



*LUCID's Land Use Change Analysis as an Approach
for Investigating Biodiversity Loss and Land Degradation Project*

**Root Causes of Land Use Change in the Loitokitok Area,
Kajiado District, Kenya**

LUCID Working Paper Series Number: 19

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A. INTRODUCTION¹

The Loitokitok area of Kajiado District, Kenya has witnessed extensive land use change since the independence of Kenya in 1963. These changes represent the response of the population to local and exogenous opportunities and constraints. This paper describes the patterns of land use change and presents an interpretation of their root causes, the driving forces that underlie the changes in land use. These driving forces represent the interaction between biophysical and societal processes over time, and they reflect the interaction between local and national scales.

This paper adopts political ecology as its conceptual framework.² The parameters of the approach emphasize that land use change results from interactions between society, reflecting economic, social and political processes, and the physical environment. Further, these interactions occur between different scales (global, national, local) over time and space. This conceptualization of society-environment interaction incorporates the following principles (after Campbell and Olson 1991a,b):

- integration of environmental and societal processes as active components of land use systems;
- employment of a historical time frame relevant to understanding the temporal dimension of current patterns of interaction between society and environment;
- recognition that different processes - for example, ecological ones such as soil formation and erosion, and societal ones such as population growth or changes in government policy - have different temporal characteristics. Some are long term processes, others shorter-term and some are characterized by sudden change;
- explicit examination of both top down/bottom up processes *and* the connections across sectors: a "spiral" of interactions between sectors and between scales;
- examination of interactions over space, recognizing that events in one area may have repercussions in other areas through processes such as migration, increased economic competition and institutional change;
- recognition of the role of power in determining outcomes of policy and in resolving conflicts.

While the implications of environmental changes are often discussed in terms of global consequences, there is growing recognition that many of the critical causes arise from interactions between societal and biophysical processes at the local level. The decisions that lie behind these actions that create environmental problems are influenced by a wide variety of interrelated factors, driving forces, that emanate from both local and external circumstances, cross boundaries between societal and environmental systems, and are driven by the exercise of power in the interests of particular objectives.

¹ The authors acknowledge with gratitude the support for this research from the Ford Foundation, the Rockefeller Foundation, the National Geographic Society, Michigan State University, the United Nations Environment Programme, the International Centre for Research in Agroforestry, the African Conservation Centre, USAID, and the International Development Research Centre. The authors also thank Louis Gachimbi for his comments. Responsibility for the content of this paper rests entirely with the authors.

² Regional Political Ecology (Blaikie and Brookfield 1987; Blaikie 1994; Peet and Watts 1996; Rocheleau et al. 1996; Zimmerer 1994, 2000) examines interactions between society and environment in ways that explicitly identify the political and power dimensions of environmental change. According to Blaikie and Brookfield (1987:17) the "phrase 'political ecology' combines the concerns of ecology and a broadly defined political economy. Together this encompasses the constantly shifting dialectic between society and land-based resources, and also within classes and groups within society itself." Application of the framework to the broad pattern of land use change in Kajiado District is found in Campbell and Olson (1991a).

The driving forces of land use change are therefore many-faceted. They may change in relative influence over time, and their impact will vary as the context changes. Analysis of global change demands conceptual frameworks and analytical methods that are both comprehensive enough to capture the dynamics of society-environment interaction at different scales, and flexible enough to accommodate the temporal dynamics of these processes (Campbell 1998; Ewel 2001; Kinzig 2001).

This landscape scale study employs a combination of analysis of a 30-year time-series of satellite imagery and information from field studies extending over 25 years to assess the extent and causes of land use change in the Loitokitok area, southeast Kajiado District, Kenya (Map 1). This area has experienced rapid and extensive land use change over the past 30 years in response to a variety of economic, cultural, political, institutional and demographic processes (Campbell et al. 2000). The study describes patterns of land use change and explores their underlying driving forces that are both local and exogenous. They reflect ecological and societal conditions and the interactions between them over space and time. Figure 1, the Kite, represents a conceptual framework that has been used as a heuristic device to explore these interactions in a number of different settings, including the study area (Campbell and Olsson 1991b). While the complexity of the dynamic interactions can be described, and significant driving forces identified, future outcomes are uncertain. Policy-making will continue to influence land use and have implications for the land users. Identification of past and ongoing patterns and processes can assist planners in coping with the uncertainty associated with planning for future developments in the area.

Map 1. The Study Area

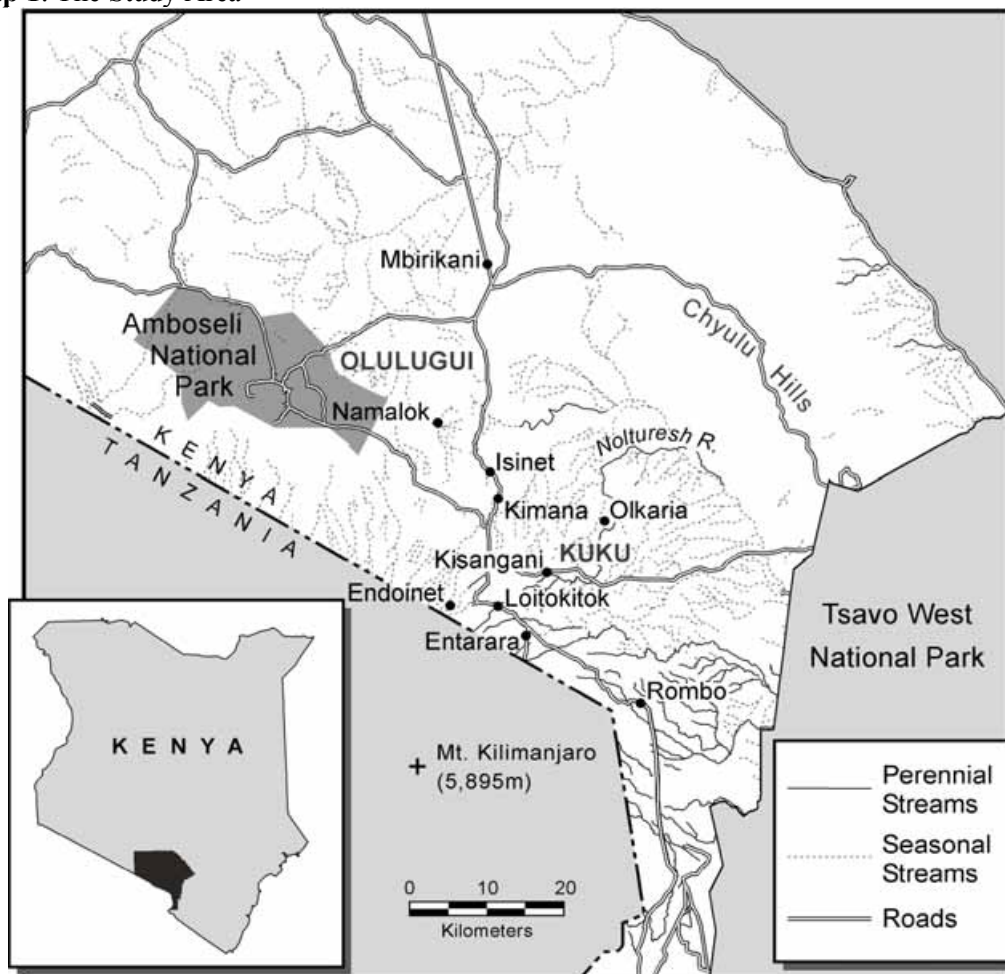
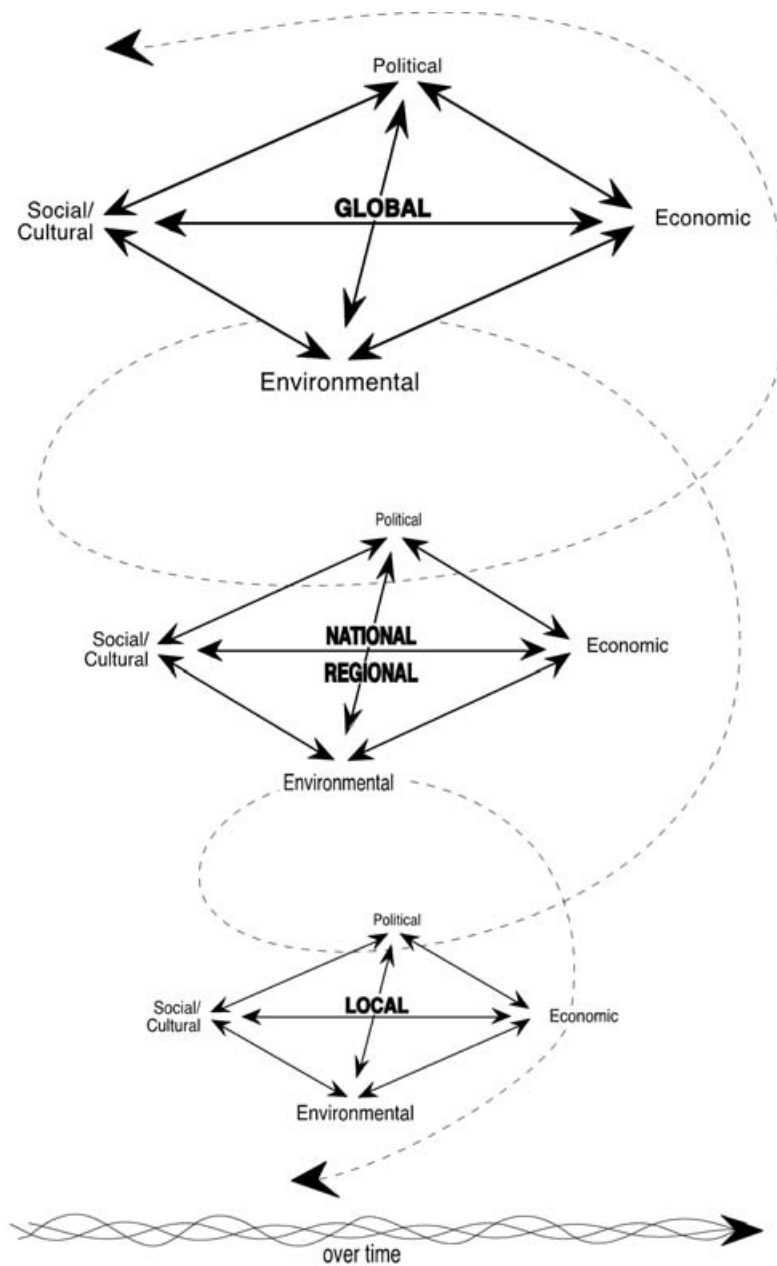


Figure 1. “The Kite,” A Representation of the Political Ecology Framework of this Study



David J. Campbell and Jennifer M. Olson, 1991. "Framework for Environment and Development: the Kite." *Occasional Paper Number 10*, Center for Advanced Study of International Development, Michigan State University

B. METHODS

The study employs a variety of methods to describe changes in land use patterns and to identify the driving forces of these changes. Pattern and process are explored through a complementary application of interpretation of satellite imagery and case study analysis that explicitly addresses the local-national spatial scale over a time frame appropriate to the identification of fundamental causal processes. The results illustrate that a combination of analysis of remotely sensed imagery and detailed field study provides an effective basis for describing and explaining patterns of land use change and their root causes.

B. 1. Land Cover Change 1973-2000

B.1.a. Analysis of Satellite Imagery

In order to cover the maximum time span and in light of the difficulty of obtaining cloud-free imagery in this part of Africa, three different image types were obtained for this study. For 1973 (December 20) and 1984 (December 17), Landsat MSS images (80 meter pixels) were used. On February 7, 1994, the study area was imaged by SPOT; the resulting 20-meter, multispectral scene was interpreted. The Landsat 7 ETM+ sensor imaged the study area on January 29, 2000 (path 167) and again on February 21, 2000 (path 168), providing 30-meter multispectral imagery of the entire study area.

Each satellite image was georeferenced to the UTM Zone 37 South grid. Vector maps of roads and towns were overlaid on the images for visual referencing purposes. Recognizing the dramatic differences in appearance between the 80-meter MSS and the 20-meter SPOT images, a new scene was created by spatially resampling (4 x 4 averaging) to simulate an 80-meter image. The side-by-side display of the 20-meter SPOT scene and its spatially degraded counterpart assisted the two image interpreters in better understanding the information content of the 80-meter data sets.

Attempts to use both supervised and unsupervised classification methods proved woefully ineffective, due largely to the lack of a consistent spectral signature associated with the rainfed agriculture category. Visual interpretation of contrast-stretched false-color composites proved much more reliable. In order to minimize interpreter bias, the visual interpretation process was begun on the 1973 MSS data. Both interpreters (Lusch and Campbell) worked side-by-side at the same computer workstation, allowing the independent assessment of each interpretation by the remote sensing specialist (Lusch) and the study area specialist (Campbell). The initial work was done using PCI *ImageWorks* software, but was completed using ERDAS *IMAGIN* software. The result was a vector map, drawn by heads-up-digitizing, of the selected land uses and cover of interest: rainfed agriculture, irrigated agriculture, and forestland. This map was completed over a several week period with many days lapsing between interpretation sessions. This forced the interpreters to continually reevaluate their previous interpretations at each subsequent session – a process which proved invaluable.

After the 1973 land use/cover map was finished, it was displayed on the 1984 MSS imagery and changes in land use/cover were interpreted. Once again, the interpretation was done during several widely-spaced sessions. After completing the 1984 land use/cover mapping, these vectors were overlaid on the 1994 SPOT image and, once again, changes in land use/cover were interpreted. Since the 20-meter resolution of the SPOT image allowed so much more landscape detail to be seen, the 1973 and 1984 vectors were reevaluated in light of the higher-resolution 1994 image. The various segments of the temporal boundaries (i.e. 73 – 84 and 84 – 94) were scrutinized using adjacent, spatially-linked views of the two early-date images and the 1994 SPOT scene. Several errors of commission were detected and corrected using this process.

The 1994 land use/cover vectors were displayed on the 2000 ETM+ image and the most recent changes in land use/cover were interpreted. In all four images, the chief clues to both

types of agricultural land uses were the distinct edges that often bounded them and the spatial heterogeneity associated with their surfaces. In some places the agricultural land was brighter than the surrounding grassland while in other places it was darker. The spatial characteristics of the agricultural lands were much more powerful as classification criteria than the spectral signatures were.

Once all four dates of imagery were interpreted, their boundaries were simultaneously displayed on the higher-resolution 1994 and 2000 images to reconcile the small, splinter polygons that were formed. Where the image evidence supported it, the arcs creating these problem areas were made coincident. After all the arc segments were edited using this process, they were exported as arc coverages, combined with the Kenya-Tanzania border coverage, and cleaned and built into a polygon coverage in ArcInfo. The polygon attribute table created by the build process listed polygon area as one of its fields. This table was edited to isolate the various land use/cover - year combinations and the areas of the three land uses/cover categories were tabulated.

B.1.b. Air reconnaissance 1996

A low-altitude flight was taken over the study area to provide a visual and photographic record of the distribution of land use in the area. These photographs and visual observations were important to the interpretation of the satellite imagery, particularly where the agricultural land uses were less contiguous. They served both as training data and, in a limited way for the 1994 map, as evaluation data.

B.2. Land Use Change 1977-96

B.2.a. Household Questionnaire survey, 1977 and 1996

Household surveys were conducted in 1977 and 1996 using the same sampling methodology and similar questionnaire. The 1977 survey interviewed 225 farmers and 166 herders and that of 1996 227 herders and 332 farmers. These were distributed among the group ranches and farms around the slopes of Mt. Kilimanjaro, and included pastoral lands, irrigated areas and areas of rainfed agriculture.

B.2.b. Landsat MSS imagery for 1973 and 1984, SPOT imagery for 1994, 2000

Land cover categories were identified and mapped for each image. Land cover change was mapped for 1973-1984, 1984-1999, 1994-2000.

B.2.c. Air reconnaissance 1996

Air reconnaissance assisted in the delimitation of the land cover categories.

B.2.d. Household Questionnaire survey, 1977, 1996, and 2001

Household surveys were conducted in 1977 and 1996 using the same sampling methodology and similar questionnaire. The 1977 survey interviewed 225 farmers and 166 herders and that of 1996 227 herders and 332 farmers. These were distributed among the group ranches and farms around the slopes of Mt. Kilimanjaro, and included pastoral lands, irrigated areas and areas of rainfed agriculture.³

B.2.e. Field Workshops 1977, 1996, and 2001

Subsequent to initial analysis of the survey data, meetings were held in the communities where the surveys had been conducted to present and discuss results of household surveys and

³ The survey was conducted along ecological transects that descended from the Tanzania border into the semi-arid rangelands. Four transects were surveyed - from Entonet to Namelok, from Loitokitok, to Kimana, Isinet, to Imbirikani, from Entarara, to Kuku, and in Rombo. The sampling along the transects was stratified by major land use to include rainfed agriculture, irrigated lands, and pastoral areas. The surveys provided information on demography, economy, land use, land use conflicts, perception of development issues etc.

assess interpretations. The survey team presented the principal findings specific to each area and also stated the major problem identified in each area. The workshop participants were then asked the following questions: (i) Is this the problem?, (ii) What are the causes?, and (iii) What can we do about it? (Campbell 1984, 1987). There was lively and pointed discussion at each of the workshops. The issues raised by the research findings were discussed critically and this contributed to a more focused interpretation of the information from the survey.

B.2.f. Key Informant Interviews 1977, 1996, and 2001

Interviews with individuals who have particular knowledge of various dimensions of land-use issues change in the study area provided additional information, particularly about the impact of external forces upon the study area. Such key informants included chiefs, representatives of non-governmental organizations (NGOs), government officials, and others.

C. LAND USE CHANGE PATTERNS

The principal changes in land cover resulting from land use change are related to the expansion of the area under cultivation (Map 2). This map only portrays those areas which expanded outside of the previous years extent. There were minor cases of "expansion-contraction-greater expansion" in the Loitokitok area and, to a lesser extent SE of Rombo, however these cannot be shown effectively at this scale. Table 1 summarizes the changes in area of forest, irrigated, and rainfed agriculture, and rangeland as measured from the four satellite images.

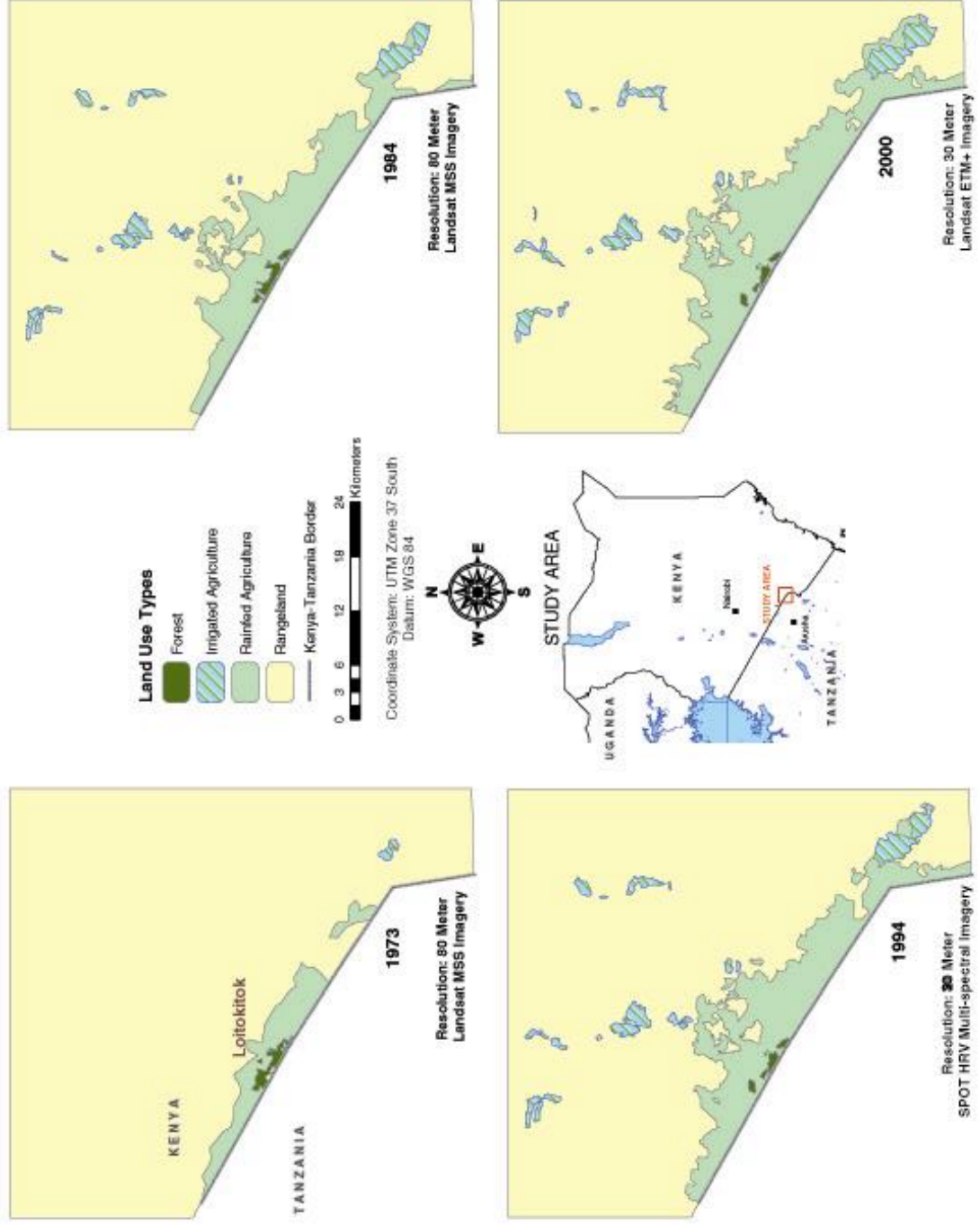
The forest area on the upper slopes of Mount Kilimanjaro adjacent to the national forest in Tanzania, declined 2.3 percent from an estimated 646 hectares in 1973 to 417 hectares in 2000. Over that time period, the area of rainfed agriculture expanded 177 percent and that of irrigated agriculture 45.2 percent. The principal changes are associated with the availability of water for crop production.

The period of most rapid expansion of both irrigated and rainfed cultivation was between 1973 and 1984. The general pattern of agricultural expansion between 1973 and 1984 (Map 2) matches the distribution of rainfall that follows a concentric pattern conforming to the slopes of Mt. Kilimanjaro (Jaetzhold and Schmidt 1983). An uneven expansion extended farther down slope around the district headquarters town of Loitokitok and along the main road from the town to Nairobi. These slopes receive over 800 mm of rainfall annually and a number of perennial streams flow down them to the plains. They offered, therefore, considerable opportunities for cultivation and by the mid-1980s almost the entire area between the Tanzania border and the semi-arid plains has been cleared and planted, by immigrant farmers, mostly from Central and Eastern Provinces, and by Maasai themselves. Land adjacent to permanent water sources, e.g., at Kimana, Rombo and around swamps at Namalok and Isinet had also been cleared for cultivation. The second focus of the expansion of cultivation is that around swamps and around rivers, taking advantage of opportunities for irrigated crop production.

Since the mid-1980s the pattern of expansion of the area under rainfed agriculture on the slopes of Mt. Kilimanjaro has altered from down slope expansion to that of intensification of land use in, and infilling of, areas at the edges of established rainfed cultivation. However, expansion of irrigation around swamps and along rivers has continued. The impetus for expansion does not only come from the migration to the area of agriculturalists from elsewhere in Kenya, but also from a diversification among many herders to include farming alongside their livestock production activities.

This increased agricultural activity among herders is reflected in the expansion of cultivation between 1994 and 2000 (Maps 2 and 3) in areas that had hitherto remained as grazing land, for example to the west of Loitokitok.

Map 2. Land Use in 1973, 1984, 1994 and 2000



The analysis of satellite imagery permits a description of the changes in the distribution of broad land cover categories that can be interpreted as land use changes. General trends such as the relationship between crop cultivation and rainfall or irrigation potential can be inferred from the imagery.

Map 3. Change in the extent of agriculture, 1973-2000

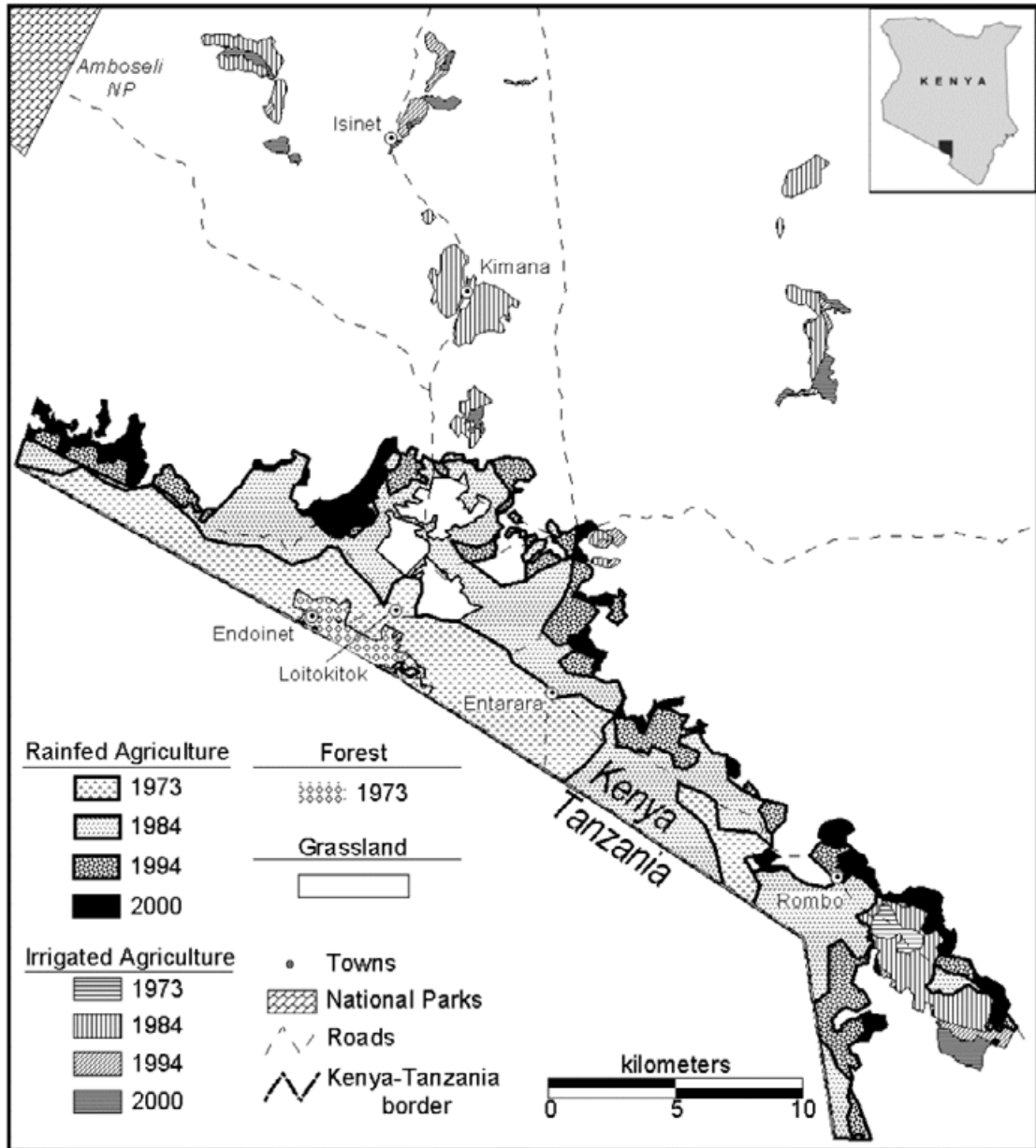


Table 1. Distribution and Change in Selected Land Uses in the Loitokitok Area 1973-2000
(Calculated from Interpreted Satellite Imagery – Map 3)

LAND USE	AREA IN HECTARES				PERCENT CHANGE IN AREA				
	1973	1984	1994	2000	1973 - 1984	1984 - 1994	1994 - 2000	1984 - 2000	1973 - 2000
<i>Forest</i>	646	596	417	417	-7.7	-30.0	0	-30.0	-35.4
<i>Irrigated Ag.</i>	245	3513	4045	4768	1333.9	15.1	17.9	35.7	1846.1
<i>Rainfed Ag.</i>	7213	17762	22034	24911	146.2	24.1	13.1	40.2	245.4
<i>Rangeland¹</i>	160847	147095	142474	138871	-8.5	-3.1	-2.5	-5.6	-13.7

¹ The Rangeland area is calculated for the field study area. In reality, the rangelands extend well beyond this.

Field verification is needed to explain anomalies to general trends in patterns of land use change, it is useful in identifying where future land cover changes might be observed, and it is necessary to describe land use changes that are not revealed in the patterns observed in the imagery. These include intensification of cropping activities in established areas of cultivation such as is occurring in the areas on the slopes of Mt Kilimanjaro that were brought under crops prior to 1984, and the impact on the bush vegetation of reduced grazing pressure implied by the change in the herding economy from livestock-dominant to one that is more mixed herding/farming, and is more sedentary.

This increased agricultural activity among herders is reflected in the expansion of cultivation between 1994 and 2000 (Map 2) in areas that had hitherto remained as grazing land, for example to the west of Loitokitok. The reasons for the relative delay in these areas being brought under cultivation could not be inferred from the imagery but were clarified by field interviews. These revealed that there were no edaphic constraints to cultivation and that the delay was caused by the decisions of individual landowners to maintain these areas under grazing until very recently. There are additional areas where cultivation is taking place but the impact on land cover is insufficient to be readily visible in the imagery. These include ‘expeditionary’ activities on the lowest slopes of the mountain and to the north of the irrigated area at Rombo. The rainfall in these locations is highly variable and in many, if not most years is insufficient for a harvest. The fields are scattered in the bush land and do not establish a distinct land cover pattern. Field reports also indicated the beginnings of cultivation at swamps near the Chyulu Hills but their extent is insufficient to be apparent in the 2000 imagery of the area.

The imagery also does not easily reveal implications for wildlife of the altered cropping and herding systems. Field study established that the patterns of expansion of cultivation shown in the imagery are associated with fragmented habitats and disrupted wildlife movements, reduced access to water in riparian zones, and altered livestock grazing patterns. These have also affected the distribution of vegetation and opportunities for predation. Competition between wildlife, livestock, and cultivation for access to reliable water has increased and led to conflict (Campbell, Gichohi, Mwangi and Chege 2000).

These findings illustrate the importance of combining field study and satellite imagery analysis.

D. ROOT CAUSES OF LAND USE CHANGE

Conceptual approaches for analyzing land use change and identifying driving forces, such as political ecology and landscape ecology, have emphasized the need to examine the interaction between biophysical and societal processes over time, not only at the local scale but also in ways that elucidate the interaction between local patterns of land use and the national and global context. The discussion that follows is structured to begin with a section that sets out the national historical context within which the local dynamics of land use change may be understood. This is followed by a discussion of the broad processes that have influenced the pattern of land use in the Loitokitok area, with particular attention to the changes over the past 30 years, changes that can be mapped from interpretation of satellite imagery.

In order to illustrate the interactions between biophysical and societal processes, brief synopses are presented of specific issues that are important to understanding land use dynamics in the study area. These include issues often seen as more biophysical in nature such as vegetation and soil fertility, and others that are more socio-economic such as the responses of people to drought and the impact on land use of policy and power.

D.1. The National Context

The national context of change in Loitokitok has evolved greatly since Kenya attained Independence in 1963. Changes in the national and international political economy impact local communities in the study area through time, provoking a diversity of responses. The political economy context is closely linked to the evolution of Kenya's land and agricultural policies, as the government continues to respond to emerging land use issues.

The early colonial period (1900-1930) in Kenya was marked by extensive land expropriation, large-scale agricultural production, and European settlement. The resulting high population densities in areas allocated to the African population were identified as a primary obstacle to agricultural development, prompting new soil and water conservation campaigns and policies aimed at relocating the "excess" agricultural population. During the late colonial period (1930-1963), the government reduced restrictions on African land ownership and participation in the commercial agricultural economy. Government support for relocation and individual initiatives on the part of those who identified the emerging economic value of land created new interactions and conflict between agricultural and pastoral groups as farmers settled in areas of high agro-ecological potential that had served as dry season grazing areas for pastoral communities (Campbell 1993; Kitching 1980).

In the first decade of Independence, state infrastructure to support rural development expanded, particularly in the central and western highlands. The expansion of cash crop production was bolstered by state investment in input and marketing infrastructure. Rather than state investment in marketing, the Kenya government promoted a diversification of land use in arid and semi-arid lands (ASAL) through the expropriation of land for wildlife tourism. For many pastoralist communities, wildlife conservation represented an emerging, competing land use that placed further restrictions upon transhumant production systems. By the end of the 1970's, there was a growing recognition that arid and semi-arid lands development policy had neglected and constrained pastoral and agro-pastoral land use system while offering little support for adapting to new conditions (Campbell and Migot-Adholla 1981).

At the same time that a greater emphasis was placed on ASAL's development, government resources for addressing ASAL development issues were in decline. Limits on government budgets were introduced via structural adjustment policies and were furthered by the expansion of graft and corruption within government ministries by the end of the 1980's. Periodic suspensions of international assistance to the Kenyan government in the 1990's contributed further to the decline in government services to support agricultural and pastoral development. Through the 1990's, the retraction of state assistance for rural development continued in the context of international competition for agricultural produce and dairy

products, the expansion of individualized land tenure, and rapid population. The relationship between land use policy and the Kenya's political economic trajectory remains dynamic.

This broad periodization is central to understanding population growth and its environmental impact. Kenya is often cited as a classic case of countries where rapid population growth is causing land pressure and environmental degradation, and thus contributes to rural poverty. As in other countries experiencing rapid population growth and land degradation, the causal relationship between these processes is neither simple nor deterministic. Explanations that emphasize population growth as the determinant variable often ignore the social, political and economic processes that underlie demographic trends, and questions of power that determine the distribution of resources among the population, and influence land use. The links are complex and are based in long-term interactions between ecological, political, socio-cultural and economic forces.

In Kenya the population-resource balance is precarious. Population pressure arose as a consequence of colonial alienation of land for European settlement, population growth following improvements in medical care, and restrictive agricultural policies. In the ASAL demarcation of national parks exacerbated the land shortage. Attempts to remedy the situation in agricultural areas focused on land consolidation and intensification, migration to towns, particularly to Nairobi, and on the expansion of cultivation into the wetter margins of the rangelands. Such rural to rural movement continues to be widespread and contributes to the imbalance between population demands and resources in the ASAL. Population pressure is one indication of the disparity between different regions, economic sectors, and socio-economic groups in Kenya

Kenya's population growth rate is among the greatest in the world. During the 1970s it reached a peak of over 4 percent a year. The population increased from 15.3 million at the 1979 census, to 21.4 million in 1989, and is projected to reach over 30 million by 2000. More than 75 percent of the people are involved in agriculture. The number of rural households doubled from 1.7 million in 1976 to an estimated 3.5 million in 1992. As the population grew the land has been sub-divided among family members to the extent that many farms are today unable to support the people dependent upon them. 75 percent of farms cover less than two hectares, and the average farm size dropped from 2 hectares in 1982 to 1.6 hectares in 1992. The percent of landless increased from 18 to 25 over the same period. Poverty is widespread.

Ecological conditions limit the possibilities for expanding the area under crops. The vast majority of Kenya is arid and semi-arid and drought is a recurrent problem. Approximately 25 percent of the population lives in the ASAL, which constitute about 80 percent of the country. Only 17 percent of the land area is suitable for rainfed cultivation. In the areas of smallholder production much of the land is under continuous cultivation with little or no fallow. Most farmers cannot afford fertilizers and irrigation, and thus land productivity is declining and soil erosion is increasing.⁴

According to a recent World Bank report, the majority of the residents of the ASAL live in

⁴ Tiffen et al. (1994) identify population growth as the primary driver of sustainable, intensive agriculture in Machakos. Projecting such an optimistic scenario to the rest of Kenya and, particularly, Kenya's ASALs, all of which have experienced rapid population growth, is problematic. Machakos benefited from many advantages in the colonial and post-colonial political economy which led to increased income, market access, government investment, and assistance from non-governmental organizations. Furthermore, in addition to agricultural intensification, population growth also led to an extensification of cultivation through the "shedding" of population to lowland Machakos, Kitui, Loitokitok, and as far as Tanga in Tanzania. Thus, assessments of changing society-environment interaction must take into account forces at multiple scales and, in particular, broad political economy and policy dimensions of change that may expand or limit adaptation of the land use system to localized changes such as population growth.

poverty. The contributory factors include vulnerability to drought, poor infrastructure, and long distance from markets. The residents of the ASAL depend upon the natural resource base for their survival. Diversification is a characteristic of their livelihood systems. People value biodiversity; it is reflected in their livestock and crop management strategies, and in the importance of wild foods in the diet on a daily basis and particularly during periods of food scarcity occasioned by drought, insect infestation or other causes.

Maintenance of plant biodiversity is important to the sustainability of rural production systems. The ecological gradient between the highlands and adjacent semi-arid lowlands in East Africa has long afforded people access to a diversity of opportunities for agricultural and livestock production, and access to wild foods. Many risk management strategies were based on long-term attention to soil productivity and in access to the diversity of resources afforded by the gradient. Soil management and biodiversity were concepts fundamental to the long-term sustainability of production systems. Conservation of biodiversity and reduction in land degradation to preserve the productivity of the fundamental land resource are essential components of sustainable systems.

Over the past 50 years, and particularly since independence a number of economic, demographic and political processes have altered the patterns of land use along East Africa's ecological gradients. Among the most important consequences of land use change are land degradation and a reduction in the biodiversity available to rural people. Under such conditions people have to find alternative resources, usually in the commercial market. In the absence of either geographical or economic access to the market, the poor become poorer, and their continuing dependence on land base resources may result in intensification of land use that threatens the maintenance of biodiversity and entails increased potential for soil degradation.

These issues permeate the scientific and policy literature on Kenya's ASAL. The ASAL represent about 80 percent of the country's land area. There is great pressure on arable land and reliable water. Poverty is almost universal, only about 40 percent of primary school age children are in school and infant mortality rates are more than double those in the rest of the country. At the same time, these areas are not without potential. There are examples where, when resources are available and local people have access to them, economic growth has occurred. This area of S. E. Kajiado District, with its dynamic horticultural production and opportunities related to wildlife-based tourism, is a prime example.

The nexus between demographic conditions, environmental sustainability, agricultural production and poverty is of critical contemporary policy interest. Effective remedial policy will be enhanced by an understanding of the driving forces behind these changes in land use and access to resources. These include changing population densities, access to land, cultivation of marginal and/or vulnerable soils, adoption of soil fertility maintenance and conservation techniques and the development of the region.

D. 2. Development and Change in the Loitokitok Area

Regional and rural development policies in Kenya have done little to reduce poverty and the related land-population problems (Bigsten 1980; House and Killick 1983; Norcliffe and Freeman 1985). This is particularly the case in the dry lands of the country whose economic potential has, until recently, only been selectively promoted. In Kajiado District the ineffectiveness of existing strategies in reducing land-population problems raise the specter of continuing poverty among many and access to wealth for a few, a situation intricately bound to access to productive land, and to the economic gains related to wildlife-based tourism.

D.2.a. Physical Background

The study area is located in southeast Kajiado District, Kenya. The study area has a bimodal rainfall regime, with peaks in March-April and October-December. Lower elevations between

Amboseli National Park and the Chyulu Hills receive less than 500mm and higher rainfall occurs on the Chyulu Hills and on the slopes of Mt. Kilimanjaro (Jaetzhold and Schmidt 1983). The rainfall is however inconsistent in time and space and drought is a recurrent problem in the area. During the present century droughts are recorded in 1933-35, 1943-46, 1948-49, 1952-53, 1960-61, 1972-76, 1983-84, and the early 1990s.

D.2.b. Socioeconomic Trends

The area's rural economy is diverse. Subsistence production dominates, though horticultural production has expanded over the past two decades and the area has become one of Kenya's foremost producers of horticultural products (Krugmann 1996). Livestock herding by the Maasai is still widespread. Wildlife-based tourism is the most important activity in terms of the national economy.

Population growth in the District has been rapid since independence (Table 2). In the Loitokitok area it reflects natural increase as well as migration of large numbers from the congested central highlands to cultivate the fertile and relatively well-watered slopes of Mt. Kilimanjaro and other hills.

Table 2. The Population of Kajiado District 1969-1999

Census Year	KAJIADO DISTRICT			KENYA
	Population	Inter-Census Growth (%)	Avg. Annual Growth (%)	Avg. Annual Growth (%)
1969	85,093*			
1979	149,005*	75.1	5.76	3.8
1989	258,659*	73.6	5.67	3.4
1999	405,000**	56.6	4.58	2.9

* Kenya, Central Bureau of Statistics, Population Census 1969,1979,1989

**Ministry of Finance and Planning, February 2000. Provisional Results of the 1999 Population and Housing Census.

Agricultural potential is highest on the slopes of Mt. Kilimanjaro due to reliable rainfall and fertile volcanic soils. The lowlands are of relatively low productivity, supporting a savanna bushland in which livestock herding and wildlife predominate. This broad classification hides the presence of relatively small, localized areas that due to the existence of permanent water and fertile soil are potentially more productive than the surrounding rangelands. These areas include the swamps at Namalok, Isinet and Kimana, and the valleys of the perennial streams that originate on Mt. Kilimanjaro, such as at Rombo (Jaetzhold and Schmidt 1983).

Prior to the arrival of the British at the end of the 19th century, the Maasai, transhumant pastoralists whose subsistence economy was based upon the herding of cattle, sheep and goats, inhabited the area. These animals formed the basis of their social and economic system, and their primary goal was to maintain sufficient livestock in the face of an unpredictable physical environment in which periodic drought and disease jeopardized their survival.

Maasai herds grazed extensively, their movements responding to seasonal and annual fluctuations in the availability of water and grazing. During the wet season the herds dispersed as resources were ample and widespread, but during the dry season they gathered near reliable supplies of water and grazing on slopes of hills and on swamp margins. Access to these resources was maintained by force by the *murrans*, the Maasai warriors. The land was communally owned, while the livestock belonged to individual families.

The process of colonization directly affected the Maasai. Treaties between the Maasai and the

British in 1911 and 1912, created the Masai Reserve that restricted the Maasai to the southernmost of their former grazing lands while Europeans assumed control over the best of Maasai territory, including important dry-season and drought-retreat areas (Great Britain 1934; Huxley 1935; Low 1965). Events elsewhere in Kenya also reduced their access to grazing and water resources. Alienation of land for European settlement affected farmers in adjacent areas (Kitching 1980) and the resultant land scarcity forced many to seek alternative locations to cultivate. This stimulated migration to the better-watered locations in neighboring rangelands, including the slopes of Mt. Kilimanjaro. After World War II a second land use began to compete with the Maasai for grazing and water. The National Parks Ordinance in 1945 set aside large areas as national parks for the exclusive use of wildlife. Enclosed in the parks were lands that formerly provided dry season pasture for the Maasai livestock.

After Kenya's independence in 1963, the government was concerned to address issues of land management in pastoral areas, and land shortage in farming regions. In the study area it encouraged a herding strategy that would be less destructive to the environment, promoted wildlife management, and encouraged cultivation.

Government-sponsored land adjudication was seen as an incentive for more prudent environmental management in herding lands. On the mountain slopes high quality land was allocated to prominent individuals as Individual Ranches (IR). As there was insufficient high quality land to distribute to all families, the option for the majority of Maasai was to establish Group Ranches (GRs) that would be communally owned and managed (Table 3). It was originally intended that each GR would be based on traditional grazing areas and include sufficient wet and dry season resources. In practice, while the ranches have met peoples' needs in years of good rainfall, in bad years movement beyond the ranch boundaries has been necessary.

Table 3. Group Ranches in the Study Area

RANCH	Date Incorporated*	Area (Ha)*	Number of Parcels*	Number of Members 1987***	Number of Members 1999**	Number of Members 2001***
Mbirikani	1981	122,893	922	922	4650	4585
Kimana/ Tikondo	1972	25,120	169	167	843	843
Lolarashi/ Olgulului	1975	147,050	1380	1300	4000	3418
Kuku 'A' & 'B'	1984 1975	48600 96,000	Na 604	1400 417	A + B 4401	1996 5516
Rombo	1973	38,365	512	366	3565	3665

Sources:

* Ole Katampoi, K, G.O. Genga, M. Mwangi, J. Kipkan, J. Ole Seitah, M.K. van Klinken, and M.S. Mwangi. 1992. Kajiado District Atlas. Kajiado: ASAL Programme Kajiado, Republic of Kenya.

**Mbogoh, S.G., Munei, K., and Thornton, P. 1999. "CRSP Study on Wildlife, Livestock And Human Interaction in Kajiado District, Kenya: Results of the Economic Study." Nairobi: Draft Report Global Livestock Collaborative Research Project.

*** Ntiati, P. 2002. Group Ranches Subdivision Study In Loitokitok Division Of Kajiado District, LUCID Working Paper 7, Land Use Change Impacts and Dynamics. Nairobi: ILRI.

The Maasai responded positively to the concept of GRs, not so much because they supported the government's view that the ranches would result in improved resource management and economic conditions, but rather because they hoped that legal title to the land would achieve the political objective, of securing their land from the encroachment of farmers. Such an impetus for supporting land reform has been observed elsewhere in Kenya, and is linked to the broader perception of the acceleration of unscrupulous allocations of public land and land held under customary tenure systems during the 1990's (Klopp 2000; Smucker 2003).

The issues of unequal land distribution that developed during the colonial period, particularly in Central and Western Kenya, were not solved at the time of independence and became more acute as population growth imposed a greater strain on the land resources. To relieve problems of land pressure, the Kenyan government encouraged migration of farmers by removing colonial restrictions on where people of different ethnic groups could live. The better-watered margins of the rangelands provided outlets for farmers in the land-scarce highlands (Campbell 1981). Migration to the study area was rapid and Maasai owners of IRs were quick to respond to the demand for land, leasing and selling to immigrant farmers. Population growth increased, and by 1973 significant areas on the slopes of Mt. Kilimanjaro were under cultivation, and initial steps to establish irrigation along perennial streams were under way.

Between the mid 1970s and mid-1980s, the processes encouraged by government policy, and readily bought into by farmers and herders accelerated. They led to a transformation in the land use on the northern, lower slopes of Mt Kilimanjaro. These slopes receive over 800 mm of rainfall annually and a number of perennial streams flow down them to the plains. They offered, therefore, considerable opportunities for cultivation and by the mid-1980s almost the entire area between the Tanzania border and the semi-arid plains has been cleared and planted, by immigrant farmers, mostly from Central and Eastern Provinces, and by Maasai themselves. Land adjacent to permanent water sources, e.g., at Kimana, Rombo and around swamps at Namalok and Isinet had also been cleared for cultivation (Map 2). The expansion of agriculture was supported in government plans, and as opportunities expanded for grain production on the mountain slopes and vegetable production for export around swamps, so agriculture has attracted the attention of land speculators and business people, who market crops in Mombasa, Nairobi, and overseas.

According to the Maasai herders, the change in land use to farming from herding in these better-watered locations reduced the availability to herders of the most reliable of their water resources experienced when Tsavo and later Amboseli National Parks were established. The general pattern of agricultural expansion between 1973 and 1984 (Map 2) matches the distribution of rainfall that follows a concentric pattern conforming to the slopes of Mt. Kilimanjaro (Jaetzhold and Schmidt 1983). An uneven expansion extended farther down slope around the district headquarters town of Loitokitok and along the main road from the town to Nairobi.

This expansion of agricultural activity coincided with a sustained increase in the population of Maasai herders, with the implication that more livestock were needed at a time when resource availability was declining. The drought of 1972-76 first revealed the impact of these changes in land use on the population (Campbell 1984). Some began to cultivate plots on the GRs and, by the late 1970s there was widespread discussion over subdivision of GRs to accede to demands for individual land ownership from the growing population, and particularly from younger Maasai who had not been registered as GR members (Campbell 1986, 1993; Galaty 1994; Kimani and Pickard 1998; Ntiati 2002).

The change in land use patterns also had an impact on the area's wildlife-based tourist activities. Tourism is among the leading three earners of foreign exchange in Kenya. The study area plays a central role in the wildlife-viewing sector of tourism. Tourists come to look at the wildlife, particularly the elephants, in Amboseli National Park, view Mt. Kilimanjaro, and visit Maasai communities. The cultivation of mountain slopes and around swamps reduced the access of wildlife to browse and water resources, fragmented habitats and altered seasonal dispersal patterns. In the process damage to crops by wildlife increased (Campbell et al. 1999).

The issue of competition or complementarity between herding, farming, and wildlife and tourism is complicated and politically sensitive. Since the 1970s, wildlife managers have attempted to develop and implement strategies that would encourage people living adjacent to wildlife parks to accept the parks and the wildlife. A major strategy has been to return some of the revenues from wildlife viewing activities to the adjacent landowners as compensation for the losses they incurred due to wildlife grazing and damage to crops during their wet season dispersal (Western 1982; Lusigi 1981). These strategies have failed to provide the political benefits of greater popular support for wildlife conservation policies.

Since the mid-1980s the pattern of expansion of the area under rainfed agriculture on the slopes of Mt. Kilimanjaro has altered from down slope expansion to that of intensification of land use in, and infilling of, areas at the edges of established rainfed cultivation. However, expansion of irrigation around swamps and along rivers has continued. The latter is largely a function of increased opportunities for commercial horticulture arising from market liberalization, abandonment of controls on currency exchange, and improved transportation linkages, including those to European markets using wide-bodied aircraft.

The change in distribution of land use, particularly the expansion of cultivation around the critical water sources, has resulted in many Maasai taking up cultivation. While 20 years ago the majority of Maasai were herders, and most farmers were immigrants to the area, a more complex pattern has emerged. Calls for subdivision of group ranches have gained momentum as significant numbers of Maasai have informally claimed well-watered land on the GRs and leased it to farmers (Ntiati 2002). This has led to conflict among GR members and to increased conflict between farmers and herders whose animals frequently damage crop.

Further, many Maasai have taken up cultivation and are herder-farmers. They have diversified their economy thus providing diversification and flexibility that is important in mitigating drought.⁵ Their success is illustrated by their having herds of comparable size, if not larger, to those of the herders who continue to occupy the rangelands. The latter have fared less well due to the loss of critical dry season water sources. At the same time, many farmers around swamps and rivers have also accumulated livestock. Thus the Maasai are no longer dominant ethnically, and herding is being replaced by mixed livestock-cropping enterprises, and the better-watered margins of the rangelands are extensively cultivated (Campbell et al. 2000).

E. THE DRIVERS OF LAND USE CHANGE: ILLUSTRATIONS OF INTEGRATION OF BIOPHYSICAL AND HUMAN PROCESSES

The preceding discussion has illustrated the complexity of local and exogenous forces that have been driving the land use changes that have been so clearly illustrated by the imagery. The drivers that have altered over time from colonial days to the present are illustrated in Table 3.

Land use change can be effectively explored through the inter-related impact of local drivers each of which is associated with both local and external processes. Local circumstances were altered as colonial restrictions on ethnic distributions were removed, and as after independence the economy responded to national and international opportunities. National policies on economic issues, agricultural strategies, wildlife management and land tenure reform have all influenced the pattern of land use change.

The following discussion presents brief illustrations of interactions between biophysical and socioeconomic processes as they effect important components of the land use system in the

⁵ Household diversification has been identified as a primary means of household adaptation in many African societies. Diversification often includes the sale of specialized crops, off-farm wage income, and investment in small businesses.

study area. These illustrations draw upon more detailed studies that have been conducted by the LUCID team. The drivers (economic, political, institutional, and cultural) have international, national and local components. Some were initiated long in the past, others are more recent. They interact in complex ways and have important implications for resource use, water quality and for the biodiversity of flora and fauna.

This case study deals with an area of about 100 square miles. This raises the question as to what impact processes such as those described below might have for broader issues including climate change and “biodiversity. Are the consequences merely local or do they have meaning for broader systems? This poses the question as to what scale we should be working at to understand the interlinkages? Should we be looking at broad zonal processes, and if so do we necessarily miss critical linkages between socio-economic and biophysical processes that are elucidated by more local studies and that should be the focus of remedial strategies?

E.1. Soil Erosion, Soil Fertility, and Fallow

The soils on the hills are derived from volcanic rocks, those at lower elevations from the basement complex, while along rivers and swamps there are alluvial soils. The results of the transect survey (Gachimbi 2002:13) show that the “distribution of soil and its nutrient status is largely determined by parent material and physiography. Lower highland/ upper midland zones have moderately deep to very deep soils while the plains have shallow soils. Most of volcanic soils from mount Kilimanjaro are deep and well drained. However, imperfectly drained soils were found along the plains and bottomlands where alluvial deposits are common.”

The results of the 1996 survey (Tables 4 to 7) demonstrate that the people of the area recognize significant environmental consequences of changes in land use. Soil erosion was reported as a growing problem by more than 50 percent of farmers. There is a general pattern of perceived increase in erosion over the period 1986-1996, with the greatest incidence of erosion reported at the agro-ecological extremes of the gradient. Households in the upper mountain and rangeland zones reported the highest prevalence of increased erosion. Declining soil fertility was identified by 54 percent of households, with variation along the gradient highlighted by greater prevalence of soil fertility decline reported in the swamp and lower mountain zones. This is confirmed by Gachimbi (2002:12): “Soil organic carbon and phosphorus is generally low in cultivated areas e.g. maize, coffee or maize/beans or other crops in irrigated agriculture. This is due to continuous cultivation and high mineralisation rate of soil organic carbon prompted by high temperature and adequate moisture. These low levels are due to continuous nutrient mining through crop products without replenishment in form of fertilizers or farmyard manure.”

The responses of land managers to the changing environment and their efforts to avert long-term decline in productivity often intersects with short-term subsistence needs. Approximately 70 percent of households in the farming and mixed zones report no use of fallow. Forty-five percent of households in the farming zone and 37 percent in the mixed zone report increased fallow. This evidence of land being taken out of production together with reports of changing crop choice to hardier species such as millet and sweet potatoes may suggest that soil fertility decline is having an impact upon production decisions. While recognition of the problems of land degradation is widespread, the capacity of land managers to address this problem through changes in production varies. For example, in the rainfed agricultural zone, short-term subsistence needs of land renters may weigh more heavily than long-term productivity of soils in land management decision-making. Land owners exercise no control over the production and management practices of renters. Manure application, widely seen as preferable to chemical fertilizer in the long term, is not a priority for renters given the delayed effects on crop productivity. In some cases, wealthy renters, or those from Tanzania who receive subsidized inputs, apply fertilizers in order to ensure immediate productivity. The benefits are short-lived, and farmers claim that a lasting “dependency” on

fertilizers develops such that soils become very unproductive in the absence of ever greater amounts of fertilizer. For many in Loitokitok, the rising price of chemical inputs over the past ten years has reduced the use of inputs with deleterious effects on productivity and soil fertility. Thus, the pressure of production on resources, as well as responses to perceived land degradation, vary geographically in relation to the resource base and the social and economic organization of land use.

Table 4. Farmers - Fallow Among Plots By Farming Zone (1996)

Portion Fallow	Farming Zone		Mixed Zone		Total	
	Number	Percent	Number	Percent	Number	Percent
None	235	69	116	74	351	70
¼	35	10	14	9	49	10
1/4 -1/2	20	6	12	8	32	6
1/2-3/4	23	7	6	4	29	6
3/4-All	27	8	6	4	33	6
All	3	1	1	2	4	1
N =	343		155		498	

Table 5. Farmers - Change In Fallow 1991-1996 By Farming Zone

	Farming Zone By Percent Of Plots	Mixed Zone By Percent Of Plots
Increase	45	37
Decrease	36	35
No Change	19	28
N =	111	60

Table 6. Change In Soil Fertility 1986-1996 By Site (Percent Of Responses)

	Increase	Decrease	No Change	N =
Rangeland	2	38	52	92
Valley	3	23	6	32
Valley Side	6	17	6	29
Hilltop	3	6	8	17
Swamp	33	74	40	147
Lower Mountain	28	72	21	121
Upper Mountain	6	30	5	41
N =	81 (17%)	260 (54%)	138 (29%)	479

Table 7. Change In Soil Erosion 1986-1996 By Site (Percent Of Responses)

	Increase	Decrease	No Change	N =
Rangeland	68	12	20	92
Valley	26	48	26	31
Valley Side	19	42	38	26
Hilltop	18	53	29	17
Swamp	27	40	38	147
Lower Mt.	45	41	14	120
Upper Mt.	59	32	10	41
N =	297 (52%)	167 (29%)	110 (19%)	574

The ability of land managers to maintain the productivity of their soil resources depends upon a variety of interdependent factors including local edaphic conditions, the history of land use, the socio-economic status of the land manager and her/his ability to respond to the opportunities, and constraints deriving from external conditions (Blaikie 1985; Blaikie and Brookfield 1987). These may include access to credit, price incentives and subsidies for crops and inputs such as fertilizers, import policies, and the characteristics of extension services (Barbier 1998; Scheer 1999). It is essential that the interactions between the broader policy and biophysical context and the decision-making framework of the land manager be addressed in any discussion of the root causes of soil degradation in the study, or elsewhere in Africa.

E.2. Vegetation

The vegetation of the study area is influenced by the ecological gradient on the northern slopes of Mt. Kilimanjaro that extends from the remnant forested area adjacent to the Tanzanian border to the savanna rangelands of the Amboseli Basin. The forest has been largely removed by extensive smallholder cultivation over the past 50 years. The middle slopes were characterized by bushland, woodland and thickets. The undulating hills in the region were characterized by bushland, woodland and thickets. In the central part of the basin, open and bushed grasslands characterized the erosional plains eventually merging with the wooded grasslands dominated by *Acacia drepanolobium* and dense forests on the lava flows in the Chyulu Hills.

Prior to the expansion of cultivation following independence, illustrated in Map 2, the area's land use was dominated by the herding economy of the Maasai, and by wildlife. The seasonal rainfall pattern resulted in extensive grazing in the lowlands during the rainy seasons, while during the dry seasons animals concentrated on those areas with reliable water. During droughts the mountain slopes became refuges for both domestic livestock and wildlife. The expansion of cultivation in the dry season and drought-retreat areas has had a significant impact on the movement of animals.

While there has been extensive clearance of vegetation on the mountain slopes, along rivers, and around swamps, the people of the area value the vegetation for a variety of reasons. Almost all trees/plants have multiple uses, the most frequently reported being medicine, animal feed, food and cooking spices, toothbrushes and cosmetics construction of buildings windbreaks and fences, and fuel. For example, *Acacia tortilis* is the most common tree used for charcoal making, and the pods/seeds provide excellent fodder for sheep and goats and in particularly dry years may be main source of food for the livestock. Oloirien (*Boscia Augustifolia*) is important for animal feed and medicine, human food and fuel, and Olbili (*Aphenia senegalensis*) as human medicine and animal feed.

For the people of the area, one of the most important uses of trees and plants is for medicines. Over 60 trees/plants are identified as having medicinal uses. The leaves, bark and tubers of plants are seen as effective against a variety of ailments including: headache, vomiting, stomach pain and STDs. The most frequently reported medicinal trees/plants are Olaisai, a plant that has multiple uses including animal feed, cosmetics and fuel alongside medicine; Eremit, whose bark is used to treat STDs; and Osokonoi - whose leaves are used to alleviate headache and stomach pain. The bark of *Acaia mellifera* is used for treatment of stomach pain and backache, and *Sericocomopsis hlidebrandtii* is used for medicinal purposes and is particularly preferred by women to cleanse the uterus after birth.

One of the important consequences of the changes in land use over the past 30 years is a decline in access to the resources provided by plants and trees. The results of the household surveys conducted in 1996 demonstrate that most respondents have experienced a general decline in availability of plant/tree species over the last 10 years, as illustrated for woodland

in Table 8. The dominant reported cause of the decline in availability of plants is drought and disease. Among farmers the most frequently reported reason for decline in the number of trees is cutting building materials and among herders it is cutting for firewood. It will be interesting to discover whether these trends identified in the 1996 survey are borne out by the results of specific follow-up investigations of environmental conditions in the area conducted in 2002.

Table 8. Change In Woodland 1986-1996 By Site (Percent Of Responses)

	Increase	Decrease	No Change	N =
Rangeland	9	69	9	87
Valley	2	22	4	28
Valley Side	2	19	2	23
Hilltop	4	14	0	18
Swamp	26	88	25	139
Lower Mountain	15	90	16	121
Upper Mountain	12	25	4	41
N =	70 (15%)	327 (72%)	60 (13%)	457

E. 3. Water Availability and Quality

The research conducted by team members over the past 25 years in the study area has shown that over time the competition between herding, wildlife, and farming has changed in its focus. Initially the issue was that of land per se, but in recent years the most valuable land has become more specifically defined as that with access to reliable sources of water. Thus the areas with reliable rainfall, that along streams, and the swamp margins have become to locus of intense competition for access to resources between the dominant land use systems of the area.

The concern over water availability is occasioned by continued experience of recurrent drought, and by the occupation of riparian zones by cultivators that threatens access to water for domestic use, agriculture, livestock and wildlife. In addition, the farmers who irrigate along the Nolturesh River in Kuku Group Ranch have experienced a reduced flow of the river as a result of diversion of water into a pipeline serving areas near Nairobi. Along with concerns about the availability of rainfall and surface water, people express concern over the quality of water resources. Chemical pollution of water in irrigated areas including Isinet and Rombo is seen as having implications for the health of people and wildlife.

The concern over water quantity and quality arises from the expansion of cultivation and the intensification of land use this implies. This has its origins in population growth, particularly in distant areas of Kenya where land scarcity consequent upon an uneven land distribution has forced land-poor farmers to move to the better watered margins of the rangelands. Supported by government agricultural policy, and with incentives consequent upon SAPs, there has been a dramatic extension of cultivation. Local people have seen crop production as allowing economic diversification and greater flexibility to mitigate the impact of recurrent drought. This has provided an impetus to the individualization of land tenure that was already proceeding as a result of concerns of young people that they were in danger of being denied rights to land. The most desirable land is that which has access to perennial water. Demographic and economic pressures therefore have combined to increase competition for these areas, and revised land tenure arrangements will codify individual rights to resources that formerly were held under common property arrangements.

Water is the essential resource for all land uses. Access to water resources has been increasingly denied to herders, and to wildlife outside of protected areas. Some herders have joined the cropping economy to maintain access to water. There are however winners and losers. Those that have taken the opportunity early have a better chance of obtaining land

titles to the lands with water access than others. Many of those cultivating are however tenants, renters and sharecroppers whose rights to land under subdivision are limited. The local land users are joined in the debate over land use and land rights by outsiders with specific interests in wildlife, and in economic gain through crop production and tourism. The outcome is a more diversified economy, but one in which water resources are increasingly scarce as they are being diverted for irrigation with its higher evapotranspiration, and their quality is being diminished by chemical runoff.

E. 4. People and Wildlife (after Campbell et al. 1999)

The drivers of change in the interactions between people and wildlife have altered over time. The precolonial land use was dominated by wildlife and Maasai herding. During the colonial period and since independence, a number of processes were set in motion that had immediate and cumulative impacts upon society and resource use. The Maasai land use system was altered by excision of vital dry-season resources to protect wildlife, and cultivation has been promoted in other such areas. While limited in area, these permanent sources of water and grazing were essential to the much more extensive land use systems of herding and wildlife.

The altered accessibility and use of these vital water sources has resulted in competition between the major land use systems. The potential for land degradation can be explored through a number of intersecting “chains of explanation” (Blaikie 1994) that examine the impact of local drivers each of which is related to both local and external processes – wildlife conservation, population growth, and economic opportunity in agriculture.

Wildlife conservation was initiated in 1945 with the demarcation of reserves and national parks. With the development of the tourist industry the proponents of wildlife conservation were joined by commercial interests – international and national, and government institutions (Ministry of Tourism and Wildlife, Kenya Wildlife Service) in efforts to protect wildlife. They recognized the dangers from antagonistic relations with communities in areas of wildlife dispersal and policies were enacted to engage local communities in conservation of wildlife and promotion of tourism. This was necessary because the parks had enclosed important dry season retreat areas and the wildlife continued to disperse outside the parks in the wet season. Conflict between wildlife and herding, and with farming, was therefore a problem.

A variety of strategies to involve local people in wildlife management has not resolved the issue and contemporary efforts have involved government agencies in negotiations that are complicated by subdivision that is a response to population growth and to the emergence of economic opportunities in vegetable production. At the core of the issue is access to water, and as competing land uses expand concerns with water quality arise. Further, cultivation is clearing, and disturbing and fragmenting habitats, and disrupting wildlife migrations.

E. 5. Impact of Drought (after Campbell 1999a)

Campbell (1999a) has examined continuity and change in farming and herder communities’ strategies for coping with food deficits in S. E. Kajiado District, Kenya, through a comparison of coping strategies reported in surveys conducted in 1977 and 1996. The study provides empirical evidence of the dynamic responses that one rural society prone to recurrent drought-related food insecurity has made to the complex interactions between exogenous and local political, economic, social and demographic, and environmental processes. It demonstrates that, while driving forces emanating from national and international scales create the broad context for developmental change, local processes mediate these. As these alter, so do the options available for coping with food insecurity. The availability of these options differs according to a person’s age, gender, and socio-economic status. Such dynamism and differentiation is inherent in rural development and should inform development planners and those seeking to include monitoring of coping strategies as a component of famine early-warning systems.

Many students of coping strategies have hypothesized that they are dynamic, and will change as the development context of a community develops. Few have been able to examine this dynamism. The study illustrates how the suite of coping strategies in the research area has responded to rapid and significant changes in economic and social circumstances over the past 20 years. There are relatively few studies that have examined how the coping strategies of societies change over time. This study directly compares the coping strategies reported by herding and farming groups in surveys conducted in 1977 (Campbell 1984b) and in 1996. The 1977 survey followed a prolonged period of drought from 1972-1976 and that in 1996 a less intense drought in 1994 and 1995.

Since the mid-1970s an extensive literature has appeared on the subject of strategies used by rural societies in Africa to ameliorate the impact of recurrent food shortages. This includes many important contributions from research in Kenya. One of the important postulates of this literature is that the strategies used to cope with food shortage are embedded within existing rural socio-ecological systems. They are facets of that system that are deliberately maintained as security against shortages. In times of low stress they may be subdued, employed regularly by the very poor for whom coping is a constant necessity, but they assume general significance in times of stress.

Being integral components of existing production systems, the viability and efficacy of these coping strategies may alter as the wider society in which they are embedded undergoes structural changes in response to exogenous and endogenous forces. Existing strategies may falter and new alternatives may present themselves as economic, social, political and environmental conditions alter (Campbell 1999).

Dynamism is characteristic of rural societies. Production systems and coping strategies are closely related. Both change over time as a community's development context is modified by national structural change, and by exigent conditions such as drought. There is both continuity and change in the related processes of adaptation and coping. Altered circumstances may offer different prospects for coping. Rural societies are both conservative and opportunistic and will avail themselves of alternatives. Should such opportunistic coping strategies be effective, they will be protected through adaptation of the system to conserve them.

The comparison includes: an assessment of the patterns of change in the socio-economic systems of the area, and of their driving forces; examination of the similarities and differences in the strategies for coping with food deficits reported in the two surveys; and a discussion of the relationships between patterns of coping and the developmental context.

The paper provides empirical evidence of the dynamic responses that one rural society, in an area prone to recurrent drought-related food insecurity, has made to the complex interactions between national and local political, economic, social and demographic, and environmental processes that characterize rural development. It demonstrates that, while driving forces of change emanating from national and international scales create the broad context for developmental change, local processes embedded in a community's interactions with the natural resource base mediate these. Globalization might imply that the world is becoming more homogenous but we may in fact be finding that the local is becoming more differentiated, not less, as societies mediate global trends, and their susceptibility to power, through their history, institutions, resources and their location

The outcome is a complex mosaic of societal processes and land use patterns. As these alter, so do the options available to rural people for coping with food insecurity. Not all options are available to all people or groups. Differentiation by age, gender, socio-economic status exists in the availability of such options, as with most aspects of livelihood systems. Such dynamism and differentiation is inherent in rural development and should inform

development planners and those seeking to include monitoring of coping strategies as a component of famine early-warning systems.

E. 6. Role of Power in Access to Resources

The application of power is a critical and fundamental component in the process of LULCC and demands our analytical attention. Power is exercised by institutions and differentiated social groups and is evident in the creation and implementation of national level policies, changing local patterns of resource access, and divisions of the labor and benefits of production within communities. The relationship between social structural conditions and the ability of individuals and groups to challenge or renegotiate their position within society is a central point of contemporary social theory (Giddens 1979; Scott 1985). In analyzing land use change processes, we must reflect on the existence of power to resist local action, which can often disrupt the objectives of the powerful through resistance that may be chronic and insidious and or rapid and violent. Two salient examples of the role of power in mediating land use change processes in Loitokitok are related to the organization of land tenure and gender divisions of labor.

E.6.a. Land Tenure and Group Ranch (GR) Sub-Division

In the contemporary setting it is the ongoing process of subdivision of the GRs that has the most significant implications for future land use change (Ntiati 2002). It has resulted in a political debate with economic, environmental and social implications at both the local and national levels. The motivation for subdivision came from the sons of original GR members. By the mid-1970s many found themselves owners of livestock but without legal rights to the land on which to graze them. Nearly all GR committees in the district were forced to consider the issue, and politicians and administrators joined the debate in support of subdivision. The government welcomed subdivision and in 1981 enacted a policy to promote it.

Anticipating subdivision, many group ranch members have claimed land that has access to water – the vital resource areas for all land users. Some rent to immigrant farmers, some hire seasonal labor, and others have taken up cultivation. The diversification of the herding economy to include farming is thus related not only to a need to increase flexibility to mitigate climatic risk, or to take advantage of the recently developed trade in vegetable production for urban markets and for export, but also to the process of transformation of land tenure from “communal” to individual title.

Many during the initial discussions and implementation of the land adjudication process anticipated what we wrote then about the national and local elites colluding to control the economic resources. It has only taken as long as it has because the elites had other interests in the interim. What has happened previously in other parts of Kenya is now accelerating in the Loitokitok area. As Ntiati (2002) explains, the degree of control exerted by various groups in the sub-division process varies among group ranches, but generally includes the group ranch committee, the land adjudication committee, surveyors, politicians, and chiefs. Renters and lessors who fund the sub-division process are also engaged in decision-making regarding the sub-division of ranches.

In their specifics, the foci of the interests of the elites have changed. Horticulture is a major interest, as are the new possibilities for earning tourist revenues outside the national parks and in isolated locations in the parks. The increased local visibility of KANU has allowed powerful politicians to use it, together with the district bureaucracy, to manipulate institutions in their favor. Alignment with local elites, and the fomenting of the young-old debate among the Maasai, and of Maasai resentment of those of other ethnic groups who are “recent” immigrants has also served the powerful well.

Powerful people from within and beyond the area recognize the opportunities for economic gain from the altered land holding system. The awareness of the economic potential of the

rangelands has altered national-level attitudes to development in the area. The economy of Maasailand is currently being transformed by government policies defined through collusion between local and national elites. The motive behind national policy is not merely that of seeking a means to resolve the problem of population pressure or overgrazing in Kajiado District. The realization that areas which have been consistently defined as "marginal" have significant revenue-earning potential has contributed to the motivation to break up the GRs. The resulting IRs will be unable to support a dairy herd under existing practices and the majority of Maasai will be forced by economic circumstances to sell their IRs. The demand for such land is not wanting. Astute politicians and economic elites will seize the opportunity to purchase the IRs as a means of gaining access to the potential revenues from wildlife-related activity and beef ranching. It has been estimated that by the year 2010 Kenya will become a net importer of beef and thus the potential economic returns to beef production in areas now under subsistence dairy production are great.

Local Maasai who have themselves benefited from past apportionment of IRs. Families in the Loitokitok area who were allocated the first IRs have become wealthy by subdividing and selling the land to immigrant farmers. They are now supporting the political initiative to break up the GRs as they are in a position to purchase land.

Such local opposition to the break up of the GRs is confronted not only by the political alliance between local wealthy people and national elites but also by powerful national and international groups lobbying on behalf of the wildlife sector. Currently, the Ministry of Tourism and Wildlife (MTW) compensates for wildlife dispersal beyond the boundaries of the parks by paying landowners for the loss of pasture with revenues generated by wildlife-viewing activity. The MTW fears, however, that with the break up of the GRs, the IRs may be fenced and fencing would interfere with the seasonal movements of the wildlife. The MWT believes that wildlife protection would be best achieved were the land owned by a small number of people owning large tracts. It is in such a context that a coalition appears likely between the MTW, its attendant international wildlife lobby, and the political/economic elites which seek to own the land. Such a coalition would be extremely powerful and would likely overwhelm any attempts by Maasai to maintain their already tenuous hold on the lands allocated them as the Maasai Reserve.” (Campbell and Olson 1991).

E.6.b Gender and Land Use Change

Changing intra-household production relations reflect the interaction of new requirements of household reproduction with household and community-level negotiations over the labor contributions of men and women. The expansion of cultivation and the blurring of the distinctions between pastoral and agricultural land use systems has had diverse effects on the organization of household production in Maasai communities and among other ethnic groups, primarily the Kikuyu, that have settled on the lower slopes of Mount Kilimanjaro (Wangui 2003). In many cases, it has created opportunities for the renegotiating of division of labor, resource access, and decision-making processes which in turn can create new trajectories of land use change (Schroeder 1993; Turner 1999).

In all agro-ecological zones, households report increasing labor requirements for meeting subsistence needs. In the upland zone dominated by rainfed agriculture, increased school enrollment and diversification into non-farm activities has reduced the quantity of labor available for agricultural activities. At the same time, many farming households have expanded production by renting land from Maasai owners who are not engaged in crop cultivation. As labor needs intensify many communities report a relaxing of strict gender divisions of labor in household production. For example, many women have become more involved in livestock production. In some Kikuyu communities, men have begun to undertake more labor intensive crop-related tasks, such as weeding, which had been primarily the domain of women.

In the rangeland zone, where irrigated crop production is more common, a gender division of labor within Maasai communities reflects a straddling of the subsistence and cash economies: men contribute most to the production of experimental and established cash crops, while women's labor is focused on subsistence crop production. The emergence of new patterns of cultivation in the rangeland are mediated by an apparent dominance of male household heads in land use and economic decision-making. Although women contribute the majority of labor to crop production, the involvement of men in cash crop production remains important as Maasai land use diversifies in the rangeland zones and new production relations are negotiated within households and communities. The dynamic between cash crop production, subsistence crop production, and intra-household divisions of labor will continue to evolve as farmers in the semi-arid rangelands attempt to maximize emerging opportunities for diversification while facing recurrent subsistence crises and food shortages (Campbell 1993, 1999a).

F. CONCLUSION

This case study has illustrated that the process of land use change is the outcome of complex interactions between biophysical and societal processes. By providing details of the history of land use in the area within the context of the history of Kenya, it has demonstrated the importance of linking local conditions to national and global ones. Further, it has shown that the nature of the driving forces, and thus of their interactions, has altered over time in response to important events such as droughts and changes in government, and to trends such as migration and population growth, and climatic patterns. The study has shown the importance of a methodological pluralism that integrates analysis of remotely sensed data with analyses multiple sources of social data.

Figure 2, represents a "braid of time" (Figure 1), a time line of significant events and processes that have affected the study area over the past 70 years. It illustrates how events and processes in different components of the system have sometimes coincided, and at other times been independent of each other. In analysing the root causes of land use change it demonstrates that there may be times when a combination of events or processes triggered land use change, and that it is important to understand the conjunctures between different processes over time and the immediate and lagged, direct and indirect effects they might have for the decisions of land managers and their land use practices.

The impact upon land use varies from area to area, and indeed among land managers, depending upon the resource base and the opportunities and constraints of the local and the external societal context. Land use change is therefore the outcome of the dialectic both between agency and structure in the societal system, and local and exogenous biophysical processes, and their interactions.

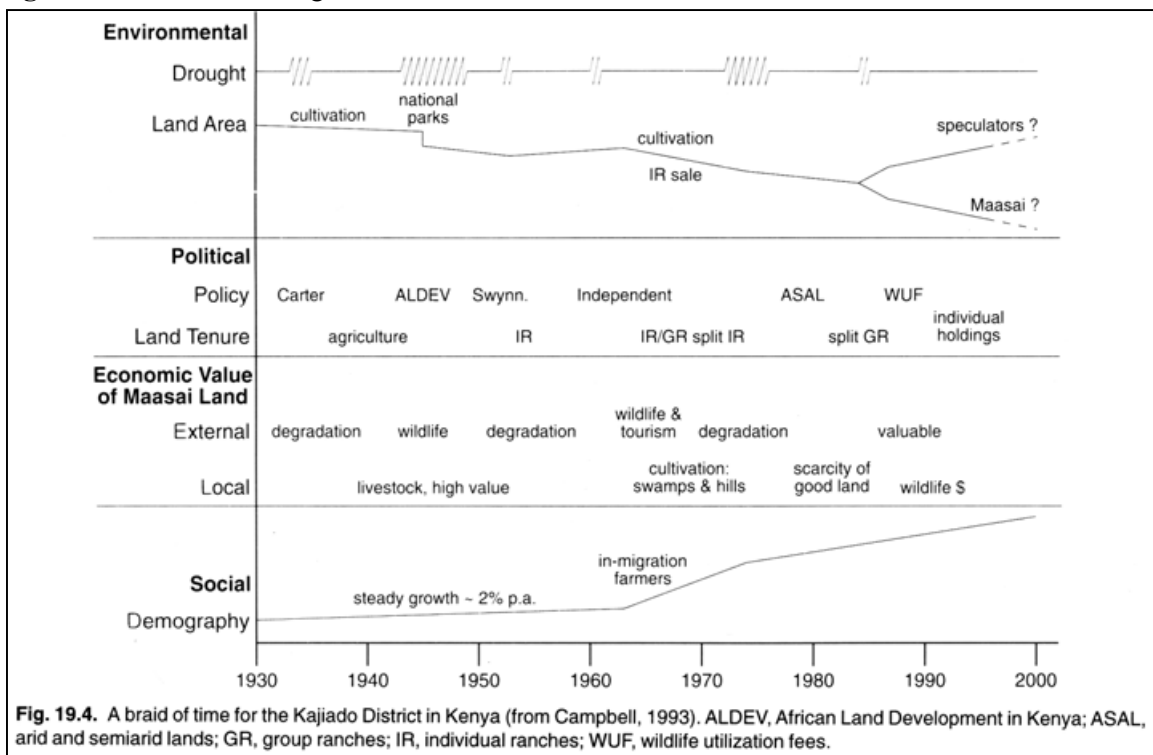
In a time when processes of globalization may be thought to be resulting in more homogenous patterns of human activity, it is of note that even in this small study area (~ 4000² km) differences exist in the patterns and processes of land use between production systems, and between localities. Thus in response to the changing driving forces of land use over the past 30 years (Table 9), farming and herding systems have had different and interacting trajectories, and neighboring places such as Rombo, with its commercial links to Mombasa, and Kimana-Isinet, with links to Nairobi and export markets, have developed different land use dynamics (Campbell et al. 2003).

The processes identified as affecting the Loitokitok area will continue to have implications for the major sectors with economic potential of the study area, namely:

- Herding - traditional milk production, beef production, livestock-based industry
- Wildlife and Tourism - National Parks, Tented Camps, Wildlife Sanctuary, cultural bomas, artifacts
- Rainfed Agriculture - maize and beans dominate, some marketed locally.

- Irrigated Agriculture - commercial vegetable production for Mombasa, Nairobi and European markets. Some marketed locally.

Figure 2. Time Line of Significant Events and Processes in the Loitokitok Area



Since the mid-1980s pressures for subdivision has built up on the group ranches. It has taken place over much of the north of the District and pressures are intense in the study area. Opportunities from irrigated horticulture, rainfed farming and tourism make individual land ownership attractive. The consequences for the majority of herders, and for wildlife dispersal are problematic.

The intensity of competition for land and water resources will inevitably escalate as population pressure, within both pastoral and farming societies, imposes a greater demand upon them. Over time the larger number of farmers in marginal lands will represent more people at risk to drought and by occupying vital, drought-period pastoral resources they will increase the vulnerability of the pastoral population. The open conflicts, between herders and farmers will become more frequent and the demands by herders for entrance to wildlife reserves will become more strident.

The problem of appropriate resource use in S. E. Kajiado District, particularly at the intersection between wildlife-based, pastoral and farming economies, is significant. The KWS and local community groups are actively concerned with the need for land use planning. Effective policies designed to reduce poverty, food insecurity and conflict need to address the management of different components of the resource base by different land users, and the issue of differential access to resources among the population.

Table 9. Drivers of Land Use Change in The Study Area and Environmental Implications

ECONOMIC DRIVING FORCES	
<i>International</i>	<ul style="list-style-type: none"> • Market Forces • Trade Policy and Agreements • Structural Adjustment / Resumption and Suspension of Aid
<i>National</i>	<ul style="list-style-type: none"> • National <i>Economic Policy</i> – Agricultural pricing, transport, exchange rates • National <i>Land Use Policy</i> – Coherent land use plan often lacking. Individual sectoral bureaucracies implement strategies in uncoordinated manner and with perhaps conflicting goals. • <i>Land Tenure Policy – Explicit and Perceptual</i> • Land Tenure Laws • Customary Tenure: continuity and change; Continuing national <i>land ethos</i> often based on ethnicity, roots in colonial land alienation and post-independence land acquisition by political class. • Dynamics of <i>Primary Production</i> (dependent on soil and water resources) • Modified Subsistence – Dynamics of Cropping and Livestock Systems • SAP and economic liberalization • Exports: meat, vegetable , flower growing • Urbanization - Urban demand for meat and vegetables encourages commercial production, pollution of air and water. • Irrigation <i>policy</i> – chemical pollution, salinization • Cash <i>crops</i> – chemical pollution of water
<i>Local</i>	<ul style="list-style-type: none"> • Markets • Herding - diversifying to include agriculture, particularly at perennial water sites (swamp edges; streams; mountain slopes) • Rainfed <i>agriculture</i> – immigration, intensification/extensification • Irrigated <i>agriculture</i> - market demand, wholesalers • Economic <i>differentiation</i> – options in land, labor and capital
INSTITUTIONAL/POLICY DRIVING FORCES	
<i>International</i>	<ul style="list-style-type: none"> • International Conventions: Biodiversity, Climate Change etc. • Bilateral and multilateral governmental and commercial interests; NGOs • Warfare, political instability, refugees
<i>National</i>	<ul style="list-style-type: none"> • Centralization versus decentralization • Uncoordinated policy framework – no land use planning • Land tenure policy • Political and economic power: Intersecting interests of government policy, commercial institutions, NGOs, and individuals • Structural Adjustment Programs and Economic liberalization • Contraction of government input provision, extension, and marketing infrastructure
<i>Local</i>	<ul style="list-style-type: none"> • Land tenure – communal versus individual rights to land, trees and water • Social differentiation in land rights – gender, young/old, tenants and squatters • Informal land claims: Tenants/renters/squatters claim land rights • Local NGOs

SOCIAL/CULTURAL DRIVING FORCES

National

- Urbanization
- Immigration
- Leadership – interference from “big” men

Local

- Population dynamics: growth, migration (gender and age specific), decline (AIDS) – intensification/extensification; maintenance of erosion control measures, cropping patterns, health and food security
- Diversification of herders into agriculture changes mobility and settlement patterns. Altered vegetation complex under reduced grazing pressure in rangelands; removal of riparian and swamp-edge vegetation for cultivation.
- Cultural change - leadership issues debated (age, gender)
- Violence in inter-ethnic conflict situations in all areas where heterogeneous populations – disruption of production, emigration.
- Ethnic heterogeneity - ethnic self-identification changing, particularly in farming areas
- Less trust in and recourse to traditional institutions. Disputes formerly settled by discussion; now more recourse to chiefs, police, courts and violence
- Redefinition of cultural and economic categories – e.g. herders become herder-farmers; farmers become farmer-herders; changes in gender roles and divisions of labor;

ENVIRONMENTAL FACTORS

Rainfall

- Variability of Rainfall: long-term, inter-annual, seasonal, within growing season

Surface Water

- Swamp margins/ riparian zones/ hillsides - occupied and crops vulnerable to damage by livestock and wildlife
- Water quality – chemical pollution of water in irrigated areas – implications for the health of people, livestock and wildlife
- Water quantity - irrigation water in reduced supply
- Access to water more difficult for domestic use, agriculture, livestock and wildlife
- Change in hydrological cycle

Land Cover and Soils

- Vegetation – Dry savanna on plains, riparian forest, gradient on Mt. Kilimanjaro
- Soils
- Fertility decline – Evidence of land being taken out of production; enforced fallow
- Management – stall fed cattle – application of manure; chemical fertilizer
- Soil Erosion – increased runoff, siltation, wind erosion- dust
- Woodland – change in species mix, change in spatial pattern – biodiversity of flora; potential for trees to replace grasses under less extensive grazing
- Habitat Depletion and Fragmentation – biodiversity of fauna

Source: After Campbell 1999b

The primary trends in land use change that have occurred between the 1970s and the present are:

- Intensification of land use on the mountain slopes, e.g. stall feeding;
- Down slope expansion of agriculture, a process of extensification;
- Swamp-edge cultivation has expanded ;
- Riparian irrigation expanded along perennial streams;
- The herding system has moved towards a more sedentary agro-pastoral system;
- A wildlife sanctuary has been established at Kimana .

These different economic systems compete for access to land and water. In 1977 the major reported conflicts were over access to land and between people and wildlife. The 1996 survey showed that while these continued, there has been a critical change in focus in areas of irrigated agriculture from “land” to “water”. In 1977 the major local outcome of various driving forces of land use change in the region was the pressure on land for crop production, both rainfed and irrigated.

The expansion of the numbers of people engaged in these activities has continued through the 1980s and 1990s but there are indications that environmental processes set in motion by these activities are now accumulating to restrict the area under cultivation. On the mountain slopes these include increased irregularity in rainfall patterns and declining soil fertility, resulting in increased land being placed in fallow while in the irrigated areas the issues of water quantity and quality now dominate. It is no longer an issue of access to land but of the quality and quantity of water that is available for production on that land. In the rangelands more herders have taken up cultivation, particularly around swamps at Isinet, and Namelok. With these changes there has been a significant increase in reported conflicts with wildlife, and a change in species concerned.

The responses of herders and farmers recorded in the 1996 survey illustrate the range of problems that they confront. Drought, hunger and related issues of poor harvests and inadequate pasture dominate (Tables 10 and 11). When asked if the land resources available would be sufficient to support their children a vast majority stated that they would not (Table 12). The principal alternative was to rent or purchase additional land (Table 13). Given the existing trend towards subdivision and the likelihood that many herders will rent or sell their individual holdings (Ntiati 2002) this may represent a viable short-term recourse

In the long term however, this paper suggests that reliance on land based livelihoods such as agriculture, herding and those relying on wildlife may not be sustainable due to their competing needs for scarce land and water resources. Indications are that many of these are declining in quality, and indeed there is concern over water availability due not only to drought but to the diversion of water from the area. In the past recommendations have been made for investments in secondary and tertiary economic activities based upon the existing livelihood systems (Western and Thresher 1973; Thresher 1977; Campbell 1981). While some gains have been made in terms of horticultural production and in wildlife-based activities such as the Wildlife Sanctuary at Kimana, overall policy towards the area has not encouraged the development of off-farm livelihoods. In the future, these will be essential if exacerbation of poverty and accelerated environmental degradation are to be avoided.

This case study illustrates themes that are important to understanding the root causes of land use change in the broader context of East Africa, and indeed elsewhere. These themes are echoed in the analyses of land use change in the other LUCID case study sites. Table 9 summarizes the nature of the driving forces both local and exogenous, both societal and biophysical, while Figure 2 illustrates the importance of understanding the temporal dynamics of the processes. Together they depict the importance of adopting an analytical framework that explicitly addresses interactions between societal and biophysical processes, from the local to the national and global, and recognizes that a long-term perspective allows assessment of the dynamics of the processes and their interactions, as well as an understanding of the immediate and lagged impacts upon land use.

G. REFERENCES

- Barbier, E. 1998. "The economics of land degradation and rural poverty linkages in Africa." UNU/INRA Annual Lectures, 1998. Tokyo: United Nations University. (<http://www.unu.edu/inra/pub/barbier/AL98-preface.pdf>)
- Bigsten, A. 1980. *Regional Inequality and Development: A Case Study of Kenya*. Farnborough: Gower.
- Blaikie, P. 1985. *The Political Economy of Soil Erosion in Developing Countries*. London ; New York : Longman.
- Blaikie, P. 1994. "Political Ecology in the 1990s: an evolving view of nature and society." *CASID, Distinguished Speaker Series*, 13. Center for Advanced Study of International Development, Michigan State University.
- Blaikie, P. and H. Brookfield. 1987. *Land Degradation and Society*. London: Methuen.
- Campbell, D.J. 1981. "Land use competition at the margins of the rangelands: an issue in development strategies for semi-arid areas" in G. Norcliffe and T. Pinfeld (eds.) *Planning African Development*. London: Croom Helm, 1981.
- Campbell, D.J. 1984a. "Community participation in field research: an example from Kenya Maasailand." *Occasional Paper*, 4. Center for Advanced Study of International Development, Michigan State University.
- Campbell, D.J. 1984b. "Response to drought among farmers and herders in Southern Kajiado District, Kenya." *Human Ecology*, 12,1:35-64.
- Campbell, David J. 1987. "Participation of a community in social science research: a case study from Kenya Maasailand." *Human Organization* 46,2:160-167.
- Campbell, D.J. 1993. "Land as ours, land as mine: economic, political and environmental marginalization in Kajiado District," in T. Spear and R. Waller, eds., *Being Maasai*. London: James Currey. pp.258-72.
- Campbell D.J. 1998. "Towards an analytical framework for land use change." In *Carbon and Nutrient Dynamics in Natural and Agricultural Tropical Ecosystems*. Ed. L. Bergström and H. Kirchmann, pp. 281-301. Oxford: CAB International.
- Campbell, D. J. 1999a. "Response to Drought among Farmers and Herders in Southern Kajiado District, Kenya: A Comparison of 1972-1976 and 1994-1996." *Human Ecology*, 27,3, September 1999: 377-416.
- Campbell, D.J. 1999b. "A Socio-Economic Perspective on Land Degradation and Linkages to GEF Focal Areas – Biodiversity, International Waters and Climate Change." Paper prepared for the Global Environment Facility, Scientific Technical Advisory Panel, June 1999.
- Campbell, D.J., H. Gichohi, R. Reid, A. Mwangi, L. Chege, and T. Sawin. 1999. "Interactions Between People and Wildlife in S.E. Kajiado District, Kenya." LUCID Working Paper, November 1999. Nairobi: International Livestock Research Institute.
- Campbell, D.J., H. Gichohi, A. Mwangi, L. Chege. 2000. "Land Use Conflict in S.E. Kajiado District, Kenya.", *Land Use Policy*, 17, 4: 337-348.
- Campbell, D.J., and J.M. Olson. 1991a. "Environment and development in Kenya: Flying the Kite in Kajiado District." *The Centennial Review*, XXXV,2, pp.295-314.
- Campbell, D.J., and J.M. Olson. 1991b. "Framework for environment and development: The Kite." *CASID Occasional Paper*, No. 10. East Lansing: Center for Advanced Study of International Development, Michigan State University.

- Campbell, and S.E. Migot-Adholla, (eds). 1981. *The Development of Kenya's Semi-Arid Lands*. Nairobi: Institute of Development Studies.
- Ewel, K.C. 2001. "Natural resource management: the need for interdisciplinary collaboration." *Ecosystems*, 4: 716-722.
- Gachimbi, L.N. 2002. "Final Technical Report of Soil Survey and Sampling: Amboseli – Loitokitok Transect", LUCID Technical Report, November 2002.
- Galaty, J. 1994. "Rangeland tenure and pastoralism in Africa". In E. Fratkin, K.A. Galvin, and E.A. Roth (Eds.). 1994. *African Pastoralist Systems: An Integrated Approach*. Boulder: Lynne Rienner.
- Giddens, A. 1979. *Central Problems in Social Theory: Actions, Structure, and Contradictions in Social Analysis*. Berkeley: University of California Press.
- Great Britain. 1934. *Report of the Kenya Land Commission, September 1933*. London: HMSO.
- House, W.J. and Killick, T. 1983. "Social justice and development policy in Kenya's rural economy," in D. Ghai and S. Radwar, eds. *Agrarian Policies and Rural Poverty in Africa*. Geneva: ILO, pp.31-69.
- Huxley, E. 1935. *White Man's Country, Lord Delamere and the Making of Kenya. Volume II*. London, Chatto and Windus.
- Jaetzhold, R and H. Schmidt. 1983. *Farm Management Handbook of Kenya*. Rossdorf, W. Germany: Ministry of Agriculture Kenya in Cooperation with the German Agricultural Team(GAT) of the German Agency for Technical Cooperation (GTZ).
- Kimani, K., and J. Pickard. 1998. "Recent trends and implications of group sub-division and fragmentation in Kajiado District, Kenya". *The Geographical Journal*, 164: 202-216.
- Kinzig, A.P. 2001. "Bridging disciplinary divides to address environmental and intellectual challenges." *Ecosystems*, 4: 709-715.
- Kitching, G. 1980. *Class and Economic Change in Kenya: The Making of an African Petite-Bourgeoisie*. New Haven: Yale University Press.
- Krugmann, H. 1996. "Water management, use and conflict in small-scale irrigation: the case of Rombo". In: Rached, E., Rathgeber, E., Brooks, D., (Eds.), *The Kenyan Maasailand, Water Management in Africa and the Middle East -- Challenges and Opportunities*. Ottawa: IDRC Books, pp 253-273.
- Klopp, J.M. 2002. Pilfering the public: the problem of land grabbing in contemporary Kenya. *Africa Today*, 47: 8-26.
- Low, D.A. 1963. "The Northern Interior 1840-84." In R. Oliver and G Mathew, eds. 1963. *History of East Africa, Volume One*. Pp.297-351. Oxford: Oxford University Press.
- Lusigi, W. 1981. "New approaches to wildlife conservation in Kenya." *Ambio*, 10, 2-3:87-92.
- Norcliffe, G., and Freemann, D. 1985. *Rural Enterprise in Kenya: Development and Spatial Organization of the Nonfarm Sector*. Chicago: University of Chicago, Department of Geography, Research paper, 214.
- Ntiati, P. 2002. *Group Ranches Subdivision Study In Loitokitok Division Of Kajiado District*. LUCID Working Paper 7, Land Use Change Impacts and Dynamics. Nairobi: ILRI.
- Ole Katampoi, K, G.O. Genga, M. Mwangi, J. Kipkan, J. Ole Seitah, M.K. van Klinken, and M.S. Mwangi. 1992. *Kajiado District Atlas*. Kajiado: ASAL Programme Kajiado, Republic of Kenya.
- Rocheleau, D., Thomas, B. and Wangari, E. (eds.) 1996. *Feminist Political Ecology : Global Issues and Local Experiences*. New York: Routledge.

- Scheer, s. 1999. "Soil degradation: A threat to developing-country food security by 2020." *Food, Agriculture, and the Environment Discussion Paper*, 27. Washington, D.C.: IFPRI.
- Schroeder, R. 1993. "Shady practice: gender and the political ecology of resource stabilization in Gambian garden orchards." *Economic Geography* 69: 349-65.
- Smucker, T. 2003. *Land Reform and Changes in Land Use and Management in Tharaka, Kenya*. LUCID Working Paper: 11. Nairobi: ILRI.
- Thresher, P. 1977. "Economic characterization of Kenya's wildlife." *Mimeo*. Nairobi, Kenya Wildlife Management Project.
- Turner, M. 1999. "Merging local and regional analyses of land-use change: the case of livestock in the Sahel." *Annals of the Association of American Geographers*, 89: 191-219.
- Wangui, E.E. 2003. *Links between gendered division of labour and land use in Kajiado District, Kenya*. LUCID Working Paper: 11. Nairobi: ILRI.
- Western, D. and P. Thresher. 1973. *Development Plans for Amboseli*. Cyclostyled. Nairobi: International Bank for Reconstruction and Development.
- Western, D. 1982. "Amboseli National Park: Enlisting landowners to conserve migratory wildlife." *Ambio*, 11, 5:302-8.
- Zimmerer, K. S. 1994. "Human geography and the new ecology: the prospect and promise of integration." *Annals of the Association of American Geographers*, 84,1:108-125.
- Zimmerer, K. S. 2000. "The reworking of conservation geographies: Nonequilibrium landscapes and nature-society hybrids." *Annals of the Association of American Geographers*, 90,2:356-369.