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Improved Land Management in the Lake Victoria Basin: Annual Technical Report, July 2000 to June 2001

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Natural Resource Problems, Priorities and Policies Programme
Working Paper Series

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Natural Resource Problems, Priorities and Policies Programme (Programme One)

The ICRAF vision for the year 2010 is that *through agroforestry, 80 million poor people will have more options for improved livelihoods, and the global environment will be more sustainable.* Outputs from the Natural Resource Problems, Priorities and Policies Programme (Programme One) contribute to this vision by providing policy makers and policy 'shapers' with information about the nature and extent of poverty and natural resource problems, the actual and potential impacts of agroforestry research and development, the priorities for investment in improved natural resource management and agroforestry, and the ways that policies and institutions shape farmers' incentives to manage their resource base and adopt agroforestry practices.

The Natural Resource Problems, Priorities and Policies Programme is one of five thematic programmes of ICRAF. As of January 2001, there were senior Programme One staff located in Thailand, Indonesia, Zimbabwe, Zambia, Kenya and Peru, with research activities in most of the 18 countries where ICRAF has a long-term presence.

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Improved land management in the Lake Victoria Basin: Annual Technical Report, July 2000 to June 2001*

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Abstract

ICRAF and the Kenyan Ministry of Agriculture and Rural Development (MOARD) are implementing a project on "Improved Land Management in the Lake Victoria Basin." The project began in 1999 – 2000 with a one-year startup year of activities under the Sida-sponsored National Soil and Water Conservation Programme (NSWCP). The collaborative project of ICRAF and MOARD has now been continued for another three years under the National Agriculture and Livestock Extension Programme (NALEP). This paper summarizes achievements and findings for the project for the year 2000 / 2001. The Swedish International Development Agency (SIDA) supports "Improved Land Management in the Lake Victoria Basin" through NALEP. Additional financial support for the activities reported herein was also provided by the Rockefeller Foundation, ICRAF core funds, Danida, the University of Florida and the USAID.

Research conducted during 2000 / 2001 addressed a range of issues across a large tract of Western Kenya. A coarse resolution assessment of soil erosion risk conducted for the entire Lake Victoria Basin identified the Nzoia / Yala and Kagera river basins as those with the greatest percentage of land at risk. Biophysical research on land management problem domains has quantified the widespread spatial extent of soil physical and chemical degradation in the Nyando river basin and illustrated four contrasting biophysical problem domains within the basin. District-level data on population density, poverty and agricultural production available from secondary sources have been complemented with baseline household and community survey data collected in 9 villages around the Nyando river basin. The overall picture that is emerging is that while much of the Nyando river basin has experienced some physical and chemical land degradation, there are pockets of severe poverty, severe environmental degradation and extremely low agricultural production. Different approaches to extension, investment and policy may be needed to address poverty – environment – agricultural problems in different parts of the river basin.

Reversing trends in environmental deterioration will require interventions on farmers fields and in the many areas between farms that publicly-used, although usually privately-owned. Farmers have demonstrated their willingness to adopt recommended conservation practices on their individual family fields, but the intensity of adoption depends upon the potential returns to investments, their cultural grouping, and the approach that extension providers take to the provision of information and mobilization of community participation. Adoption of improved practices and investments on publicly-used areas between farms requires the mobilization of collective action among small, medium and large groups. Collective action in the Nyando River basin is most likely to be effective where it harnesses local institutional arrangements (e.g. sub-clan affiliations among the Luo) and advances common interests in the provision of high quality water and the generation of additional cash income. Among other opportunities, there appears to be good prospects for market-oriented agroforestry for production of fruit, fuelwood and timber. Changes in local and national policies would help to ensure good returns for smallholder farmers.

This report begins with a presentation of a number of major findings, implications of those findings for extension and investment and implications for policy. A summary of progress by activity is then presented, followed by lists of personnel involved, presentations and publications. An annex presents detailed accomplishments by activity.

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A. Background and introduction

Lake Victoria, with a surface area of 68,000 km^2 is the world's second largest fresh water lake and the largest in the tropics. Lake Victoria is the source of the river Nile, the lifeline for much of Uganda, Sudan and Egypt. The Lake produces about 170,000 tonnes of fish each year, with thousands of lakeshore residents employed in fishing and fish processing. Harvesting of Nile Perch (*Lates niloticus*) generated about $US 100 million of foreign exchange per year in the mid-1990s (Ayes et al., 1996). But Lake Victoria is under threat. Accelerated soil erosion and nutrient runoff, urban and industrial point source pollution and biomass burning have induced a rapid eutrophication of the lake over the last 50 years. Phosphorus levels have increased 2-3 times (Hecky, 1993, 2000), algal concentrations have increased three to five times, and prolonged periods of anoxia in the lake bottom are much more common (Mugidde, 1993; Johnson et al., 2000). These conditions favour the growth of aquatic weeds such as water hyacinth (*Eichornia crassipes).*

The Lake Victoria Basin covers an area of 184,200 km^2 comprised of 11 major river basins and a large lakeshore area. The lake basin supports one of the densest and poorest rural populations in the world, with population densities up to 1200 persons per square kilometre in parts of Kenya (Hoekstra and Corbett, 1995) and a total population of about 28 million people. About 21 million people in the Lake Victoria Basin (estimated from data by Deichmann, 1995) rely primarily on subsistence agricultural and pastoral production for their livelihoods. Poverty levels are high and agricultural production is low. For example, in 1996 the average annual value of crop output per hectare was Ksh 6,761 in Kisumu (including current Nyando District) and Siaya districts, Ksh 8,275 in Kisii and Vihiga districts, and Ksh 10,965 in Kakamega and Bungoma Districts. This compared to Ksh 14,126 in Nakuru, Narok, Bomet, Trans-Nzoia and Uasin-Gishu districts and Ksh 21,653 in Nyeri, Muranga and Meru districts (Owuor, 1998).

In July 1999 ICRAF and the Kenyan Ministry of Agriculture and Rural Development initiated a collaborative project on "improved land management in the Lake Victoria Basin" with finance from the Swedish International Development Agency (SIDA). The first year of the project (1999 – 00) was conducted within the National Soil and Water Conservation Programme (NSWCP), while the subsequent three years will be conducted under the new National Agriculture and Livestock Extension Programme (NALEP). During 2000 / 2001 additional resources were by the Rockefeller Foundation, Danida, ICRAF Core, the University of Florida and USAID.

The ***purpose*** of the project is 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 ***objectives*** are:
(1) Identify and evaluate land management 'hot spots' in the Lake Victoria Basin and identify intervention points for preventing or mitigating those hot spots.

(2) Identify and evaluate technologies, institutional arrangements, and policies for alleviating poverty while protecting the local and regional environment of the Lake Victoria Basin.

(3) Quantify the actual and potential impacts of promising land management interventions on human welfare (food security, income, gender equality) and the environment (soil quality, water quality and hydrologic function).

(4) Enhance research and extension linkages for improved land management in the Lake Victoria Basin *(funded from A&A funds of NALEP).*

These objectives are achieved through a programme of applied research, dialog with a range of stakeholders, and direct interaction with farmers in a number of pilot focal areas. Staff from the Ministry of Agriculture and Rural Development provide the main point of contact with farmers.

This document summarizes results from the second year of the project, July 2000 to June 2001. It contains five substantive sections: a summary of major findings; an analysis of implications for extension; an analysis of implications for policy; a summary of progress toward objectives; and a more detailed report of activities and results.

B. Major findings from 2000 / 2001

1. ***Approximately 46 percent of the 3516 km^2 Nyando River Basin (or 1,624 km^2) has experienced severe soil physical degradation.*** The most dramatic forms of soil degradation in the Nyando river basin are related to soil erosion. This includes the formation of gullies and badlands in parts of the Kano plain and often severe sheet, rill erosion and well as land-slides in the upper parts of the river basin in proximity to Tinderet and Londiani. We estimate that 1443–1932 km^2 (39.5–52.9%) of the river basin are currently affected by visibly apparent soil physical degradation of various types. Laboratory analyses show that eroded soils have very low levels of soil fertility, as evidenced by low cat ion exchange capacity and soil organic matter contents, lack of mineralizeable nitrogen reserves and phosphorus deficiency. Affected areas are unlikely to be able to support any kind cropping activity without substantive investment in erosion control and soil fertility replenishment activities.

2. ***Of soils that do not show visible signs of accelerated soil erosion, approximately 48% have similar soil physical and chemical properties as the sites displaying visible signs of soil degradation.*** Thus, we estimate that only 868 km^2 of the 3516 km^2 basin remains unaffected by soil physicochemical degradation or soil nutrient deficiencies of one form or another. Most of this remaining area is concentrated on residual forest lands (Tinderet, South Nandi, and NW Mau forests).

3. ***The majority of soils in the Nyando river basin are deficient in plant available phosphorus.*** We estimate that between 63 and 73% of the Nyando River Basin is deficient in plant available phosphorus (defined as <8.5 mg kg^{-1} P-Olsen). Low soil P-levels constrain the production of all crops that people depend upon for their livelihoods, and limit the yield responses that could be achieved through the use of organic amendments of nitrogen such as improved fallows.

4. ***Soil degradation and soil nutrient mining characterize many land-use types, including grazing areas and agricultural land.*** The most degraded parts of the landscape, both in terms of nutrient deficiencies and soil physical degradation, are areas currently used for open grazing and extraction of fuelwood. Areas currently used for subsistence agriculture are characterized by both types of degradation, but at lower prevalence rates than grazing areas. In part, the lower prevalence may be due to abandonment of severely degraded cropland. Proximal causes of degradation on croplands include low investments in physical or biological methods of soil conservation and low use of external sources of mineral fertilizers.

5. ***Across the Lake Victoria Basin, there is very little evidence of conservation structures or agroforestry***. An ICRAF research team has now collected detailed data on vegetation cover, land use and soil quality from over 1000 sites across the Nyando/Awach River and Yala River basins. Sites were selected to represent the range of land uses and soil types that characterize the river basin. Each plot measured 30 metres by 30 metres. Only 29 of the 1025 plots had any soil conservation structures (2.7%). Agroforestry practices tend to be restricted to establishment of eucalypt woodlots and improved fallows associated with agroforestry projects. Data collected in 1999 / 2000 show that 175 catchments were covered by the National Soil and Water Conservation Programme between 1988 and 2000 in the Nyando River Basin. These 175 catchments covered 17.2% of the river basin, while farms that are reported to have implemented some type of soil conservation structure on some part of their farms covered 7.7% of the river basin.

6. ***Within the Lake Victoria Basin, there are communities that have been severely affected by death and disease.*** Data supplied by local authorities for three Luo communities in the Lower Nyakach division of Nyando District show rural communities with few economically-active men and large numbers of orphans. Only 57.7 percent of the1083 households in the three communities contained any resident adult males; 25.5 percent of households were headed by widows and 6.4 percent of households were headed by orphaned children. In contrast, in three Kipsigis communities in nearby Sigowet Division in Kericho District, 84.6 percent of the 641 households included resident adult males, 13.5 percent of households were headed by widows, and there were no households headed by orphaned children. In three Nandi communities in Tinderet Division, 88.2% of 687 households included resident adult males, 7.3% were headed by widows and there are no households headed by orphans.

   Other data collected by ICRAF emphasize the link between poverty, family degradation and the status of children in Western Kenya. In mid 1999 ICRAF conducted a survey of 815 street children and children staying in children's homes in the City of Kisumu. Each child was asked about their origin and the reasons why they had left their home and village. The greatest numbers originated from Vihiga (191), Kisumu (181), Siaya (157), Bondo (59), Kakamega (46), Nyando (42), Homa Bay (39) and Rachuonyo (25). These are the same districts of Western Kenya that are shown in studies by the Tegemeo Institute to have the lowest agricultural production in Kenya. By contrast, there were very few street children from nearby districts with higher agricultural production and more intact families (Kericho, Trans-Nzoia, Uasin Gishu). The children indicated that the most important reasons for leaving their homes were lack of food, school fees and care

(69%), dead parents (55.5%), child abuse or neglect (27.9%), and influence from peers (24.2%).

7. ***Within the Nyando and Yala river basins there are large differences in livelihood strategies and culture.*** Household and community surveys conducted in focal areas in Nyando, Kericho and Nandi Districts illustrate very different livelihood strategies and cultural norms. In the Chebitit focal area in Sigowet Division (Kericho district), the top five sources of cash income are reported to be: 1) livestock and livestock products, 2) maize, 3) tomatoes, 4) charcoal and 5) sand harvesting. Seventy-two percent of households are male-headed monogamous and 6.8% are male-headed polygamous. The main ethnic group is Kipsigis, Kalenjin. Ten kilometers away is Nyalunya village in Lower Nyakach Division in Nyando District, the main sources of cash income are reported to be: 1) mat making, 2) sand harvesting, 3) farming, 4) petty business, and 5) remittances. Only 50 percent of households are male-headed monogamous and 9.4 percent are male-headed polygamous. In the Kipsiwo focal area in Nandi District, the main sources of cash income are: 1) maize, 2) beans, 3) livestock, 4) tea and 5) coffee. Seventy percent of households are male-headed monogamous and 17% are male-headed polygamous. The main ethnic group is the Nandi.

8. ***Community regulation of resource use is very important for maintaining the integrity of the resource base and for stimulating private investment in resource management.*** Across the Nyando river basin, there is large variation in the effectiveness of collective management and regulation of resources**.** It appears that the single most important resource use regulation is livestock movement and livestock grazing. Overgrazed hillsides are some of the most severely degraded patches of landscape in the river basin. In the Rongo catchment in Upper Nyakach Division of Nyando District, our analysis shows that both runoff and soil loss are highest in degraded grazing areas, even higher than on footpaths. In addition, data collected for 175 NSWCP catchments in the Nyando River basin indicates that the 98 communities that restricted grazing had about 60 percent of farmers implementing recommended conservation practices, while the 74 communities that did not restrict grazing had about 38 percent of farmers implementing the recommended practices. Farmers frequently state that they do not invest in private or public conservation structures, water pans or trees because free-ranging livestock will destroy those investments.

   Regulations on removal of vegetation and cultivation of the areas around springs and the headwaters of first-order streams are also very important. During the course of fieldwork in the last year, our research team have discovered many instances in which local residents are actively cultivating areas immediately surrounding springs and the headwater areas that contribute overland flow to form first-order streams. Right from their headwaters, these streams are highly turbid.

9. ***One promising entry point for group investment for improved livelihoods and land management along the Nandi and Kericho escarpments appears to be water harvesting structures.*** The participatory rural appraisals conducted in 17 focal areas in the Nyando River Basin in 2000 / 2001 indicated water to be the number one priority in nearly every focal area. Water harvesting along the escarpments can provide dry-season sources of water for livestock, domestic use, vegetable production

and tree nurseries. Well-designed water management structures may also be the most effective and most rapid method to reduce the velocity of water runoff and subsequent erosion. In the Burkamach / Rakwaro Focal Area in Upper Nyakach Division and in the Chebetit focal area in Kericho District, we have witnessed farmers contributing a great deal of labour toward the construction and reconstruction of water pans. In the longer-term, however, significant increases in vegetative cover will be required in all escarpment areas.

10. ***There appears to be very good prospects for market-oriented agroforestry in Nyando River Basin.*** Shortages in the availability of construction materials, charcoal, fuelwood and high-quality fruit are creating new opportunities for other protective land uses in Western Kenya. A rapid study of agroforestry product markets show good potential returns to grafted mangos, grafted avocados, granted oranges and lemons. In addition, high quality wood for furniture, medium quality wood for building materials, and low quality wood for charcoal and fuelwood are all in short supply in Kenya at the present time. Predictions are that these shortages will become more acute in the next 20 years. These shortages increase pressure on the few remaining forest reserves, while increasing the potential profitability of tree farming, which is generally a protective land use. Smallholders could benefit greatly from this situation if appropriate policies are put in place. If appropriately designed and located, smallholder tree planting schemes can also contribute to the conservation and restoration of the resource base.

11. ***The NALEP focus on common interest groups and enterprise development is showing very positive signs in some focal areas.*** The Ministry of Agriculture and Rural Development and ICRAF worked together in eight focal areas in 2000 / 2001. Six of these areas were located in Nyando District, one in Nandi District and one in Kericho District. While overall implementation of the NALEP approach was constrained by delays in project finance, there were some successful initiatives with common interest groups and micro-projects. In the Ombeyi focal area in Miwani Division of Nyando District, 1200 farmers in 6 rice growing clusters have banded together to form a new multi-purpose cooperative society. Farmers in the area hope that by working together they will be able to produce and market the higher quality rice that fetches a price premium from local millers. In the Kipsiwo focal area in Tinderet Division of Nandi District, 51 improved cookers have been purchased. A 15-member environmental conservation group has been formed with a target of planting 5600 trees within one year, and a spring protection group has been formed and put up barriers around the local spring. And in the Burkamach / Rakwaro focal area in Lower Nyakach Division of Nyando District, 30 – 50 farmers have contributed one to two days of labour per week for three months to construct a water pan.

12. ***Local cultural norms and groupings are crucial to the success of externally-assisted development and conservation initiatives in some parts of the Nyando river basin.*** A study of the socio-cultural constraints and opportunities for improved land management in the Awach catchment was undertaken in 2000 / 2001 by a team of three researchers. The Awach catchment is an area of severe land degradation that crosses parts of Nyando and Kericho districts. The Luo people who live in the lower part of the catchment belong to four clans, each of which have a number of sub-clans, with further divisions within sub-clans. Clans and sub-clans live in distinct areas and

are strong social units. In that context the most effective small groups are comprised of members of the same sub-clan and the most effective village-level groups are comprised of members that represent each of the sub-clans and clans. Among the Kipsigis people who occupy the upstream part of the catchment, however, clanism is less important and people do not live in distinct clan groupings. Clanism is also less important among the Nandi people.

13. ***There is almost no land available for locating public infrastructure or for protecting the public interest in the Awach river basin.*** Almost all land in the Awach river basin was adjudicated for individual allocation over 20 years ago. The result is that it is difficult to identify locations for public infrastructure, such as schools or water pans. Every piece of public infrastructure is in fact located on the land of some individual or individuals. In addition, land areas that should be excluded from intensive private use – such as gullies and catchment areas – are also under private ownership.

C. Implications for extension and investment

This project has been implemented through a collaboration between ICRAF and the Kenya Ministry of Agriculture and Rural Development under the National Agriculture and Livestock Extension Programme (NALEP). The objective of NALEP is to facilitate and coordinate the activities of a variety of extension providers, including private firms and non-governmental organizations, to deliver the services that farmers demand. It is hoped that government extension services will become more participatory, demand-driven and transparent. NALEP also seeks to facilitate farmers to have greater commercial orientation and to reach out to other stakeholders in order to improve the technologies, infrastructure and markets that affect the viability of new commercial enterprises. NALEP is based on a Focal Area approach to extension in which communities of 200 – 400 households are engaged in the participatory identification of problems, development of farm-specific and community action plans, micro-projects, and the establishment of common interest groups. After one year of intense activities, the extension team moves to a new area, leaving the community and the Front Line Extension Worker to follow up the recommendations made. The goal of NALEP is to work with 100,000 new farmers each year across 43 districts in Kenya.

Results from the project are intended to inform future investments in extension in the Lake Victoria Basin. Results generated to date indicate that the resources availed to the NALEP programme can produce important impacts on farmer welfare and local land conservation. The results also suggest that additional public and private resources and investments will be needed to arrest and reverse trends of increasing poverty and resource degradation.

1. ***Given the large-scale and systematic nature of both poverty and land degradation in the Nyando River Basin, we recommend that the area be designated for special attention by the Ministry of Agriculture and Rural Development and other extension and service providers.***

This study has demonstrated that the 3,800 square kilometer Nyando River Basin is generally characterized by low water quality and widespread soil physical and chemical degradation. Sediment from the Nyando river is a major source of sediment and nutrients entering Lake

Victoria via the Winam Gulf. Evidence compiled by the Tegemeo Institute and by the International Livestock Research Institute show that those same areas are also characterized by low agricultural productivity and high rates of poverty. The entire basin thus warrants greater investment of extension input, infrastructure and a number of other public services. Public programmes need to avoid building dependency by local communities. For example, special rewards could be given to communities that demonstrate initiative and sustainability.

2. Extension and development agencies working within the Nyando River Basin should consider four general problem domains, each of which warrant different approaches to extension and investment for sustainable development.

(1) The Kano plain is an area of extreme poverty, relatively high population density, social disruption through death and disease, low agricultural productivity and fragile and eroding soils. The possibilities for intensification of agriculture are quite limited in those areas and extension and development agencies need to consider opportunities for reducing pressure on land and alleviating the sad social circumstances of people living in the area. Areas with good access to roads may be well-suited for producing niche products for the Kisumu market. The viability of the industries associated with Lake Victoria (fisheries, manufacture of papyrus products) are particularly important for those areas. (2) The Nandi and Kericho escarpment areas are transition areas between the Kano plains and the higher potential upland areas. Some of these hillside areas are now under severe stress from cultivation, land clearing, grazing and fuelwood extraction. Community groups in this area need to become better organized in order to protect vulnerable areas from over-use and to invest in public infrastructure such as water pans. Extension and development agencies need to consider opportunities to increase on-farm availability of water, fuelwood and livestock feed and to support community efforts toward improved resource management, community infrastructure and collective enterprise. Agroforestry systems for improved soil fertility and commercial production of tree products may be particularly well suited to farms in this areas. (3) Most of the lands that were formerly forested in the Mau and Tinderet areas are subject to high levels of soil hardsetting and low agricultural productivity. Many of these areas have also subject to low population pressures in part because of the tribal clashes of 1992. Extension and development agencies need to consider these special circumstances and the possibility that people living in these areas will be reluctant to undertake long-term investments because of insecurity of land tenure. (4) Some areas in the Nandi and Kericho hills have much higher agricultural potential, lower levels of poverty, and less problems with resource destruction. People in these areas appear to be relatively receptive to extension advice and to the need for collective investment and resource management. We would expect rates of return to extension to be high in those areas, in terms of increased income, increased soil quality and reduced erosion and runoff. Common interest groups will form around both income generation and environmental conservation because of an appreciation for high quality resources.

4. Key messages for farmers and rural communities

Some key messages for individual farmers and rural communities have already emerged from the collaborative activities of the Ministry of Agriculture and Rural Development and ICRAF in selected focal areas.

a) Most farmers in the Nyando river basin and the Yala river basin should apply some type of phosphorus fertilizer to their crops. Vihiga, Siaya, Nyando and Kericho districts have

the most severe and consistent deficiencies in available phosphorus. Crop yields will increase with phosphorus application, although the best returns will be generated when phosphorus is applied in combination with nitrogen fertilizer, improved fallows or biomass transfer.

b) Farmers interested in increasing livestock production need to consider a package of new practices including increased on-farm feed production, disease control, housing and improved genotypes. Dairy goats may be a viable option for poorer people.

c) Farmers should give greater consideration to tree planting for improved soil fertiity and commercial production of tree products. Demand for fuelwood, timber, high quality hardwoods and fruit is increasing in many parts of Kenya. Farmers should be aware of market opportunities before choosing tree species and management regimes.

d) Community groups concerned with water management, erosion and livestock production should restrict livestock grazing with a combination of physical barriers, fines and rules. Physical barriers around cropped fields or degraded areas can be used to generate income and other valuable products, e.g. sisal and tithonia diversifolia. Grevillea robusta trees can be planted along boundary lines with little negative effect on nearby crops.

e) Community groups concerned with water quality should give special attention to the areas around springs and the headwaters of streams. Community groups should consider ways to share the costs of conservation with the owners of those areas.

f) Degradation of resources in areas that are not cropped—through over-grazing or excessive harvesting of fuelwood—has negative effects on those areas and every place downstream from those areas. Water runoff can be managed to reduce erosion and increase agricultural production.

g) Community groups interested in engaging in new commercial activities should explore possibilities for formulating agreements with potential consumers of their products. Potential consumers may be willing to provide superior inputs, credit and transport as part of an agreement.

5. Extension services should facilitate support to a wide range of agricultural and non-agricultural common interest groups and micro-projects.

Research conducted by this project shows that communities across the Nyando River Basin generate their livelihoods from a wide range of agricultural and non-agricultural activities. This means that the extension teams that work with communities to develop community action plans and common interest groups need to be familiar with a range of issues and opportunities. They also need to have access to more specialized extension assistance – e.g. private suppliers of improved germplasm and appropriate technology for fruit processing. The NALEP policy of pluralistic extension is consistent with this need.

6. The best size for a common interest group needs to be determined on a case-by-case basis. In some circumstances the optimal size may be much larger than the population of a focal area. In other circumstances, the best size may be just a few households.

The experience from the Ombeyi / Kore rice growing area in Miwani Division indicates that there are circumstances in which a focal area may be just the center point or catalyst for a common interest group covering a much larger area. The Kore Focal Area includes 400 households, while the Multi-Purpose Cooperative Societies being formed to support rice production include over 1200 households. On the other hand, some of the common interest

groups forming in Kipsiwo focal area in Tinderet Division of Nandi District include just 10 to 12 individual members.

7. There is urgent need for interventions and planning outside of agricultural fields, esp. on degraded pastures and hillside areas.

Most of the resource degradation problems in the Nyando river basin occur outside of cultivated fields or homesteads. Communities should be made more aware of these problems and supported to deal with those problems. In many circumstances, the most appropriate action may be inaction – resting and exclosure of severly degraded areas such as hillsides and gulleys. In other circumstances, common interest groups may be able to form around the objective of increasing income from former grazing and fuelwood collection areas. Community woodlots may be considered, with mixtures of species likely to produce income in the short (3-5 years), medium (7-12 years) and long term (15-20 years).

8. NALEP should consider the ways in which Focal Area Development Committees are constituted and operate.

Experiences gained in eight focal areas in 2000 / 2001 indicate the following challenges with the constitutions and operation of Focal Area Development Committees. First, community barazas may not attract people of certain clans or interest groups. Second, the members of Focal Area Development Committees may need to be drawn from particular sub-groups within the area; those sub-groups may need to be clan-based or area-based. Third, the members of Focal Area Development Committees should have some particular personal interest in focal area development, either as members of other common interest groups or as members of a common interest group formed around the Focal Area Development Committee.

D. Implications for policy

The results of this project have implications for the formulation and implementation of policies at the local level, for specific national policies, and for national and regional policy frameworks. Here we offer some guidance for each of those policy areas.

D1. Implications for local policy makers

1. There is a need to empower legitimate local authorities and community groups to develop and enforce regulations on resource use.

From various PRA exercises it appears that few chiefs or sub-chiefs are maintaining local or national regulations on resource use. Some form of local enforcement power is needed, however, through re-vitalization of chiefs and empowerment of community organizations. The newly created district, division, location and sub-location environmental management committees may be able to play key roles. Regulations or by-laws should pay increased attention to the regulation of grazing, fuelwood harvesting and the protection of headwaters and riverbanks.

2. There is need for mechanisms for community groups to exert control over the use of public infrastructure, catchment areas, and disturbed lands.

We have evidence that community groups will form and invest considerable resources in public infrastructure for transportation and water management. These investments are hampered, however, by the lack of public or community control over land use. Community groups, possibly organized along clan lines, may be able to devise new arrangements for compensating private land owners for yielding control over critical land areas.

3. Government agencies at the national, district, division, location and sub-location levels should try to calalyze more effective and creative synergies between government ministries, local community groups and private firms.

Improved resource management in areas such as the Awach catchment requires inputs from many agencies and sectors, along with more effective collective action by local community groups. A planning workshop convened in May 2001 recommended the formation of three types of linkages in order to stimulate more effective management of the catchment. First, common interest groups should be linked with specific market opportunities in order to increase the commercial viability of new enterprises and thus to increase the incentives for investment in land improvement. Second, three focal area development committees active in the area should be linked through an umbrella committee. Third, an Awach catchment task force should be formulated to draw in all relevant governmental (including the district administration) and non-government organizations with interest in the area in order to develop an overall plan for resource management and investment for the area. District, division, location and sub-location environmental management committees could have roles in play in such a task force.

D2. Implications for specific national policies

4. There ***is need to clarify the policies affecting the harvesting and sale of tree products.*** The Government of Kenya maintains a number of environmental laws meant to prevent overuse of forest resources. While the appropriateness or effectiveness of these laws can be agrued, one thing that is certain is that these laws reduce incentive for farmers to plant forest trees on their farms. With demand for fuelwood, charcoal, pulp and building materials ever increasing, farmers could generate good returns from the production of forest trees on their farms. But some policies need to be clarified. Would it be legal for a farmer or rural community to produce and sell trees for charcoal production?

5. There is inadequate legal / institutional support for the types of groups that are needed to support improved resource management and small-scale commercial activity. At this point the options available to common interest groups are to remain informal, to register with the District Department of Social Services as self-help groups, or to register with the Attorney General's office in Nairobi as cooperative societies. Informal groups cannot open bank accounts so are inappropriate for commercial activities. Self-help groups are not meant to cross district boundaries or to borrow money, so they are limited for both commercial operations and for transboundary resource management. Cooperative societies are meant for commercial operations, but are difficult to register, are scrutinized closely by the Attorney General's office, but are not linked with any particular Government Ministry for extension

assistance. This appears to create a "policy gap" viz improved resource management – that might cut across district boundaries – and small-scale commercial activity.

D3. Implications for national policy frameworks

The Government of Kenya is now considering a wide range of policies that could have sweeping impacts on Kenya's agriculture, environment, forests and rural economy. This includes the Poverty Reduction Strategy Paper (PRSP), the Kenya Rural Development Strategy (KRDS), the forestry policy, the environmental management act, the energy policy, the water policy, land tenure policy, a number of agricultural policies pertaining to extension, livestock development, dairy, fertilizers, pesticides, plant varieties, seeds, irrigation, cereals, oilseeds, tea, coffee, horticulture, cooperative societies, fisheries, cotton, sugar, veterinary services, and farming training centers (B. Godana, Statement in the *Daily Nation*, July 30, 2001). All of these policies could, in one way or another, have effect on agricultural production, poverty and land degradation in the Lake Victoria Basin. Perhaps even more important are the policies that affect Kenya's position in the world and regional markets. Under the East African Cooperation, it is envisaged that Kenya will move to harmonize more of its trade and environmental policies to be more consistent with Uganda and Tanzania. Under COMESA, Kenya should lower tariffs and non-tariff trade barriers to other economies in East and Southern Africa. Within these various policies, there are likely to be a range of policy instruments available to national and district policy makers. Therefore the following recommendations focus more on policy objectives than on particular policy instruments.

6. Government agencies at all levels must recognize the close inter-relationships between livelihood strategies, agriculture and environment.

The rural population of Western Kenya is intimately integrated into the landscape of the Lake Victoria basin. Rural Kenyans earn their livelihoods through cultivation of food crops, intensive and extensive husbandry of livestock, collecting water and fuelwood, producing vegetables, growing tree crops such as tea and coffee, harvesting sand, harvesting and adding value to papyrus reeds. Fishing is of minor importance to the people of the lake basin, even in areas located within ten kilometers of the lake. The industrial and service sectors are small, with most industries directly dependent upon the agricultural sector. It is the people who live in the Lake Victoria basin, therefore, who are the main userd and main custodians of the environment.

Under the right conditions, these people will invest in the long-term health and productivity of their land, water, tree and livestock resources. The most important conditions influencing those investments are profitability, power and certainty. Land users need to be sure that investments will yield good future returns; they must have the economic and social power to procure key inputs and reap returns from those investments; and they must be certain that they will be able to reap what they sow. Agricultural and environmental policies affect all three of these key conditions. For example, environmental policies that prohibit harvesting of trees from private plantations will discourage people from planting new plantations. Agricultural policies that prohibit the uprooting of coffee trees will discourage people from planting new coffee trees or maintaining the quality of their coffee trees, and will hamper them from turning former coffee land into more productive uses. The long-term prognosis for the international coffee market is bleak. On the other hand, agricultural policies that

discourage fertilizer use or encourage free grazing of livestock will cause continued degradation of agricultural and non-agricultural land.

Every policy targeted to rural Kenya – be it for agriculture, transportation, environment, forests or land – should be reviewed for its likely impact on the incentive of individual farmers and communities to invest in the future of their agricultural enterprises. Government agencies at all levels should seek to identify win-win policies, that is, policies that will stimulate land conserving investments at the same time as improving the livelihoods of the rural population.

7. A key policy goal should be to expand capital assets of the poor.

Most people living in the Nyando River Basin are asset poor. That is, they have very low levels of financial capital (to meet cash needs and buffer income shortfalls), natural capital (soil quality, trees), physical capital (seeds, techniques, ploughs, oxen, tractors), human capital (education, information, health) and social capital (trust, networks). While one type of capital may be more limiting than another – e.g. soil quality – it is likely that an investment in any type of capital will have knock-on effects on the others. One way to have positive effects across the board is to promote multi-market contracts between the purchasers of commercial products and producers. Multiple market contracts – often involving fertilizer, extension assistance, purchased inputs, outputs and credit – provide purchasers with assurance about the quality of the outputs that will be produced and reduce the risk exposure of farmers. Multiple market arrangements can be successfully targeted to the poor. For example, the successful dairy goat programme in Meru District is targeted to poor women. Similarly, a tea factory could target woodfuel production schemes to poor and child-headed households in Nyando District.

E. Summary of achievements by activity

Project objective and activity	Expected achievement for 2000 / 2001	Actual achievement for 2000 / 2001	Comment
Objective 1: Identify and evaluate land management hotspots in the Lake Victoria basin and identify preventive and curative intervention points for dealing with priority areas			
1.1 Quantification of recent historical changes in vegetation cover, land use, sedimentation and nutrient loading for the major river systems that drain into Lake Victoria from Kenya			
1.1.1 Quantification of historical changes in sedimentation in Lake Victoria	Collection and analysis of sediment cores from all major Kenyan rivers draining into Lake Victoria.	New sampling equipment designed and constructed locally. Six sediment cores collected. 2 cores characterized using spectral analysis and 3 cores dated using radionuclide techniques.	Progress hampered by lack of an adequate boat and time taken to perfect sampling equipment.
1.1.2 Workshop to present results of core analysis	Workshop planned for September 2001.	Workshop postponed until analysis of the sediment cores is complete.	
Output 1.2 Land use and land management problems identified and quantified for priority river basins			
1.2.1 Identify land degradation problems using ground surveys, soil reflectance properties and satellite images.	Continue work in the Nyando river basin and expand into the Nzoia and Yala basins.	Over 1000 sites have been surveyed in the Awach, Nyando and Yala basins. 300 sites in the Awach were selected for monitoring of erosion. Maps showing areas of high risk of soil physical degradation and physiochemical degradation developed for the Nyando.	More emphasis was placed on this than expected because of the delays in the coring.
1.2.2 Identify and map poverty and NRM problem domains.		An analysis of soil erosion potential for the entire Lake Victoria Basin was conducted. Secondary information on agricultural production and poverty collected.	Fine resolution socio-economic data will be collected in 2001 / 02.
1.2.3 Link soil reflectance to soil properties and degradation indicators	Continue work in the Nyando river basin and produce thematic maps for use in planning.	Effects of soil degradation on soil properties quantified. Maps of soil physical degradation produced for entire Nyando river basin.	Production of district maps will be facilitated in 2001/2 through purchase of wide-format printer.
Output 1.3: Causal models of land management problems developed			
.3.1 Simulation model developed to assess historical relations between population, land use and degradation in each river basin.	Model under development.	Land use change analyses were conducted in 3 locations in Nyando District. A socio-cultural study of the history of settlement and land use in the Awach catchment was completed. In the vicinity of the Kakamega and South Nandi forests in the Yala basin, 100 paired sites contrasting primary forest with subsistence maize were surveyed. Soils were collected to ascertain their productive capacity and interviews were conducted with farmers to obtain approximate timelines since forest conversion.	This activity was be strengthened with the appointment of the environmental economist, Samuel Murithi.
1.3.2 Analysis of flows of environmental and economic resources	Collection of field data by students from the University of Florida.	A complete emergy analysis has been conducted for Kenya to estimate the importance of different energy sources to the Kenyan economy. A detailed emergy analysis of soil erosion in the Awach catchment was initiated, with 420 case control plots sampled, 60 infiltration trials	This work is primarily financed by project funding from Rockefeller and USAID.

Project objective and activity	Expected achievement for 2000 / 2001	Actual achievement for 2000 / 2001	Comment
		conducted and erosion pins placed in 183 sites.	
1.4 Quantification of filter functions of wetlands			
1.4.1 Analysis of land cover changes in wetlands and riparian forests	An analysis of land use change in wetlands and riparian forests over the last 15 years completed.	Additional funding and human resources for this project have been secured from the University of Utrecht. Operations will begin in late 2001 and be completed during 01 /02.	
1.4.2 Analysis of the nutrient filter function of wetlands	An analysis of the nutrient filter functions of the Nyando wetland initiated with Linkoping University	A review of the literature on the filter functions of wetlands is under preparation. A proposal was developed with Linkoping University and Osienala.	The Linkoping – Osienala project has been slow to develop but now appears on track.
Objective 2: Identify and evaluate technologies, institutional arrangements and policies for alleviating poverty while protecting the local and regional environment of the Lake Victoria Basin.			
Output 2.1 Identify and evaluate "best bet" options for upland conservation			
2.1.1 Assessment of effects of agroforestry on runoff in the Ragen watershed	Water and nutrient losses from a pair of watersheds in Ragen monitored over throughout the year. Agroforestry interventions installed in some monitoring sites.	Continued monitoring of 2 streams and the larger Ragen river with water measurement flumes. Erosion and runoff from erosion plots measured using automatic tipping buckets and pipe sampliers. After one year of data collection from untreated plots, interventions have been installed on some plots. Improved fallows of Tephrosia candida have been established on 8 crop plots and fencing has been established around 4 degraded plots and 4 grazing plots.	RELMA assisted with the purchase of monitoring equipment and with the construction of the water pan.
2.1.2 Community trials with agroforestry technologies	Community trials established.	Four type I and 55 type II Striga control trials were established on farmers' fields in four focal areas. 80 type II improved fallow trials were established in 8 areas.	Trials will establish recommendation domains. Conducted with KARI.
2.1.3 Identify key socio-economic factors affecting adoption and diffusion of conservation practices	Participatory research established in a transect of communities in Nyando District. PRA writeups complete. Household survey implemented.	PRA writeups completed. Participatory research in Rakwaro became basis of a NALEP / ICRAF focal area. Survey of over 200 households conducted. Christian Tegtmeier returned to the University of Bonn to complete his PhD studies.	Christian Tegtmeier is continuing his studies in Bonn.
Output 2.2 Identify and evaluate "best bet" options for river bank protection			
2.2.1 Participatory research on riparian strips tested	Participatory research on riparian strips conducted along the Nyando river in the Kobong'o focal area.	Participatory techniques were used to understand community perceptions of riparian areas in Kobong'o and wetland areas in Kore. 3 sensitization meetings held. 3 sites of about 100 metres protected for natural regeneration of grass and shrubs. Sisal planted along 50 meters of river. 10 meter wide band pegged along a 1 km stretch of the river.	
2.2.2 Soil and nutrient losses associated with riparian strips measured	Research conducted along a 1 km stretch of the Nyando in the Kobong'o focal area.	Runoff, soil loss and loss of N and P were estimated for paths, farms, bushland and grassland in the Kobong'o focal area. Paths had the highest runoff. Bushland and farmland had the highest nutrient loss per mm of runoff.	
2.2.3 Analysis of land use and river course use along	Reseach conducted along a 1 km stretch of the Nyando in the	Aerial photos and images obtained for 1948, 1963, 1967, 1979 and 2000. The width and depth of the river and land use along a 1 km	

Project objective and activity	Expected achievement for 2000 / 2001	Actual achievement for 2000 / 2001	Comment
rivers	Kobong'o focal area.	stretch of the river was estimated.	
Output 2.3 Develop and evaluate policies and institutional arrangements for watershed management			
2.3.1 Catalyze collective catchment management among upstream and downstream communities	Convene 3 seminars on institutional arrangements for watershed management. Organize meetings of focal area development committees in nearby communities.	3 1-day workshops were held in Kisumu in with a variety of stakeholders. The first two workshops focused on general issues regarding watershed management in western Kenya. The third workshop developed specific proposals for managing resources in the Awach catchment. Supported development of a multi-purpose cooperative society for rice production and resource management in the Kore focal area.	
2.3.2 Determine land use patterns and rules governing use of riverbank and hillside areas	Studies of land use and rules governing land use conducted in two riverbank areas and two hillside areas.	A team of 3 consultants implemented a study of socio-cultural constraints and opportunities for improved resource management in the Katuk-Odeyo area of the Awach catchment. A review of the legal foundations of watershed management institutions in Kenya was commissioned from ACTS.	The Awach / Katuk-Odeyo area was selected for intensive research and participatory development.
Objective 3: Quantify the actual and potential impacts of promising land management interventions on human welfare and the environment			
Output 3.1 Assess impacts of alternative land management interventions on human welfare and environment			
3.1.1 Collect baseline indicators of human welfare	Collect baseline data on human welfare indicators and food security. A study of the environmental impact of the NSWCP completed.	9 areas were selected for collection of baseline data: 3 focal areas (1 each in Nyando, Kericho and Nandi) implemented by NALEP and ICRAF; 3 focal areas in implemented by NALEP; 3 nearby non-intervention areas. Baseline data collected through a household survey, community survey, yield survey and food consumption survey.	These data will be analyzed during the first half of 2001 / 02 and used in subsequent impact studies.
3.1.2 Analyse impacts of SWCP catchment approach.	Complete an analysis of the environmental impact of the SWCP catchment approach.	The study of environmental impacts of the NSWCP was completed by Tina Sven-Hanson.	Partially financed by Danida. Tina left ICRAF during 2000/01.
Output 3.2: Estimate the costs of land degradation and benefits of land improvement			
3.2.1 Analysis of the costs of land degradation and land improvement	Recruit an environmental economist from the region. Convene workshop to identify priorities for valuation research.	A Kenyan environmental economist was recruited and began work late in 2000 / 01. Samuel Muriithi joined ICRAF on leave of absence from the Ministry of Environment and Natural Resources, Forestry. He participated in an international workshop on valuation of agroforestry systems in Zambia in May.	This study is part of a multi-country ICRAF project. Participation in workshop supported by project financed by CIDA.
Output 3.3 Develop models and decision support tools for predicting the impacts of land management options at spatial scales from the village to the river basin			
3.3.1 Develop models for predicting the impacts of land management options at spatial scales from village to the river basin.	Monitor sediment and nutrient loads in key rivers. Establish collaboration with Linkoping University for river basin modeling. Calibrate the TOPOG model for modeling of small catchments. Use the ANSWERS model	Sediment and nutrient loads monitored at three points along 4 rivers (Nyando, Nzoia, Yala and Sondu). Long-term discharge data for these rivers availed from the Kenya Ministry of Water Development. Collaboration with Linkoping University and Osienala established. The WANULCAS, ANSWERS and TOPOG models were successfully installed. Long-term data from the EAAFRO / ODA experimental catchments in Kericho is being used to calibrate	Completion of this activity will require more resources. In 2000/01, David Mungai from the UoN led this research as a part-time consultant. In 2001 / 02, David

Project objective and activity	Expected achievement for 2000 / 2001	Actual achievement for 2000 / 2001	Comment
	for analyzing the filter functions of agroforestry at the small farm scale.	the TOPOG model. For the Ragen catchment, data are available on topography, runoff and soil loss for different land uses, climate and soils.	will devote 100% of his time to the work, through a sabattical leave. We applied for additional resources from Rockefeller.
3.3.2 Develop decision support tools for identifying priority areas for intervention	Begin work on decision support tools.	The focus this year was on the identification of gaps in information needed for constructing decision support tools (e.g. land use, poverty indicators, population density, road network for the entire Nyando river basin). Collaborative arrangements and additional resources were secured to fill those gaps.	
Objective 4: Enhance research and extension linkages for improved land management in the Lake Victoria Basin *(funded from A&A funds of NALEP – organized by 2001 / 02 workplan).*			
4.1 Conduct PRAs in new focal areas	PRAs completed in new focal areas in Nandi and Kericho districts.	5-day PRA completed in the Chebitit area in Kericho district and 3-day PRA completed in the Kipsiwo focal area in Nandi distrct.	All new PRAs will be conducted using NALEP procedures.
4.2 Develop farm specific action plans	Complete farm specific action plans in all focal areas	1031 farm-specific action plans completed and 1846 preliminary farm specific action plans prepared out of total of 2709 households in 8 focal areas.	Focal area activities began in late 2000.
4.3 Production and planting of tree seedlings	Nurseries established in all focal areas.	75 individual and group nurseries established in 8 focal areas; communities planned to raise and plant 290,000 trees but actually raised and planted about 90,000 trees.	
4.4 Enterprise development		An assessment of the market potential for various agroforestry products was conducted – fruits, fuelwood, charcoal and timber. Possible market outlets for fuelwood and charcoal were identified.	
4.5 Livestock improvement		Livestock improvement was identified as a high priority in several focal areas, with improved feeds and genotypes identified as the highest priority interventions. Several focal areas built sheds in anticipation of receiving improved bulls, but were later told that they should instead consider arrangements for sourcing AI services.	This was a matter of some confusion and contention within the project during the year.
4.6 Energy saving devices		75 improved wood stove demonstrations were conducted.	
4.7 Soil and water conservation		20 water pans were planned; 4 were completed.	
4.8 Training		All FADCs were trained; about 100 people were trained in nursery management; 150 people were trained in improved fallow management; 150 4-K Club members were trained; over 100 people participated in farmers' tours.	

F. Personnel

Long-term ICRAF Staff

Luka Anjeho	Senior Field Technician
Dorcas Awino	Field attendant
Alex Awiti	GIS expert
Sharmila Babu	Secretary
Eunice Imali	Data entry clerk
Sammy Kimau	Senior Field Attendant
Isaac Learamu	Field Assistant
Cleophas Miheso	Driver
Benjamin Muoki	Field Attendant
Samuel Muriithi	Environmental economist (since May 2001)
Raphael Ndambuki	Field Attendant
Benjamin Ndwallah	GIS Technician
Quresh Noordin	Research-Extension Liaison
David Nyantika	Research – Extension Liaison (since July 2001)
Oscar Ochieng	GIS technician (since March 2001)
Nahashon Odieny	Guard
Antonia Okono	Admin Assistant
Peter Okoth	Driver
Kennedy Okula	Driver
Chin Ong	Co-leader, Hydrologist
Charles Otieno	Caretaker
Frank Place	Economist
Steven Ruigu	Tree domestication expert
Keith Shepherd	Systems agronomist
Nicholas Shitsukane	Accountant
Paul Smithson	Lab manager, soil scientist
Brent Swallow	Project Leader, Economist
Markus Walsh	Landscape ecologist
Robert Zomer	Landscape ecologist (since August 2000)

Associate Scientists

Tina Svan-Hansen	Geographer (left in October 2000)

Long-term Consultants

Deborah Bossio	Wetland ecology
Eva Gacheru	Striga control
David Mungai	Landscape hydrology and modeling
Fridah Mugo	NRM specialist and field coordinator

Short-term Consultants

Ahmed Khan	Instrumentation
Njeri Muhia	Socio-cultural analysis

Ministry of Agriculture and Rural Development

National Level

Arne Eriksson	NALEP Advisor
Japheth Kiara	NALEP – National Coordinator
John Kimani	Agroforestry Coordinator
Christopher Marekia	Range Management Officer
Peter Mbogo	Socio-Economic Department – Collaborator
Francis Mbote	Chief of Land & Agriculture – Development Division
Joseph Mburu-	Head of Soil & Water Conservation Branch
Fabian Muhia	Training Officer
Francis Muhoro	M& E Section
Ziporah Mugonyi	Soil Fertility Management Officer
Kithinji Mutunga	Water Harvesting & Moisture Management Officer
Lincoln Mwarasomba	Socio-Economist
Lotta Nycander	

Provincial Level

1) Nyanza Province

Zakayo Magara	Provincial Agricultural Officer
David Nyantika	Provincial Soil and Water Conservation Officer
Wycliff Omutsani	Provincial Director of Agriculture and Livestock Production

2) Rift Valley Province

John Melly	Provincial Agricultural Officer
Wepukulu Fwamba	Provincial Soil and Water Conservation Officer
David Nyansani	Provincial Director of Agriculture and Livestock Production

District and Divisional Level

Nyando District

<u>District Headquarters</u>

Tom Bonyo	District Agricultural and Livestock Extension Officer
David Ombalo	District Agricultural Officer
Bernard Onyango	District Soil and Water Conservation Officer

<u>Lower Nyakach Division</u>

Shem Okora	Divisional Extension Coordinator
Silas Deya	Divisional Soil and Water Conservation Officer
Wesley Ong'or	Divisional Crops Officer
Zedekiah Kajuku	Divisional Animal Production Officer
James Abudi	Frontline Extension Worker

<u>Miwani Division</u>

Evans Tinega	Divisional Extension Co-ordinator
James Odundo	Divisional Soil and Water Conservation Officer
Lornah Aluodo	Divisional Home Economics Officer

Charles Kakuku	Divisional Animal Production Officer
John Odhiambo	Divisional Crops Officer
Martin Sinogo	Frontline Extension Worker

Muhoroni Division

Vincent Wanzala	Divisional Extension Co-ordinator
Luke Musewe	Divisional Soil and Water Conservation Officer
William Alando	Divisional Home Economics Officer
Solomon Ondore	Divisional Animal Production Officer
James Kharinda	Frontline Extension Worker

Nyando Division

James Ang'awa	Divisional Extension Coordinator
Henry Owiti	Divisional Soil and Water Conservation Officer
Esther Onyango	Divisional Crops Officer
Pamela Akal	Divisional Home Economics Officer
William Olwera	Divisional Animal Production Officer
Felix Omondi	Divisional Irrigation Officer
Paul Owiti	Frontline Extension Worker
Evans Onsinde	Frontline Extension Worker

Upper Nyakach Division

Thadeus Ouko	Divisional Extension Coordinator
Nelson Ageno	Divisional Soil and Water Conservation Officer
Phanuwel Okoth	Divisional Crops Officer
Pamela Jowi	Divisional Home Economics Officer
Jack Adwar	Divisional Animal Production Officer
Simon Origa	Frontline Extension Worker

Kericho District

District Headquarters

Jeremy Langat	District Agricultural and Livestock Extension Officer
Simon Kirui	District Soil and Water Conservation Officer
Michael Obura	District Agricultural Officer
Daniel Bundotich	ICRAF/NALEP Coordinator

Sigowet Division

Daniel Rop	Divisional Extension Coordinator
Langat Samuel	Divisional Soil and Water Conservation Officer
Bii John	Divisional Crops Officer
Simon Langat	Divisional Animal Production Officer
Juma Margaret	Divisional Home Economics Officer
Richard Koskei	Frontline Extension Worker

Nandi District

District Headquarters

Phillip Makheti	District Agricultural and Livestock Extension Officer
Alfred Musia	District Soil and Water Conservation Officer
Mary Tonui	District Livestock Production Officer

Tinderet Division

Boit Abraham	Divisional Extension Coordinator
Paul Keter	Divisional Soil and Water Conservation Officer
Moses Togom	Divisional Crops Officer
Robert Ngeno	Divisional Ruminant and Non-ruminant Officer
Robinson Rotich	Divisional Animal Production Officer
Samuel Sitenei	Frontline Extension Worker
P Magut	Frontline Extension Worker

Steering Committee

Brent Swallow, Chin Ong, Francis Mbote, J. Kiara, Arne Erikkson, Bashir Jama

Graduate students

Matthew Cohen	PhD in emergy analysis and spatial modeling, U of Florida, USA
Lisa Fernius	BSc in env engineering, Uppsala University, Sweden (minor field study)
Mwangi Hai	PhD in systems ecology, U of Stockholm & Ministry of Agriculture
Duncan Onyango	MSc on land use, run-off and soil erosion, Kenyatta University
Asa Bengtsson Sjors	BSc in env engineering, Uppsala University, Sweden (minor field study)
Michelle Swallow	BSc in resource management, Caribou College, Canada
Christian Tegtmeier	PhD in social geography, U of Bonn
Thuita Thenya	PhD in bioeconomic modelling, U of Nairobi

Trainees from the Ministry of Agriculture in GIS

Kithinji Mutunga
Christopher Marekia

G. Publications

Journal Articles

Shepherd KD and Walsh MG (2000) Light reflectance provides rapid assessment of soil quality. Ready for submission to *Science.*

Soule, M J and K D Shepherd, **(**2000). An ecological and economic analysis of phosphorous replenishment for Vihiga Division, Western Kenya. *Agricultural Systems* 64:83-98.

Swallow B., M. van Noordwijk and D. Garrity (2000) The effects of scales, flows and filters on property rights and collective action in catchment management. Paper presented at the Technical Workshop on Watershed management Institutions, System-wide Program on Collective Action and Property rights (CAPRi), Managua, Nicaragua, March 13-16, 2000.

Shepherd, Keith D and Markus Walsh (submitted). Use of Reflectance Spectral Libraries in Risk-Based Assessments of Soil Properties in Africa. Submitted to the *Soil Science Society of America Journal*.

Shepherd, K D and M G Walsh (in progress) Diffuse reflectance spectrometry for rapid measurement of soil properties and performance. To be submitted to *Soil Science Society of America Journal*.

Shepherd, K D and M G Walsh (in progress) Measurement of management-induced changes in soil quality using diffuse reflectance spectrometry. To be submitted to *Soil Science Society of America Journal*.

Walsh MG and Shepherd KD (in progress). Screening for soil degradation in the Lake Victoria Basin. To be submitted to *Journal of Environmental. Quality.*

Walsh MG and Shepherd KD (in progress). Remote sensing of soil physical degradation in the Lake Victoria Basin. To be submitted to *Remote Sensing of Environment*.

Walsh M, Shepherd K, Verchot L, Albrect A, Noordvijk M van and Palm C (in progress). A rapid method for assessing soil carbon saturation deficit. To be submitted to *Soil Science Society of America Journal*.

Posters and Papers at International Meetings

Awiti, A (2000). Assessment of soil erosion potential in the Lake Victoria Basin. Poster for ICRAF Decision Support Systems Lab, Nairobi, Kenya.

Hansen, T Svan (2000) Evaluating the Environmental Impact of Participatory Soil and Water Conservation at the Watershed Level in Nyando Watershed, Western Kenya. Poster presented at the KL-2000 UNESCO/IUFRO Symposium: Forest – Water – People in the Humid Tropics: Past, Present and Future Hydrological Research for Integrated Land and Water Management. University of Kebangsaan, Malaysia, 30 July – 4 August 2000.

Mungai D, Ong C, Hai M (2000) The impact of land use and rainfall on sedimentation and runoff in the Lake Victoria Basin. Poster presented at the KL-2000 UNESCO/IUFRO Symposium: Forest – Water – People in the Humid Tropics: Past, Present and Future Hydrological Research for Integrated Land and Water Management. University of Kebangsaan, Malaysia, 30 July – 4 August 2000.

Other Publications

Brenner, A. (1999). Improved land management in the Lake Victoria Basin. Consultant's report, 26-29 October 1999. Nairobi: ICRAF.

ICRAF (1999). Quarterly report for the first quarter (July – September 1999). Work plan for the second quarter (October – December 1999). December 1999. Nairobi: ICRAF and Ministry of Agriculture and Rural Development.

Ang'awa, James A (2000). Kobong'o and Miwani Farmers Tour to Ombala. (2 March 2000). Intervention Report No 3. ICRAF-Ministry of Agriculture and Rural Development.

Ang'awa, James A (2000). Kobongo Farmers' Tour to Maseno. (9 March 2000). Intervention Report No 4. ICRAF-Ministry of Agriculture and Rural Development

ICRAF (2000). Report for the second quarter (October – December 1999). Work plan for the third quarter (January – March 2000). January 2000. Nairobi: ICRAF and Ministry of Agriculture and Rural Development.

ICRAF (2000). Improved Land Management in the Lake Victoria Basin: Linking Land & Lake, Research & Extension, Catchment & Lake Basin. First Report of Progress and Results, July 1999 to March 2000. Nairobi: ICRAF and Ministry of Agriculture and Rural Development.

Khan, A. (2000). Design, use and production of a simple, robust, low cost pipe sampler for measuring soil and water loss in catchment. Consultant report, 16 November – 13 January 2000. Nairobi: ICRAF.

Mugo F W, D Ombalo, B Swallow and F Place (2000). Adoption of soil conservation measures in Dirubi catchment. ICRAF, Ministry of Agriculture and Rural Development, Nairobi, Kenya

Mugo F W, B Swallow and F Place (2000). Adoption of soil conservation measures in Rongo focal area. ICRAF, Ministry of Agriculture and Rural Development.

Mugo F W, Nyantika D and Nyasimi M, eds (2000). Proceedings of the Agroforestry seminar held in Kisumu, 14-20 May 2000. ICRAF, Ministry of Agriculture and Rural Development.

Ondieki, Jafeth (2000). Rongo and Kobong'o Farmers' Tour to Kibwezi (April 26 – 29 2000).). Intervention Report No 7. ICRAF-Ministry of Agriculture and Rural Development

Rommelse, Ralph (2000). The impact of improved fallows and biomass transfer on household poverty indicators in western Kenya**:** Methodology and Empirical Results from Baseline Survey. Natural Resource Problems, Priorities and Policies Programme Working Paper 2001-2. International Centre for Research in Agroforestry, Nairobi, Kenya.

Shepherd, Keith D and Markus G. Walsh (2000). Sensing Soil Quality: The Evidence From Africa. Natural Resource Problems, Priorities and Policies Programme Working Paper 2000-1. International Centre for Research in Agroforestry, Nairobi, Kenya.

Shepherd, K D, M Walsh, F Mugo, C Ong, T Hansen, B Swallow, A Awiti, M Hai, D Nyantika, D Ombalo, M Grunder, F Mbote & D Mungai, 2000. Improved land management in the Lake Victoria Basin: Linking land & lake, research & extension, catchment & lake basin. First technical report start-up phase, July 1999 to June 2000. (Working Paper 2000-2). ICRAF, Ministry of Agriculture and Rural Development, Soil and Water Conservation Branch & National Soil and Water Conservation Programme. Financed by SIDA.

Shepherd, Keith D and Markus G. Walsh (2000). Diffuse reflectance spectrometry in the NARL long-term experiment—preliminary results. Natural Resource Problems, Priorities and Policies Programme Working Paper 2000-3. International Centre for Research in Agroforestry, Nairobi, Kenya.

Wangila, J and F Place (2000). Working Together for Rural Development in Western Kenya: A Meeting of Policymakers, Local Leaders, development Agents and Researchers. Summary Proceedings of a follow-up workshop held at Alliance Hotel, Chavakali, Vihiga District, Kenya. 14 March 2000.

ICRAF (2001). Semi-Annual Report to SIDA (July – December 2000).

Shepherd, Keith D and Markus G. Walsh, (2001). Light reflectance provides rapid assessment of soil quality. Natural Resource Problems, Priorities and Policies Programme Working Paper 2001-1. International Centre for Research in Agroforestry, Nairobi, Kenya.

Wangila, J. and B. M. Swallow (compilers) (2001). Design Principles for Land and Watershed Management in Western Kenya. Proceedings of a Workshop held on 9th April 2001, Kisumu, Kenya. Natural Resource Problems, Priorities and Policies Programme Discussion Paper 2001-1. International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya.

Muhia, R Njeri, David Nyantika and Wilson Nindo (2001). The socio-cultural constraints and opportunities of the collective resource management of the Asawo and Awach catchments in Western Kenya: Report of a study on the Katuk-Odeyo catchment area. Consultants' Report. May 2001.

PRA Reports

1. Mugo, F.W. (1999). Natural Resource Use, Constraints and Possible interventions: The case for Kandaria West Focal Area. Start-up Phase Report No. 1. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

2. Mugo, F.W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Katuk-Odeyo Focal Area. Start-up Phase Report No. 2. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

3. Mugo, F.W. and Omushieni, S. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Ombaka Focal Area. Start-up Phase Report No. 3. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

4. Mugo, F.W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Rongo (Kabienge) Focal Area. Start-up Phase Report No. 4. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

5. Mugo, F.W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kobong'o River Bank Focal Area. Start-up Phase Report No. 5. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

6. Mugo, F.W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Lumbwa Catchment. Start-up Phase Report No. 6. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

7. Mugo, F.W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kosida village. Start-up Phase Report No. 7. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

8. Owoko, P., J. Anga'awa, F.W.Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kakola village. Start-up Phase Report No. 8. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

9. Ombalo D. and F.W. Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Olwa Catchment. Start-up Phase Report No. 9. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

10. Mugo, F.W. (1999). Natural Resource Use, Constraints and Possible interventions: The case for Nyalng'anya Catchment. Start-up Phase Report No. 10. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

11. Ombalo, D. and F.W. Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Ombeyi village. Start-up Phase Report No. 11. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

12. Anga'wa, J. and F.W. Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Jaber village. Start-up Phase Report No. 12. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

13. Tegtmeier, Christian (2000). Natural Resource Use, Constraints and Possible interventions: The case for Rakwaro Village. Start-up phase report No. 13. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

14. Tegtmeier, Christian (2000). Natural Resource Use, Constraints and Possible interventions: The case for Ochieng Odongo. Start-up Phase Report No. 14. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

15. Tegtmeier, Christian (2000). Natural Resource Use, Constraints and Possible interventions: The case for Achingure Catchment. Start-up Phase Report No. 15. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

16. Tegtmeier, Christian (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kamgan village. Start-up Phase Report No. 16. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya

17. Tegtmeier, Christian (2000). Natural Resource Use, Constraints and Possible interventions: The case for Olwalo. Start-up Phase Report No. 17. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

18. Mugo, F. W. (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kwoyo. Start-up Phase Report No. 18. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

19. Mugo F. W., B Swallow and F. Place (2000). Natural resource use constraints and possible interventions: Synthesis report for 18 PRAs in Nyando District. ICRAF, Ministry of Agriculture and Rural Development, Nairobi, Kenya.

Pilot Phase Reports

1. Langa't, S., Kirui, S. and F. Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Chebitet Upstream Focal Area. Pilot Phase Report No. 1. ICRAF, Ministry of Agriculture and Rural Development, Nairobi, Kenya.

2. Owoko, P. and F. Mugo (2000). Price Survey of common tree products in Nyando district. Pilot Phase Report No. 2. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

3. Mugo, F. (2000). Livelihoods Strategies in Lumbwa Catchment. Pilot Phase Report No. 3. ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

4. Keter, P. and Fridah Mugo (2000). Natural Resource Use, Constraints and Possible interventions: The case for Kipsiwo Head Waters Focal Area. Pilot Phase Report No. 4. ICRAF, Ministry Of Agriculture and Rural Development. Nairobi, Kenya.

5. Mwangi, H. and K. Mutunga (2000). Design of water dams and other water harvesting structures. A training report for soil conservation officers' course. Pilot Phase Report No. 5. ICRAF, Ministry of Agriculture and Rural Development.

6. ICRAF and MARD (2000). ICRAF-NALEP 2000-2001 activity workplan for Nyando, Kericho and Nandi. Pilot Phase Report No. 6, ICRAF, Ministry of Agriculture and Rural Development. Nairobi, Kenya.

7. Owoko, P. (2000). Tree nursery establishment and management. Training report for nursery managers' course in Nyando district. Pilot Phase Report No. 7. ICRAF, Ministry of Agriculture and Rural Development, Nairobi, Kenya.

Annex A. Progress reports by activity

Objective 1: Identify and evaluate land management hotspots in the Lake Victoria basin and identify preventive and curative intervention points for dealing with priority areas.

Output 1.1 Quantification of recent historical changes in vegetation cover, land use, sedimentation and nutrient loading for the major river systems that drain into Lake Victoria from Kenya

1.1.1 Quantification of historical changes in sedimentation of Lake Victoria (Markus Walsh, Alex Awiti, Keith Shepherd)

Objective:

The purpose of this activity is to quantify changes in sedimentation rates vis-à-vis changes in land use and vegetation cover for each basin over the 150-200 years.

Methods:

Sedimentation rates are determined through radionuclide dating of 1 cm sections of the cores. Backtracing of the sediment to the landscape is done by comparing the spectral signatures of the cores with the signatures of the various soil samples that have been collected in the catchments. Sediment cores will be collected and analyzed for all of the major river systems (Nzoia, Yala, Sondu Miriu, Gucha) that drain into Winam Gulf from Kenya. During the year 1999 / 2000, two such cores were recovered at the mouth of the River Nyando.

Results:

The following progress was achieved in 2000 / 2001:

- Sampling equipment for collection of undisturbed sediment cores was designed and built in Nairobi. After some trial and error, the equipment now works extremely well, and can be used to recover up to 2 meter long undisturbed sediment cores in both inshore and offshore situations.
- Six sediment cores were recovered from the Winam Gulf of Lake Victoria in 2001 to establish historical changes in sedimentation rates and river basin biogeochemistry. All cores were extruded and processed in 1 cm thick sections. Spectral characterization has been completed for 2 cores collected at the outlet of River Nyando. Radionuclide dating of sediment samples and stable isotope characterization of two additional cores is currently being undertaken at the University of Colorado and at Texas A&M University.
- One 150 cm long core, collected at the outlet of River Nyando, was dated using ^{210}Pb and ^{137}Ce radionuclide markers. Based on this technique we estimated that the average long-term (i.e., the last 148 years) sedimentation rate of River Nyando at its outlet was 1 cm per year (95% CI = ± 0.18 cm yr^{-1}). While this figure indicates a high rate of sedimentation compared to average sedimentation rates in other tropical river systems, it should be regarded as preliminary as it is based on a single core. We are currently firming

up the long-term sedimentation rate estimates for the basin as well as ascertaining likely changes in sedimentation rates over the last one and a half centuries.

- Notably, access to a suitable boat for sampling has been problematic and has slowed progress toward completing this activity over the last year. Currently, the ICIPE research vessel "Dragonfly" has been contracted for offshore sampling. However, due to the fairly deep draft of the boat, it is not suitable for sampling in estuaries.

1.1.2: Workshop to discuss results of sediment core analysis

It was planned that a small workshop be convened in September 2001 to discuss the results of the sediment core analysis with Min. of Agriculture, KMFRI, KARI, KEFRI and other stakeholders. This workshop will be postponed until the analysis is completed.

Output 1.2 Land use and land management problems identified and quantified for priority river basins.

1.2.1: Identify land degradation problems using ground surveys, soil reflectance properties and satellite images (Markus Walsh, Alex Awiti, Keith Shepherd)

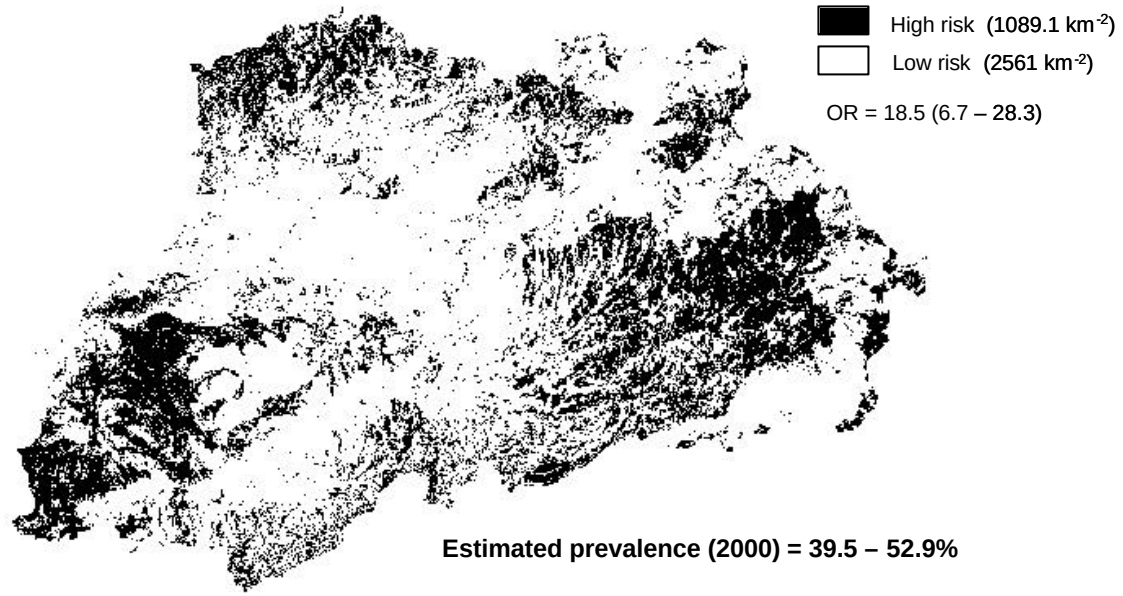
Objectives:
The objectives of this ongoing study are: (1) to assess the extents, magnitudes and causal processes of different soil erosion and non-point sediment source pollution processes in the Kenya portion of the Lake Victoria Basin; and (2) to evaluate the risks of current land use practices with regard to selected soil fertility indicators.

Methods:
A case-control protocol was designed to assess the prevalence and impacts of soil degradation problems was developed and refined during 1999 / 2000. Ground sampling locations are selected using a spatially stratified random sampling approach. All locations are geo-referenced through a survey-grade GPS and observations on land use, vegetation cover and composition, signs of accelerated soil erosion and occurrence of soil conservation structures were recorded. Samples of surface soil and sub-soil are collected at each location and those samples are analyzed in terms of basic soil properties. Samples are also scanned with a diffuse reflectance spectrometer under laboratory conditions. Relationships between soil properties and reflectance measurements are then assessed using advanced statistical techniques. During the 1999 / 2000 period, the protocol was used to survey 267 locations in the Nyando, Sondu Miriu and Nzoia / Yala river basins.

During 2000/01 the protocol was applied more intensively to the Nyando, Awach, Yala and Nzoia river basins. To date, just over 1000 sites have been surveyed to establish baselines for early-detection and diagnostic surveillance of biogeochemical changes associated with land degradation. About 6000 top (0-20 cm) and subsoil (20-50 cm) samples were collected over the course of this exercise (3 top and 3 subsoil samples per site). Soil condition assessments based on laboratory physicochemical measurements, soil reflectance and bioassays for Awach, Yala and Nzoia are currently being conducted in Nairobi and Kisumu.

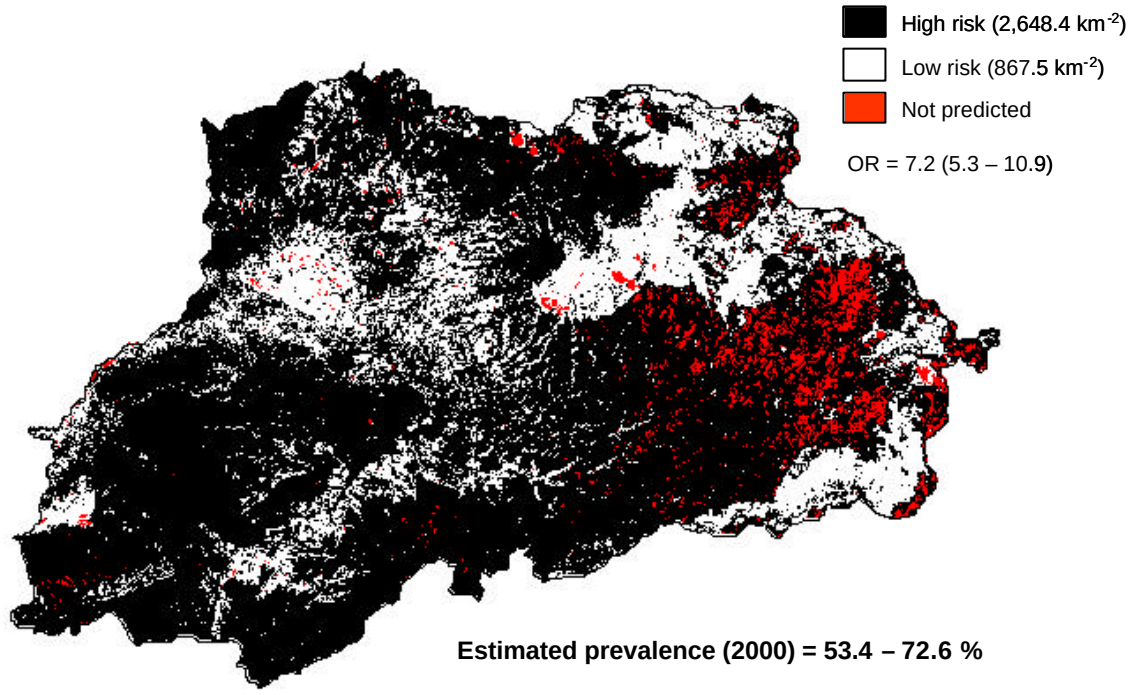
Results:

- In the Awach basin, over 300 sites have been selected for monitoring of erosion rates using erosion pin fields. Approximately 7,200 erosion pins have been placed on site. Soil displacement was monitored during an initial three-month period and will be followed up again in Dec 2001. Though this dataset is still being analyzed, our initial impression is that soil displacement in this basin is a major problem, which contributes to sediment deposition in Lake Victoria.
- This impression was supported by satellite observations and field survey data. Preliminary findings for the Nyando / Awach basin show that visible signs of soil physical degradation, including sheet, rill and gully erosion and soil hardsetting, are widespread and currently affect an estimated 1443–1932 km^{-2} (39.5–52.9%) of the area (see Map A1). Field survey results and laboratory tests further showed dramatic reductions in virtually all measured soil fertility indicators, such as in the exchangeable base complex and soil organic matter components, once symptoms of soil physical degradation become visually apparent in the field (see Table A1).
- A new technique for early-detection of soil physicochemical degradation was developed. A multivariate finite mixture model was used to resolve degraded (or case) from reference soils for sites where we observed no visible signs of soil erosion or hardsetting (see Table A2). Results of applying this technique in the Nyando Basin showed that 47.9% (95% CI ± 4.3%) of soil samples obtained from apparently intact sites, displayed physicochemical profiles commonly associated with severely degraded and/or nutrient depleted soils. Circa 84.3% (95% CI ± 2.1%) of soils from visibly degraded sites fit the case profile. Case soils were severely deficient in soil organic carbon (SOC) and other nutrients absorbed on the mineral and organic fractions of the soil. This is consistent with gravitational sorting and preferential transport of soil fines, which typically occur during the process of soil erosion. We believe that it is unlikely that case soils would be productive in the context of cropping activities, and have therefore initiated several greenhouse experiments to contrast soil productive capacities using maize as an indicator species. Based on satellite observations, we believe this to be a widespread problem in the Nyando /Awach basin, with 53.4 – 72.6% of the area being affected (see Map A2).
- New techniques for rapid spectral characterization of soils have been developed and successfully tested across a wide range of conditions in the Lake Victoria Basin and in other parts of Africa.



***Map A 1**: Spatial distribution of visible erosion risk strata in the Nyando River Basin.*

(Visible signs of soil erosion or hardsetting are predicted to occur 18.5 times more more frequently in the black [high risk] than in the white [low risk] portions of the map.)



***Map A 2:** Spatial distribution of physicochemical degradation risk strata in the Nyando River Basin.*

Physicochemical degradation is predicted to occur 7.2 times more frequently in the black (high risk) than in the white (low risk) portion of the map. Physicochemical degradation risk of red areas is unknown.

***Table A 1**: Summary statistics of soil properties by visual signs of soil degradation.*

Soil Property	Visual Signs of Soil Degradation (VSSD)			
	App. intact [n = 351]	*Sheet & Rill* [n = 152]	*Hardset* [n = 42]	*Gully* [n = 65]
pH (water)	6.42a‡ (5.20 – 8.10)†	6.37a (5.38 – 7.92)	6.76 (5.80 – 8.13)	7.28 (5.52 – 9.24)
Sand (g kg^{-1})	353 (110 – 762)	454a (157 – 760)	475a (222 – 770)	496a (130 – 884)
Silt (g kg^{-1})	234a (80.0 – 400)	217ab (80.0 – 36.0)	193b (62.0 – 390)	186b (6.00 – 430)
Clay (g kg^{-1})	413 (120 – 742)	329a (120 – 636)	331a (151 – 499)	318a (80.0 – 654)
CECC (cmolc kg^{-1} clay)	57.4a (8.3 – 191)	46.8b (12.0 – 171)	41.4b (17.7 – 64.3)	54.0ab (19.7 – 145)
Exch. Bases (cmolc kg^{-1})	21.7 (3.61 – 45.9)	15.2a (1.99 – 41.0)	13.6a (4.29 – 28.8)	16.1a (1.53 – 39.6)
Ca	16.2 (2.01 – 36.0)	11.1a (1.58 – 29.1)	10.1a (3.41 – 21.5)	12.4a (1.32 – 30.6)
Mg	4.58 (0.724 – 11.7)	3.51a (0.300 – 11.8)	2.50a (0.719 – 5.85)	2.67a (0.340 – 7.23)
K	0.670a (0.128 – 2.14)	0.586ab (0.100 – 2.40)	0.467b (0.116 – 1.03)	0.495b (0.091 – 2.19)
Na††	*0.858* *(nd)*	*0.482* *(nd)*	*2.31* *(nd)*	*1.19* *(nd)*
Ext. P (mg kg^{-1})	5.44a (0.588 – 95.7)	4.25a (0.483 – 153)	3.12a (0.702 – 21.1)	3.51a (0.363 – 35.0)
SOC (g kg^{-1})	18.3 (6.84 – 54.6)	15.0 (5.12 – 46.8)	10.9 (5.71 – 16.7)	6.94 (1.43 – 3.63)
AMN (mg kg^{-1} d^{-1})	6.54a (0.278 – 30.6)	6.39a (0.065 – 27.4)	4.65a (0.260 – 13.5)	2.13 (-0.335 – 22.1)
? $_{sed}$	19.1a (-1.33 – 39.4)	21.5a (1.27 – 45.4)	28.3 (15.1 – 37.5)	39.6 (4.01 – 72.7)

† Values in rounded brackets are 95% non-parametric reference ranges (Solberg, 1987).
‡ Mean values sharing the same superscript are not significantly different based on 95% Bonferroni contrasts.
†† No mean comparison performed due to sample size restriction (n = 66)

Table A 2: *Case definition for physicochemical soil degradation based on a two-component multivariate finite mixture model of soils originating from "apparently intact" sites in the Nyando River Basin.*

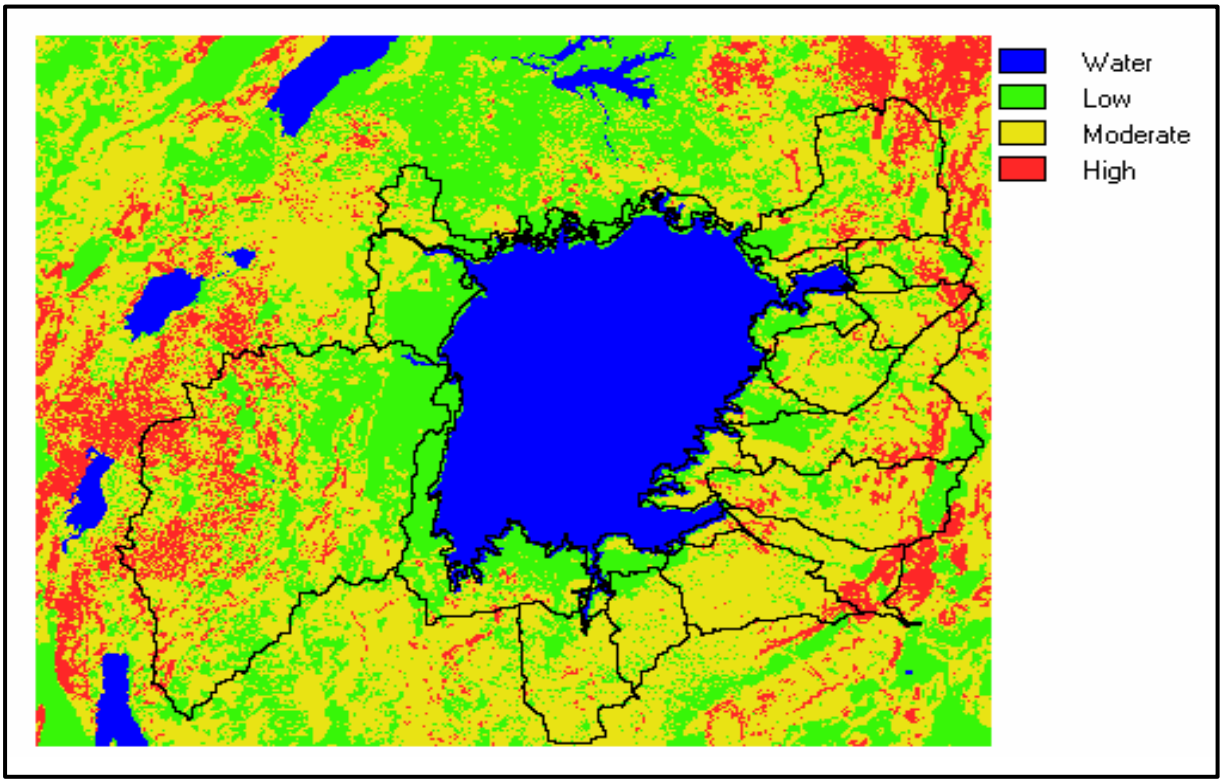
Soil Property	**T**[†]	**Reference** (f_r = 0.521)[§]	**Case** (f_c = 0.479)	**Contrast**[‡]
PH (water)	$1/\sqrt{}$	0.387[††] (0.0193)[§§]	0.403 (0.0192)	-0.37 to -0.61
Clay (%)	$\sqrt{}\ \sin^{-1}$	6.35 (1.54)	6.20 (1.16)	-1.74 to -0.832
CECC (cmol kg^{-1} clay)	$\sqrt{}$	9.03 (2.39)	6.01 (1.03)	-50.1 to -40.6
Exch. Bases (cmol kg^{-1})	$\sqrt{}$	5.50 (1.01)	3.76 (1.14)	-17.8 to -14.4
SOC (g kg^{-1})	ln	3.16 (0.573)	2.62 (0.376)	-11.2 to -8.36
Ext. P (mg kg-1)	ln(+1)	2.48 (1.14)	1.18 (0.607)	-9.25 to -7.98
δ_{sed}	$\sqrt{}$	13.7 (7.61)	27.2 (8.21)	11.8 to 15.2

† applied transformation
†† estimated mean
§ estimated proportion of soil samples from app. intact sites.
§§ estimated standard deviation

1.2.2 Identify and map poverty and NRM problem domains (Alex Awiti, Keith Shepherd, Markus Walsh and Brent Swallow)

A coarse resolution assessment of the soil erosion potential in the Lake Victoria Basin was conducted in order to contribute to regional-scale priority setting. Sediment transport capacity, USGS seasonal land cover classes and USDA soil taxonomic orders were reclassified into three classes of soil erosion potential: low, medium and high. The results show that the Kagera and Yala / Nzoia basins have the greatest proportions of areas with high erosion potential (see Map A3).

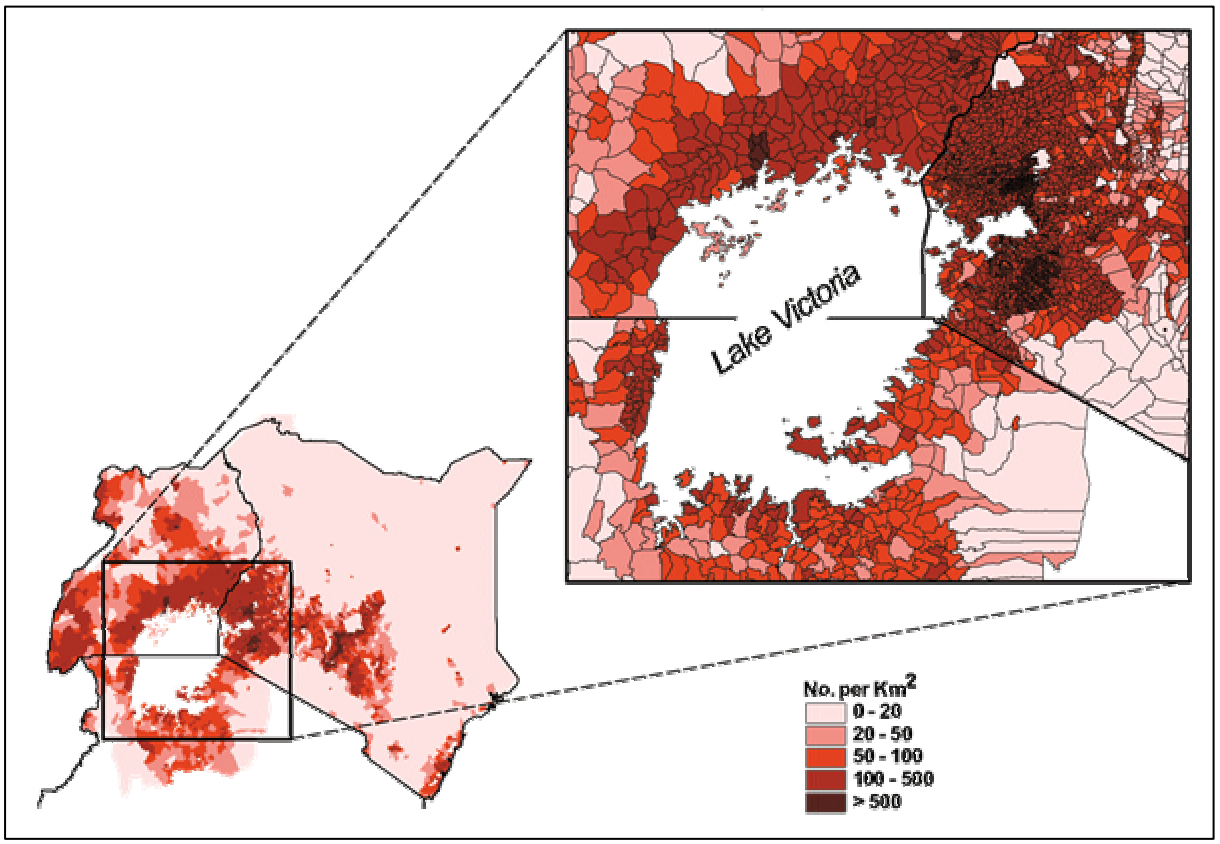
Map A 3: *Model of erosion potential in the Lake Victoria Basin*



Secondary data on agricultural production, poverty and human population density in the Lake Victoria basin were assembled from studies conducted by the Tegemeo Instiute and ILRI. The Tegemeo Institute collects household survey data from over 1500 households across the agricultural areas of Kenya in order to track levels and trends in agricultural production. Their results show the Western highlands (represented by Kisii and Vihiga) and the Western lowlands (represented by the former Kisumu and Siaya districts) have very low agricultural production per capita and per hectare compard to the other agricultural areas of Kenya. ILRI has worked with Uwe Deichmann from the United Nations Population Fund in New York in developing coarse-resolution population estimates for all of Africa. Map A4 shows that the show that the Lake Victoria basin is among the most densely populated areas of Uganda, Kenya and Tanzania.

Map A 4: *Human Population Density in East Africa*

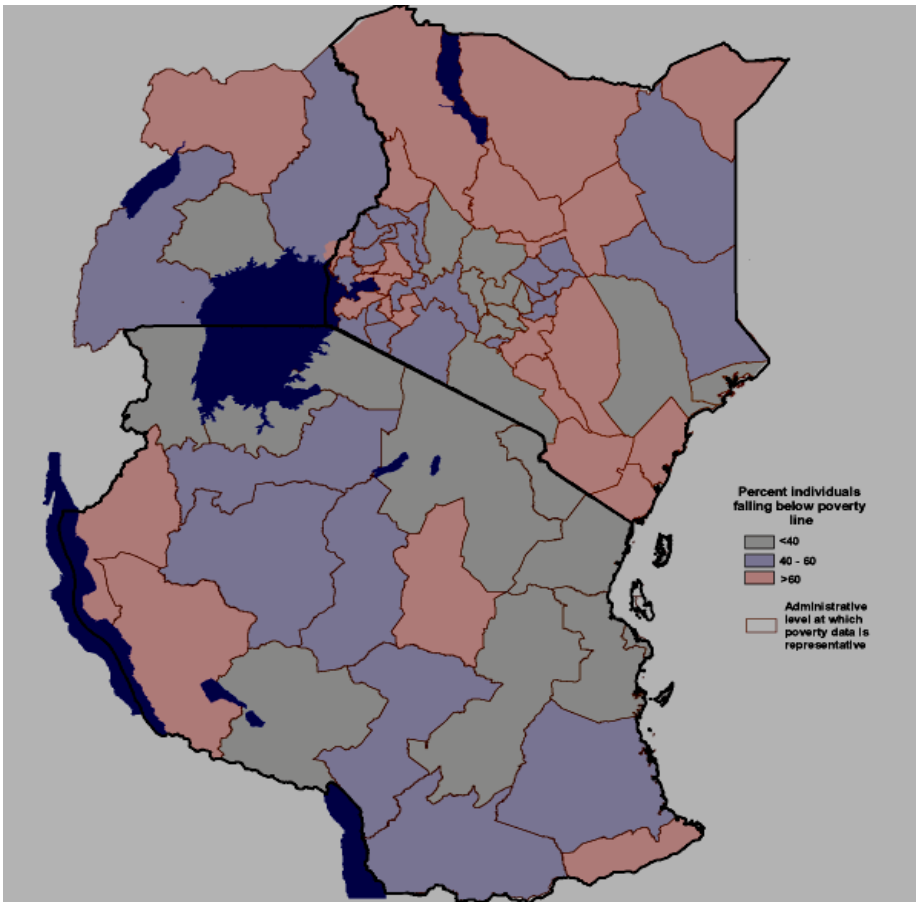
(Source: P K Thornton, R L Kruska, N Henninger, P Kristjanson, R S Reid, F Atieno, A Odero, T Ndegwa. 2001. Mapping Poverty and Livestock. Report to DfID. International Livestock Research Institute (ILRI), Nairobi, Kenya.)



ILRI is working with a consortium of national and international institutions to develop poverty maps for Kenya, Tanzania and Uganda. Map A5 shows that the highest levels of poverty (greater than 60% of the population below the absolute poverty line) are found in western Kenya.

Map A 5: *Poverty map of East Africa*

Source: P K Thornton, R L Kruska, N Henninger, P Kristjanson, R S Reid, F Atieno, A Odero, T Ndegwa. 2001. Mapping Poverty and Livestock. Report to DfID. International Livestock Research Institute (ILRI), Nairobi, Kenya.



Poverty measure = % of households falling below the absolute poverty line, based on local costs of a basket containing minimum food and non-food requirements. Kenya data source is the Welfare Monitoring Survey of 1997; absolute poverty line of $21 / month for rural; Tanzania data is for 1993; and Uganda data is for 1997.

Output 1.3 Causal models of land management problems developed and used to identify priorities for preventing and mitigating land management problems

1.3.1: Simulation model for assessing historical relations between population, land use and degradation in each river basin (Alex Awiti, Markus Walsh and Keith Shepherd)

The analysis of land degradation in the Nyando River basin identified an extensive area between the Mau and Tinderet forests in the upper part of the catchment as a land degradation "hotspot." This area was formerly under forest and was cleared for agricultural production at various times over the last 50 or more years. A study has thus been initiated in order to assess the effects of forest conversion on the functional capacity of soils.

One hundred paired-sites contrasting primary forest with subsistence maize agriculture were surveyed in the vicinity of the Kakamega and South Nandi forest reserves. Interviews were conducted with local farmers to obtain approximate timelines since forest conversion. Soils collected from these sites will be analyzed to ascertain their productive capacity in greenhouse experiments, carbon, nitrogen, phosphorus and sulfur contents and reflectance properties. Multivariate linear mixed and proportional hazards modeling approaches will be used to test time-space dependent impacts of forest conversion to subsistence agriculture.

1.3.2 Analysis of flows of environmental and economic resources using eme rgy analysiss techniques (Matt Cohen and Keith Shepherd)

Objective:
An analysis of the flows of environmental and economic resources in the Kenya portion of the Lake Victoria Basin was initiated in 2000 with complementary funding from the University of Florida, Rockefeller Foundation and USAID. The work is implemented by a Ph.D. student from the University of Florida, Matt Cohen, and is supervised by Keith Shepherd. Ongoing project objectives include the following: (1) characterize the resource basis for the region including assessments of the nation, the lake system, local districts and various sub-systems within the Awach basin using environmental accounting tools. 2) Assess the extent of soil degradation and factors that accelerate it in the basin and produce a spatial modeling framework for assessing alternative interventions using data from a detailed soil sampling protocol. And 3) Link the biophysical degradation assessment with socio-economic data from the same region to determine the effects of degradation on livelihoods and resource sustainability, and determine optimal land-use activities and intensities for the area.

Methods:
The main conceptual approach used in this study is energy memory or EMERGY analysis. Emergy (spelled with an "m") is simply defined as the energy used both directly and indirectly in creating a product. By accounting for energy embodied in something, including losses that are inevitable in all transformations as predicted by the 2nd Law of Thermodynamics, an alternative biophysical measure of value, cost and ultimately environmental sustainability emerges. These values can then be linked to standard economic components within a system to facilitate comparison of flows such as soil loss and household income on a common basis.

Emergy evaluations involve accounting for all the flows that cross the boundary of the system of interest. For a national analysis, flows of renewable environmental resources (sunlight, wind, rain) are coupled with non-renewable or slowly renewable extraction from within the country (forest logging, top-soil loss, mining activities) and import/export data to develop a picture of the resource basis and internal partitioning for the system. The data was compiled from a wide variety of sources, including the national statistical abstract, UN trade statistics, climatic and weather station data, and internal government/NGO reports. Each flow was extracted (and cross-referenced where possible) and a table of energy and material flows was generated. These flows were modified by an energy quality factor, or transformity, to produce an emergy value for that flow. Flows were then compiled and a series of standard metrics computed. Transformities are defined as the ratio of total inputs (embodied energy or emergy) to energy (measured using conventional methods) for any product.

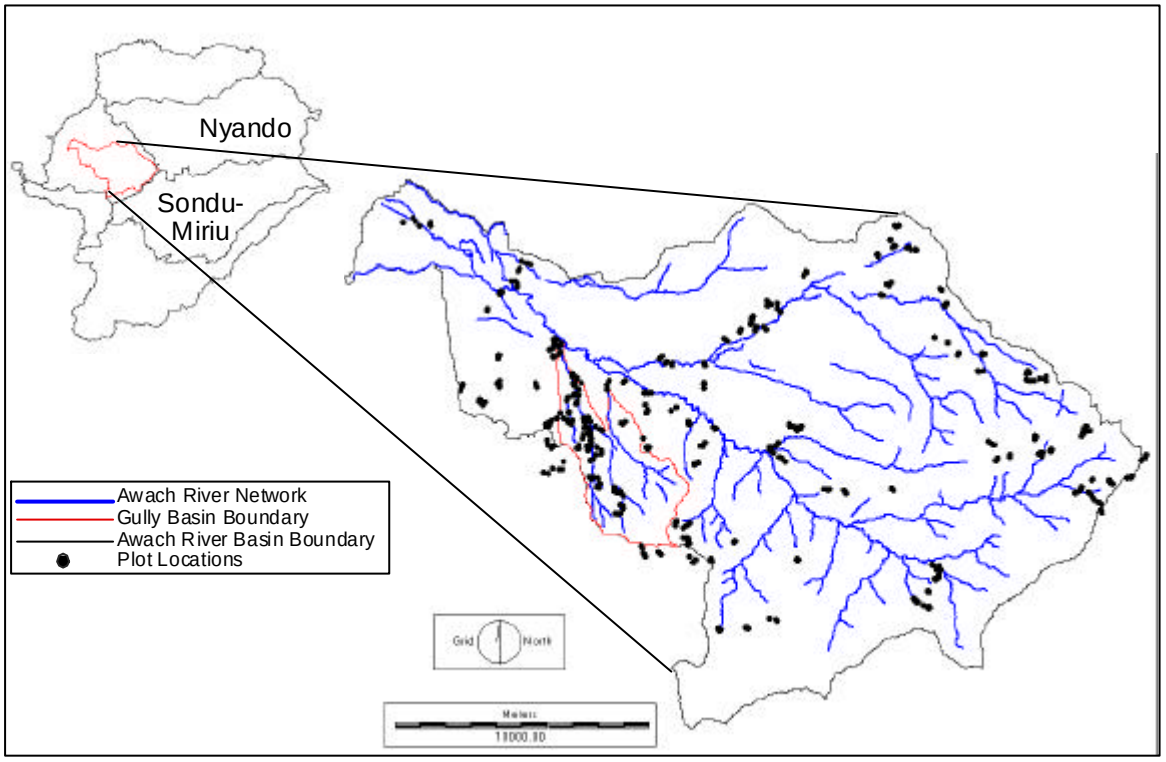
In order to provide meaningful information on the local mechanisms that accelerate soil loss and the potential of proposed interventions to adequately address the problem, a spatial and statistical modeling framework was conceived. To parameterize the models, a comprehensive case-control sampling protocol was employed and the sampling is now complete. A series of 420 case-control plots have been done in the basin (Map A6) along with a suite of related assessments including 60 infiltration trials, monitoring erosion pins located at 183 sites throughout the basin, and a detailed mapping exercise to determine the extent of the major gully that has developed in the region. Plots were spatially stratified by elevation and landuse, with particular focus on the gully catchment (Map A6). Each georeferenced plot includes nine soil samples for assessing soil physical and chemical characteristics, and observations of vegetation cover and substrate, terrain features, incidence of soil conservation techniques, and the presence/absence of visible signs of erosion and/or hardsetting. Soil analysis will be undertaken using the Diffuse Reflectance Spectrometry (DRS) soil property calibrations that were previously developed by ICRAF.

Results:
A complete emergy analysis has been conducted for Kenya in order to estimate the importance of different energy sources to the Kenyan economy, including renewable, local non-renewable flows, imports and exports. Key results from that analysis are the following:

- Large amounts of embodied energy are lost from Kenya every year through soil erosion and deforestation. It is estimated that the annual soil loss represents the same cost to society as the benefit accrued from 80% of all imported goods.

- In 1999 Kenya suffered a trade deficit in both monetary and emergy terms. The monetary trade deficit was about $750 million, while the emergy trade deficit was about 7% of total emergy use. This compounded problem is emblematic of the situation in most developing countries where raw or semi-processed goods, with high emergy-$$ ratios, are exported and highly processed goods, with lower emergy-$$ ratios, are generally imported. The implications are that each dollar of external currency received buys six times more of Kenya's "environment" than Kenya receives from the world for each dollar it spends.

Map A 6: *The Awach River basin, as shown a tributary of the Nyando River, in West Kenya. Shown are the basin boundaries for the entire watershed and for the developing gully, the stream network, and the spatial location of each of the 420 plots that were done between March and June 2001*



1.4 Quantification of the nutrient filter functions of wetlands

1.4.1: Analysis of land cover changes in wetlands and riparian forests (Robert Zomer and Oscar Ochieng)

Objectives:
Assess the current status and 20-year changes in lakeshore and inland wetlands.

Methods:
This study will combine remote sensing analysis and ground truthing in order to quantify current areal extent, seasonal change and change over the last twenty years. A visiting graduate student from the University of Utrecht will participate in this activity with funding from the University of Utrecht.

Results:
This study was conceived and funding has been secured from the University of Utrecht.

1.4.2 **Analysis of the nutrient filter function of wetlands** (Debbie Bossio, Chin Ong)

Objective:
To assess the effectiveness of wetlands surrounding urban areas and major rivers for their nutrient filtering roles;

Methods:
This activity will be undertaken through collaboration with Linkoping University, Osienala and other key stakeholders. During 2000 / 2001 the main activity was the identification of key stakeholders and the development of collaborative arrangements with Linkoping University and Osienala.

Results:
Current activities include regular interaction with Linkoping University and research into on-going activities of various stakeholders in the region. Continuing communication with Linkoping University has resulted in a preliminary agreement for a collaborative project to assess the nutrient filter and sink functions of the wetlands of the Nyando River basin. To prepare for this research effort ICRAF is contacting and conferring with key stakeholders in the Lake Victoria wetlands (primarily in Kenya) to identify opportunities for collaboration and explore possible linkages with other projects. In addition, collection and synthesis of relevant studies of wetlands in the Lake Victoria Basin (esp. Kenya portion), and review of literature on freshwater wetlands (especially tropical wetlands) is underway.

There are a number of organizations working on various aspects of wetland science and management in Kenya. We have met with representatives from a wide range of projects conducted by National Agencies, International Programmes and NGO's. These projects focus on wetland inventory, development, sustainable use of wetland products, economic valuation, buffering capacity, and protection and community awareness issues. The most extensive inventory project is a collaborative effort of the Kenya Wetlands Working Group of the East Africa Natural History Society, National Environment Secretariat, Moi University, IUCN Wetland Programme, Kenya Wildlife Services, and National Museums of Kenya. They have also developed a Wetland Database housed at the Center for Biodiversity at the National Museum of Kenya. National programs working on wetlands include larger development projects mainly driven by the Lake Basin Development Authority (LBDA), smaller scale development projects of the Ministry of Agriculture and Rural Development (MARD), and research of the Kenya Marine and Fisheries Institute (KMFRI). The Lake Victoria Environmental Management Programme (LVEMP, World Bank) has a wetlands component that is active in Uganda, Tanzania and Kenya. NGO's in the area including Nyando Wetlands Conservation Programme are very active in the social and historical context for wetland utilization and impacts on wetland function. They have already done substantial work organizing local communities. Sustainable use of wetland products is a component of most of the projects, and economic valuation of wetlands is an active area for IUCN.

Objective 2: Identify and evaluate technologies, institutional arrangements, and policies for alleviating poverty while protecting the local and regional environment of the lake Victoria Basin.

Output 2.1 'Best bet' options for upland conservation developed and evaluated

2.1.1 Assessment of the effects of agroforestry on runoff in the Ragen watershed (Mwangi Hai and Chin Ong)

Background:
The escarpment from the Nandi, Kericho and Belgut platteaus down onto the Kano plain has already been identified as an area of active and substantial land degradation within the Lake Victoria Basin. An example of such an area is found in the adjacent Rongo and Nyamarimba catchments. Ephemeral rivers emanate from the steep Nyabondo escarpment and drain the two catchments into the marshes of Nyakach Bay. The Principal Investigator for this research is Mwangi Hai, a senior staff member in the Ministry of Agriculture and Rural Development. Mwangi is enrolled as a PhD student in the Department of Systems Ecology at the University of Stockholm in Sweden.

Objectives:
(1) Assess land use changes over time;
(2) Assess infiltration, runoff and soil erosion rates from different land uses;
(3) model the effects of specific intervention measures to reduce runoff and erosion; and
(4) assess how particular interventions for runoff reduction and runoff management will effect runoff and erosion.

Methods:
The Rongo and Nyamarimba catchments were selected for intensive study of the effects of land use on infiltration, runoff and soil erosion rates. Although this was originally designed as a paired catchment study, it has since become apparent that there are important differences between the two catchments. The researchers have therefore adopted more of a before / after and modelling approach in both catchments.

Both streams and the larger Ragen river are monitored with water measurement flumes. Erosion is measured using a combination of standard erosion plots with automatic tipping buckets for each land-use and H-flumes at the Rongo and Nyamarimba catchments. After one year of collecting data from untreated plots, interventions have been installed on some of the erosion plots. Improved fallows of *Tephrosia candida* have been established on four plots in Rongo and four plots in Nyamarimba. Fencing has been established around two degraded plots and two grazing plots in both Rongo and Nyamarimba. Data collection which began in April 2000 is continuing.

In addition, the local community in Rongo is contributing a great deal of labour toward the construction of a water pan. Water inflows, evaporation and consumption from the waterpan will be monitored. The water pan is being established with support from RELMA.

Results from the analysis of different land uses and interventions will be used examine the impacts on runoff and sedimentation of present land use and potential interventions using a terrain- based model, TOPOG, developed by CSIRO in Australia. TOPOG is a process- based

model for predicting water yield, storm flow runoff production, sediment, production and soil moisture dynamics. Water balance is computed for the area represented by each element. Non-topographic spatial attributes, such as soil and vegetation properties, are accounted for with overlays similar to those found in Geographic Information Systems.

Results:
The Rongo / Rackwaro area was selected as a NALEP / ICRAF focal area. Detail on the progress with the focal area activities is reported below. As part of the focal area activities, a public meeting was held in Rongo in order to report research findings, possible interventions, and identification of possible key players and their roles. A series of interventions have now been initiated as a result.

Data analysis has continued for runoff, soil and nutrient loss. The results at plot and catchment scale are being prepared for a paper. An emerging story based on the samplers paired with tipping buckets is that the pipe sampler is not very reliable for runoff measurement as it underestimates runoff.

Figure A1 is a comparative hydrograph for the Ragen, Rongo and Nyamariba catchments for a particular rainfall event on August 6th. Hydrographs for other similar rainfall events look very similar. Runoff from Rongo is more rapid and much greater in quantity than runoff from Nyamarimba. Total runoff volume from Rongo is 436 cubic meters, while total runoff volume from Nyamarimba is 76 cubic meters. These contributed to the total runoff from the Upper Ragen of 3018 cubic meters. The low amplitude for Nyamarimba compared to Rongo is attributable to land use composition, distribution and arrangement, and steepness. The corresponding runoff volumes are 436, 76 and 3018 m^3, respectively.

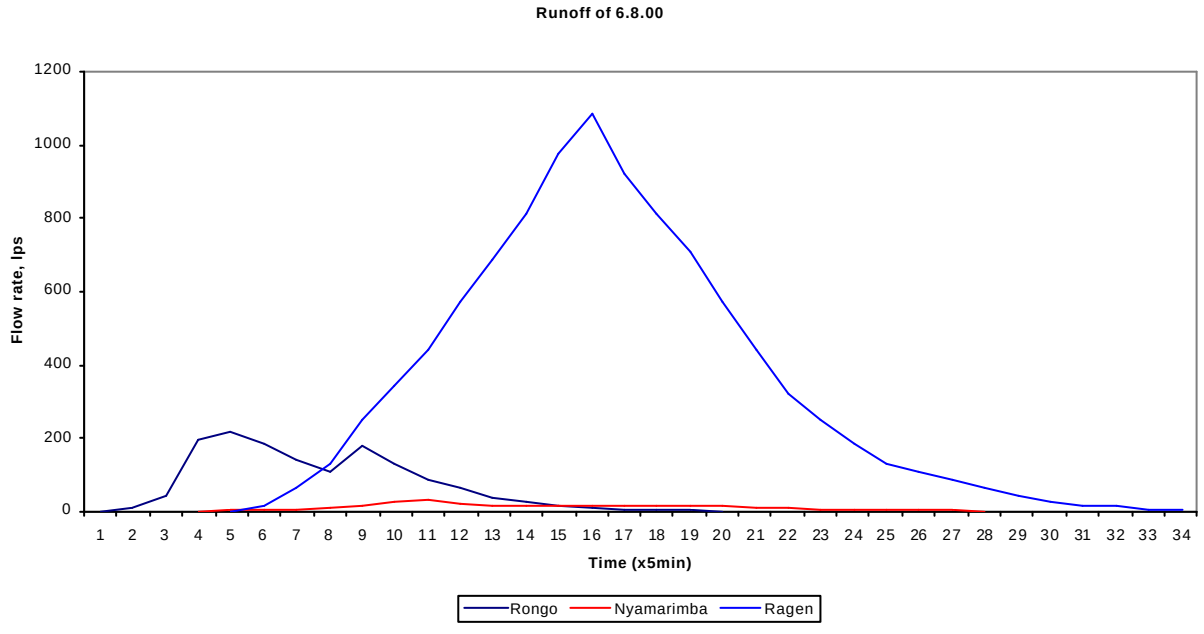


***Figure A 1**: Comparative hydrographs for Rongo, Nyamarimba and Upper Ragen (6th August 2000).*

2.1.2 Community trials with agroforestry technologies

1. Striga Control trials

Objective:
Striga infestation was identified as a serious problem in four focal areas: Katuk-Odeyo, Kobong'o, Burkamatch / Rakwaro and Chebetit (Map A8). Striga control trials were established on farmers' fields in the four focal areas in order to assess the potential for using different herbaceous vegetation to control striga. This activity was undertaken in collaboration with the Kenya Agricultural Research Institute in Kakamega.

Methods:
Type I and Type II trials were established in all four focal areas. The type I trials are conducted on farmers' fields, but with both design and management provided by the researchers. Type I trials establish biophysical parameters for the technologies without variation in management. Type II trials are researcher designed and farmer managed. Type II trials are used to explore the biophysical parameters for the technologies under various intensities of farmer management. Farmer exchange visits and farmer training in the technologies is conducted as part of the trials.

Results:
A total of 55 type-II trials have been planted (intercropped with KSTP maize) in the four focal areas. The species planted are *Crotolaria grahamiana*, *Tephrosia candida*, *Sesbania sesban* and *Desmodium intortum*. A total of four type-one trials have been planted in the four focal areas. Soil samples were taken from all the four sites and are being analyzed for nutrient composition and striga seeds count. Type II- failed in Kobong'o because of the limited rains. The type-one trials survived because they were planted with the maize at the same time.

A maize and groundnuts plot heavily infested with Striga in Upper Nyakach Division of Nyando District.

2. Improved fallow trials

Objective:
Soil fertility reduction featured as a major problem in the PRAs conducted in the focal areas. Trials with improved tree fallows were established in all eight focal areas. Improved fallows have proven to be viable, productive and profitable in Vihiga and Kakamega Districts – these trials will establish the viability, productivity and profitability of various types of improved fallows under a wider range of conditions.

Method:
The improved fallow trials adopted a similar approach to the striga control trials. Type I and Type II trials were established with farmer training and awareness building.

Results:
A total of 80 farmers have been trained on improved fallow management. Type II improved fallow trials have been planted on 80 farms in the eight focal areas. The species consist of *Tephrosia candida, Crotolaria grahamiana*, *Crotolaria paulina*, *Cajanus cajan* and *Sesbania sesban*. The purpose of the trials is to screen the species for effectiveness for striga control and soil fertility improvement across the eight focal areas. Each farmer has three plots of 5m x 5m. One plot is for continuous cropping of the crops that the farmer usually grows. The second plot has the improved fallow alone while the third plot has improved fallow and Phosphorous will be applied as Rock Phosphate (RP) or Triple Super Phosphate (TSP). Soil samples have been taken from a sample of these plots.

2.2 Identify and evaluate "best bet" options for river bank protection

2.2.1 Participatory research on riparian strips (James Ang'awa, David Ombalo, Fridah Mugo)

Objective:
Evaluate the feasibility of protecting the banks of the Nyando river through the active participation of individual farmers and farmer groups in tree planting within 10 meters of the river.

Method and location:
In 1999 people in the Kobong'o area in the lower portion of the Nyando River approached the Ministry of Agriculture and Rural Development office in Ahero requesting assistance with protection of riverbanks in their area. After a PRA was conducted, the area was selected as a Focal area, with particular emphasis on the problems of riverbank deterioration and the need for riverbank stabilization. The Focal Area Development Committee became the common interest group for riverbank stabilization. The area represents a thoroughly degraded portion along the Nyando River on the Kano plains situated approximately 6 km from Ahero Township and 28 km from Kisumu town off the Kisumu-Kericho highway.

Results:
Six activities were identified for the riverbank stabilization common interest group and objectives set for 2000 / 01. Those objectives and the actual achievements are noted in Table A3.

Table A 3: *Progress with participatory trials in riverbank stabilization in the Kobong'o area*

Objective	Accomplishment
Hold sensitization meetings on the importance of the riparian land	3 informal and several informal meetings held with the community and FADC
Facilitate community to re-vegetate a width of 4 metres width of the 1 kilometer stretch of the Nyando river with appropriate reeds, fast growing shrubs and other aquatic grasses	3 sites of about 100 metres naturally regenerating with grass and shrub species, involving 9 farmers
Encourage community to peg 10 metres of the riverbank along the 1 kilometer stretch	Pegged both sides of the river for 1 kilometer
Encourage community to use thorns to fence off 300 metres of the marked stretch of the river to experiment with natural re-vegetation	40 meters fenced, involving 4 farmers
Plant woodlots and sisal along 350 metre stretch of the pegged river bank	Sisal planted along 50 metres, no woodlot established yet
Encourage the establishment of high value mangos and banana orchards by 20 farmers on both sides of the river with a width of 6 metres of the remaining 350 meter stretch	Holes have been dug by 4 farmers and await planting materials.

2.2.2 Soil and nutrient losses associated with riparian strips measured (Duncan Odiwuor Onyango and Chin Ong)

Methods

This study investigated the causes, patterns and magnitudes of soil erosion along the lower portion of the Nyando river. Specifically the study determined historical land use changes and river dynamics in the study area, quantified and compared runoff, sediment and nutrient (N & P) 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 date by use of aerial photographs. PRA tools were used to capture local opinions on riparian management.

This study was conducted at Kobong'o village of Nyando district on an area of 2 ? 2Km^2 straddling the river. Kobong'o soils are black cotton clayey and prone to flooding. Alluvial deposits characterize the riverbed and immediate river valley. Major natural resource problems in the area include overgrazing and cultivation of fragile soils, poor agricultural practices, high demand for scarce tree products, high run-off from scarps, drought, erodible subsoil and poverty (Mugo, 2000). The mean annual temperature is about 25^0 C and precipitation of 1360mm bi-modally received. The average slope is 5% but can be as low as 0.1%. Soil degradation through erosion, depletion of organic matter and nutrients, is a wide spread and is linked to water quality degradation in Lake Victoria.

Four different land use systems were studied and compared for runoff loads by use of a pipe sampler; Sites under cultivation (farms), bush land, paths / cattle tracks and grassland. An area of 5 x 20m^2 was fenced off with corrugated iron sheets, from which the influence of each land use pattern was monitored through amount of generated runoff, sediment, phosphorus and nitrogen content. 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.

Results

Runoff, soil and nutrient loss from different land use types is given in Table A4. The collected run-off 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 was highest on paths and next highest on farms. 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.

Table A 4: *Mean Runoff per event, soil and nutrient loss from different land use types*

	Paths	Farms	Bush land	Grasslands
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

2.2.3 Analysis of land use and river course change along rivers (Duncan Odiwuor Onyango and Chin Ong)

Methods:
Aerial photographs were obtained for the area for the years 1948, 1963, 1967, 1979 and 2000. Land use was classified for each polygon according to Level II land use classification. Mean river depth, stretch length and valley volumes for each coverage year calculated and compared. The depth readings were taken on the aerial photomaps using a parallax bar, where a base of known height used as reference. Using Arcview for GIS, the river area was derived from the digitized coverage attribute tables. The length and width values were measured from the resulting map manuscripts. The valley volume was therefore calculated as a product of river area and depth assuming the river to be a long straight cube.

Results:
Results presented in Table A5 show that the river channel was widest in 1967 and 2000. These times both follow periods of extremely high rainfall, that is, the mega *El nino* event of 1963-4 and the *El nino* event of 1997. This suggests that the extremely high rainfall periods may be associated with severe loss of soil.

Table A 5 *Mean River Nyando dimensions at the Kobong'o stretch*

Coverage	1948		1963		1967		1979		2000	
	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%	Mean	CV%
Length	2920		3170		2920		3140		3000	
Width	33	25	43	26	50	47	36	12	50	40
Depth	11.6	13	11	29	7	29	5	13	8	48
Area	80224		124626		123338		102969		125763	
Volume	928988		1394565		843631		553973		1018071	
*Volume	1112467		1557234		995220		603087		1230000	

Figures are derived from the digitized attribute tables, except for depth values (cartographic for all but 2000 coverage which was determined using GPS tools) and *volume arrived at by use L×W×H as opposed to area from attribute table ×H used for volume calculations

The mean land use area by types are summarised in the Table A6. Fifty years ago, bush land 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 increased to 2.1%. Riparian deforestation is obviously not a recent event. Grasslands halved from 70.3% to 36.8% during the last 50 years, while farmlands doubled from 23.4% to 54.9%. The tendency to concentrate farms along the riverbank is an increasing trend. Within 20 meters of the riverbank, cultivation has increased from 0.2% in 1948 to 12% in 2000.

Table A 6 *Kobong'o mean area, std(Ha) and CV land use coverage tables*

LAND USE		Farmland	Bush land	Homesteads	Grasslands	River	Total
Whole area	Mean	174.5	8.6	7.1	198.7	11.1	400
	std	72	5.1	5.6	70.1	2.0	
	CV%	41	59.3	78.9	35.3	18.0	
300m River	Mean	36.4	6.5	1.8	64.5	11.1	120.4
Buffer	std	17.8	3.1	1.6	15.3	2.0	
	CV%	48.8	47.7	88.9	23.7	18.0	
50m River	Mean	7.3	2.9	0.1	19.9	11.1	41.3
Buffer	std	4	0.7	0.2	3.2	2.0	
	CV%	54.8	24.1	200	16.1	18.0	
20m River	Mean	2.8	1.2	0.004	8.2	11.1	23.3
Buffer	std	1.6	0.5	0.01	1.4	2.0	
	CV%	57	41.7	227.3	17.1	18.0	

Local community perceptions of riparian areas: The area was previously referred to as *thim* (Luo for a heavily forested area inhabited by wild life) and was settled in the early 1900's. The area was forested with trees about 25 meters tall and approximate diameter at breast height (dbh) between 60-90cm. The recognized tree species included Albizia, Ficus, Balanites and Acacia spp among others. Wildlife species included giraffes, elephants, hyenas, impalas, buffaloes, and rhinos among others. 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, domestic constructions and climatic change resulting in drought and flooding.

Observable land degradation began to occur in the 1960s. This included river bank 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 run-off on paths, deforestation, livestock trampling and increased rainfall volumes. Not many control measures have been put into place.

Conclusions:
These results indicate that degradation within the riverbank area in Kobong'o is due to three causes:
1) over cultivation due to conversion of most of the riparian land areas into farms and or pastures,
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.

2.3 Develop and evaluate policies and institutional arrangements for sustainable watershed management

2.3.1 Catalyze collective catchment management among upstream and downstream communities (David Ombalo, Tom Bonyo, Fridah Mugo)

1. Workshops on land management convened

Method:
Three one-day workshop were convened in April and May 2001 at St. Anne's conference center in Kisumu. The first workshops were attended by 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 was held on April 9th and focused on the identification of key design principles for watershed management institutions. It featured presentations by the coordinator of NALEP (Francis Mbote), the Provincial Agricultural Officer for Nyanza Province (Z. Magara), a review of lessons from experience with Landcare organizations in the Philippines by ICRAF's Regional Coordinator for Southeast Asia (Dennis Garrity), a review of lessons learned from experience with watershed management in India and challenges in applying those lessons in western Kenya (Brent Swallow and David Nyantika), and a summary of the socio-cultural study summarized above (Njeri Muhia and David Nyantika). Comments were solicited in plenary discussions and in written notes.

The second workshop was held on May 22rd. It focused on the development of more specific plans for watershed management institutions in Western Kenya. After the proceedings from the previous workshop were summarized by Brent Swallow, presentations were given on the state of poverty in Western Kenya by Action Aid, the state of natural resource degradation in the Nyando River Basin (Keith Shepherd and Markus Walsh), and legal dimensions of watershed management organizations by the African Centre for Technology Studies (). Working groups then met to develop plans viz-a-viz general policy issues, wetlands and riverine areas, gully areas, and upland forest margins.

The third workshop was held on May 23rd in the same venue. This workshop included a smaller number of individuals and agencies with direct interest in the Katuk-Odeyo and Awach areas. Presentations were given on the state of land degradation in the area (Matt Cohen and Alex Awiti) and the socio-cultural foundations of land management in the area (Njeri Muhia and David Nyantika). Working groups developed specific plans for how

external agencies can work more effectively with each other, with local authorities and with community groups in the area.

2. Support to development of institutions for enterprise development and land management in an irrigation area

Background:
In 1999 / 2000 a participatory rural appraisal (PRA) was conducted in the Ombeyi / Kore area of Miwani Division, Nyando District. The Ombeyi area is located in the sugarcane belt of the Kano plains. Four irrigation schemes were designed and implemented by the Ministry of Agriculture and Rural Development through the Provincial Irrigation Unit. (P.I.U.) At the end of the implementation work the schemes were handed over to the communities. It was expected that the communities, through their trained scheme committees, would sustainably handle issues on operations and maintenance of the schemes. It was envisaged that the scheme committees would derive their legitimacy from registration with the Department of Social Services as self-help groups.

The PRA identified deficiencies with the existing local institutions as a major problem in the area. None of the existing institutions – churches, women groups, youth groups, rice scheme committees -- were found to have the necessary professional competence, legal authority and capital base to effectively coordinate irrigation development and land management activities in the area. This results in water-use conflicts, low farm prices and complaints of exploitation of farmers by middlemen. Development and revitalization of the local institutions for rice production and resource management was therefore identified as a priority for the Focal Area Development Committee.

Methods:
A Community Action Plan (CAP) was developed with the community members to put in place an intervention strategy and define roles and time lines for implementation of agreed activities. Four micro-projects were agreed on: (1) promotion of tree planting for improved supply of tree products; (2) promotion of sustainable utilization of wetlands and wetland products; (3) promotion of livestock improvement; and (4) development of institutional arrangements for better management of the natural resources of the area.

Results:
1) Key collaborators were contacted and informed about the PRA results and components of the community action plan. This included the Lake Basin Development Authority, the National Irrigation Board, the National Fiber Research Centre at KARI-Kibos and United Millers.
2) The District Irrigation Unit for Nyando District visited the area to establish the current status of the rice schemes in terms of the irrigation infrastructure, area, estimate costs of repair of damaged structures and completion of new additional structures.
3) A meeting of collaborators and officials of the existing irrigation scheme committees was held in February 2001 to discuss the issues raised in the PRA and develop an action plan for addressing the highest priority problems.
4) At the meeting of collaborators and local officials there was unanimous agreement that an Umbrella local farmers organization to achieve the following objectives: marshal farmers' effort towards natural resource management (water, wetland products, soils etc);

minimize water use conflicts between farms and between schemes; and organize marketing. It was suggested that this umbrella organization be either a cooperative society or a local farmers development group bringing together all the schemes committees. A task force comprising of one elected representative from each scheme and the Divisional Extension Coordinator, the DAO, the District Cooperative Officer and the District Social Development Officer was mandated to prepare for the formation of the umbrella farmers organization, make recommendations and take necessary steps towards its formation.

5) A meeting of collaborators and scheme committee representatives was held to discuss and agree on the appropriate farmers' organization to address marketing problems, water-use conflicts, and resource management. The Nyando District Cooperative Officer and the District Social Development Officer gave presentations that outlined the roles and functions of cooperative societies and community development groups, the legal authority of each type of group, and the process and requirements for formation and registration of each type of group. It was agreed that the schemes should register as a multipurpose cooperative society.
6) A cooperative society was registered in July 2001 comprising 120 of a possible 1200 members.

Conclusion:
Good progress in the development of a new institutional arrangement has been achieved in the Ombeyi / Kore focal area. The development of the new institutional arrangement was prompted by local residents in response to needs articulated during the PRA. Local residents anticipate that the new multi-purpose cooperative society will be an avenue to higher quality rice, less conflict over water and more effective marketing of their rice. The Ombeyi focal area was the starting point for these developments, but the reach of the new organization goes well beyond the focal area. Ministry of Agriculture and Rural Development extension staff played key roles in facilitating contacts with other government agencies.

2.3.2 Determine land use patterns and rules governing use of riverbank and hillside areas

1. **Socio-Economic and Cultural Constraints and Opportunities to Institutions for Watershed Management: A Study of the Katuk-Odeyo Catchment** (Njeri Muhia, David Nyantika and Wilson Nindo)

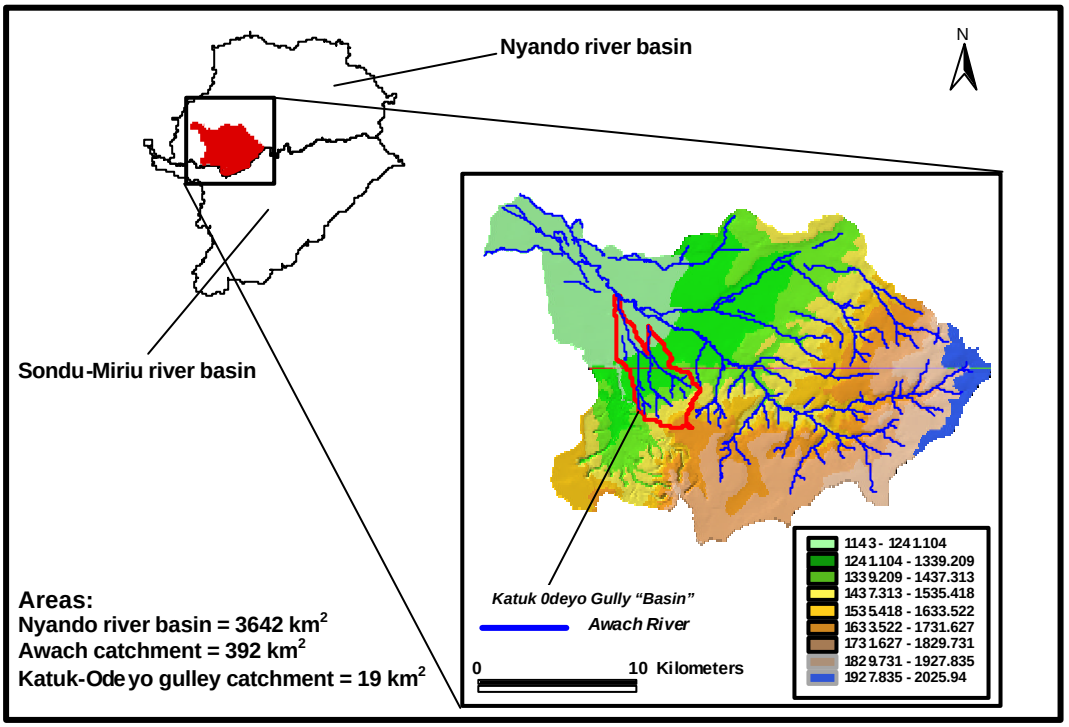
Background:
In 1999 / 2000 participatory rural appraisal exercises were conducted in the Katuk-Odeyo and Chebitit areas. The Katuk-Odeyo area is in Lower Nyakach Division of Nyando District, Nyanza Province, while the Chebitit area is located in Sigowet Division of Kericho District, Rift Valley Province. The two areas of adjacent and form part of the larger Awach catchment. The area was chosen because of its obvious environmental problems (severe gulley erosion) and because it represents an extreme "hot spot" within the Nyando River Basin. The area in which the Belgut, Kericho and Nandi hills drop down onto the Kano plains is an area of severe gully erosion and badland development.

After the PRA was conducted, ICRAF and the Ministry of Agriculture and Rural Development decided to give special attention to the Awach catchment, particularly to the drainage area of the Katuk-Odeyo gully. This special emphasis included focal area activities in the Chebitit and Katuk-Odeyo areas. In addition, we agreed to undertake an agenda of biophysical and socio-economic research in order to guide future development in the area. The following specific activities were identified to be undertaken by ICRAF and the Ministry of Agriculture and Rural Development: (1) environmental accounting of the costs of land degradation in the Awach catchment; (2) detailed GPS survey to accurately delineate the catchments of the Awach and the Katuk-Odeyo gully; (3) an analysis of the runoff and erosion associated with different land use types; (4) economic analysis of the costs of land degradation; and (5) an assessment of the socio-cultural and economic constraints and opportunities for institutions for watershed management. This section is specifically concerned with the latter study, implemented by a team of consultants – Njeri Muhia, David Nyantika, Wilson Nindo -- in consultation with Brent Swallow, Lotta Nycander, Frank Place, Fridah Mugo and Chin Ong. The fieldwork for the study was conducted in March / April 2000.

Study site:

The study was conducted in the Asawo and Awach hydrologic catchment areas in the Nyanza and Rift Valley area. The primary focus was the hydrologic catchment area of the Katuk-Odeyo gully, an area of 19 square kilometers covering a toposequence from the Belgut hills ridge in Kericho, to the Katuk-Odeyo gully and along the gulley to its outlet along the Kisumu- Kisii road.

Map A 7: *The Awach catchment and the Katuk-Odeyo catchment, Western Kenya*



Objectives:

The specific objectives of the study were to :

1. Construct a socio-economic-cultural history of land use and settlement in the Asawo and Awach catchment areas, with particular emphasis on the Katuk-Odeyo catchment.
2. Construct a history of soil and water conservation and socio-economic development intervention in the area
3. Identify all the ethnic groupings (language groups, clans, sub-clans), socio-cultural-economic groups and local organisations that have interest in the collective resource management in the catchment.
4. Assess how common use areas, especially dams, springs, protected forests, hillsides, riverine areas, gullies, are owned, used and managed.
5. Identify the nature, magnitude and history of land leasing activities between the upstream and downstream communities in the Catchments.
6. Identify all the governmental agencies, non-governmental organisations and international organisations that have interest in the collective resource management of the catchment.
7. Assess how the interests, objectives and capacities of the local and external groups, organisations and agencies constrain or facilitate improved management of resources on particular farms, between neighbouring farms, within common use areas, and between upstream and downstream residents. Identify the institutional arrangements that would catalyse more effective action among these different stakeholders.
8. Identify and assess socio-cultural constraints to the participation of different community members in the collective resource management.

Methods:

The study used a variety of secondary information about the area, which included the catchment maps, report of the PRA conducted in the area in January 2000, the 1992 study by Ann Mwangi, the 1994 PRA report for Kapsitii catchment for the National Soil and Water Conservation Programme and others. The research was conducted using participatory learning tools which included mapping exercises, extensive transect walks, historical trend lines, historical resources analysis, resource flow maps, institutional analysis, focus and key informant discussions, informal discussion sessions with groups, and individuals, randomly conducted to cover specific issues in the TOR and semi-structured interviews with knowledgeable people about the history of the area and the inhabitants.

Results:

1. History of land use and settlement

   Before any settlement took place in the area in the early 1800s, the area was grassland, reserved for grazing of cattle. The Luo people were using it mostly for grazing, but Kalenjin people also used its salt licks when they came to graze in the neighbouring areas of Kericho. There were some scattered indigenous trees but most of the vegetation was tall grass. The Luo settled first, in small groups along the lakeshore near "Sango" in Nyando District, and slowly moved to the catchment area. At around the same time, the Kalenjin, who had been used to periodically grazing their cattle in the area also started settle in the area. The livelihoods of the Luo at that time revolved around fishing, herding, hunting and a bit of farming, while the Kalenjin mostly relied on herding and some farming. Some conflicts between the Luo and Kalenjin did appear, particularly over access to grazing

resources and cattle theft. By 1900 the Kalenjin had achieved some territorial gains at the expense of the Luo.

Around 1920s the Luo regained grounds by pooling together with other clans such as the Agoro. They pushed the Kalenjin up to the present day border near the Kericho escarpment. Around the same time both groups resorted to permanent settlement of the area to secure their grazing areas. Crop farming using the traditional hoes started on a small scale around the 1930s and ox-plough cultivation began in the 1940s. The Government introduced water pans in the 1940s in an attempt to reduce inter-ethnic conflicts over water. In-migration continued through the 1960s, with floods causing the death of large numbers of livestock. In the 1990s the area suffered from tribal clashes between the Luo and Kalinjin people. (See Table A7).

***Table A 7**: Timeline of settlement and land use in the Katuk-Odeyo catchment*

TIME	ACTIVITY
Up to 1800s	Mainly pastoral grazing, communities taking advantage of the existing salt licks.
1900-20	♦ Beginning of settlement ♦ Inter-clan fighting for territory, especially against the Katolo in Kano, and the Kabodho in Nyakach. Also fighting with the Kalenjin ♦ Luo clans were pushed by the Kalenjin to the lake but fought back and pushed the Kalenjin to the present boundary ♦ Both the Luo and Kalenjin settled in their areas as a strategy for ownership of grazing areas
1940s	♦ Increased livestock theft prompted the colonial government to introduce boundaries ♦ Severe drought prompted the Kasaye clan to dig a water pan on communal basis ♦ Forced settlements by the colonial government ♦ Establishment of water points by the colonial government in Kericho
1950s & 60s	♦ Continuous settlement of the clans to fully occupy the area ♦ Floods cause massive livestock deaths.
1970-80	Frequent incidences of cattle theft.
1990s	♦ Clashes between the Kalenjin and Luo ♦ Increased settlement as returnees from other tribal clash areas settled back home ♦ Increased pressure on land forces people to start farming on steep hillsides
2000	All area is fully settled and as parents subdivide their land for inheritance by their sons, the parcels get smaller and smaller.

2. History of soil and water conservation

Pasture burning was banned in 1940 by the colonial government. Later in the 1940s and 1950s, the government government began to compel farmers to have soil conservation structures. The colonial government could detain or cane people who failed to implement these structures. These included stone terraces, “fanya juu”, unploughed strips between plots and contour ploughing.

After independence in the early 1960s there was very little obvious soil and water conservation for at least a decade since soil conservation was associated with the coercive policies of the colonial government. It was not until the 1970s that the Government formally recognized the severity of the land degradation problem. In the late 1970s the Winam Gulf project began. Under the Winam Gulf project, the Government constructed a

variety of physical conservation structures for soil and water management with little involvement from local farmers. This prompted a long-lasting attitude that conservation is the work of the government. Almost all structures have been disregarded since their initial installation.

3. Social–cultural composition of the area
   1) Clan affiliation is very important to the socio-cultural conditions in the Luo area. Four of the eleven Nyakach Luo clans occupy the lower part of the study area: the Gem, Agoro, Kawaye and Jimo. Within each clan there are a number of sub-clans named after their ancestral father and, in most cases, micro-sub-clans. Clans, sub-clans and micro-sub-clans are associated with particular areas of land, making them very important units for land management. Facilities such as dams, wells and schools are often considered to be the property of specific clans. Clans are also the basis of most effective collective action in the area. Clan affilitation is less important among the Kalinjin people who occupy the upper parts of the study area.
   2) Polygamy is practiced by both the Luo and Kalinjin ethnic groups, although it is more prevalent among the Luo. Data provided by local chiefs indicate that 8 percent of households in the Kalenjin area male-headed polygamous, while 17 percent of households in the Luo area are male-headed polygamous.
   3) Religious institutions play strong roles in development in the area. In the Gem area, church conflicts in the 1970s are regarded as having been responsible for creating divisions within the formerly united community.
   4) Common use areas include cattle dips, schools, market places, gullies, hillsides, riverin areas and irrigation structures. In both the Nyando and Kericho sides of the area, most of these common use areas are located on land registered to individual land owners. Because of this, the wider community cannot freely participate in their rehabilitation and maintenance.
   5) Land leasing is surprisingly prevalent in the area. The most common patterns of leasing include: a) annual leasing of land along the Awach river to entrepreneurs from the nearby market town who are interested in vegetable production for sale in the town; b) annual leasing of crop land in the Chebitit area to Luo farmers who are being displaced by the expansion of the gully and young Luo men who are unable to gain access to land controlled by their fathers; and c) short-term leasing of land in the hillside area of Chebitit to Luo farmers for grazing and fuelwood harvesting. There are no strict rules applied regarding the use of leased land, except the restriction against growing of long-term crops like sugarcane. As a result, a lot of this land has no soil conservation efforts, and is getting badly degraded. I t is also a source of run-off build-up.
   6) Groups and organizations with interest in resource management.

      Kericho: There are a several agencies working in the area although their activities are neither co-ordinated nor collaborative. ARDA is involved in small enterprise development, agriculture and development of water resources on the eastern side. Other agencies working in the area include the 1) Ministry of Agriculture and Rural development (NSWCP and LVEMP); 2) the Forestry Department; 3) National Council of Churches in Kenya (92/3); and 4) ICRAF. In addition, there are several community-based organisations, although their activities have remained dormant for a

time. These include women groups, dam committees and the Catchment committee formed when the Kapsitii catchment was developed in 1996. Except the women group which have been largely welfare oriented, all the other groups have been externally motivated (resulting from an external intervention in their area.)

Nyando: Agencies working the area include: (1) Ministry of Agriculture and Rural Development; (2) Rural Development Fund; (3) Winam Gulf Project (1970s – 1980s); (4) CARE-Kenya; National Council of Churches of Kenya; (5) Ministry of Public Health; (6) Min. of Water; (7) Min. of Public works; and (8) Office of the President. In addition, there are several community-based groups operating in the area. These include clan based welfare associations, women's groups (mostly sub-clan based), dam committees, village elders (appointed by the chief or Assistant chief), informal marketing groups (especially for trade purposes), farming groups, sand harvesters group, Bodaboda groups and other youth groups. As on the Kericho side, the groups and agencies operating within the Nyando side are neither well co-ordinated nor collaborative.

7) Opportunities for more effective action.

Most of the activities in the Nyando side are organised around clans, sub-clans and Micro sub-clans. Many people are averse to inter-clan groupings because of fear of failure and conflicts, which may involve their clan. This is especially so with women. Most women who are nominated to participate in inter-clan groupings are usually reluctant to participate.

The community are concerned about the low level and sometimes total lack of involvement of the local committees in the work of externally-based development agencies. Most development agencies "ignore them". They feel they should be more involved and informed about what is going on in their area. Another concern is that the development agencies do not always work with the community recognised leadership and institutions. Some agencies are too quick to form new committees for the implementation of their projects, without taking time to understand who it is they are putting in their committees, and if there are similar committees already operating in the area.

Sometimes, as happened in Kapsitii in Kericho and in Kamula dam in Nyando, committees are haphazardly created with members from one sub-clan or family benefiting from the assistance to be given by the agency. The rest of the community feels disenfranchised by such behaviour and will not willingly get involved in their activities. Where clan rivalry is strong, there may be motivation to sabotage such activities.

2. A review of the legal foundations of watershed management institutions in Kenya

(Marion Motari,, ACTS)

Objective

An issue that prompted a great deal of discussion during the policy seminar of April 9th was the legal foundations of different types of organizations that might be put in place for watershed management. ICRAF therefore contracted the African Centre for Technology Studies to undertake a rapid study of the legal foundations of watershed management institutions in Kenya. The paper was presented at the May 22nd seminar.

Methods:
A review and interpretation of the literature and legal statutes was conducted. International, regional and national policies affecting water resources were reviewed.

Results:
The appearance of community groups in the environmental field has upset the hitherto dominant institutional actors in resource management (notably the central government, NGOs and the 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.

It is instructive to note that the different forms of legal associations available in Kenya are not 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 in Kenya the best form of organizations appear to be registration as self-help groups under the Ministry of Social Services since the groups are most unlikely to be in a position to undergo the rigours and expenses of registering and operating a cooperative society. Larger groups that can bear the costs of register will consider forming cooperative societies. The merger of the Department of Cooperatives into the Ministry of Agriculture and Rural Development has made cooperative societies slightly more accessible to farmer groups interested in the promotion of new businesses.

Objective 3: Quantify the actual and potential impacts of promising land management interventions on human welfare (food security, income, gender equality) and the environment (soil quality, water quality and hydrologic function).

Output 3.1 Assess the impacts of alternative land management interventions on human welfare and environment (Fridah Mugo, Lincoln Mwarasomba, Frank Place and Brent Swallow)

Objective:
To assess how improved land management institutions and technologies affect people's lives and the environment of the Lake Victoria basin.

Methods:
The focus in 2000 / 2001 was on the collection of baseline information so that the impacts of subsequent focal area activities can be assessed. Three sets of three focal areas were selected for the collection of baseline information, one set of three focal areas in each of Nandi, Nyando and Kericho Districts, for a total of nine focal areas. Each set of three areas included a NALEP focal area in which ICRAF was not involved, a nearby focal area in which ICRAF was involved, and another nearby non-intervention area in the same division. This design will allow comparisons across space and time, allowing later studies to separate the influence of the project activities from more underlying socio-economic processes.

Basline data were collected through a household survey, a community survey, a yield survey, and a food consumption survey. The household survey was used to collect quantitative information on: household structure, education, livelihood strategies, sources of income and expenditure, land ownership and leasing, soil conservation practices, agricultural production, planting and management of trees, information sources, productive capital, food security and time spent collecting fuelwood and water. The household survey was administered to over 500 households. The community survey employed a number of participatory techniques (resource flow diagrams, participatory maps, transect walks) to collect more qualitative infoformation on resource quality, production trends, food security, sources of income and expenditure, wealth status and ranking, reliance on natural resources, and importance of external organizations. Lincoln Mwarasomba led the implementation of the community survey.

By the end of June 2001 the household and community surveys were completed and the results of the community survey were compiled into 9 separate reports. The yield survey was implemented in July 2001 and the food consumption survey will be implemented later in the year. Analysis of the household survey data will continue into 2001 / 2002.

Results:
Table A8 presents data collected from local chiefs and sub-chiefs on the demographic structure of the nine communities. 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.

***Table A 8**: Demographic structure of the 9 areas included in the baseline survey*

Focal area (Total HH)/Type of hh.	**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 (16 to 31 percent). The Katuk-Odeyo area, subject of the intensive study described above, is a particularly striking case: 6 percent of households headed by children, 28 percent headed by widows and 16 percent headed by polygamous husbands.

Table A9 shows the sampling strategy A stratified random sample of between 44 and 66 households was interviewed in each area, with a total of 499 households interviewed. Across all nine areas, the total number of households interviewed by type were: child-headed (23), single female headed (11), female-headed widow (112), female-headed husband away (45), male headed single or widower (28), male-headed polygamous (86) and male-headed monogamous (194).

***Table A 9**: Sampling strategy for household baseline survey*

	Number of households interviewed of each type							
Focal area (Total HH)/Type of hh.	**Child headed**	**Single Female headed**	**Female headed widow**	**Female headed husband away**	**Male headed single or widower**	**Male headed polygamous**	**Male headed monogomous**	**Total hhs**
Katuk-Odeyo (621) – Icraf / NALEP	4	0	20	5	3	9	19	60
Olwalo- Nyabola (165) – NALEP	4	0	15	11	6	10	14	60
Nyalunya (297) – non-intervention	10	0	1	15	3	6	16	51
Chebetit – ICRAF / NALEP (133)	0	0	17	1	3	9	25	55
Chemrusoi - NALEP (207)	0	2	12	3	5	10	23	55
Musaria - (301) – Non-Intervention	1	0	15	6	3	10	20	55
Kipsiwo (165) – Icraf / NALEP	1	0	4	0	2	4	33	44
Kamelil (NALEP) (287)	1	3	14	3	0	18	27	66
Got Ne-Lel (235) - Non Intervention	2	6	14	1	3	10	17	53
Total for all areas	23	11	112	45	28	86	194	499

Source: Authors

Table A10 presents results from the community survey on the sources of income reported in the nine areas. Maize and livestock are the most important sources of income across the 9 areas. Otherwise, it appears that each area has quite distinct approaches to income generation. Tea, vegetable production, off-farm employment, sand harvesting, beans, remittances and coffee are important in two or more areas. Some areas have quite unexpected sources of income. In the Nyalunya – non-intervention area in Lower Nyakach Division, for example, the most important source of income is mat making, followed by sand harvesting, farming, petty business and remittances. It is important to note enterprises that are not listed as important. Sugar cane, for example, was only mentioned by one community.

***Table A 10**: Sources of income in the 9 areas included in the baseline survey*

	Source of cash income				
Focal area	Most important	2nd most important	3rd most important	4th most important	5th most important
Lower Nyakach Division, Nyando District					
Katuk-Odeyo – Icraf / NALEP	Crop production	livestock production	employment	sand harvesting	remittances
Olwalo- Nyabola – NALEP					
Nyalunya – non-intervention	Matmaking	sand harvesting	farming	petty business	remittances
Sagowet Division, Kericho District					
Chebetit – ICRAF / NALEP	livestock & livestock products	maize	tomatoes	charcoal	sand
Chemrusoi - NALEP	maize	tomatoes	kales	potatoes	livestock, trade
Musaria – Non-Intervention	tea	maize	bananas	milk	beans
Tinderet Division, Nandi District					
Kipsiwo – ICRAF / NALEP	Maize	beans	livestock	tea	coffee
Kamelil (NALEP)	Maize	livestock	milk	beans	coffee
Got Ne-Lel - Non Intervention	livestock & livestock products	employment	business	sugar cane	not reported

Source: Community surveys by Lincoln Mwarasomba

Output 3.2 Estimate the costs of land degradation intervention and benefits of land improvement in different parts of the lake basin (Brent Swallow, Samuel Murithi and Frank Place)

Objective:
Assess the on-farm and off-farm costs of land degradation and land improvements in different parts of the lake basin.

Methods:
Economic, ecological and GIS methods will be used in this study. Appropriate techniques will be selected once the research questions are prioritized. From the outset of this project, it was planned that this activity would only start in earnest in 2001 / 2002.

Results:
A senior Kenyan environmental economist was recruited to lead this work. Thirty-six applicants responded to an advertisement placed in the local dailies and 3 finalists were selected for interview by a panel comprised of ICRAF and the Ministry of Agriculture. Samuel Murithi was selected and joined ICRAF in mid-May 2001 on secondment from the Forestry Department of the Ministry of Environment and Natural Resources. In May 2001 he attended an ICRAF / University of Alberta global workshop on valuation of the environmental services generated by agroforestry in Zambia. The following priorities were identified for valuation research:

a) quantification of the way that different types of farmers discount future benefits and costs, both inter-annual and inter-generational benefits and costs;

b) effects of soil degradation and deforestation on agricultural production and household behavior (water collection times, fuelwood collection times, cooking);
c) values associated with soil in different parts of the Awach catchment;
d) better understanding of property rights in the Awach catchment; and
e) establishment of a panel data set for households located in different locations within the Nyando River Basin.

Output 3.3. Models and decision support tools developed for predicting the impacts of land management options at spatial scales ranging from village to the river basin.

Activity 3.3.1 Develop models for predicting the impacts of land management options at spatial scales from village to the river basin (David Mungai, Chin Ong, Robert Zomer, Mwangi Hai)

1. River basin modeling

Spatial and temporal water quality data to support a quantitative assessment of basin-wide sources and sinks of sediment and nutrient loads continued to be collected at several sampling points along the Yala, Sondu, Nyando and Nzoia rivers. Long-term discharge data for these and numerous other rivers in the basin have been availed form the Kenya Ministry of Water Development. These data will be used to assess the sediment and nutrient contributions of different land uses in the Lake Victoria (sub)-basins using Linkoping University's statistical and source apportionment modeling framework (HBV). A collaborative arrangement between ICRAF, Linkoping University and Osienala was developed and now awaits approval by Sida.

2. Small catchment modeling

The objectives of the modeling work at the scale of the medium to small watersheds are to: (a) calibrate the TOPOG catchment model using the comprehensive long-term data from the EAAFRO/ODA catchments in Kericho; (b) quantify the hydrological and soil erosion impact of land use and vegetation cover changes in selected sub-catchments in the Nyando and Sondu river basins; and (b) assess the potential impact of proposed interventions on run-off and soil loss in the selected sub-catchments. Consideration is being given to a number of agroforestry interventions both in the grazing and agricultural land. The specific land management problems being addressed include the conversion of forest to tea plantations and/or subsistence agriculture (or the conversion of areas presently under tea to eucalyptus plantations); the role of riparian vegetation in providing ecosystem goods and services; the potential of improved fallows and enclosures and, based on the assessment of run-off production in the Katuk-Odeyo area, the adequacy of the existing dams to store the run-off water.

The following have been accomplished:

- The modeling framework selected for this work (CSIRO's TOPOG, Vertessy et al., 1993) has been successfully installed in a Linux environment. Before the model can be used with confidence, it needs to be properly calibrated with credible, high quality

data. The high quality long-term data for Kericho obtained from the EAAFRO/ODA experimental catchments have been identified as being suitable for this purpose.

- The Digital Elevation Model (DEM) for one of the Kericho calibration catchments (Sambret) has been developed from scanned original hand-drawn maps. A TOPOG-generated element network has been prepared for one of the catchments. GPS measurements have been taken in the catchments for geo-referencing purposes.
- Apart from the DEM, other inputs include climate, soil and vegetation parameters. Quality control of the climate and soil data obtained from the Tea Research Foundation (Kericho) has been carried out. Parameterization of the model has began as we await a more extensive and detailed data set for the two catchments from the Centre for Ecology and Hydrology (UK) that includes observed streamflow and sub-daily climatic data.
- A land use map has been obtained from KARI (Muguga) from which a polygon map for overlay on the TOPOG DEM will be obtained.
- A DEM and TOPOG-generated element network for Rongo catchment have also been developed in readiness for the modeling scenarios of various improved land management intervention strategies. The DEM for Katuk-Odeyo has also been made.

3. Farm modeling

The following has been accomplished for the Ragen catchment:

- data available on topography, runoff, soil loss and nutrient losses for different land uses, climate, soils, land use
- a study of the dimensions and growth of gulleys in the Ragen catchment completed by two Swedish students
- improved fallows and exclosures introduced in the Ragen area
- WANULCAS, ANSWERS and TOPOG models all installed and running.

4. Monitoring of sediment load in rivers (Chin Ong)

Objective:
Regular monitoring of the sediment load from the four main rivers (Nyando, Sondu, Yala, Nzoia) began during the startup phase in 2001 in order to quantify and to trace the source of erosion from these rivers.

Methods:
Samples were taken at 14- day intervals during the rainy season and less frequently during the dry season from the headwater, midway and at end of each river for analysis of turbidity (expressed as NTU, normalized turbidity unit). NTU is calculated by measuring the dispersion of a light beam passed through a sample of water. Water with a high turbidity will almost certainly be considered unsafe to drink. The acceptable NTU range for human consumption is 1 –5 NTU; for recreation is less than 5 NTU; and for aquatic life is less than 50 NTU (For more information on the measurement and interpreation of turbidity measures, see the Water, Soil, and Hydro-Environmental Decision Support System, North Carolina State University Water Quality Group, http://h2osparc.wq.ncsu.edu/info/turbid.html).

Results:
Average values from February 2000 to July 2001 indicated that Nyando river carries the highest sediment (191 NTU), followed by Nzoia (135 NTU), Yala (84 NTU) and Sondu (34 NTU). These observations are consistent with the satellite images that the Nyando river has the highest sediment load into the Winam Gulf. All of these loads are indicative of very low quality water – 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 levels of fish population.

During the first long rains maximum turbidity of the Nyando reached 576 NTU followed closely by 515 NTU from the Nzoia (Figure A2). The next long rains produced less sediment with values of about 250 NTU from both rivers. The high sediment loads of both rivers probably reflect the erosion from the cultivated hillslopes and the de-vegetation of the riverbanks in the lower reaches of the rivers. This is particularly striking along the Nyando river at Kobongo in the Kano Plains, where large changes in land uses and cultivation close to river-banks over the last 50 years have taken place (see section on riverbank). High sediment load of the Nyando river has already blocked the distribution channels and hence reduced the viability of the numerous irrigation schemes for rice cultivation in the Kano Plains. In the Yala and Nzoia river basins considerable land use changes are also taking place especially the use of valley bottoms for vegetable cultivation. Fortunately, the large Yala swamp is still relatively undisturbed and sediments are trapped before the river flow out into the Winam Gulf. The Sondu river carries the least sediment load throughout.

Analysis of nutrients will be made in the coming months to determine the contribution form each river.

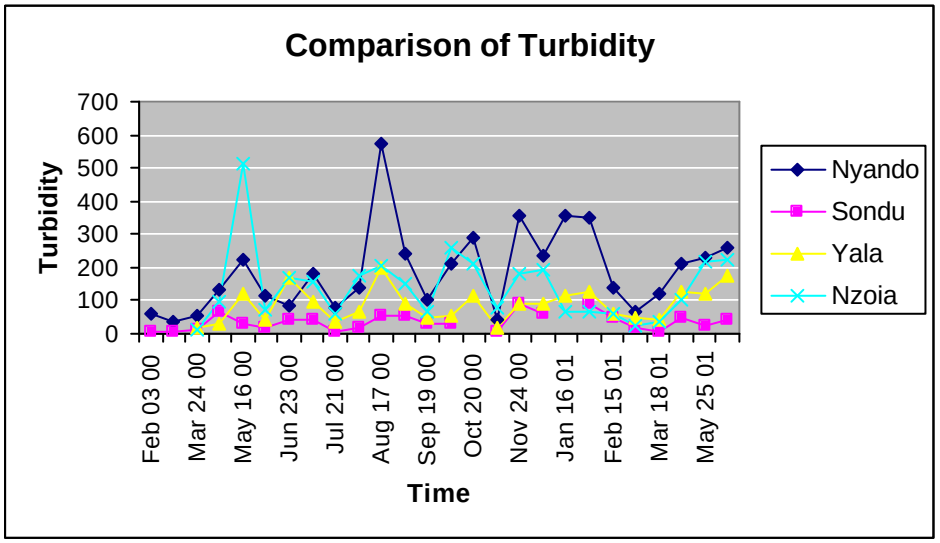
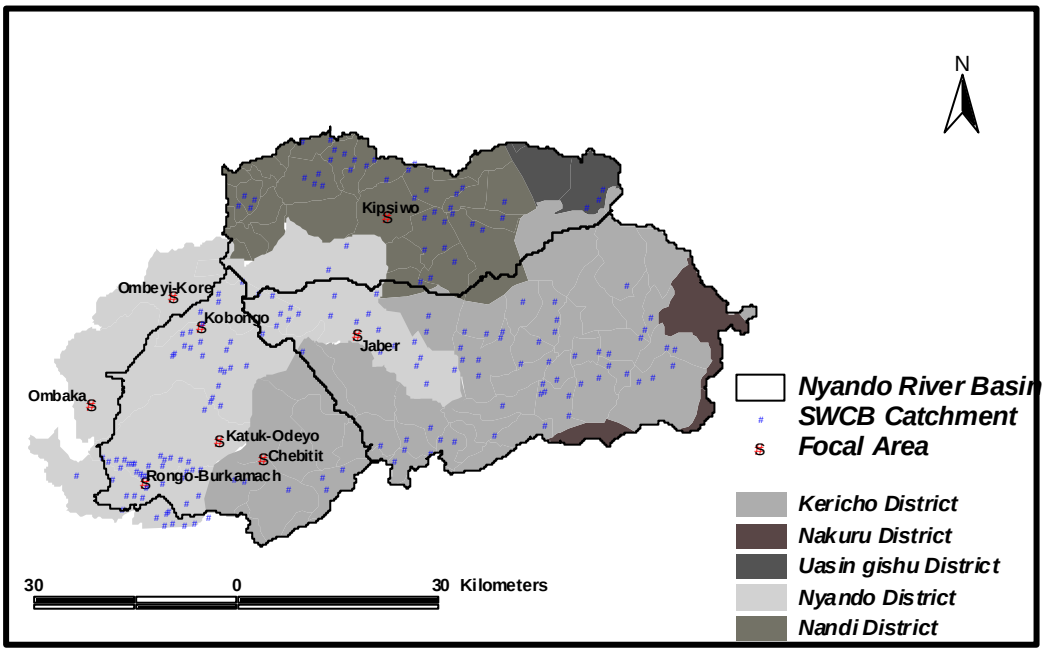


***Figure A 2**: Turbidity of four rivers in Western Kenya, Februrary 2000 to June 2001*

Objective 4: Enhance research and extension linkages for improved land management in the Lake Victoria Basin *(funded from A&A funds of NALEP).*

The main element of the Sida-financed NALEP programme is agriculture and livestock extension in 42 Kenyan districts. The shifting focal area approach is the center-piece of that programme. Secondary components of NALEP include research on agroforestry and land management. Research on agroforestry is implemented by KARI-Embu (with some backstopping from ICRAF) and research on land management in the Lake Victoria basin is implemented by ICRAF in collaboration with the Ministry. Progress against the land management research is reported above.



***Map A 8**: NSWCP catchments and NALEP / ICRAF focal ares in the Nyando Basin*

In addition, through NALEP the Ministry of Agriculture and Rural Development has some fungible funds categorized as appropriation and aid (A & A) funds for extension in the Lake Victoria Basin. ICRAF and the Ministry of Agriculture and Rural Development have agreed that these funds should be used to enhance linkages between research and extension in the Lake Victoria Basin. In the year 2000 / 01, these funds were primarily used to support collaborative activities in 8 NALEP focal areas; areas that were chosen to represent a range of land management "hot spots" within the Nyando River Basin. Other activities supported by these funds included training (PhD for Mwangi Hai, GIS training for Ministry staff), workshops, financial administration, impact assessment and monitoring and evaluation.

Planned activities in the eight focal areas included: PRA studies for the two additional focal areas that had not been covered in the start-up phase, nursery establishment for tree and fruits

seedlings, promotion of farm forestry planting for timber, poles, fuelwood and fruits. Other activities implemented were diversification of food production, soil fertility replenishment, striga weed control and livestock improvement. Energy conservation devices, soil and water conservation, gully control, run-off control and utilization, water harvesting techniques, natural regeneration and artificial control of degraded land were also promoted. Trainings were conducted on different topics for different target groups and farm specific action plans developed for a proportion of the farmers. To gather information for decision making, two surveys were conducted one on tree nurseries the other on prices of agroforestry products.

4.1 Conduct PRAs in new focal areas

A six-day PRA was conducted in July in Chebitet Upstream Focal Area (Sigowet Division, Kericho District) and another of three days done in October in Kipsiwo Head Waters Focal Area (Tinderet Division, Nandi District).

The results for Chebetit showed that the most constraining factors in the optimal utilization of natural resources in the area were lack of roads, numerous human diseases, water scarcity, water run-off and soil erosion, animal diseases, striga infestation, wildlife, land tenure, fire outbreaks, stock theft, soil infertility and unemployment in the given order. Various interventions were proposed for each constraint. Implementation of the interventions was initiated in November 2000 and is continuing. While the agricultural and environmentally based interventions are being undertaken, the farmers are disappointed that less emphasis was placed on their priority problems particularly the road which they feel is the most critical for any useful development to occur in the area.

The findings of the Kipsiwo PRA indicated that water scarcity was their number one problem followed by fuelwood, food shortage, low milk yield and low incomes. The interventions proposed included promotion of roof harvesting through construction of water storage tanks and jars by farmers. Construction of a water supply system for the whole community was however seen as the most reliable supply of water. The problem of fuelwood and construction poles could be solved by planting appropriate trees and using the wood that is available effeciently. Food security, it was proposed, could be improved by increasing the quantity and diversity of the foods grown through expansion of the acreage and improving productivity per unit area. Income can be increased by treating farming as a business and investing in the most productive enterprise(s). Implementation of the interventions is ongoing.

4.2 Develop farm specific action plans

Of the 2,709 planned farm specific action plans, 1,846 have been laid. Implementation of the planned farms is ongoing on but most of them are done partial depending on farmers' interest and abilities.

Table A 11: *Planned, Preliminary and completed FSAPs*

Focal area	No. of farms	Total area (ha)	Preliminary FSAPs	Completed FSAPs
Nyando District				
Kobong'o	414	580	330	160
Ombaka	432	300	432	149
Jaber	230	300	157	149
Burkamach	345	300	210	180
Kore	420	230	240	182
Katuk-Odeyo	550	450	189	94
Nandi District				
Kipsiwo	198	500	168	117
Kericho District				
Chebetit	120	-	120	-
Total	2,709	-	1,846	1031

4.3 Production and planting of tree seedlings

4.3.1 Tree nurseries established

A total of 26 tree nurseries of varying capacities ranging from 500 to 30,000 seedlings were initiated in the eight focal areas. Half of the nurseries were initially managed by groups but have slowly changed management to individuals. The only remaining group nursery is in Kipsiwo where the group nurseries have been consistently strong. Managers of group nurseries in other focal areas have started their own nurseries. With the initiation of these individual nurseries, there now are a total of 75 nurseries in the eight areas. Nurseries in two of the focal areas (Kore and Ombaka on the Kano plains) were destroyed by floods. Kore farmers resolved to try direct seeding and it worked well for them. In the other seven focal areas trees were planted from seedlings. The tree seedlings being raised in the nurseries include those for fruits, fuelwood, timber and fencing. The price of seedlings range between Ksh.5-50 depending on the species and the size. Improved fallows were direct seeded in the farms.

Table A 12: *Tree seedlings raised in the focal area nurseries*

Focal area	Planned fruits	Raised fruits	Planted fruits	Planned forest	Raised Forest seedlings	Trans-planted forest seedlings	Planned fodder	Fodder shrubs planted	Planned fence (seedlings)	Live fence planted (m)
Nyando District										
Kobong'o	9,600	441	137	2,225	8,678	5,140		0		440
Ombaka	5,000			60,000						
Jaber	7,500	6,300	140	46,000	4,500	2,023	30,000	2,100	30,000 (seedlings)	5,997
Bur-Kamatch	4,235		60		13,500	11,000				
Ombeyi - Kore	-	447	-		-	20,442 direct seeded		-		-
Katuk-Odeyo	8,000			40,000	31,465	5,889		60		
Nandi District										
Kipsiwo		377	9		18,508	11,483		2,656		
Kericho District										
Chebetit	24,000	113	0	24,000	7,500	300				
Total	57,835	7,678	346	172,225	84,151	56,287	30,000	4,816	30,000	6,437

The buying and transplanting of seedlings was slow. Farmers tended to buy very few seedlings in the range of five to 100. Three reasons were given for this observation. These are: lack of money to buy seedlings, limited awareness on the usefulness of planting trees and the gender roles.

The financial constraints appear justified since seedlings are supposed to be bought in April at the beginning of the long rains. This is the time when there is no food and also farmers need money to invest in crop production to buy fertilizers, seeds and pay for labour. Therefore, it is mainly the well-off who can afford. Land owners lack the appreciation for the need to plant more trees mainly because they do not see a direct short term benefit of planting the trees since the market for tree products is not well developed. In addition, the women who are the main users of domestic wood do not have express rights to plant trees. During the tree planting day, six thousand tree seedlings of varying species were planted along Katuk-Odeyo gully area. Grevillea seedlings were stolen but the others were left. This shows the high demand for Grevillea seedlings. However, farmers were not buying those which are in the tree nurseries to plant on their farms. There is an obvious need to introduce a greater market orientation to the business plans of the nurseries.

4.3.2 Tree nursery survey

During the PRAs conducted during 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. Two months after the initiation of the nurseries, a follow up visit to all nurseries revealed that a total of 24 tree and fruits nurseries had been established in the Nyando river basin. Four months later after the tree planting season, a survey was conducted to determine the performance of the nurseries, establish how the nurseries are being managed (individual

or group), identify the species being raised and their relative turnover rates, determine the factors responsible for the type of seedlings produced by different producers, the tree species that nursery owners would want to increase, the reasons why they have not increased and new species they would want to try or to have in their nurseries, determine the marketing strategies for the seedlings and grafts that are raised and propose interventions for encouraging planting of more trees and fruits. A total of 75 tree nurseries were visited.

4.3.3 Management of nurseries, species raised and their relative turn over

The results show that out of the 75 tree and fruits nurseries surveyed, 24(32%) of them were group nurseries and 51 (68%) individual nurseries. The three tree species that were reported to have the highest turn over for group nurseries were Eucalyptus (78%), *Grevillea robusta* (57%) and *Mangifera indica* (22%). For individual tree nurseries, the species were the same as those of group nurseries as shown in Table 4.2. The only difference was in the third species where for individual nurseries it was *Dovyalis caffra* while for the group it was *Mangifera indica*.

Table A 13:- *Tree species with the highest turn over*

Tree species	Percent of group nurseries reporting as highest turn over - N=23*	Percent individual nurseries reporting highest turn over - N=27**
Eucalyptus spp.	78	82
Grevillea robusta	57	33
Mangifera indica	22	22
Dovyalis caffra	13	26
Citrus sinensis (lemon)	17	22
Carica papaya	17	19
Passiflora edulis	4	22
Persea americana	13	15
Calliandra callothyrsus	13	11
Terminalia mentalis	0	4
Terminalia brownii	4	0
Leuceana leucocephala	4	4
Custard apple	0	4
Delonix regia	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 turn over.

The first four species that have the highest turn over in Table A13 have marketable products with high market demand. This is an indication of what appeals most to farmers. There is

need to identify species that have a high demand on the market and encourage the nursery managers to stock them. Considering both group and individual nurseries, the species that the nursery owners would want to increase are as indicated in Table A14.

***Table A 14**: Tree and fruits species that farmers would want to increase.*

Tree species	% of nurseries wishing to increase the number of seedlings - N=41
Eucalyptus spp.	54
Grevillea robusta	42
Mangifera indica	20
Dovyalis caffra	17
Citrus sinensis	15
Senna siamea	7
Cupressus lusitanica	5
Calliandra callothyrsus	5
Moringa oleifera	5
Markhamia lutea	5
Carica papaya	5
Persea americana	5
Mauritious thorn	5
Custard apple	5

The reasons for wanting to increase these particular ones are as mentioned already. They have a relatively higher turn over than others. The main reason given for not having increased before is lack of seeds at the right time. Others include lack of polytubes and knowledge about the level of demand, lack of knowledge on the side of farmers as regards the importance of some of the species. For new species most of the nusery owners wish to try species that are fast growing and marketable. The driving force in all these activities appear to be expected revenue. This leads to the need to avail information to farmers and nursery managers on the economic potential of selected agroforestry products as an incentive for their adoption.

4.4 Enterprise development

4.4.1 Market opportunities for common interest groups

A rapid assessment of market opportunities for the products of farmer groups, particularly rice, milk, fruit and wood products, was conducted. Potential private stakeholders to be considered for collaboration are Chemelil Sugar Company, Homaline factory and Tinderet Tea Estate for purchasing fuelwood from farmers. The Premier Company purchases milk and there are several ginneries that purchase cotton from farmers.

Most farmers do not plant certain crops because of lack of knowledge as regards their potential benefits. A survey of the prices of the common tree products was done in Nyando district to provide basic information to assist farmers in making decisions on the type of tree related enterprises that they could invest in. The five towns surveyed in Nyando district included Kisumu (Jubilee), Sondu, Ahero, Chemelil and Awasi.

The prices obtained were for fruit trees e.g. pawpaws, mangoes, oranges, lemons, bananas and avocadoes. Other products considered were fuelwood, timber and poles. The results are as summarized in Table A15.

***Table A 15**: Potential production and revenue from various fruit trees*

Species	Time to first fruit (Years)	Economic life span (Years)	Time to full bearing (years)	Average annual yield (fruits/tree)	Market price (Ksh.) per fruit - July 2001	Potential annual revenue / tree -July 2000 prices Ksh.)
Mangoes (grafted)	3-4	25	8	200-500	10	2,000-5,000
Avocado (grafted)	3	20-30	8	100-500	10	1,000-5,000
Pawpaw	1	2	-	10-15	10	100-150
Oranges (grafted)	3-4	20-25	7	300-700	5	1,500-3,500
Passion fruits	8 months	3-4	2	30-60	2	60-120
Lemons	3-4	20-25	7	1,000-1,500	2	2,000-3,000
Bananas-Desert	1-1.5	8-10	2	1	100	100
Bananas-Cooking	1-1.5	8-10	2	1	50	50

Source: Literature review and field survey data

Some products like guavas are usually not sold since they are seen as not important while others like honey were not found on any of the markets. Honey was reported to be in very high demand.

The price for fuelwood and charcoal was also obtained. Most of the markets had *lantana camara*, *Euphorbia tirucalii* and dry sugarcane available as fuels. All three are some of the lowest preferred form of cooking fuel. It was reported that in most cases the wood is usually sold on the way before reaching the market due to the scarcity. This reflects the high level of woodfuel scarcity in Nyando district. There is therefore great potential to improve the quality and quantity of wood available for woodfuel by planting desired and adequate trees for woodfuel supply. A bundle of Lantana wood for cooking one meal was sold for Ksh. 10. Split wood that could cook two meals was sold for Ksh. 30/= for a bundle of five, one metre long pieces. Additional research is needed to further assess the market for fuelwood.

Charcoal was sold for Ksh.15 per Kg. The per capita annual consumption for the urban centres of the region is120 kg (Republic of Kenya/Royal Netherlands Government/UNEP, 1997). Most of the charcoal used in Nyando is brought in from Kericho.

Tree seedlings were sold for between Ksh. 3-50 depending on the size, value and demand. Small seedlings for common species like eucalyptus sold for Ksh. 3, while bigger seedlings particularly raised for ornamentals sold for Ksh. 10. Grafted fruits of mangoes, avocado and citrus sold for an average of Ksh.50/=

Cyprus timber also sold for an average of Ksh. 8 (2"x2") and Ksh.15 (8"x1") per foot. There is no forest in Nyando and all the timber used in the district comes from outside. There appears to be potential for growing timber within Nyando particularly in Muhoroni and Miwani divisions. Eucalyptus poles were the most common and sold for an average of Ksh. 40 each. Additional research is needed to further assess the potential returns and risks associated with growing tree products in Nyando district. More also needs to be known about the environmental impacts of widespread production of trees in the Kano plain.

4.5 Livestock Improvement

Two activities were planned for livestock improvement. They include improving the production potential of the animals and increasing the forage for the animals. The production potential was to be improved by acquiring improved bulls to service the zebu cows in the focal areas. All the focal areas had identified a committee to facilitate the process, five of the focal areas had already trained the committees and four had constructed the sheds in preparation for the bulls. The activities were stopped and the officers advised to discuss with the farmers the possibility of considering the A.I. Service funded by the farmers themselves. The farmers are required to organize themselves to facilitate training for an A.I. provider and purchase a motocycle or bicycle and one semen storage equipment per division. It has been proposed that one A.I provider per division could be adequate for a start. One A.I. provider for Tinderet division was trained by the Ministry of Agriculture and Rural Development.

Increasing fodder supply was also seen as another way of improving livestock production. Farmers were encouraged to plant napier grass and calliandra for fodder. Many farmers, especially in Nandi, have planted calliandra along soil conservation structures on a trial basis. Napier grass strips have been planted by 24 farmers in Nandi. The other focal areas have a total of 9.5 acres of napier for multiplication.

4.6 Energy saving devices

The PRA results indicated that almost all households in the focal areas use fuelwood for their cooking. However, the resource is getting more scarce. Therefore energy saving stoves were introduced to save women's time used in collecting fuelwood. A total of 75 improved wood stove demonstrations have been conducted and adoption is progressing at a moderate pace. A total of 12 fireless cooker demonstrations were conducted, although there has been very little adoption to date.

***Table A 16**: Improved stove demonstrations*

Focal area	Maendeleo jiko demonstrations		Fireless cooker demonstration	
	Planned	Achieved	Planned	Achieved
Nyando District				
Kobong'o	10	20	1	1
Ombaka	10	20	1	1
Jaber	5	10	5	1
Ragen / Burkamach	10	8	1	8
Ombeyi / Kore	10	20	1	1
Katuk-Odeyo	10	9 (26)	1	1
Nandi District				
Kipsiwo	10	20 (51)	1	1
Kericho District				
Chebetit	10	3	1	1
Total	75	74	12	15

( ) Total number adopted

4.7 Soil and water conservation

In Kipsiwo, Chebetit and Burkamach, most of the land has old soil conservation structures that have not been maintained. Water pans constructed during the colonial period have filled with soil due to the high amount of eroded soil. New structures have been laid in the farms where the FSAPs have been completed and implementation is going on at a moderate pace.

Water harvesting for fruits production is being implemented at Katuk-Odeyo and Burkamach. In Katuk-Odeyo, holes have been prepared already for planting. In Burkamach, 120 banana plants were established and 20 farmers planted two fruits each using Tumbukiza technique. Twenty mother block fruit trees have been planted in Burkamach.

To reduce run-off and harvest water for domestic and livestock use, a total of 20 water pans were planned. Two water pans in Burkamach are nearing completion and survey data has been completed for three others. One has not been started. In Chebetit, one water pan has been completed and four are under construction. Five have not been started. One water pan was partially repaired in Katuk-Odeyo nothing has been done on the other four that required repairs. The main constraint reported is lack of interest by the people.

Out of the planned 40 metres of a sisal strip for gully rehabilitation, thirty metres have been planted in Burkamach. In Kobong'o, an alternative route has not been identified hence gully rehabilitation activities have been slow. A few check dams were constructed on the route/livestock track/gully that leads/drains into river Nyando.

4.8 Training

***Table A 17**: Farmer training in NALEP / ICRAF focal areas 2000 / 01*

Focal area/Type of training	FADC		Tree Nursery Management		Improved fallow and striga training		4-KClub members		Farmers tour	
	M	F	M	F	M	F	M	F	M	F
Kobong'o	5	7	8	4	18	21	-	-	+	+
Ombaka	7	12	8	4	+	+	11	9	+	+
Jaber	6	6	6	6	+	+	19	7	11	7
Burkamach	16	8	7	5	21	17	30	22	21	15
Kore	8	4	-	-	+	+	14	11	3	9
Katuk-Odeyo	8	4	8	4	+	+	15	9	+	+
Kipsiwo	+	+	+	+	+	+	+	+	+	+
Chebetit	8	5	13	7	42	35	+	+	+	+
Total	-	-	-	-	-	-	-	-	-	-

+ carried out but numbers not given

Other joint trainings held include one on the design of water dams. This was done for 12 soil and water conservation officers from Nyando and Kericho districts. Another joint training was held for front line extension staff for Nyando district on FSAPs development. Future training should emphasize on building leadership skills and handling farming and tree seedlings production as businesses.

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