings. Many nurseries were established by focal area committees and individuals to supply seedlings for farmers. In 2000/2001, a survey of individual and group tree nurseries was undertaken to provide better understanding of the performance of the nurseries and the types of species that the nurseries provide. The results show that out of the 75 tree and fruits nurseries surveyed, 24 (32%) of them were run by groups and 51 (68%) were run by individuals. The three tree species that were reported to have the highest turnover for group and individual nurseries were eucalyptus (78%), grevillea (57%) and mango (22%). Almost all of the trees species are valued for production of timber or fruit (Table 6.2).

Wood Market Study [15]

In 2002, the TransVic project undertook a study of wood product markets in Western Kenya. The objectives of the study were to (1) determine the quantities and sources of tree species used in various products by traders/processors, (2) to identify trends in species preferred for timber and other wood products, and (3) to determine the prices paid for various wood products. The study focused on dealers in the city of Kisumu and market towns in Nyando, Kericho, Nandi, Uasin Gishu, Vihiga and Kakamega Districts. In all, about 250 respondents (processors, wholesalers, retailers large and small) were interviewed. The most common wood products acquired by the dealers interviewed were timber, plywood, charcoals, and block board. Most dealers reported moderate increases in quantities acquired and prices paid over the previous five years. Processors (e.g. bed and table makers) similarly reported moderate increases in quantities purchased from wood dealers. Traders in raw wood products reported generally favorable markets throughout the year, while processed product dealers faced more variable markets. There is much trading of wood along the value chain within the district, but much of the wood is sourced from outside the district, such as poles from Vihiga, timber from Nakuru, and charcoal from Narok and Uasin Gishu. Suppliers arrange for transport for most of the wood, although dealers more commonly organize collection of fuelwood and charcoal. Most transactions are settled by cash, but about 25% of respondents indicated that they have used credit to purchase wood products. The most

[14] This section of the report is primarily drawn from annual reports, plus the final narrative report prepared by David Nyantika.

[15] The wood market study was undertaken by Joseph Kurauka, MSc student in Environmental Studies at Kenyatta University under the supervision of Robert Zomer and Frank Place. This summary is drawn from Joseph's thesis.

Table 6.1. Summary of farm specific action plans developed and implemented in NALEP / ICRAF focal areas under the TransVic projects

No.	Name of focal area	District	River Basin	Position in watershed	Year initiated	Year completed	Actual number of farms	Preliminary Farm Specific Action Plans	Refined Farm Specific Action Plans	Farm specific action plans implemented	% farm specific action plans implemented
1	Ombaka	Nyando	Nyando	Midslope	2000-1	2001-2	481	481	350	235	0.49
2	Kobong'o	Nyando	Nyando	Lowlands	2000-1	2001-2	488	480	400	204	0.42
3	Kore	Nyando	Nyando	Midslope	2000-1	2001-2	420	420	420	298	0.71
4	Bur Kamach	Nyando	Nyando	Uplands	2000-1	2002-3	345	345	330	293	0.85
5	Nyabgena	Nyamira	Sondu-miriu	Midslope	2002-3	2002-3	400	371	310	210	0.53
6	Jinjini	Vihiga	Yala	Uplands	2002-3	2002-3	370	370	360	214	0.58
7	Chobit	Kericho	Nyando	Midslope	2001-2	2002-3	386	386	386	260	0.67
8	Katuk-Odeyo	Nyando	Nyando	Midslope	2000-1	2002-3	548	548	548	395	0.72
9	Jaber	Nyando	Nyando	Midslope	2000-1	2001-2	231	231	231	166	0.72
10	Kipsamwe	Nyando	Nyando	Lowlands	2002-3	2002-3	150	150	150	105	0.70
11	Koitaburot	Kericho	Nyando	Midslope	2002-3	2002-3	341	341	187	97	0.28
12	Chemogoch	Kericho	Nyando	Midslope	2002-3	2002-3	323	323	206	96	0.30
13	Ainapngetuny	Nandi	Nyando	Uplands	2002-3	2002-3	299	299	203	133	0.44
14	Chebisas	Nandi	Nyando	Uplands	2001-2	2002-3	356	340	310	197	0.55
15	Kipsiwo	Nandi	Nyando	Uplands	2001-2	2001-2	198	198	198	112	0.57
16	Nyadorera	Siaya	Yala	Lowlands	2001-2	2002-3	360	360	360	176	0.49
17	Ochoria	Nyando	Nyando	Lowlands	2003-4	2003-4	180	178	176	110	0.61
18	Onyuongo	Nyando	Nyando	Midslope	2003-4	2003-4	430	400	330	216	0.50
19	Barngoror	Kericho	Nyando	Uplands	2003-4	2003-4	200	200	186	167	0.84
20	Chepchoyet	Kericho	Nyando	Uplands	2003-4	2003-4	250	249	240	201	0.80
21	Achego	Nyando	Nyando	Lowlands	2003-4	2003-4	430	419	400	209	0.49
22	Kaplelach	Nandi South	Nyando	Uplands	2003-4	2003-4	336	310	278	297	0.88
23	Tulwapmoi	Kericho	Nyando	Uplands	2003-4	2003-4	482	437	310	260	0.54
24	Koyebei	Kericho	Nyando	Midslope	2003-4	2003-4	362	327	241	150	0.41
25	Ishanda	Vihiga	Yala	Uplands	2003-4	2003-4	360	360	342	250	0.69
26	Hawinga	Siaya	Yala	Lowlands	2003-4	2003-4	498	420	275	68	0.14
27	Nyakogotera	Nyamira	Sondu-miriu	Uplands	2003-4	2003-4	402	400	340	327	0.81
28	Motongo	Nyamira	Sondu-miriu	Uplands	2003-4	2003-4	560	540	331	417	0.74
Total							10186	9883	8398	5863	0.59

Source: TransVic annual project reports and previous unpublished data important species bought by timber dealers are eucalyptus, followed by cypress and pine. Black wattle is the preferred charcoal species, eucalyptus again for poles, beds, and fuelwood. Though some dealers acknowledge the superiority of other hardwoods, their clientele can only afford the more commonly found softwood species.

Introduction of giant bamboo for enterprise and ecological health

ICRAF introduced giant bamboo (*Dendrocalamus giganteus*) into selected parts of the Lake Victoria basin in late 2003. By June 2004, 800 seedlings had been distributed to farmers in Kericho, Kisii, Nandi, Nyamira, Nyando, Siaya and Vihiga Districts. Bamboo products fetch high prices on the global market: a

Table 6.2 Tree species with the highest turnover.

Botanical name	Common English name	Native range	Percent of group nurseries reporting as highest turn over - N=23*	Percent individual nurseries reporting highest turn over – N=27**
Eucalyptus spp.	Eucalyptus	Australia	78	82
Grevillea robusta	Silver oak	Australia	57	33
Mangifera indica	Mango	South Asia	22	22
Dovyalis caffra	Kei apple	Southern Africa	13	26
Citrus sinensis	Lemon	China, Vietnam	17	22
Carica papaya	Papaya	Costa Rica, Mexico, USA	17	19
Passiflora edulis	Passion fruit		4	22
Persea americana	Avocado	Central America nd Caribbean	13	15
Calliandra calothyrsus	Calliandra	Mexico, Central America and some northern parts of South America	13	11
Terminalia mantaly		Madagascar	0	4
Terminalia brownii		Eritrea, Ethiopia, Kenya, Somalia, Sudan, Tanzania, Uganda	4	0
Leucaena leucocephala	Lead tree	Mexico, Central America and some northern parts of South America	4	4
Annona spp.	Custard apple	Belize, Guatemala	0	4
Delonix regia	Flame tree	Madagascar, Zambia	0	4

* One group nursery is new and did not report on previous distribution of seedlings.
** 24 of the individual nurseries are new so they did not report on the three species with the highest turnover.

square meter of bamboo flooring sells for about USD 112. At household level, bamboo can be a valuable source of firewood and charcoal, yielding more than 7000 kilocalories per kilogram, equivalent to half the yield from an equivalent amount of petroleum. In terms of ecological services, bamboo rhizomes anchor topsoil along steep slopes and riverbanks, effectively controlling erosion. Bamboo leaves, sheaves and old culms (poles) that die and fall on the ground create a thick humus layer that enriches the soil. Studies in Southeast Asia and Kenya have also shown that natural bamboo forests have excellent hydrological functions that promote soil health, with some species absorbing as much as 12 tonnes of atmospheric carbon. Bamboo is also used for treating waste water and ICRAF introduced bamboo to the municipal authorities in Kisumu and Kakamega.

Workshop on market-oriented agroforestry

Market-oriented agroforestry…where does it take us? A group of 49 interested people from diverse sectors met in Kisumu, Western Kenya for two-and-a-half days in 2002 to share experiences, ideas and demonstrating products and technologies. The group consisted of representatives of the private sector, organizations involved in marketing of wood and agroforestry products, government officials and researchers (Mungai et al., 2004).

The major goal of the workshop was to learn about demand for agroforestry products. Agroforestry system and technology development tends to be driven by interests in improving productivity. In many cases, we find that farmers produce more but are unable to market what they produce. They have not been well informed about market demand, including price, quality, seasonality or market opportunities. In other cases, farmers may be informed but not organized to meet the demand. Market demand changes all the time as well—liberalization of markets, shifting policies, changing tastes and the economic conditions of consumers all affect demand. Extension efforts have not kept pace with market realities. Other objectives of the workshop included fostering links between farmers, private sector and researchers, and coming up with ideas for how to integrate market information into extension materials.

Some key findings of the workshop included:

- Profitability can enhance sustainability. When farmers, processors and market actors make a profit they can invest back into the business or branch out into new enterprises. Enterprises can involve not just farming but also providing services to farmers such as extension advice, business services, marketing and processing.

- The private sector is dynamic and can provide a wealth of useful information to farmers and extensionists. However, little extension material is available on markets and enterprise options.

- There are several new opportunities such as clonal eucalyptus, contract honey production, commodity export services, and links with fruit wholesalers.

- The workshop provided opportunities for exploring links between the private sector and farmers but we should consider also trade fairs, sector-specific conferences (such as fruit or timber), inviting private sector to farmer field days.

- Understanding the policy dimensions of markets is critical, and this entails being up-to-date on policy changes and also on implementation of policies at the local level. Policies on tree-cutting and charcoal marketing can confuse farmers and inhibit investment.

- Nearly all of the research and development institutions represented at the workshop are interested in market-led production but have little experience and expertise in it.

Training workshop on enterprise development

In 2004 a training workshop on enterprise development was held for NALEP staff from seven districts in Western Kenya. Enterprises were assessed on the basis of gross margin analysis and initial capital requirements. A draft enterprise development manual was presented to the workshop participants. This has since led to the identification of a cluster of enterprises selected for farmers in different categories of prosperity/poverty. Relatively poor people are assumed to be able to afford to invest less than 1200 Kenya shillings; medium income people are assumed to be able to afford to undertake investments of no more than 10,000 Kenya shillings; relatively wealthy people are assumed to be able to undertake investments up to 100,000 Kenya shillings.

6.3 Monitoring and evaluation

A preliminary framework and approach for PM&E was developed by a working group of MoARD and ICRAF personnel in July to October 2001. A nine-day training course on Participatory Monitoring and Evaluation was put together for 20 MoARD extension staff from Siaya, Nyando, Nandi and Kericho districts. A proceedings document of that course has been published (Muhia 2002) and will be revised after subsequent training courses. In October and November 2001 the PM&E approach was used in new focal areas in Nandi (Chebisas) and Siaya (Nyadorera) to frame the expected outputs, activities, indicators and schedule for the community action plan. In June 2002 the MoARD staff and the communities undertook the first evaluation using the PM&E workplan. Farmers in both sites realized that they had indeed surpassed their initial objectives and expectations. The results from the workshops were then used to refocus approaches and extension methods in the two sites. For example, exchange visits were found to be more useful and effective than formal farmer training. The PM&E approach was then used in three of the five new focal areas that were undertaken in 2002/2003.

6.4 Extension innovations

***A New participatory tools for identifying and supporting the resource-poor*[16]**

A new approach to characterize households on the basis of their past and current ‘Stages of Progress’ was adapted to the needs of NALEP. This approach, entitled PAPOLD – Participatory Analysis of Poverty and livelihood Dynamics, is based on the ‘Stages of Progress’ analysis developed by Dr Anirudh Krishna of Duke University (USA). As of 2005, Dr Krishna and colleagues had applied this method in India, Uganda, Western Kenya, and Peru (see http://www.pubpol.duke.edu/krishna for more information and publications). The Stages of Progress studies in Western Kenya were conducted in collaboration with Duke University and the International Livestock Research Institute (ILRI) and culminated in the paper by Krishna et al, 2004. The Safeguard project, described in Chapter 4 of this report, modified the Stages of Progress method to include a greater emphasis on livelihood strategies and the assets needed to support those livelihood strategies, and called the expanded approach PAPOLD.

In mid-2003, the Research–Extension Liaison Officer identified the opportunity to integrate the PAPOLD methods into the Participatory Rural Appraisal approach used by NALEP for planning focal area development activities. In 2003/2004 the PAPOLD methods were integrated into the PRA approach in four focal areas: Achego, Onyuongo, Matongo and Barng’oror. There was strong interest among the extension agents involved. In August 2004 the TransVic Project provided a one-week training course in the PAPOLD methods to 12 NALEP headquarters and field staff. In 2004/2005, the PAPOLD methods were applied in NALEP focal areas in two districts, Kisii and Nyando. In 2005/2006, the NALEP project has embarked on a major exercise to train all of its staff in the use of the PAPOLD methods, with over 230 extension staff trained in the methods as of May 2006. The NALEP project has resolved that the methods must be used in all NALEP focal areas initiated in 2006/2007.

[16] This sub-section was prepared by David Nyantika and Brent Swallow. It has not been reported before .

In brief, the PAPOLD method is a fully participatory approach to: (1) the construction of a stages of progress ladder for households in the village; (2) characterization of each household in the village according to their current and past stage of progress, livelihood strategies, age and gender of household head, and land size; (3) assessment of the past, current and future importance of different livelihood strategies in the village; and (4) identification of the assets required for each livelihood strategy. NALEP staff use this information to characterize and stratify the village into clusters of households (male-, female- and youth-headed; poor, medium and wealthy; livelihood strategies) and to better understand the needs, resources, and opportunities for each cluster. Results are used to identify livelihood strategies that the households in a cluster may reasonably aspire to and to link those households to appropriate extension providers (eg micro-credit and local chickens for the poorest households). The results are also used to identify the most vulnerable households in the community (eg child-headed, female-headed, handicapped people) for the small grants that are now available under the second phase of NALEP. Early indications are that this approach has allowed the NALEP project to reach the poorest members of communities who generally were not reached through the standard NALEP methodology.

Consortium approach to promoting innovation–COSOFaP

In alignment with the national policy on pluralistic extension, the TransVic Project has encouraged the development of networks among extension service providers active in Western Kenya. This started in 2001 with the formation of a loose network of organizations that were promoting use of promising agroforestry technologies for soil fertility enhancement. In January 2002, the TransVic Project sponsored a meeting of extension providers who had shown interest in the soil fertility practices. Participants resolved to formu the Consortium for Scaling up Options for Increasing Farm Productivity in Western Kenya (COSOFaP). The consortium began operations in earnest in the second half of 2002, receiving financial support from The Rockefeller Foundation. COSOFaP brings together over 40 research and development organizations in Western Kenya that work on poverty alleviation, land rehabilitation and improving farmer livelihoods. COSOFaP identified a number of "learning centres" where consortium members are encouraged to add value to each others' work and to share experiences across learning centres. Two NALEP/ICRAF focal areas were identified as learning centres–Burkamach in Nyando District and Chebisas in Nandi District.

Two-year rolling approach to extension

Experiences from the first ten focal areas in Nyando, Kericho, Nandi and Siaya districts showed that individual farmers and common interest groups made the greatest advances during the second year of interaction with front-line, division and district-level extension staff. In the 2001/2002 annual report, we recommended that "consideration should be given to the possibility of a two-year rolling approach to focal area development". We proposed that year one begin with the development of community action plans, with the Ministry of Agriculture drawing in a range of service providers to address priority needs expressed by the communities. Farm-specific action plans could be developed and common interest groups encouraged to form during the year, with the approach to CIG formation varying depending upon the local culture. Year two could then focus on the provision of support for implementation of the recommendations and the start-up of enterprises based on the common interest groups.

This approach to extension planning was largely adopted into the plans for the second phase of NALEP, with a further change to enlarge the focal areas to administrative sub-locations.

Extension and training materials

Extension and training materials produced by the TransVic project include the following:

- *A project poster.*
- *A project newsletter - TransVic News - was developed and two issues circulated widely. In the final year of the project, 03/04, farmer stories were published in TransVic Voices and NALEP GIS training reported in TransVic Science.*
- *A project brochure was drafted and circulated at the World Summit on Sustainable Development in Johannesburg.*
- *An internet web page has been developed and updated.*
- *One extension manual was completed on Market Oriented Agroforestry (ICRAF 2002) on the basis of the workshop held in January 2002.*
- *One extension manual on improved fallows was drafted and will be completed and circulated by October 2002.*
- *One training manual on PM&E was published*

6.5 Training of extension staff

Graduate training: *A senior staff person from the Ministry of Agriculture and Rural Development (Mwangi Hai) was supported by the project, and other sources, to undertake a PhD study on the hydrology of land use as part of the project. He was registered at Stockholm University and is yet to complete his dissertation. Another Ministry of Agriculture staff person, Simon Oyasi, completed his Masters thesis on a similar topic in 2004.*

GIS training for NALEP staff: *In the early stages of the TransVic Project, two senior Ministry staff were given on-the-job training in GIS at the ICRAF GIS lab in Nairobi. This was not considered successful, and was discontinued after the first year. Much more successful, however, was the training of six field-based NALEP staff in practical tools for GIS (ArcView) and the use of handheld GPS units (global positioning system). The training is to equip them with a planning and monitoring tool which complements PM&E (participatory monitoring and evaluation) training. Training sessions were held in March and May 2003 at Kisumu. The training also included non-spatial data input in MS-Excel. Each trainee was issued with a handheld GPS unit for field data gathering after the first training session. Trainees were drawn from Kericho, Kisii, Nandi South, Nyamira, Nyando and Vihiga Districts. Four of the districts above now have GIS-capable computers.*

GIS training for Survey of Kenya staff: *A strong collaborative arrangement was formed with Survey of Kenya—the government agency responsible for mapping in the Republic of Kenya. Over a two-year period between 2001 and 2003, seven Survey of Kenya staff spent varying lengths of time, usually between three and six months, at the ICRAF GIS lab in Kenya to develop detailed digital map layers for the Lake Victoria area—map layers that will be very useful for modelling and decision support. All of the 1:50,000 ordinance survey maps for Western Kenya were digitized and rectified by the Survey of Kenya staff, who received on-the-job training in digitization and various GIS software and applications. The results are of use for the TransVic Project and for Survey of Kenya.*

Chapter 7. Support to programme, policy and institutional design

As research results were generated through the various research activities, the results were communicated through a variety of forums that ranged from project reports, maps and articles in the national and international media. And through organizing and co-hosting a number workshops and seminars, ICRAF and NALEP were not only able to link research to extension but also to regional policy makers, related programmes and NGOs. Close links were fostered with important stakeholders such as the Lake Victoria Secretariat of the East African Commission (EAC), the Lake Victoria Environmental Programme (LVEMP), National Environmental Management Authorities (NEMAs), the United Nations Environment Programme (UNEP) and district-level authorities. Results from the project have become widely circulated, for example, in the UNEP GEO assessment of Lake Victoria.

7.1 Further investment in land restoration research and development

The TransVic Project raised the national and international profile of land degradation in the Kenya part of the Lake Victoria basin, clarifying the massive, systemic and inter-related nature of the problems. The results presented in this report make it clear that the problems affecting the basin need to be addressed at a broader landscape level. This has prompted new investments in land restoration in the basin. For example, the Swedish non-governmental organization, Vi Agroforestry, used TransVic project results as the basis for its expansion into the Nyando river basin. The ViAgroforestry project is delivering agroforestry technologies to thousands of farmers in key hotspot areas the Nyando basin, especially in the Katuk-Odeyo area.

TransVic project results also contributed to the initiation and design of the Western Kenya Integrated Ecosystem Management Project. This 4.1 million project is being financed by the Global Environmental Facility (GEF) in order to reverse the immense environmental degradation in the Kenyan portion of the Lake Victoria basin, create income-generating opportunities for local farmers and improve the quality of water. Interventions are both technical and institutional. Technical interventions focus on the use of hardy indigenous trees, supplemented by other trees selected by local farmers. Institutional innovations focus on conservation set-aside areas where groups of farmers pool their holdings of degraded land. The project is jointly executed by the Kenya Agricultural Research Institute (KARI) and ICRAF. The project is expected to benefit up to 12,000 households among the seven million people living in the Nzoia, Nyando and Yala river basins. It is expected that the successful implementation of the GEF project will lead to a further $60 million investment in land management in the Kenya part of the Lake Victoria basin.

7.2 Further investment in water resource and watershed management research

The TransVic project worked at the interface of land and water management. In the first instance, the water component of the project focused on the monitoring of water quality in some of Kenya's major rivers that drain into Lake Victoria: Nyando, Sondu-Miriu, Yala and Nzoia. The sediment and nutrients carried by those rivers into Lake Victoria are indicators of the extent and type of degradation in the catchment. Sediment and nutrient deposition from the rivers in turn degrade the quality of water in Lake Victoria and affect the quality of the lake ecosystem. As the TransVic project progressed, it became clear that the Nyando river basin is a major source of sediment and nutrient pollution of Lake Victoria. It also became clear that water quality and water access are also major concerns for people living in the catchment area.

In one of the NALEP / ICRAF focal areas, Kipsiwo in Nandi District, ICRAF and the Ministry of Agriculture provided support to a major community initiative on improved water management. The community protected a year-round spring, and laid an extensive network of pipes to convey that water to community nurseries, community water taps, and a nearby school. Ashita Abraham (2002) conducted a preliminary impact assessment of the Kipsiwo experience, concluding that it had major positive impacts on human health, milk production by cows, time allocation by women, and the production of tea and other tree seedlings. This first study of water management was followed in 2003 / 4 by the work of Jessica Roy, a PhD student in sociology at the University of California – Santa Cruz. Jessica focused on a set of three issues: (1) social organization around water provision; (2) gender relations in water management and water use; and (3) the impacts of improved water supplies on human welfare. Jessica died tragically in a road accident in August 2004, having just finished qualitative research in a pair of villages in the upper part of the Nyando basin. Five smaller studies were undertaken in 2005/6 to followup the work that Jessica began. This included a geo-referenced census of springs in the upper part of the basin; a geo-referenced census of water points in the lower part of the basin; a case study of Jessica's three questions in Kiptagen village; a further study of those questions in 7 contrasting villages in the upper part of the basin; and a study of 10 contrasting water point management regimes in the lower part of the basin.

7.3 Raising the profile of watershed management in Africa

Through its research in the Lake Victoria basin, ICRAF has come to be seen as a leader of watershed management research and development in Africa. In October 2003, ICRAF hosted and co-convened the Africa workshop on "Preparing for the Next Generation of Watershed Management Programmes," involving watershed management experts from across all sub-regions of Africa. The main conclusions of that workshop were summarized and presented by ICRAF at a global meeting that was held in November 2003. The proceedings of those international workshops have recently been published (Swallow et al., 2005; Swallow 2005).

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ANNEX 2: Project Personnel

Table A2.1 ICRAF Staff and long-term consultants

Name	Position
Luka Anjeho	Senior Field Technician
Sharmila Babu	Secretary
Sammy Kimau	Senior Field Attendant
Isaac Learamu	Field Assistant
Benjamin Muoki	Field Attendant
Raphael Ndambuki	Field Attendant
David Nyantika	Research-Extension Liaison
Nahashon Odieny	Guard
Peter Okoth	Driver
Chin Ong	Co-leader, Hydrologist
Frank Place	Economist
Diane Russell	Anthropologist
Andrew Sila	Data analyst
Tina Svan-Hansen	Geography
Brent Swallow	Project Coordinator, Agricultural Economist
Elvis Weullow	Laboratory technician
Eva Gacheru	Consultant, Striga control
Fridah Mugo	Consultant, NRM and field coordinator of the startup phase
Wilson Nindo	Consultant, Participatory research
Leah Onyango	Consultant, Safeguard project

Name	Position
Alex Awiti	GIS analyst
Antonia Njeri Okono	Administration and Communication Officer
Damaris Kung'u	Documentalist
Cleophas Miheso	Driver
Samuel Muriithi	Environmental economist
Qureish Noordin	Research-Extension Liaison
Oscar Ochieng	Research Assistant -- GIS
Catherine Oduor	Web designer
Kennedy Okula	Driver
Charles Otieno	Caretaker
Steven Ruigu	Tree domestication expert
Keith Shepherd	Systems agronomist
Nicholas Shitsukane	Accountant
Markus Walsh	Landscape ecologist
Robert Zomer	Landscape ecologist
David Mungai	Consultant, Landscape hydrology and modeling
Michael Maina	Interm, Data entry
Njeri Muhia	Consultant, participatory research, monitoring and evaluation

TableA2.2: Graduate and undergraduate students

Student name (supervisor)	Country of origin, funding	Discipline, Degree, University	Subject matter	Status as of May 2006
Alex Awiti (Markus Walsh)	Kenya, BIOTA	PhD, University of Nairobi	Deforestation and soil degradation processes	Completed dissertation, awaiting award
Ashita Abraham (Brent Swallow)	India, British Council	MSc, Southampton, UK	Assessment of impacts of water management	Completed PhD
David Amudavi (Brent Swallow)	Kenya, self-funded and VoP project	PhD in extension, Cornell University	Agricultural extension and community priorities	Completed PhD

Table A2.2 continued

Student name (supervisor)	Country of origin, funding	Discipline, Degree, University	Subject matter	Status as of May 2006
Jacco Brouwer (Brent Swallow)	Netherlands, self-funded	Public administration, University of Twente	Long-term impacts of agroforestry in Siaya and Vihiga Districts	Completed undergraduate
Matthew Cohen (Keith Shepherd)	USA, scholarship from University of Florida	PhD in Systems ecology, University of Florida	Accounting for environmental costs of land use and degradation at multiple scales	Completed PhD
Jeffries de Graffenfried (Keith Shepherd)	USA	PhD, University of Alabama	Landscape survey of impact of land conversion and maize cultivation on soil quality	Still in progress
Jeroen Daas (Robert Zomer & David Mungai)	Netherlands, Utrecht University and operational costs by project	BSc field studies, Utrecht University	Analysis of infiltration rates in Katuk-Odeyo	Completed undergraduate
Jean-Sebastien Detry (Frank Place)	Belgium, self funded	Economics, MA equivalent, Namur, Belgium	Survey of community use of Yala wetlands	Changed projects
Cedric Duprez (Frank Place)	Belgium, self funded	Economics, MA equivalent, Namur, Belgium	Survey of community use of Yala wetlands	Changed projects
Lisa Fernius (Mwangi Hai)	Sweden, self-funded & Uppsala University	Environmental engineering BSc, Uppsala University, Sweden	Soil properties predisposing the growth of gullies in Nyando District	Completed undergraduate
Mwangi Hai (Chin Ong)	Kenya, funded through project	Systems Ecology, PhD, Stockholm University, Sweden	Analysis of the effects of land use and interventions on runoff & erosion in Rongo	Still in progress
Joseph Kurauka (Robert Zomer &Frank Place)	Kenya operational costs from project	Environmental Science MSc Kenyatta University	Urban market for wood products in Kisumu, Nyando, Kericho and Nandi Districts	Completed MSc
Stephen Ichami Muhati (Keith Shepherd)	Kenya, Rockefeller Project	BSc, Egerton University	Soil spectral analysis	Completed undergraduate
Kelebogile Mfundisi (Louis Verchot)	Botswana, DAAD and project funds	PhD, Bonn University, Germany	Effects of wetland use on carbon sequestration and filter functions	Completed PhD
Lynette Obare (Alex Awiti)	Kenya, McGill University and project	MA, McGill University	Application of GIS in NRM	Completed MA
Christian Omuto (Keith Shepherd)	Kenya, operational costs from other ICRAF funds	MSc, Agricultural Engineering, University of Nairobi	Mapping of hydraulic conductivity	Completed. Now enrolled for a PhD in the same department.

Student name (supervisor)	Country of origin, funding	Discipline, Degree, University	Subject matter	Status as of May 2006
Leah Onyango (Diane Russell)	Kenya, , operational costs from other ICRAF funds	MA Planning, University of Nairobi	Niches for agroforestry for women	Completed MA. Now enrolled for PhD with Maseno University
Seth Ooko Onyango (Brent Swallow)	Kenya, , operational costs from other ICRAF funds	MSc, Agricultural Economics, Egerton University	Impacts of human illness and death on agriculture in Awach basin	In progress
Tom Owino (Markus Walsh &Keith Shepherd)	Kenya, Rockefeller Foundation	PhD in environmental science, Cornell University	Use of high resolution satellite spectral information in landscape diagnosis	Completed PhD
Simon Oyasi (Chin Ong)	Kenya, operational costs from project	MSc, University of Nairobi	Runoffand erosion by land use in Katuk-Odeyo	Completed MSc
Jelle Rauwerdink (Brent Swallow)	Netherlands, self-funded	Public administration, University of Twente	Long-term impacts of livestock in Siaya and Vihiga Districts	Completed undergraduate
Michelle Swallow	Canada, operational costs from project	BSc, Caribou College, Canada	Riparian vegetation and nutrient loading in Nyando	Completed undergraduate
Christian Tegtmeier (Brent Swallow)	Germany, consultant until Jan 01, self-funded since	Social geography PhD, University of Bonn, Germany	Community resource management in Rongo area	Still in progress
Thuita Thenya (Robert Zomer/Louis Verchot)	Kenya, scholarship from Univ of Bonn	Ecology, PhD, University of Bonn	Analysis of biomass, productivity, utilization and impact in Yala Swamp	Completed PhD
Johannes van der Kwast (Robert Zomer & David Mungai)	Netherlands, Utrecht University, operational costs by project	BSc field studies, Utrecht University	Characterization of land cover in Nyando river basin	Completed undergraduate
Leah Cohen	USA, self-funded	Anthropology, University of Florida, MA	Agriculture, environment and health in Western Kenya	Completed MA

Table A2.3 GIS Trainees 1.6 Publication and dissemination of results

Organization	Names of trainees
Ministry of Agriculture and Rural Development:	Abraham Boit, Daniel K Bundotich, Peter Isigi, Edwin Mwango, Bernard Onyango, Robert Orina,
Survey of Kenya:	Faith Birir, Florence Menge, David Mugwe, John Mwairo, Nancy Wanjira, Martins Okanga, Abach Owino, Nanzala Mungendo

Table A2.4 Ministry of Agriculture and Rural Development collaborators (position and assignment at the time of collaboration with TransVic)

Name	Position	Name	Position
Arne Eriksson	NALEP Advisor, HQ	Japheth Kiara	NALEP – National Coordinator, HQ
Martin Grundler	NALEP Advisor, HQ		
John Kimani	Agroforestry Coordinator, HQ	Peter Mbogo	Socio-Economic Department – Collaborator, HQ

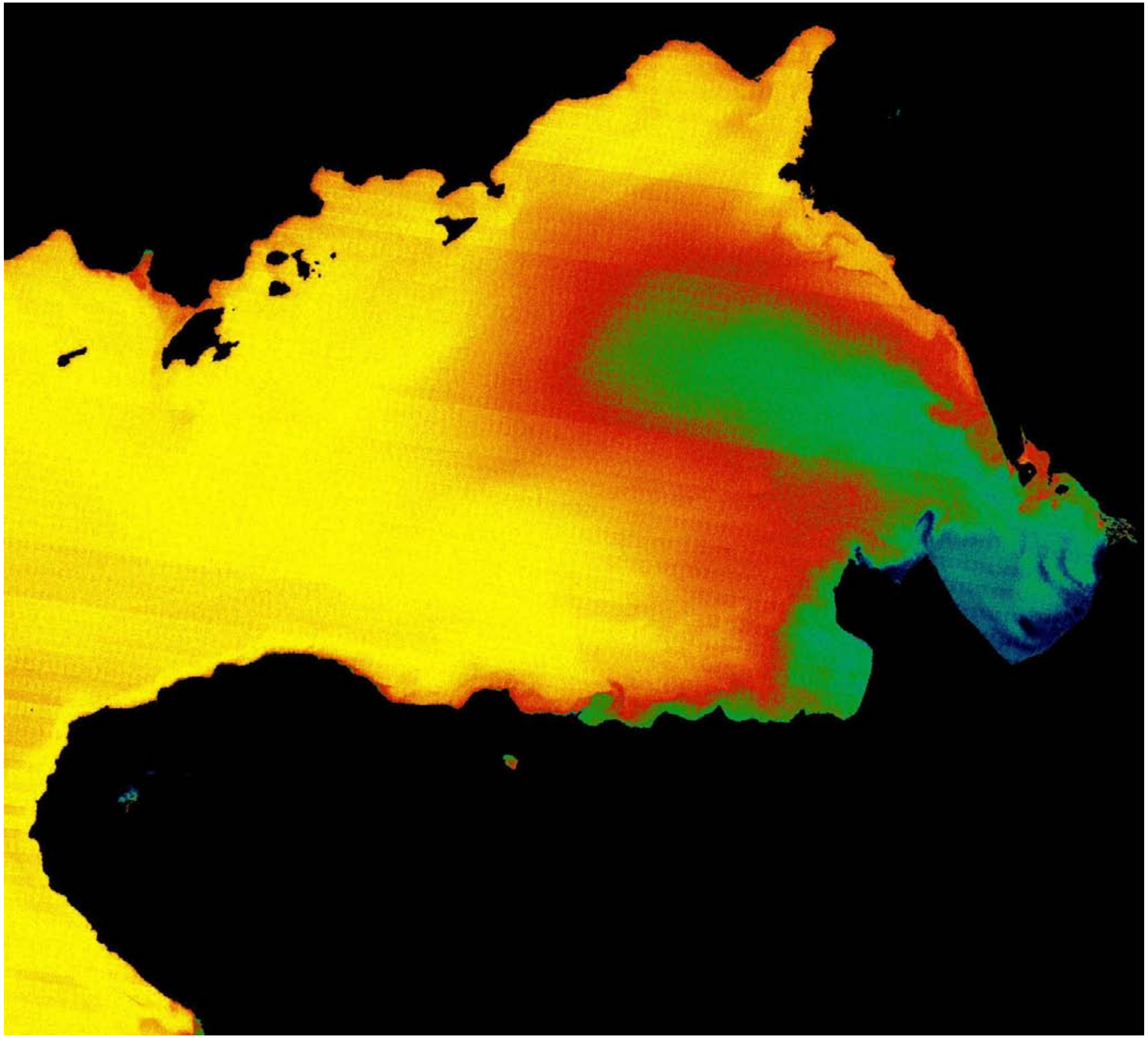
Table A2.4 continued

Name	Position	Name	Position
Francis Mbote	Chief of Land & Agriculture – Development Division, HQ	Joseph Mburu-	Head of Soil & Water Conservation Branch, HQ
Fabian Muhia	Training Officer, HQ	Francis Muhoro	M& E Section, HQ
Ziporah Mugonyi	Soil Fertility Management Officer, HQ	Kithinji Mutunga	Water Harvesting & Moisture Management Officer, HQ
Lincoln Mwarasomba	Socio-Economist, HQ	Amare Tegberu	Programme Socio-Economist, HQ
Zakayo Magara	Provincial Agricultural Officer, Nyanza Province	Odoyo J. Bittar	Provincial Soil and Water Conservation Officer, Nyanza Province
Wycliff Omutsani	Provincial Director of Agriculture and Livestock Production, Nyanza Province	John Melly	Provincial Agricultural Officer, Rift Valley Province
Wepukulu Fwamba	Provincial Soil and Water Conservation Officer, Rift Valley Province	David Nyansani	Provincial Director of Agriculture and Livestock Production, Rift Valley Province
Jeremy Langat	DALEO, Kericho District	Simon Kirui	District Soil and Water Conservation Officer, Kericho District
Michael Obura	District Agricultural Officer, Kericho District	Daniel Bundotich	ICRAF/NALEP Coordinator, Kericho District
Daniel Rop	Divisional Extension Coordinator, Sigowet Division	Langat Samuel	Divisional Soil and Water Conservation Officer, Sigowet Division
Bii John	Divisional Crops Officer, Sigowet Division	Simon Langat	Divisional Animal Production Officer, Sigowet Division
Juma Margaret	Divisional Home Economics Officer, Sigowet Division	Richard Koskei	Frontline Extension Worker, Sigowet Division
Phillip Makheti	DALEO, Nandi District	Alfred Musia	District Soil and Water Conservation Officer, Nandi District
Mary Tonui	District Livestock Production Officer, Nandi District	Boit Abraham	Divisional Extension Coordinator, Tinderet Division
Paul Keter	Divisional Soil and Water Conservation Officer, Tinderet Division	Moses Togom	Divisional Crops Officer, Tinderet Division
Robert Ngeno	Divisional Ruminant and Non-ruminant Officer, Tinderet Division	Robinson Rotich	Divisional Animal Production Officer, Tinderet Division
Samuel Sitenei	Frontline Extension Worker, Tinderet Division	P Magut	Frontline Extension Worker, Tinderet Division
Tom K. Opiyo	DALEO, Nyando District	David Ombalo	District Agricultural Officer, Nyando District
Bernard Onyango	District Soil and Water Conservation Officer, Nyando District	Shem Okora	Divisional Extension Coordinator, Lower Nyakach Division
Silas Deya	Divisional Soil and Water Conservation Officer, Lower Nyakach Division	Wesley Ong'or	Divisional Crops Officer, Lower Nyakach Division
Zedekiah Kajuku	Divisional Animal Production Officer, Lower Nyakach Division	James Abudi	Frontline Extension Worker, Lower Nyakach Division

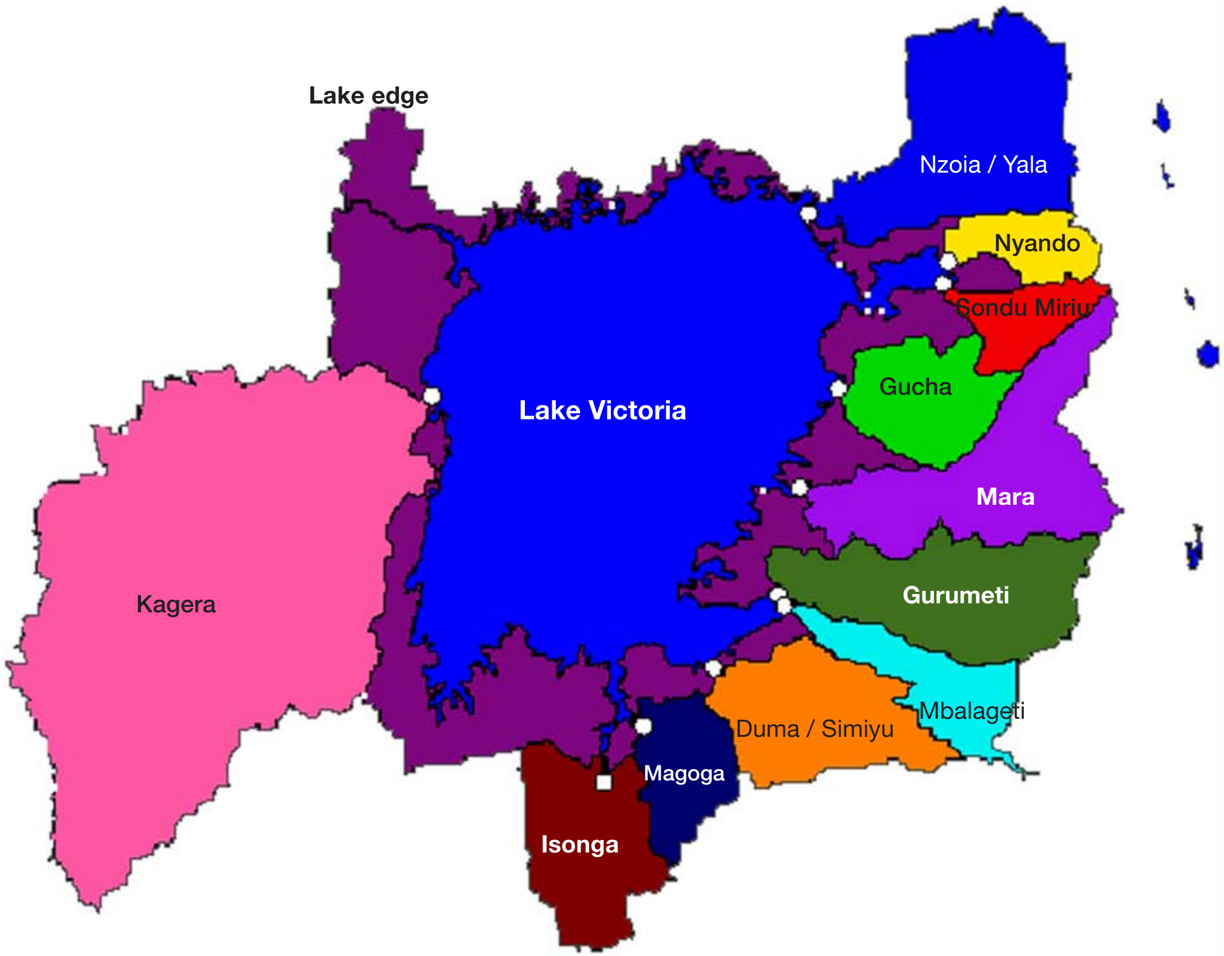
Table A2.4 continued

Name	Position
Evans Tinega	Divisional Extension Co-ordinator, Miwangi Division
Lornah Aluodo	Divisional Home Economics Officer , Miwangi Division
John Odhiambo	Divisional Crops Officer, Miwangi Division
Vincent Wanzala	Divisional Extension Co-ordinator, Muhoroni Division
William Alando	Divisional Home Economics Officer, Muhoroni Division
James Kharinda	Frontline Extension Worker, Muhoroni Division
Henry Owiti	Divisional Soil and Water Conservation Officer, Nyando Division
Pamela Akal	Divisional Home Economics Officer, Nyando Division
Felix Omondi	Divisional Irrigation Officer, Nyando Division
Evans Onsinde	Frontline Extension Worker, Nyando Division
Nelson Agengo	Divisional Soil and Water Conservation Officer, Upper Nyakach Division
Pamela Jowi	Divisional Home Economics Officer, Upper Nyakach Division
Simon Origa	Frontline Extension Worker, Upper Nyakach Division
J E Chiew	District Agricultural Officer, Siaya District
I W Ngugi	District Soil and Water Conservation Officer, Siaya District
P Kodera	District Farm Management Officer, Siaya District
M Oudia	District Home Economics Officer, Siaya District
S P Gor	Divisional Soil Conservation Officer, Lower Nyadorera Division
L O Wambiya	Divisional Animal Production Officer, Lower Nyadorera Division
L A Obunga	Divisional Home Economics Officer, Lower Nyadorera Division

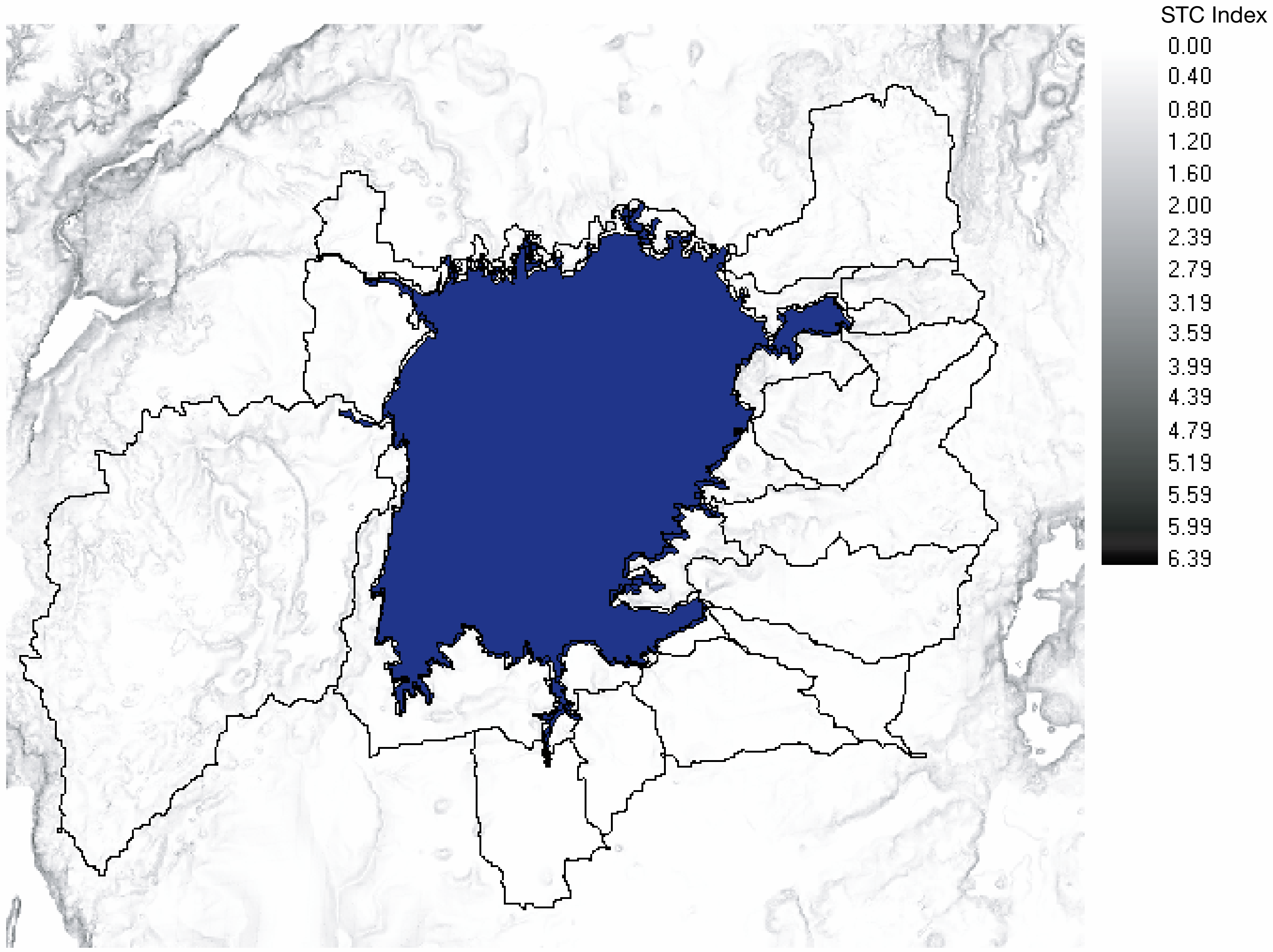
Name	Position
James Odundo	Divisional Soil and Water Conservation Officer, Miwangi Division
Charles Kakuku	Divisional Animal Production Officer, Miwangi Division
Martin Sinogo	Frontline Extension Worker, Miwangi Division
Luke Musewe	Divisional Soil and Water Conservation Officer, Muhoroni Division
Solomon Ondore	Divisional Animal Production Officer, Muhoroni Division
James Ang'awa	Divisional Extension Coordinator, Nyando Division
Esther Onyango	Divisional Crops Officer, Nyando Division
William Olwera	Divisional Animal Production Officer, Nyando Division
Paul Owiti	Frontline Extension Worker, Nyando Division
Thadeus Ouko	Divisional Extension Coordinator, Upper Nyakach Division
Phanuwel Okoth	Divisional Crops Officer, Upper Nyakach Division
Jack Adwar	Divisional Animal Production Officer, Upper Nyakach Division
K P O Onyango	DALEO, Siaya District
J Ndege	District Livestock Production Officer, Siaya District
J O Miya	District Engineer, Siaya District
P O Ogutu	District Horticultural Officer, Siaya District
D Oyugi	Divisional Extension Co-ordinator, Lower Nyadorera Division
L O Wambiya	Divisional Animal Production Officer, Lower Nyadorera Division
J A Ngonga	Divisional Crops Officer, Lower Nyadorera Division
P O Owuor	Frontline Extension Worker, Lower Nyadorera Division



Map 1. Nyando sediment plume (~40 km2) in Lake Victoria based on Landsat ETM data Feb.
(Source: Walsh, Shepherd and Awiti, as reported in ICRAF's 1999 annual report and in Science Online. 2000)

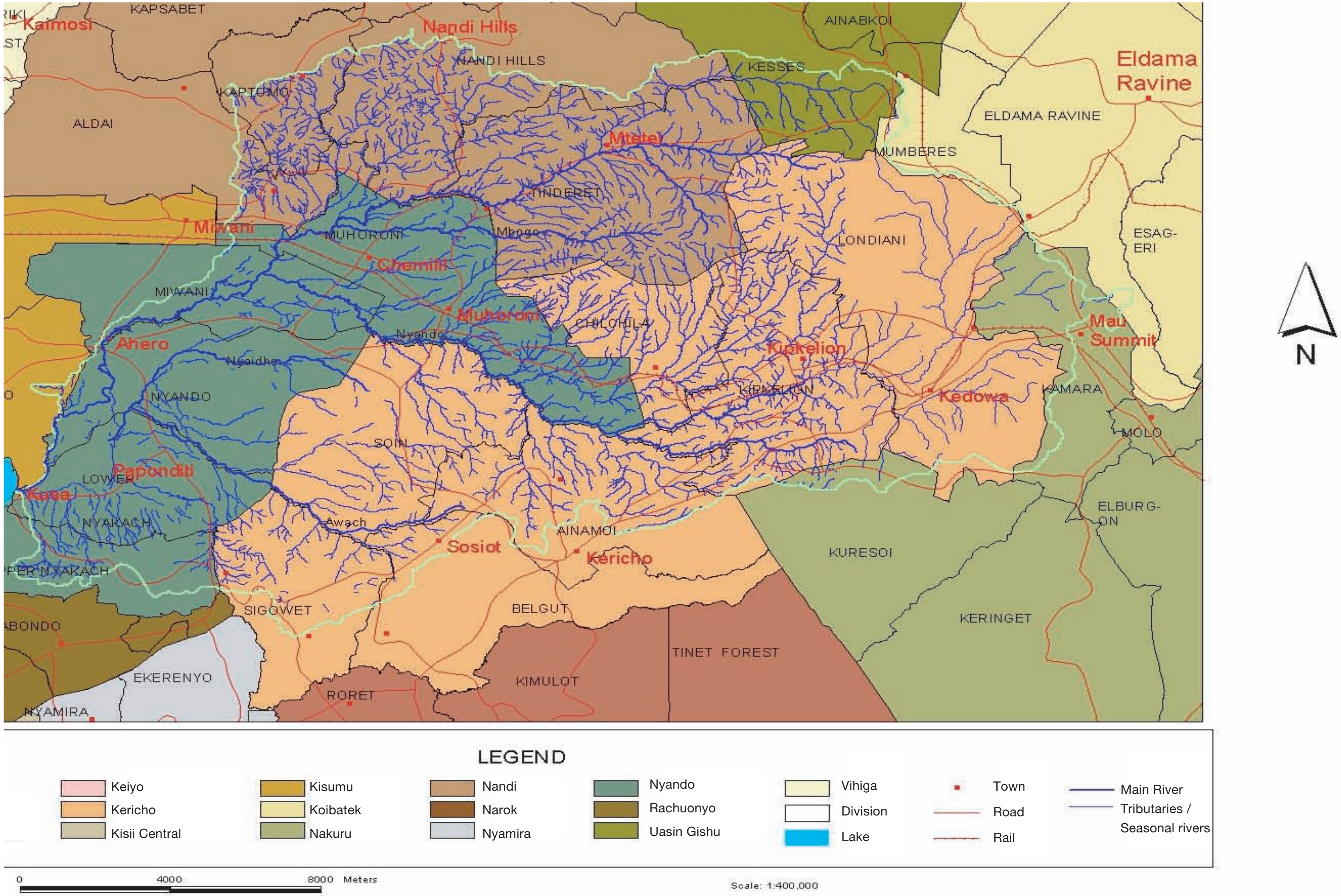


Map 2. Drainage basins of Lake Victoria Source: A. Awiti and M. Walsh, in Shepherd et al. 2000

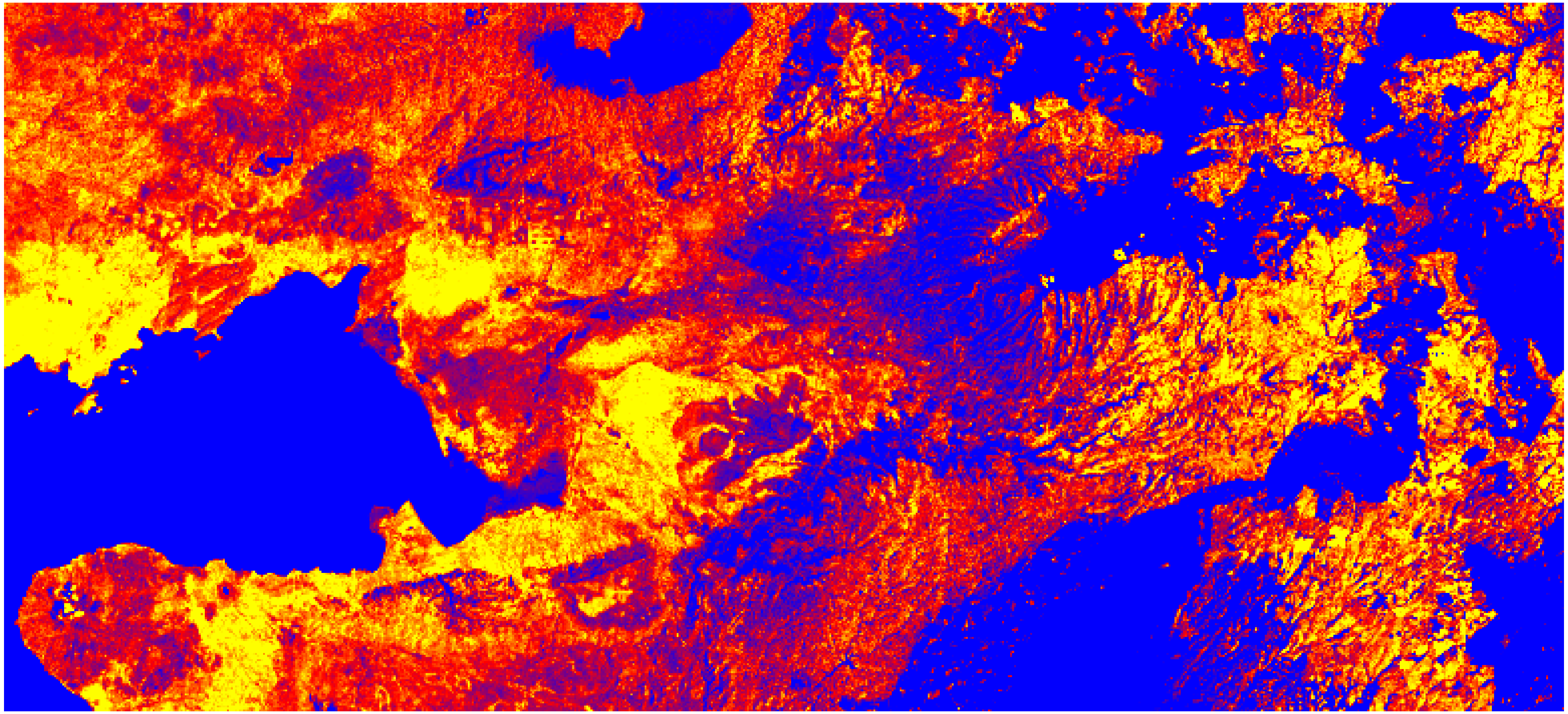


Map 3. Sediment Transport Capacity Index for Lake Victoria Basin. (Source A. Awiti and M. Walsh, in Shepherd et al. 2000

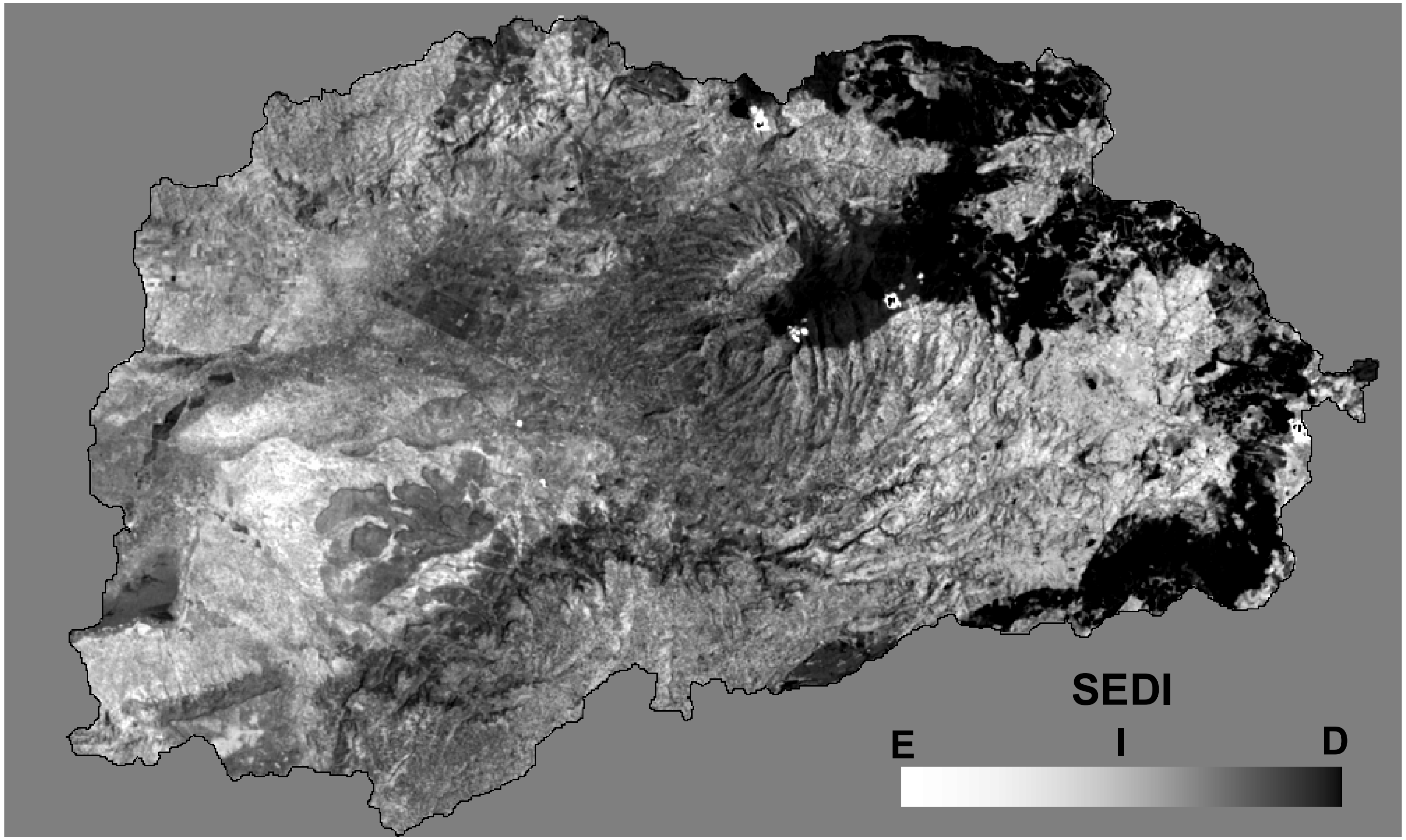
Note: STC Index (Sediment Transport Capactiy Index) combines slope angle and length of slope to characterize the influence of terrain on soil erosion potential.



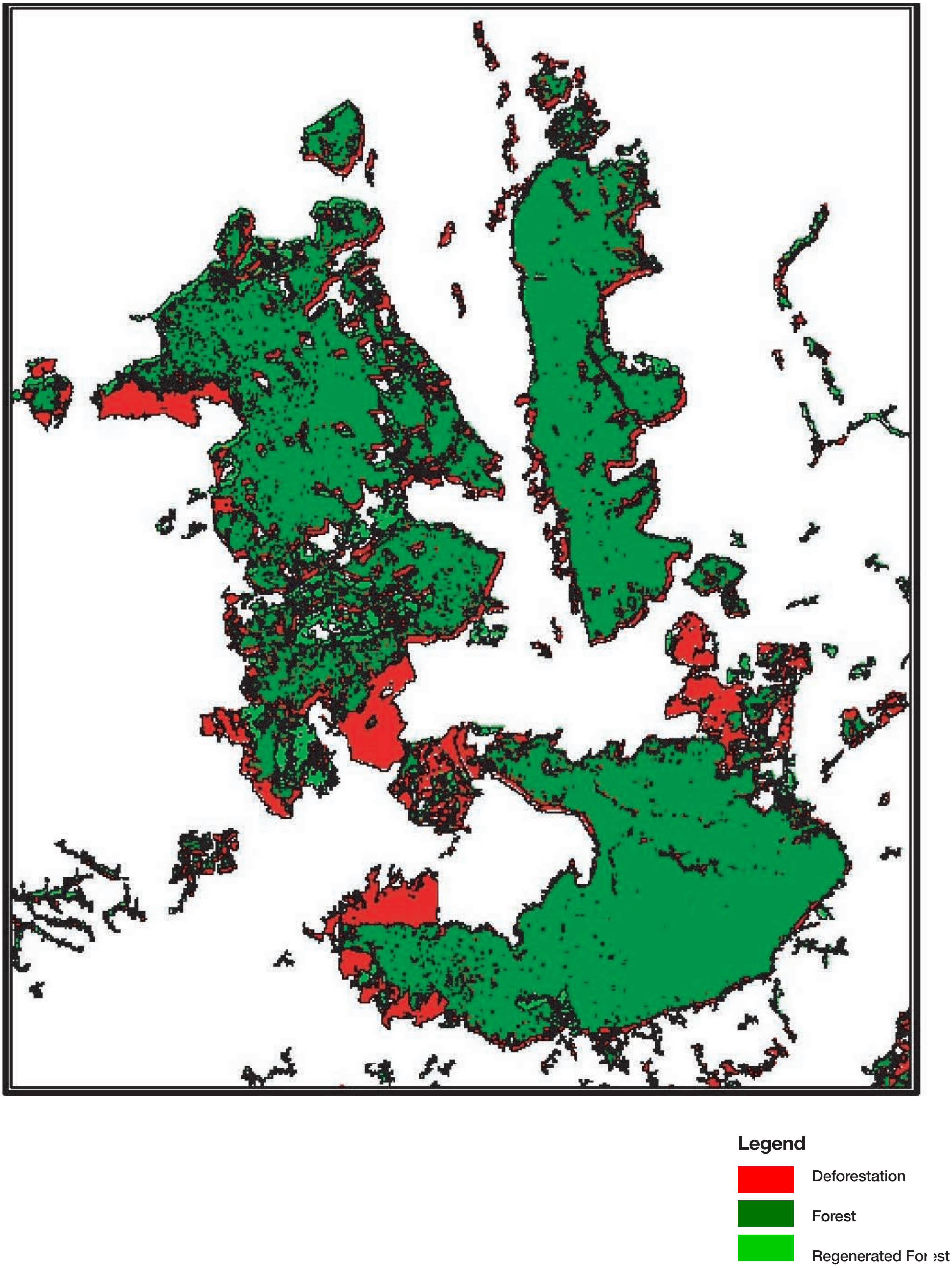
Map 4. Hydrological extent of the Nyando River Basin. (Source: Safeguard Project)



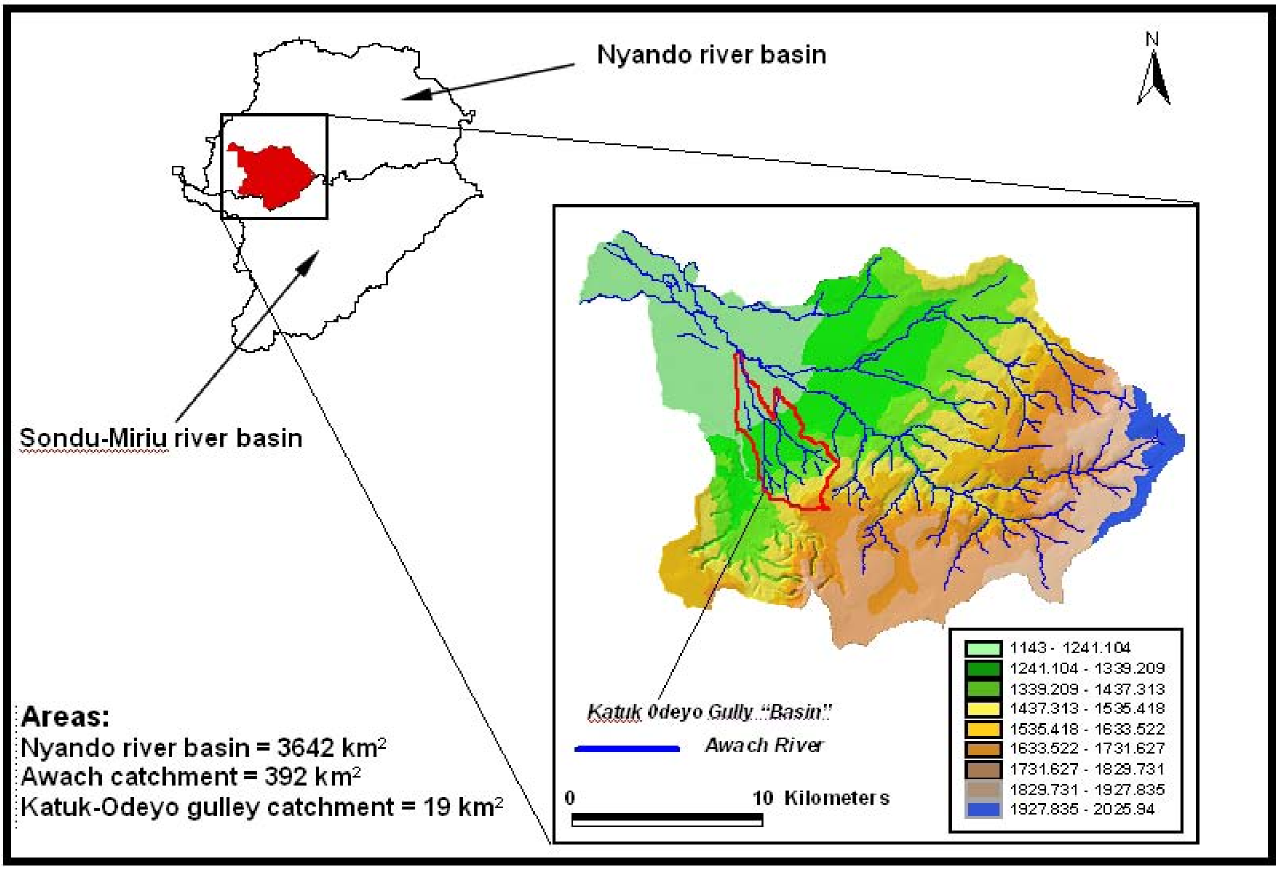
Map 5. Indicative distribution of sediment source potential in the Nyando River Basin (Interpretation based on Landsat ETM+ satellite image, February 2000). (Source: A. Awiti and M. Walsh, in Shepherd et al. 2000)



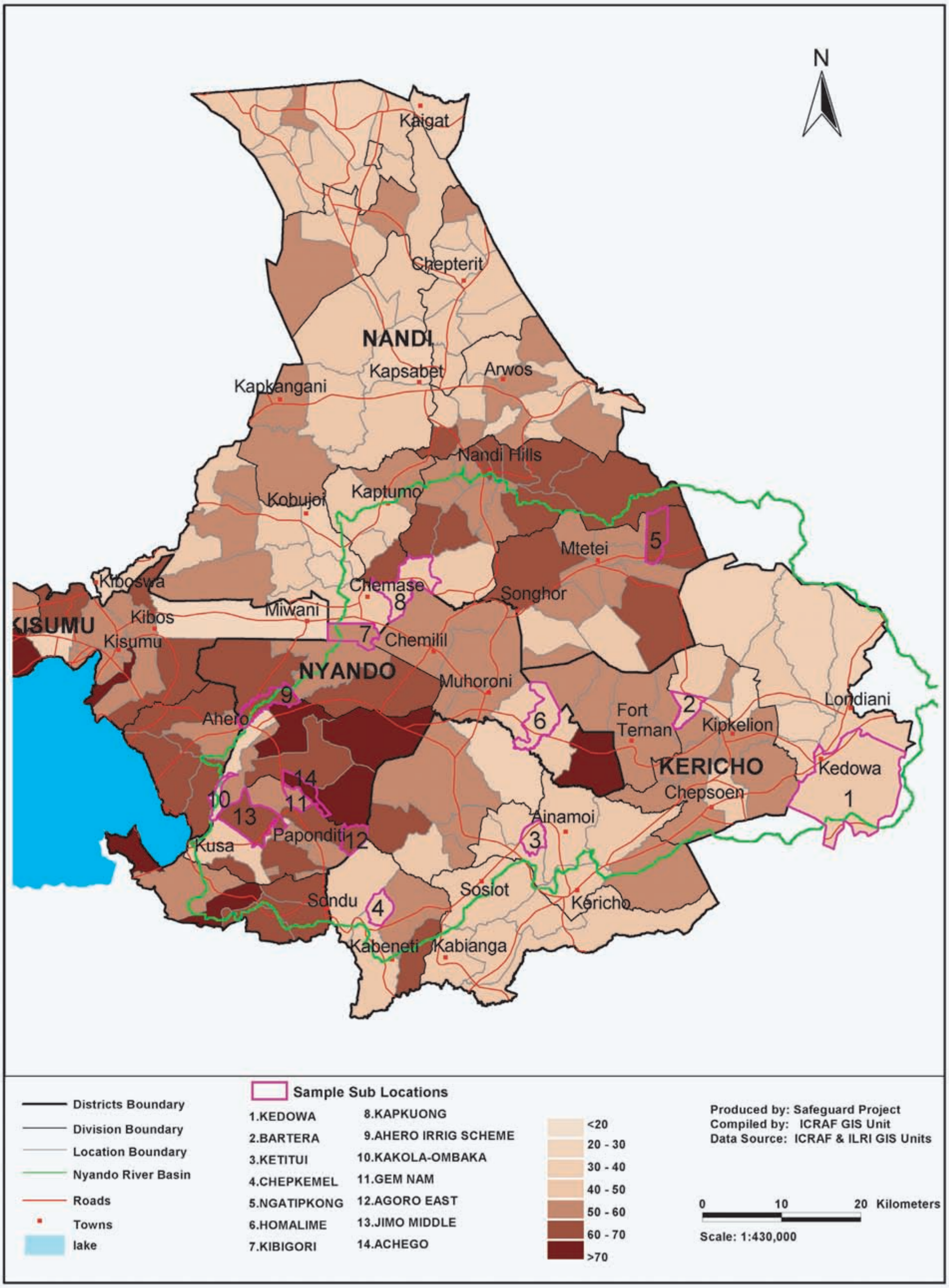
Map 6. Erosion risk in Nyando River Basin. E indicates areas with highly eroded soils. D indicates areas that have experienced high deposition of soil. (Source: M. Walsh, K. Shepherd and A. Awiti, personal communication)



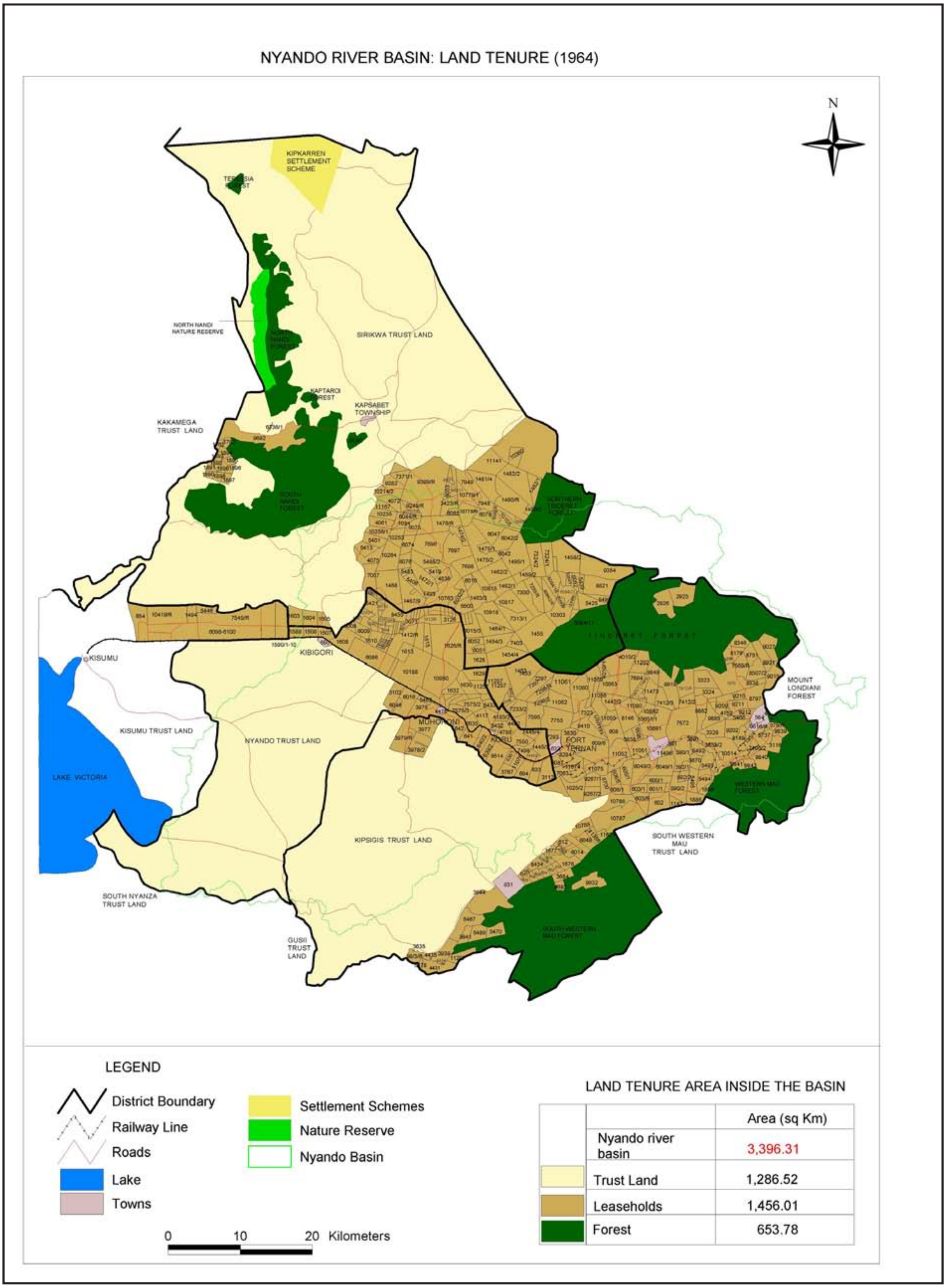
Map 7. Deforestation and forest recovery in Kakamega, N & S Nandi forests between 1986-2000 (Source: Awiti, 2006)



Map 8. Elevation gradient in the Awach catchment and the Katuk-Odeyo gully catchment. (Source: Swallow et al. 2001)

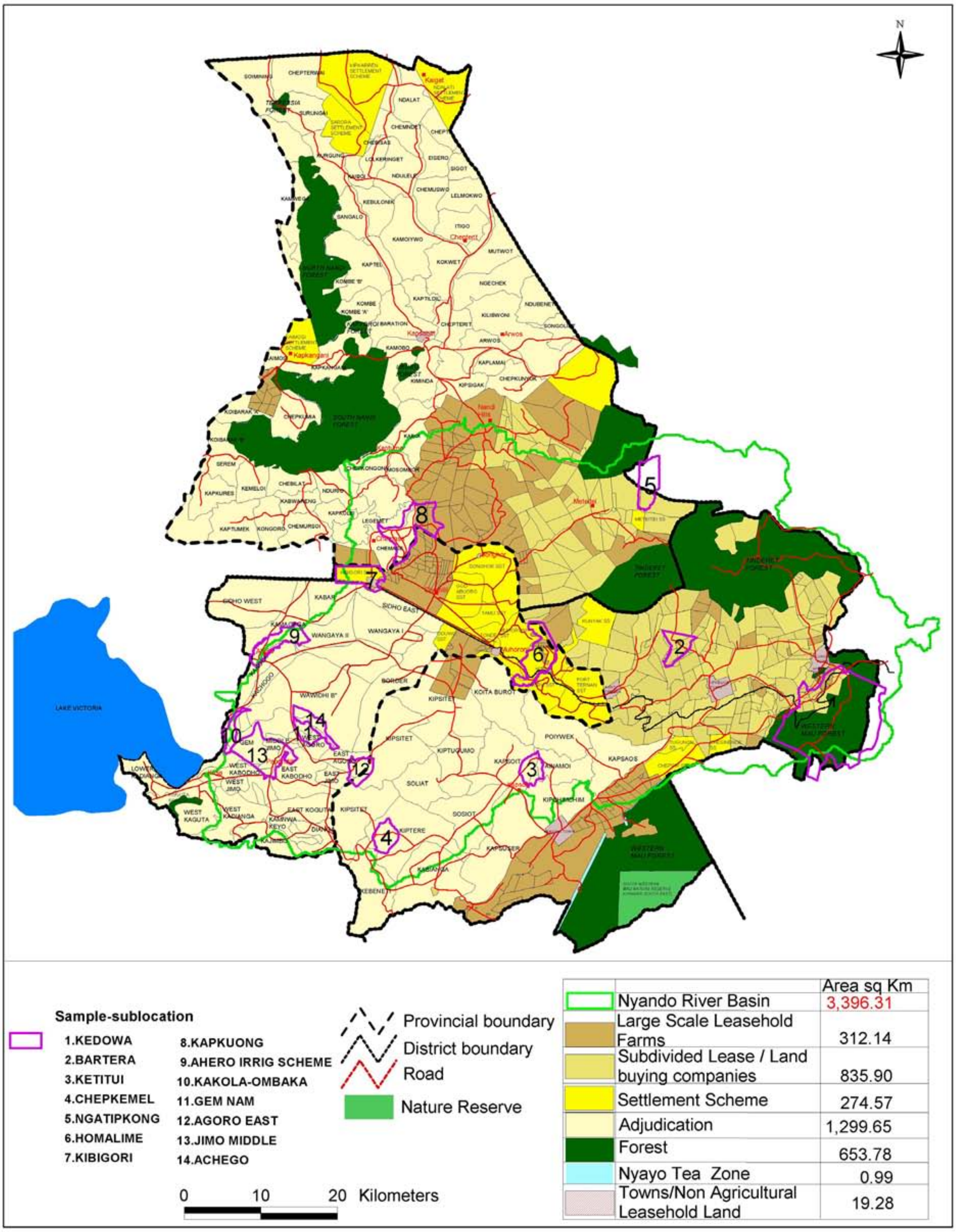


Map 9. Percent of rural population below the poverty line in the Nyando river basin. (Source: Onyango et al. forthcoming based on Central Bureau of Statistics of Kenya data)

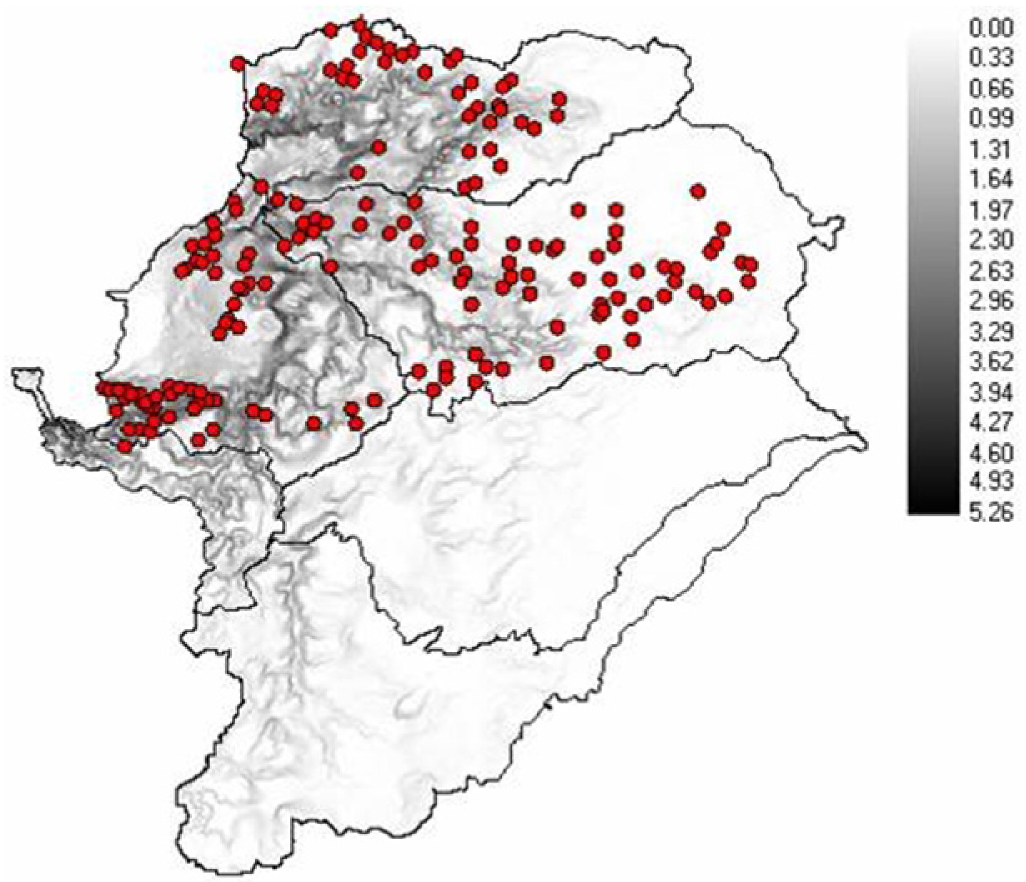


Map 10. Land tenure in the Nyando river basin, 1964. (Source: Onyango et al. forthcoming)

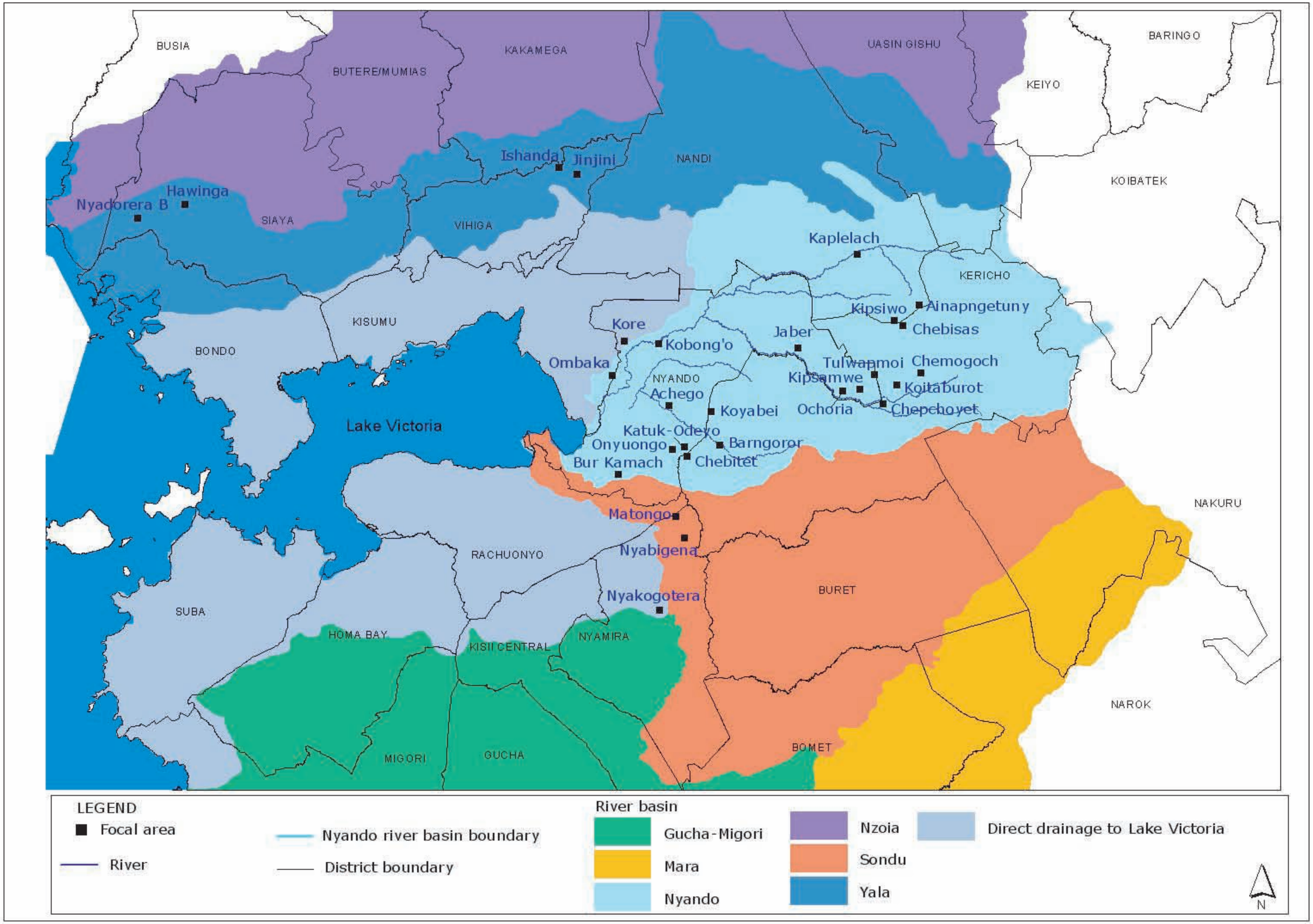
NANDI,KERICHO AND NYANDO DISTRICT: LAND TENURE



Map 11. Land tenure in the Nyando river basin, 2004. (Source: Onyango et al. forthcoming)



Map 12. Overlay of SWCB catchments in Nyando Watershed with an index of sediment transport capacity for Nyando and Sondu-Miriu watersheds (Source: Sven-Hanson and Walsh in Shepherd et al.)



Map 13. Focal areas (28) of the TransVic project covering portions of the Nyando, Yala and Sondu-Miriu river basins. (Source: ICRAF GIS Unit)

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The World Agroforestry Centre is the international leader in the science and practice of integrating 'working trees' on small farms and in rural landscapes. We have invigorated the ancient practice of growing trees on farms, using innovative science for development to transform lives and landscapes.

Our vision

Our vision is an 'Agroforestry Transformation' in the developing world resulting in a massive increase in the use of working trees on working landscapes by smallholder rural households that helps ensure security in food, nutrition, income, health, shelter and energy and a regenerated environment.

Our mission

Our mission is to advance the science and practice of agroforestry to help realize an 'Agroforestry Transformation' throughout the developing world.

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