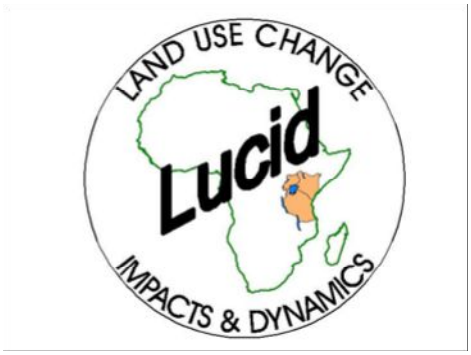


LUCID's Land Use Change Analysis as an Approach
for Investigating Biodiversity Loss and Land Degradation Project

The Spatial Patterns and Root Causes of Land Use Change in East Africa

LUCID Project Working Paper 47

By

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June 2004

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The Spatial Patterns and Root Causes of Land Use Change in East Africa

The Land Use Change, Impacts and Dynamics Project
Working Paper Number 47

by

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EXECUTIVE SUMMARY

The overriding finding of the LUCID land use changes analyses is how rapidly farming and agro-pastoral systems have changed. Small-scale farmers and pastoralists have changed their entire system several times since the 1950's. New land uses have been developed, and existing land uses have been transformed. In sum, the most significant land use changes have been:

1) an expansion of cropping into grazing areas, particularly in the semi-arid to sub-humid areas,
2) an expansion of rainfed and irrigated agriculture in wetlands or along streams especially in semi-arid areas,
3) a reduction in size of many woodlands and forests on land that is not protected,
4) an intensification of land use in areas already under crops in the more humid areas, and
5) the maintenance of natural vegetation in most protected areas.

These changes have allowed many more people to live on the land as farmers and agro-pastoralists, and the systems have shown flexibility and adaptability in face of changing international and national economic and political structures. Diversification, towards a mixture of crops and livestock, cash and food crops, and farm and non-farm income, has been a critical means for households to reduce their risk in face of these changes.

Amid the complexity of socio-economic and environmental driving forces of the land use changes across space and time, six factors appear to explain a large part of the dynamics of land use change in East Africa:

1. Government policy, laws and regulations
2. Economic factors
3. Population growth and migration
4. Changes in land tenure arrangements
5. Access to markets
6. Environmental conditions.

Despite the rapid evolution of systems responding to these forces, rural poverty is common and key environmental resources are becoming increasingly scarce, contested and/ or degraded. The LUCID team found that poverty, poor land management and land degradation are much more common and persistent in marginal environments, especially, the remote, semi-arid zones.

Even in the most productive, highly managed zones, however, the variation between households in levels of soil management and productivity is important. A common pattern emerged of how the lack of household resources affects investment on the land. Poorer households make significantly fewer investments due to the lack of labour and capital, and fewer farm and non-farm resources. The variability between households is closely related to the number of adults in the household and the gender of the acting head of household. Gender disparities reinforce the already precarious situation of poverty. The apparent spiral relationship between poverty and degradation is, however, not irreversible. Over time, as the agricultural sector becomes more profitable and other conditions more favourable, farmers increasingly invest in soil management. Policies and programs may have a large impact during this transition period, when returns to investment in the soil may be met in the short to medium term.

In the more marginal, semi-arid zones, herding systems have experienced multiple chronic pressures to alter land use. These have resulted in reduced access by herders to vital grazing and water resources, and competition over resources between herders, farmers and wildlife. Livelihood systems for many herders have become less sustainable. The relative profitability of cropping has resulted in many herders settling and diversifying into farming. Herd size and composition have altered, towards smaller herds with a higher proportion of shoats. In general, herders who have

successfully diversified manage risk better and have become wealthier than those that have not. Under both pastoralism and agro-pastoralism, patterns of land use have changed with implications for grazing intensity, fire practices, native plant species composition, and the number and distribution of wildlife.

Many of the rainfed crops in the drier zones are not intensely cultivated, however, due to low returns. The crops are often of low value, and risks of drought and pests are high. The semi-arid zones are in danger of worsening soil degradation and poverty due to the expansion of cropping into environmentally fragile and climatically risky areas. Indeed, there are signs of farmers switching to crops more tolerant of degraded soils, and the rate of expansion of cropping into semi-arid zones has slowed in the Kenyan and Tanzanian study sites. The contraction of grazing orbits and concentration of livestock occurring in some areas could also lead to a degradation of pasture and soil, continued shrinking of family herd sizes and poverty for those without alternative income sources. Out-migration is common among men of the poorest families.

The situation is thus critical in semi-arid areas—where the marginality and vulnerability of the human and environmental systems overlap and are currently in the processes of worsening.

Among the policy implications provided in this report's conclusion is that there is a great potential for more effective communication and dialogue between scientists, and between scientists and policy-makers. Much could be gained, for example, by the sharing of land use change findings by researchers working in different regions of a country, perhaps during seminars organized by universities or national environmental agencies. Policy has been an important driver of land use change, but the analyses demonstrated that unintended outcomes often later emerge as policy effects reverberate through the system. This suggests that policy-making effectiveness would be enhanced by the adoption of a comprehensive framework and a multi-sectoral discussion of policy objectives, design and strategy. In addition to improved technical approaches to land management and cross-sectoral policies, it is clear that local questions concerning changing access to land and water resources, competition over resources, and the poverty/ degradation relationship also need to be targeted in a participatory, long-term sustainable land management process.

I. INTRODUCTION

1. Purpose of study

The societies and environment of East Africa are undergoing rapid and critical changes with local, national and global implications. Highland agriculture on the slopes, and the rich wildlife and herding areas in the semi-arid areas, generate crucial sources of food and income for the population and the national economies, yet much of their productive potential depends on lands undergoing rapid land use change, making them susceptible to land degradation and biodiversity loss. These trends and their impact on land degradation and biodiversity need to be identified and understood before remedial policies and programmes can be effective in the long term. The LUCID project conducted a wide analysis of the societal and ecological trends of several areas in different countries of East Africa to provide a generalisation of patterns and processes, and lessons learned.

This analysis required studying the patterns and root causes of land use change, and the impact of land use change on the environment. The purpose of this report is to synthesise findings on the patterns and processes of land use and land management change, and their root causes. Historical patterns of land use change were examined in six sites in three countries, Kenya, Tanzania and Uganda (Map 1). The sites included the northern and the southern slopes of Mt. Kilimanjaro and the eastern slopes of Mt. Kenya, where the ecological conditions range from high altitude montane forest and intensely cultivated small farms and to semi-arid savannas; a wetlands along Lake Victoria in Uganda; and cultivated savannah adjacent to national park in Uganda. This report draws from detailed land use change and root causes analyses in site-level LUCID working papers. [1]

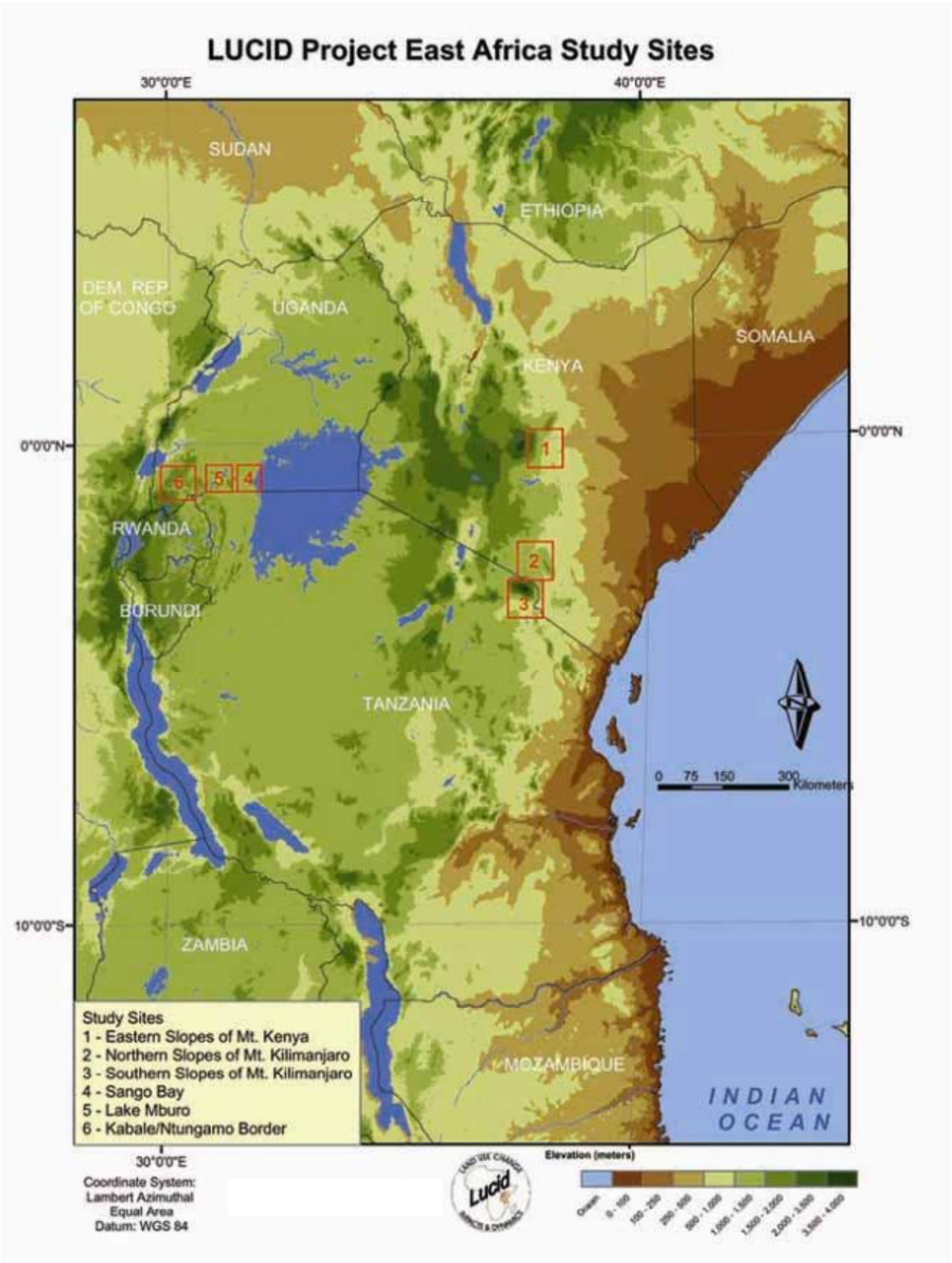
The focus of the research has been to document and analyse changes occurring in human-managed landscapes in a region characterized by rapid economic, social and political changes since the 1950's, within people's lifetimes and since remotely sensed and other information has been readily available. The rapidity of the socio-economic change has been accompanied by alterations in how land is used and managed, with accompanying impacts on the soil, native plant and animal species, and ecosystems, all of direct importance to daily livelihoods and wider ecosystem services. The presence and degree of land degradation and loss of biodiversity has been variable over time and space, however, reflecting these land management changes as well as responses by people and institutions.

The East Africa region is also characterized by spatial heterogeneity in landscapes, cultures, and political and livelihood systems. The region has undergone major political transformations, such as independence from colonialism, wars, elections that reversed decades of political power, and policies changing the economic system from socialism and statist developmentalism to neo-liberalism. Despite this high degree of spatial and temporal variability, common spatial patterns of land use change were identified across the region. These patterns were associated with similar processes driving the changes, such as agricultural sedentarisation, extensification and intensification, and urbanization. When, why and the extent of those changes, however, differed from one site to another, reflecting variations in the sites' socio-economic and environmental context and experiences. In some locations, land use conversions occurred suddenly following a change in policy, whereas in other sites comparable changes occurred gradually or not at all.

This paper will first compare spatial patterns of land use and land management change patterns across the sites, and then discuss the role of socio-economic and environment driving forces of those changes. The linkages between the driving forces, land management changes at the household or group level, and broader spatial patterns of land use change will be illustrated.

---

[1] The site LUCID land use working papers, include: for the Ugandan sites (Mugisha 2002; Tukahirwa 2002); for the Mt. Kilimanjaro/Tanzania site (Mbonile et al. 2003; Noe 2003; William 2003); for the Mt. Kenya site (Smucker 2002; Olson et al. 2004; Otuma 2004); for the Mt. Kilimanjaro/Kenya site (Ntiati 2002; Wangui 2003; Campbell, Lusch et al. 2004); and a comparison of land use change on the Kenyan and Tanzanian sides of Mt. Kilimanjaro is found in (Campbell, Misana et al. 2004).



Map 1. LUCID Project East Africa Study Sites

2. Analytical framework

Land use change analysis can illuminate the components of social and environmental processes that cause observable landscape change. However, this is difficult without a framework to direct and prioritise the exercise. This project has adopted political ecology as its conceptual framework.[2] This approach emphasizes that land use change results from interactions between society, reflecting economic, social and political processes, and the physical environment. These interactions occur between different scales (global, national, local), over time and space. This conceptualisation of society-environment interaction incorporates the following principles (Campbell and Olson 1991b; Campbell 1998; Olson 1998):

- 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 affecting outcomes of policy and in resolving competitions and conflicts;
- examination of the effect of societal differentiation—by group, wealth, gender, location—on land management.

While the implications of environmental changes are often discussed in terms of global consequences, many of the critical causes arise from interactions between societal and biophysical processes at the local level. 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. Land use change analysis 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).

The application of a political ecology approach to identify the root causes of land use and land management change in East Africa has involved identification of key social, economic, political and environmental drivers at multiple scales, from the household to the international, and interaction of those drivers over time. The research design used a systems approach: 1. multi-scale, 2. historical, 3. inter-disciplinary using variety of sources and methods, and 4. contextual, with the temporal and causal context within which local land management occurs. The identification of past policy impacts and the root causes of environment change is particularly critical for effective policy and program recommendations.

---

[2] Regional Political Ecology (Blaikie 1985; Blaikie and Brookfield 1987; Zimmerer 1994; Peet and Watts 1996; Rocheleau et al. 1996; Zimmerer 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 land use change in Kajiado District is found in (Campbell and Olson 1991a).

II. SPATIAL PATTERNS OF LAND USE CHANGE

1. Introduction

Similar spatial patterns of land use change have occurred across the research sites in East Africa over the past 50 years, characterized by increasingly intensively managed landscape outside of protected areas or extremely marginal environments. This general pattern has occurred at a very uneven pace across the region depending on historical conditions and varying driving forces. The most important land use conversions can be summarized as follows:

1. an expansion of cropping into grazing areas, particularly in the semi-arid to sub-humid areas,
2. an expansion of rainfed and irrigated agriculture in wetlands or along streams especially in semi-arid areas,
3. a reduction in size of many woodlands and forests on land that is not protected,
4. an intensification of land use in areas already under crops in the more humid areas, and
5. the maintenance of natural vegetation in most protected areas.

Perhaps less important from a geographical size standpoint, the main secondary towns in the study sites also grew rapidly. Their relatively small size belies their economic role in rural households, and the impact of off and non-farm activities on rural land use and land management.

These main land use changes will be examined across the study sites, organized first by changes occurring in the semi-arid to sub-humid areas, and then those in the humid areas. Rural land use systems in East Africa, including pastoralism, agro-pastoralism and agriculture, have in the past been roughly associated with particular agroecological zones and particular groups of people. Changes in where these land use systems are located and in who is conducting the activities is the story behind the large land use conversions in the region.

2. The Semi-arid to sub-humid areas: The expansion of crops into grazing areas.

a. The spatial pattern of land use change

The largest conversion of land use in the study sites was the expansion of rainfed agriculture at the expense of grazing land in sub-humid and semi-arid areas. Between 1887 and 1950, semi-arid and sub-humid areas were predominantly pastoral with scattered settlement and cultivation. From the 1950s to the present there has been significant transformation of grazing land to crop land, a transformation experienced in all the study sites. The rate of expansion appears to be slowing in many areas (e.g., around Mt. Kilimanjaro on both the Kenyan and Tanzanian sides, and on the eastern slopes of Mt. Kenya) where the frontier of conversion is now in drought-prone land, but in other sites (e.g., Ugandan sites) the expansion of agriculture had either not yet slowed, or the conversion had not yet occurred (the predominately pastoral sites of Sango Bay and Kabale/Ntungamo).

This conversion was usually an extension of cultivation from previously more humid areas into adjacent, if drier grazing lands. With each succeeding period examined, the land under cultivation spread into increasingly marginal land. In a few study sites where land ownership or social access to land was altered, in-migrants or large scale land users came to farm inside the rangelands forming islands of cultivation.

In our study sites on the slopes of Mt. Kilimanjaro and Mt. Kenya, the spatial pattern has been an expansion of rainfed agriculture down the agro-ecological gradient, from the high elevation, high potential (cooler wetter) zones progressively into the lower potential (hotter, drier) zones. This expansion of cultivation down slope formed land use change "rings" around the mountains that expanded outward with each time period examined (Maps 1 to 4). Both small holders and large scale enterprises played a part.

Statistically speaking, 13% of the land use in the Mt. Kilimanjaro/ Kenya site changed between 1973 and 2000—almost all a conversion from rangeland (99% of the loss) to rainfed agriculture (80%) or to irrigated agriculture (20%). The conversion rate slowed with the earliest period of 1973 to 1984 having the most rapid conversion (Map 2) (Campbell, Lusch et al. 2004). On the southern

slopes of Mt. Kilimanjaro in Tanzania, quantifying the extent of change was difficult because of cloud coverage on the images, but there was a large expansion of rainfed, and to a lesser extent irrigated, cropping into the former bush and grassland (Maps 2 and 3) (Mbonile et al. 2003).

On the eastern slopes of Mt. Kenya, land use varied across the ecological gradient with much intensive agriculture or forest on the upper slopes that did not undergo much change between 1987 and 2001; only 5% of the site's land use changed. Of the change that occurred, however, 40% consisted of an increase in mixed cropping/bush at the expense of bush (20% of all change), forest (10%) and woodland (6%) (Map 5). A closer examination around the town of Kiritiri revealed the extent of change in a semi-arid zone—78% of the land changed between 1961 and 2001 (Map 6). Almost all was a conversion from bush to fenced farms. An even closer field-level examination revealed, however, that farmers were leaving many fields fallow or in bush due to low returns, so the area actually being cropped was only 40% (Olson et al. 2004).

The conversion from bush to cropping is similar in the Ugandan sites, though the amount of conversion varied from 25% in the Kibale site between 1961 and 2001, to under 3% during approximately the same period in the other sites. In all sites, however, the conversion was from natural vegetation—mostly from savannah or grassland, but some wetlands or forests, to agriculture (Maps 7 and 8) (Mugisha 2002).

b. Smallholders as the major actors

The pattern of land use and cover change in the agro-pastoral sub-humid and semi-arid areas in East Africa appear to be characterized both by intensification and extensification, with variations in rate, timing and with reversals. While extensification occurred quite early in Kilimanjaro in Tanzania as well as in the Lake Mburo National Park area and adjacent to Kibale National Park in Uganda, it occurred much later in Mbeere and Loitokitok in Kenya. In Kilimanjaro-Tanzania, for example, there was expansion of agriculture to the lower slopes between 1940s and 1960 when food crop production was moved to the lower slopes opening up bushland areas (Mbonile, et al., 2003). This was in response to the growing population in the highlands, which necessitated conversion of shambas used to grow food crops into home gardens. Further expansion into the lowlands took place after 1960s with the conversion of grazing areas to farmland. Similarly in Uganda the agricultural expansion took place in the 1950s in both Lake Mburo area and areas adjacent to Kibale National Park (Mugisha, 2002). Such expansion was associated with arrival of new immigrants into the areas. Such an expansion led to loss of savannah and wetlands in the Lake Mburo area.

In Mbeere, expansion of cultivation into pasturelands took place prior to 1970s, though the process of was relatively slow (Olson et al. 2004) (Map 5). The 1950s and 1960s were characterized by bush or grassland used for raising large herds of goats and cattle, with small fields of shifting cultivation. More rapid expansion of cultivation, however, took place after 1970 with the privatisation of landholdings such that in a 15-year period, the landscape in much of Mbeere changed from bush and woodland to be almost completely converted by plough agriculture. In the Loitokitok area, the majority of down slope expansion of rainfed agriculture took place between 1973 and 1984 (Campbell, Lusch et al. 2004). By mid 1980s, the entire area between the Tanzania border and the semi-arid plains had been cleared and planted. The land adjacent to water sources and around swamps had also been cleared for cultivation. Since then, there has been an increase of new scattered cropland in grazing areas, with fields being scattered in the bushland, particularly on the lower slopes of Mt. Kilimanjaro (Kenyan side) and to the north of the irrigated area at Rombo. Further extensification was observed west of Loitokitok between 1994 and 2000, characterized by the expansion of cultivation into grazing land brought about by herders including farming alongside livestock production. A similar situation can be observed in the Kitendeni wildlife corridor in Tanzania where diversification has led to expansion of cultivation in former grazing and wildlife areas (Noe 2003).

In both Kenya and Tanzania, extensification was followed by intensification of agriculture. Extensification and intensification in the region have also been characterized by expansion of smallholder irrigation around swamps and rivers, particularly since the 1970s in Kilimanjaro, Tanzania and the mid 1980s in the Loitokitok Kenya as well as change in crops. These wetlands were important refuge areas for livestock and wildlife during the dry season. But because of opportunities for irrigated crop production, the swamps were cleared for cultivation.

c. Institutions/large scale actors
Large-scale landholders and the government have converted large areas, mostly of previous pastoral land, into either cultivation or ranches.

Large-scale individual and group ranches were established in Kajiado District (Kilimanjaro Kenya) in 1970s/1980s, while government ranches around Lake Mburo, Uganda were established in 1960s, replacing traditional grazing systems of the pastoral communities The establishment of ranches led to the emergence of private commercial ranch systems around Lake Mburo (Tukahirwa 2002). Today however, the group ranches in both Kajiado District (Ntiati 2002) and Lake Mburo are being subdivided into individual units, with wider implications for land use change. In the Lake Mburo area, for example, following the land restructuring policy and the government resettlement scheme, the pattern of development has been associated with expansion of cultivated areas, settlements, woodlots, and declining land for fallow, grazing land, forestry and wetland. In Kajiado District on the other hand, the subdivisions are likely to affect all land uses in the area, including the Maasai pastoral system and the wildlife, that depend on availability of large landscapes that allow both livestock and wildlife to access resources that are widely distributed in both time and space (Ntiati, 2002).

3. Expansion of agriculture in wetlands and along streams in semi-arid areas
Prior to the 20th century the semi-arid lands of each of the three countries were the domain of wildlife and livestock herders. Land management by herders allowed for access to water and grazing for both livestock and wildlife. The wetlands represented secure sources of water during the annual dry season(s) and particularly during recurrent droughts. The productivity of vast areas of semi-arid land depended upon access of wildlife and livestock to these small perennial sources of water.

The case studies along altitudinal gradients in Tanzania and Kenya show that over the past 75 years, and particularly the past 30 years, demands have increased for access to these lowland water resources from farmers practicing irrigated cultivation of high value crops, such as horticulture, rice and flowers. Farmers have migrated to these wetter margins of the rangelands in response to a shortage of land in areas of higher potential rain fed agriculture, and to market opportunities. In some cases the irrigation is under an informal smallholder system (Loitokitok, lower Moshi), in others it is by medium landowners (Mt. Kenya), while in others it is organized under a scheme sponsored by a state organization or other institution (the Japanese rice project, the Tanganyika Planting Company (TPC) sugarcane plantation and the National Food Company (NAFCO) farm in lower Moshi, Tanzania, and the Mwea Rice Scheme below Mt. Kenya). More recently immigrant farmers have been joined by herders who have diversified their economy to include crop production, often in response to the impact of drought or of the decreased access of livestock to the water in swamps and rivers. Wildlife has experienced a similar decline in access to water.

The amount of land under irrigation has grown rapidly. In the Kilimanjaro/Kenya site, for example, irrigated land expanded from 245 to 4768 hectares between 1973 and 2000, and in the Kilimanjaro/Tanzania site from 336 to 4078 hectares during the same period. The source of the water is usually rivers or swamps except for the sugarcane plantation in Kilimanjaro/Tanzania, which uses water being pumped from pumped from aquifers. Rice, flowers and vegetables are the main crops, though sugarcane is grown in Mt. Kilimanjaro/ Tanzania. The crops are destined for both national and export markets.

In Uganda the case studies illustrate a "horizontal gradient" where wetlands are found in river valleys, the borders of lakes and as swamps within semi-arid lowlands. The importance of such sources to the livelihood systems within which they are located is similar to that found along the altitudinal gradients, they offer both water and grazing, as is the competition between land uses for access to water.

The presence of wetlands has allowed the economy of the semi-arid lands to diversify to include herding, wildlife and associated tourism, and irrigated agriculture. Each depends upon access to water, and while the land management practices of herders in the past allowed for wildlife, the addition and expansion of agriculture has resulted in increased competition over access to water between and among the three uses.

Although small in land area, these activities have become important sources of income particularly for those who have ownership rights over the land or water. The vegetables and fruit produced with irrigation draws high prices in the national and international markets. Access to that water, however, is also becoming an increasingly important source of conflict between farmers, and between farmers, herders and conservationists. The limited amount of water available for watering cattle and wildlife led the streams and swamps to be contested key resources even before those same resources were used for irrigation.

The patterns of land use change exemplified by these case studies is representative of similar areas elsewhere in East Africa, for example the Turkwell River in Kenya, the Ruaha River Basin in Tanzania, and the Karamoja region in Uganda.

4. Reduction of woodlands and forests outside of protected areas.
Many woodlands and forests without enforced protected area status have been reduced in size and/ or their vegetative cover has diminished. They have either been converted to pasture for grazing, to fields for rainfed agriculture, or their woody plants have been extensively cut for charcoal production (Mbonile et al. 2003; Olson et al. 2004) (Map 4).

The Mt. Kenya site illustrates the changes. Small hills in the semi-arid zone at the foot of the mountain were mostly covered by woody savannah or woodlands in the 1950's and even into the 1970's. The expansion of cultivation in the zone occurred around these hills, leaving them in their wooded state. By 2001, however, the lower slopes of many of the hills that did not have government status as reserves were being intensively used for woodfuel collection, charcoal production and grazing, and they were classed during land cover interpretation as degraded woodlands or as mixed bush/cultivation. Some of the hills still have, in contrast, intact woodlands or forest because the surrounding communities have strongly protected them as sacred groves.

5. Intensification of cultivation in humid zones.
In areas that were already cultivated in the 1950's, land use changes have been less dramatic. They have been primarily an in-filling of cultivation into valleys, hills and other pieces of land that had not yet been cropped, changes in types of crops, fragmentation and shrinkage of farm sizes, and (although this was not measured in our analyses) an increase in planted trees in densely populated areas. These changes have been primarily associated with intensification of the existing farming system, reflecting an increase in the application of labour and, in most places, capital inputs on the land.

The general pattern of land use change in the higher elevation or more humid areas is one of early settlement and cultivation, and of later intensification of cultivation. These regions in general have high agricultural potential, and this has shaped how they have developed. The general pattern has been

1. Early clearance of the forest for grazing domestic animals and for shifting cultivation. The land cover reflected the patchwork mixture of remnants of forest, riverain woodlands, grassland covered hills and small fields.

2. Gradual conversion to crops as cultivation expanded as population densities rose from the 1940's.
3. Conversion of the remaining pastureland to permanently cropped fields, and a switch from clan-based land holdings to individual family farms. Perennial crops, such as bananas, trees, coffee and tea dominated the landscape.
4. Livestock systems changed as animals were tethered or placed in paddocks and feed cut fodder planted on the farm or purchased from the drier zones. Dairy cows replaced meat cattle, and the size of the goat/sheep herds shrunk. The manure was placed on the fields.
5. Continued intensification, including use of manure, soil conservation, and chemical fertilizers and pesticides.
6. Governments and other large scale land users have converted some land to commercial, often export, crops.

The current trend is one of changing crop choice and related land management as markets and prices evolve, and labour availability changes with out-migration and income diversification. For example, the amount of land under coffee has diminished as coffee prices have declined, and been replaced by horticultural crops sold nationally or internationally. Bananas are becoming a commercial crop for the markets in large Tanzanian cities, including Dar es Salaam. On the Kenya side of Mt. Kilimanjaro, the maize/ bean farming system continues to dominate though there are reports of declining soil fertility, increasing use of fallow and change to crops that are less demanding of soil nutrients such as sweet potatoes and millet. In Sango Bay, Uganda, the coffee/banana system remains but with reported declining soil fertility

6. Some protected areas remain intact, others not.
Protected areas such as parks and reserves have, for the most part, remained intact. Protected areas constitute a large percentage of the land—12% in Kenya, 26% in Uganda, and 40% in Tanzania. The land cover within protected areas and the other mandated lands is often the most stable in the region. The exceptions have been where a government has changed the boundaries of a protected area, during periods of civil strife, or where a government has changed enforcement of deforestation rules. In Uganda, for example, some reserve land have been degazetted to legalize existing or permit new settlements, but wetlands gained enforced protected status (Mugisha 2002). In a section of lower Mt. Kenya forest, government representatives temporarily permitted forest clearance and cultivation (Olson et al. 2004).

The Shamba System, a mixed cultivation /tree plantation system established by colonial administrations, is a special land use within protected forests. It has been expanded in some places but shrunk in others. Much of the natural forest on the Tanzania side of Mt. Kilimanjaro (the eastern and northern slopes) has recently been replaced by Shamba System tree plantations and crops. Forest villages are expanding while the land under crops is slowly replacing land under planted trees. Either no tree replanting is taking place or, if planted, the trees do not survive. In contrast, the Kenyan government evicted villagers cultivating Shamba System fields on Mt. Kenya in 2003, but it may change policies again to permit the villagers to return.

Despite the generally intact status of vegetation within protected areas, in the past 20 to 30 years cultivation has extended to their borders, creating an abrupt transition between natural vegetation for wildlife, and cultivation and settlements.3 Since wildlife are common outside parks and are protected there, several sites experienced human-wildlife conflict with wildlife destroying crops and harming people. The expansion of agricultural settlements between protected areas and to protected area borders has also reduced wildlife access to grazing and water resources, and reduced or blocked wildlife migration corridors. Wildlife and the tourists that they draw, however, can be a source of income for some. In the Mt. Kilimanjaro/Kenya site, a savannah land with a swamp has been partially fenced and privately developed with tourist lodges.

[3] See (Campbell et al. 1999; Noe 2003; Worden et al. 2003; Chira 2004; Otuma 2004).

7. Summary of spatial patterns

The conversions of land use described above have often been associated with changes in land tenure status as governments have sub-divided communally managed land for individual ownership, as governments have allocated land for private development, or as new groups have obtained land. In general, land management has evolved from primarily communal management by clans or by the government, to private individual management. The land use changes also reflect an evolution of the national and local economies as crop, livestock, wildlife and tree product income opportunities and risks have evolved, and as household level resources such as land and labour availability have changed. The rural production system changes have been accompanied by important shifts in culture and society, for example different gender roles and responsibilities in households, and how pastoralism is perceived and conducted. Migration by people seeking land for farming or grazing and, if less dramatic, local population growth, were important instigators of land use change in all the study sites. The driving forces of land use change are discussed in more detail below.

II. DRIVING FORCES

1. Introduction

The driving forces of land use change are multiple and interact, to create a complex and evolving system. As described above in the conceptual framework section, this study has adopted a political ecology categorization of driving forces encompassing social, cultural, economic, political and environmental. Population dynamics and land tenure changes, though dependent on these contextual factors, are considered separately since they have played such a large role.

Amid all this complexity six important factors appear to explain a large part of the dynamics of land use change in East Africa. These are:

1. Government policy, laws and regulations
2. Economic factors
3. Population growth and migration
4. Changes in land tenure arrangements
5. Access to markets
6. Environmental conditions.

The scale or level that these factors operate to affect land use decisions is not limited to the household or landscape, since these are shaped and influenced by national and international economic and political contexts. Consideration of the variation among households and types of land managers, including governments and institutions, and the power that they wield, is critical to understanding changes the system. Poverty and wealth, for example, greatly influence how rural households respond to a drought or to a new commodity market. In short, multiple forces and various types of agents are considered, at various scales, to understand the physical manifestation of landscape change.

2. Government Policies, Laws and Regulations

One of the least discussed drivers of land use change is government policy and related laws and regulations. Policy is viewed as a means of promoting desired future conditions, yet there is a resistance to acknowledge that it is thus inevitably a driver of land use change and as such has possible negative, as well as positive, results. The case study analyses have demonstrated that policies and laws have had a significant impact upon patterns of land use change in East Africa. Their influences can be discernible in the short term but they are most clearly seen in an historical perspective that illuminates the outcomes of their interactions with other drivers over time.

Contemporary land uses in East Africa reflect the influence of both colonial policy and laws, some extending back to the late 19th Century, and recent ones, such as structural adjustment policies that date to the 1980s. Of particular importance are the land policies since the colonial period that have shaped the land tenure systems with wide implications on the utilization of the land. These, coupled with the agricultural, wildlife and forest conservation, resettlement and more recently the structural

adjustment policies have all worked together to bring about significant changes in land use within the East African region.

Colonial policies and the legal frameworks used to enforce them led to alienation of land for Europeans settlements and large-scale farming and ranches in the East African region. This directly affected the distribution of lands between native peoples and colonial settlers in Kenya, Tanganyika and Uganda. Legislation included the British Land Act No. 3 of 1923 in the then Tanganyika, the treaties between the Maasai and British in 1911 and 1912 and other land laws in Kenya, as well as Agreements between the British protectorate government and the Kingdoms of Buganda, Toro and Ankole in Uganda that included the Buganda Agreement which was later supported by the Busuulu and Envunjo Law of 1927 and the Toro Landlord and Tenant Law of 1937.

Legislation on land complemented colonial agricultural policies that encouraged the introduction of cash crops such as coffee, cotton, tea, and sisal for the export market. This led to clearance of large areas of forests, and the spread of agriculture. Throughout East Africa land alienation and agricultural policies facilitated colonial settlement and disrupted pre-existing land use among Africans. Particularly severe was the impact upon African livelihoods in areas of reliable rainfall, and on livestock based livelihoods in the semiarid regions as settlers occupied the best watered of their lands so vital in dry seasons and periods of droughts.

The situation was worsened by the wildlife conservation legislation that was enacted in the initial years of colonization by both the British and the Germans in the late C19, and exacerbated by the later establishment of national parks and forest reserves in the three countries. The 1945 National Parks Ordinance in Kenya, the National Parks Ordinance Cap 412 of 1959 in Tanzania and the 1964 National Parks Act Chapter 227, Laws of Uganda set aside large areas as national parks, including Kilimanjaro National Park in Tanzania, Mt. Kenya and Mt. Meru National Parks in Kenya and Lake Mburo National Park in Uganda, for the exclusive use of wildlife.

Enclosed in these parks were lands that traditionally provided dry season and drought-retreat pasture and water for livestock, for example for those of the Maasai in Kenya and Tanzania. The establishment of national parks also shifted land pressure and fragmentation to new areas and became a source of land degradation, land conflicts and, in Uganda, ethnic rivalry (Tukahirwa 2002:12). Protection of forest land resulted in the denial of access to the local people. Since the land left for agriculture by the natives was small and in some cases infertile, pressure on the land was high, land fragmentation was inevitable and land productivity declined shortly afterwards.

Because of changing patterns of human-wildlife competition and conflicts over a long time outside the national parks, particularly in wildlife dispersal areas, it has been necessary for the wildlife policies to address the mounting tensions between the local communities and government institutions concerned with wildlife, as well as to curb the problem of encroachment. These include in Kenya Community-based Wildlife Management, and in Tanzania the Wildlife Policy of 1998 recognizes the need for local communities to be involved and benefit from wildlife resources. It has paved the way for the establishment of Wildlife Management Areas in areas outside national Parks, including wildlife corridors. This is likely to lead to changes in land use when the communities start to implement this policy.

Recognizing the need to invest to improve the status of African livelihood systems, the colonial governments initiated policies designed to improve African agriculture. Central to these was the implementation of settlement schemes, which led to significant land use and cover changes in the three East African countries. These schemes include the resettlement schemes in Uganda, the Emergency villages in Kenya and in the post-independence period Ujamaa villages in Tanzania.

The post-independence period witnessed a number of law reforms while new ones were enacted. Post-independence laws, whose enactment and implementation had significant influence on land use change, include the 1968 Land Adjudication Act in Kenya, the 1962 amendments to the Local

Authority Ordinance of 1953, the Wildlife Conservation Act No. 12 of 1974, the Village Act of 1975, the 1983 Labour Deployment Act, and the Land Act No. 6 of 1999 in Tanzania, among others (see Mbonile et al. 2003).

In Kenya the privatisation and individualization of land rights resulting from implementation of 1968 Land Adjudication Act transformed agricultural systems as economic and social systems changed from ones based on communal management of resources to private management, and from primarily pastoralism to cultivation with some animal raising. In Embu and both sites on Mt Kilimanjaro entire landscapes changed from those dominated by bush and woodland to those almost completely covered by agriculture.

In agriculture, post-independence governmental programmes in both Kenya and Tanzania promoted export crops through establishment of parastatals, such as the National Food Corporation (NAFCO) in Tanzania and Nyayo Tea Plantation in Kenya as well as the coffee cooperative parastatals in Kenya and Tanzania. These often incorporated existing producers and also led to the establishment and expansion of additional estates and plantations. These included the Nyayo tea plantation carved out of the forest within the Mt. Kenya Forest Reserve causing large scale deforestation on the eastern slopes of Mount Kenya, and some of the coffee estates on the slopes of Mt. Kilimanjaro were turned into large-scale maize farms while new ones became established in the lower Moshi area. But due to lack of commitment and resources, the former cultivable land reverted to grassland and bush.

In Uganda, the post-independence laws including the Land Reform Decree of 1975, legally transferred all land to the state, and most of the land was accessed for export production and commercial agriculture (Tukahirwa, 2002). However, many of the estates that had been sustainably managed with due conservation measures were laying in ruin because of the expulsion of Asians from Uganda. Other legislation with significant impact on land use in Uganda include the 1995 Constitution and the 1998 Land Act, which are likely to stimulate further changes in land use in the future. Both of them attempt to streamline and free the land market in Uganda.

What is important also to note are the reversals in the implementation of the legislation and land management practice in response to emerging land use issues and other pressures, at national and international levels, including political pressure. This is reflected first in the breakdown of enforcement of laws and removal of restrictions, which for example, led to carving out 6125 ha of the Kilimanjaro Forest Reserve by the Forest Department in Tanzania to establish forest plantations between 1960s and 1970s, and the de-gazetting of parts of Lake Mburo and Mount Kenya National Parks. In 1969, for example, the Government of Uganda de-gazetted part of the Lake Mburo Game reserve to establish a cross-breeding dairy ranch for exotic cows (Mugisha and Infield, 1996), while the Government of Kenya de-gazetted part of Mount Kenya Forest Reserve for the establishment of Nyayo tea plantation. The colonial administration and later the Government of Kenya had also maintained a Shamba system tree plantation, similar to the one practiced on Mt. Kilimanjaro, which allowed cultivation of crops around the tree seedlings by the villagers.

Since the year 2000, however, the Government of Kenya reversed the system of management of the Mt Kenya forests by introducing stricter government enforcement of laws and regulations. Thus cultivation is no longer allowed in the forest plantations. The enforcement also included forced removal of squatters, destruction of illegal crops, a halt to logging hardwoods for the national and international market, using permits to control fuel wood collection and grazing, the designation of the forest as a National Reserve to be managed by the Kenya Wildlife Service and removing administrators found to be engaged in illegal forest activities. Such a reversal has led to change in land use and cover in one large section from forest to cultivation to secondary forest growth over a period of 13 years. Such stricter enforcement of regulations, which included a ban to all kinds of harvesting in the Kilimanjaro Forest Reserve, was implemented in Tanzania since the 1980s following the Presidential Decree of 1984.

Among the most recent policy initiatives to have an impact upon land use change in the region has been Structural Adjustment. The structural adjustment policies (SAP) implemented in the since the 1980s in Uganda and Tanzania and the 1990s in Kenya have had far reaching effects on the agricultural sector and the resultant changes in land use. The liberalization of markets, removal of subsidies on inputs, price reforms and institutional reforms, all affected land use and resource management practices. For example, the privatisation process associated with SAP in Kenya led to the collapse of the coffee cooperative parastatal, which, in turn, has had far reaching effects on coffee production, resulting in its replacement by low value crops. The low coffee and tea prices have also influenced the replacement of these crops mainly by vegetables, potatoes and maize.

A similar situation has been experienced in Tanzania following the removal of subsidies and the low crop prices at the international market. The removal of subsidies has hiked prices for farm inputs such as insecticides making them unaffordable to a peasant farmer. This has in turn lowered coffee production due to the spread of the CBD, which together with the low prices has forced farmers to abandon the crop in favour of tomatoes and vegetables. The high prices of veterinary inputs has, on the other hand, negatively affected the livestock sector and forced the pastoralists to diversify their livelihoods by engaging in agriculture, thus further squeezing grazing towards the more fragile lands.

In Uganda, the implementation of SAP in the form of tax reforms and introduction of user fees in major social services like health forced many people to leave the urban areas and go to villages where they could earn a living from cultivation. This move caused an invasion of the hitherto unused lands and some gazetted areas were encroached on, causing land fragmentation, soil exhaustion and degradation.

This brief synopsis has illustrated that policies and laws have a significant impact upon land use. These changes may represent desired outcomes of policy, or in other cases the results may contradict the initial policy objectives. The latter circumstance is more likely to arise over time as unintended effects arise from the interaction of policy initiatives with the full system affected by the policy. Detrimental outcomes are less likely where policy facilitates flexibility in future outcomes.

3. Economic factors

As described above, governments have played a large role in affecting economic circumstances in the agriculture sector in all three countries. Indeed, the economic factors that most influence farm-level decisions on how to use land are all heavily influenced by government policies and programmes—the price and marketability of commodities, the availability of land and security of tenure, and the price and availability of agricultural inputs and technologies. International markets play an especially large role in East Africa, with countries' dependence on a few export crops for a large proportion of foreign earning. Similar, international institutions such as the World Bank, IMF and Western aid agencies regularly mandate macro economic policies affecting agriculture and other land uses. At the local level, governmental or other institutional programmes may promote a specific crop or technique, from tree planting to Heifer dairy cows to valley drainage and development that greatly affect household economic decisions regarding labour and land use.

The impact of these and other economic forces on land use has led to a general pattern of change in East Africa, though it varies by place and by time period. The spatial pattern of land use change—a decline of shifting cultivation and nomadic grazing and an increase in permanent cropping—has been accompanied by changes at the household and community levels associated with agricultural intensification. Intensification theory addresses how small scale farmers are expected to adapt their farming system to increasing population densities and associated reduction in farm sizes by increasing their application of labour, capital and land saving technologies (Boserup 1981; Turner et al. 1993; Tiffin et al. 1994). Changing in technologies include reduced fallow length, increased soil, water and weed management, choice of higher yielding crops, and increased use of fertilizers. The result can be, in theory, an increase in land productivity that matches the increase in applied labour. In some cases, however, the environmental effects can be negative (Geertz 1963; Grigg

1980; Biot et al. 1995). The application of the theory to East Africa is expanded in the Discussion Section below, but will be briefly mentioned here.

Boserup (1981) was not thinking of the pastoral grazing lands when she developed her land intensification theory. The general assumption of the theory, that newly experienced land scarcity led to adaptations of land use, would appear to apply, however. The major shift that occurred in the sub-humid and in several of the semi-arid sites is that crops have overtaken herded livestock as the most profitable or least risky use of household land and labour. Herded livestock require large land areas, especially in arid and semi-arid areas where patches of good pasture may be far and vary over time and space, and where dry and wet season grazing areas may be distant. With the loss of access to grazing land (it was gazetted as protected areas or lost to other groups), livestock raising changed. The evolving livestock system is based on smaller herds grazed nearer the home, so requiring less grazing land, and their feed is being met partly by crop residues. Almost all families cultivate crops, and much of the food and current household expenses are met by crops. The gendered division of labour in former pastoral communities has adjusted to these changes, with women taking up additional livestock rearing responsibilities and men working in the cash crop fields (Wangui, 2003). Social pressures to sedentarise have also encouraged people to cultivate. Intensification is occurring, although the reasons may not necessarily stem from a labour surplus.

Most of the studied humid and sub-humid areas, a large part of which are densely populated, appear to represent an intensification success story. Land and soil management is intense, and productivity is high. The value of the production, and therefore the level of inputs the crops receive, however, has greatly varied over time and location according to outside factors (from war to structural adjustment programs).

The choice of crops, especially cash crops, has varied greatly over time. East Africa is not new to globalisation forces, with their economies having been geared towards export crops from the earliest colonial period. More recently, the World Bank and IMF have followed this path and encouraged economic growth via export of these commodities. During the period examined, the international market price of many of the internationally traded crops most important in East Africa—cotton, coffee, tea, sisal and sugar, for example—has declined precipitously. Before the decline, however, they supported the intense use of labour, chemical fertilizers and other inputs, and some small scale farming systems became relatively wealthy. The vagaries of the international commodities market, agricultural subsidies in developed countries, and the large international supply for these products, however, have led some crops to mostly disappear and others, such as coffee, to rapidly decline in East Africa (see Box 1). Vegetables, fruit and flowers—high value, highly perishable and high input crops exported to Europe, have recently replaced the traditional cash crops in the national economies of Kenya and Tanzania, and are growing in importance in Uganda. The farmers producing them, however, are mostly the very wealthy and often those with political connections. Unless the international price for tea, coffee, pyrethrum or another such crop increases, most East African small farmers will not be able compete in the international market. On the other hand, the national, especially urban markets for crop and livestock products are rapidly growing. It appears that land under maize, rice and vegetables in particular is increasing to meet this demand. Food commodity prices are usually low, however, except in periods of drought. Farmers have therefore shown themselves to be quick in responding to changing market and price conditions by switching their choice of crops and their crop-livestock system.

Box 1. Responses to the decline of coffee

Smallholder farmers in the Mt. Kenya region had been a large producer of Arabica coffee that fetched a high price because of its reputation for high quality and taste. Indeed, coffee was a large cash earner—farmers reserved most of their land for coffee, and bought food from the lowlands. The coffee trees were well mulched, planted on bench terraces and treated with chemicals purchased with credit from the coffee parastatal. Although farms were small, coffee provided sufficient income for school fees and other needs, and out-migration was relatively low. Starting in the mid-1990s with the drop in coffee prices and the dismantling of the parastatal, farmers saw their returns from coffee drop. In a few years when the low prices and credit problems seemed long-term, farmers sought alternatives. Initially they trimmed their bushes to grow food crops around the stems. By 2001, many had uprooted their coffee and were growing maize, cabbages, and other vegetables even though their returns were low compared to what they had been with coffee.

The Ugandan coffee is based on the short-maturing, high-yielding and disease resistant Robusta coffee. While the volume of coffee produced in Uganda has increased, the earnings have decreased over the past several years. Small scale farmers can still break even at USD 0.5 per kg if they use few inputs. The government and donors, such as USAID, are encouraging production of Arabica coffee into areas outside of the traditional producing areas. Meanwhile, farmers are attempting to diversify to promising horticultural and floricultural crops such as pepper, vanilla and flowers.

Meanwhile, members of rural households in all zones are increasingly engaged in a variety of economic activities, both on and off the farm. Their decisions on where to invest their time and money are based not solely on how to best divide their labour and capital resources on the farm, but how to reduce risk by diversifying their food and income sources. Particularly in drought-prone areas and in areas with tiny farm sizes, both agro-pastoral and farming households have pulled their labour out of strictly livestock keeping or farming, and put it into non-farm activities such as commerce, salaried jobs and educating their children. The impacts of having less labour available on the farm in these areas include smaller herd sizes and smaller grazing orbits, more focus on fields near the home, and less investment in enlarging or improving the farm.

4. Population Growth and Migration

The study revealed that all sites were experiencing annual population growth rates exceeding 3% and in some situations with rapid in-migration, up to 6%. As in many developing countries, the fertility is still high (TFR above 5 in most sites, though declining in the Mt. Kenya site) while mortality is gradually declining due to improved nutrition and health services during the post independence period (although HIV-AIDS is pushing up mortality rates). This rapid rate of population growth has reduced land availability per capita and increased population pressure, and has led to land use intensification and to out-migration. First short-distance out-migration from higher potential zones occurred to clear adjacent land, then longer-distance moves to search for land in remote or less productive, drier areas. This has led to the invasion of semi-arid marginal lands and land use conflict with pastoralists. Migrants have also moved to find jobs in large coffee, sugar cane, flower and wheat plantations or farms.

In the Mt. Kenya and in the Mt. Kilimanjaro/Tanzania sites, the expansion of cropping into herding zones was done primarily by local farmers moving short distances down slope, to their own group's land or to land of groups with whom they had a long history of collaboration. On the Mt. Kilimanjaro/Kenya and in the Ugandan sites of Lake Mburo and Kibale, however, the conversion was done mostly by immigrants who arrived from other regions of the country to seek land. The in-migrants came from more environmentally favourable, but densely populated, areas where sufficient land was not available for young families.

In addition to the large amount of permanent rural-rural migration experienced in the sites, high rates of temporary labour migration to rural and urban areas have been critical responses to changing economic constraints and opportunities. Poverty rather than sheer population density has been associated with these movements. The pattern of labour migration is bi-modal with the poorest and the richest families most engaged (Olson et al 2004). The poorest households are, however, investing little of their outside income in the farm. Their poverty is being perpetuated by distress land sales and low investment in children's education.

5. The fluidity of land tenure arrangements

Changes in land tenure arrangements have been perhaps the most "shocking" driving force of land use in the case study sites as administrative mandates for how land was to be used were made for entire areas or regions within countries. Starting in the 1930's and continuing until the 1960's, parks were gazetted in areas that had been used for centuries for grazing, watering points and agriculture; private and governmental agricultural estates and plantations were carved out of former small scale agricultural areas; and settlement schemes and planned villages were established and farmers moved to them, sometimes forcefully. The result was large "chunks" of land were rapidly converted to new land uses under new land management structures. Individuals and groups became winners or losers in the process.

Although those mandates are being contested in some areas (e.g., whether herders have the right to graze and water their animals in protected areas), in general the boundaries and land management structures have remained intact.

Outside of these mandated areas and where customary tenure structures remain in place, however, land tenure arrangements have been undergoing equally radical changes that have altered who conducts the management of the land and has rights to use the land, and how the land is used. Most of these changes are in the agricultural or pastoral lands, and are the result of a combination of government policies, local interpretation and implementation of those laws within the existing customary land tenure structure, and social and economic changes. This combination of variables is leading to the current fluidity of land tenure arrangements throughout much of the region. In general, this fluidity is characterized by an evolution in land tenure arrangements from a more communal or group based arrangement, that had included common access to grazing, water and tree resources, to a more individual, private arrangement based on the nuclear family in which former communal resources are divided among group members. This is also leading to a rise in land markets since it is easier to sell and purchase land. The evidence is mixed whether privatisation leads to improved land management, but it has definitely led to intensification of use. Rather than this evolution being a transition from one stable state to another, however, it appears that fluidity and change in land tenure arrangements and ownership patterns will be continue for the foreseeable future.

The time line and how the evolution is occurring varies widely across the region, but common land use and land cover implications have included:

- Fencing of the individual land units, to protect the newly privatised grazing resource and/or to protect crops and livestock against diseases, and neighbour's herds. In some areas fencing has led to problems concerning wildlife migration corridors.
- The land management unit is declining in size and fragmenting as ownership is transferred from the group to the individual, and as farms shrink as seceding generations inherit and split the land holding among the sons.
- A conversion of grassland that had been reserved as pasture, to crops even in areas with marginal rainfall or soils. This is because the smaller land management units, without communal grazing and watering points, do not support large animal herds whereas the smaller units are suitable for cropping. The key resources become a focus of competition and conflict.

- An intensification of agriculture as shifting cultivation is no longer possible, all land is placed under crops, long fallowing becomes difficult to practice, and permanent cropping becomes the norm. In those areas with commercial crops and good access to markets, the intensification process has led to adoption of more intensive soil management practices such as soil conservation and application of animal and chemical fertilizers. In cases without access to markets or without high-value commodities, intensification of use occurs without sufficient soil management to prevent degradation.

6. Market Access and Infrastructure Development

Government policy has strongly influenced the spatial structure of markets in East Africa through investment in transportation infrastructure, land alienation and allocation, settlement schemes, and economic policies. The national and international economic policies that have encouraged or constrained economic activity include those affecting commodity marketing, taxation, import/export controls, monetary policies and SAP. These have combined to influence production of crops and livestock, as well as industrial activity.

In all study sites economic driving forces have had a significant impact upon land use from colonial times to the present. Their location relative to markets, determined by accessibility, and their competitiveness in supplying products relative to other sources, have influenced their response to market opportunities. In the early colonial period some pre-existing markets were isolated from the economy and declined in importance while others grew as they became more central to colonial economic activity, settlement and administration, and related infrastructural investments in roads and railways.

Later the role of within-country markets expanded with urbanization while that of overseas markets changed as opportunities arose in terms of global competitive advantage separate from the colonial pattern, though inertial effects of colonial production and marketing infrastructure continues to influence competitiveness of production activities. Only with focused investment in improved transportation have some formerly isolated areas been able to take advantage of economic opportunities resulting from liberalization of economic policy in recent years. In the sites, different livelihood systems, and individual producers within them, have had varied ability to engage in the cash economy depending upon natural resource endowments and their access to land, labour and capital.

A notable example is provided by the comparison between the Tanzanian and the Kenyan sites on Mt. Kilimanjaro (Campbell et al. 2004). With similar cultural and ecological conditions and potential for farming and herding, the location of the two areas relative to the historical pattern of national development led the Tanzanian side to be central to Tanzania's development while the Kenyan side has remained isolated from the mainstream of Kenyan development. It can be argued that the historical pattern of land use in the Tanzanian site on Mt. Kilimanjaro is more similar to that on Mt. Kenya than the Kenyan side of Mt. Kilimanjaro.

7. Environmental Conditions As Limiting/ Promoting Variables

East Africa has average rainfall ranging between 500 mm per annum in the lowlands to about 2,500 mm pa in the highlands like Mountains Kilimanjaro, Kenya and Lake Victoria islands. However, in recent years it has experienced fluctuations of rainfall, particularly droughts. These drought periods were punctuated by abnormal climatic conditions like those of El Nino in 1997. There is concern in the region with climate change illustrated by increasing intensity of such extreme events Other important biophysical factors that influence land management and biodiversity include pests such as armyworms, locusts, grasshoppers, cutworms, the banana weevil and moles, and diseases like Coffee Berry Disease and Trypanosomiasis in animals. These may cause farmers and herders to plan their use of the land to avoid the problems, or cause them to alter their land use systems when the problems get severe.

An additional factor affecting land management in East Africa is soil fertility. The analysis of soil samples in Embu and Loitokitok in Kenya, Lake Mburo and Kabale in Uganda and the southern slopes of Mount Kilimanjaro have revealed that there is decline of soil fertility due to over-cultivation (this is discussed in more detail below). The soil fertility has also declined due to inappropriate land management especially the substitution of natural vegetation with exotic trees such as pines that have a tendency of producing acidic soils.

IV. THE LINK OF ROOT CAUSES TO CHANGING LAND MANAGEMENT AND LAND DEGRADATION

1. Introduction

The discussion above has focussed on land use changes occurring at landscape and broader levels. Parallel changes have occurred in land and soil management at the field and household levels, also affected by a variety of factors including policies, economic conditions and intensification-type processes. The evolution in land use towards crop-livestock mixtures, more permanent cropping, and increasing investments in the land have affected land and soil management in the field. The impact of these changes particularly on soil productivity and degradation varies greatly over space and between households. The relationship between poverty and degradation will be particularly reviewed, as well as a comparison of situations across the ecological gradient.

2. Evolving field management over time and location

The LUCID study sites include two areas (there are others elsewhere in East Africa) that have a long history of intensive agriculture and soil management. The Chagga system on Kilimanjaro, for example, had a community irrigation system and highly productive, biodiverse home gardens. The Embu on the Mt. Kenya slopes, on the other hand, were forced to relatively quickly develop such an intense system following the implementation of land adjudication in the 1950s and 1960s when families were allocated small plots of private land. Their experience reflects changes that occurred later in other sites as people responded to new circumstances:

a) a reduction in fallow length
b) a reduction of livestock herd sizes with the loss of grazing land
c) almost continual cropping on the fields
d) severe soil erosion and loss of nutrients, declining productivity
e) eventually, adoption of terraces and other soil conservation measures promoted by governmental extension agents
f) installation of high value export bush crops (tea and coffee) with accompanying mandatory mulching and use of chemical fertilizers. Wealthy farmers found it profitable to transport manure from the dryer zones.
g) planting of trees, vines and bushes along field boundaries and around the home to prevent erosion and provide fuelwood and other products
h) raising of dairy cows fed with planted fodder and purchased concentrate. Much of the milk was sold to a parastatal organisation, and the highly valued manure was applied to the fields.
i) with less erosion and added organic materials, soil productivity increased though farmers say not to the same level as it was originally
j) changes in crop mixtures as markets for commodities (coffee and milk, for example) fluctuated. Farmers are experimenting with growing vegetables and other crops but have lower incomes.

This pattern, of declining then improving soil productivity with intensive soil management, is the best that can be expected. Whether other areas without Mt. Kenya's volcanic soils, moderate climate and ties to national programs and markets can follow this pattern is not clear.

The early stages of the pattern, i.e., declining fallow length, reduction in herd size and continual cropping on fields, is already occurring in several of the semi-arid sites. However, these areas typically have inherently poor soil, rainfall events are extreme and cause severe erosion, and high

temperatures and termites decompose organic matter quickly. Indeed, in the land degradation analyses (Gachimbi 2002), the fields in drier or lower elevation areas have significantly fewer nutrients and worse erosion. There was a strong relationship between the length of time the field had been cultivated and perceived degradation, as well.

Farmers recognize the impact of cultivation on the severity of erosion and the loss of fertility. In Kilimanjaro Kenya, a large percentage of farmers in the farming and the mixed agro-pastoral areas report taking land out of production and/ or planting crops less demanding of nutrients—signs of being forced to reduce their intensity of use because of degradation (Campbell et al. 2004). In the semi-arid zones below Mt. Kenya, farmers have benefited from soil conservation programmes and many fields have terraces, but farmers report that their soil is nevertheless rapidly degrading. The level of application of inputs, including manure, fertilizers and other chemicals, is much lower than in the upper zones. The reasons probably include the low value of the crops produced, insufficient to cover the cost of inputs, and the higher poverty levels. Ironically, a smaller percent of households own animals in the drier zones. In Uganda, farmers in a former pastoral area report that they are increasing their use of chemical fertilizer, probably from none to some, but nevertheless an indication that when economics permit, farmers will increase their investment in semi-arid rainfed cultivation. The most critical land degradation situation is, however, in rainfed agricultural areas in semi-arid zones. In these situations, the poor and declining soil productivity reflects the farming system's poverty and lack of economic stimulation.

3. Household variation in field management

Even in the most productive, highly managed zones, however, the variation between households in levels of soil management and productivity is as great as it is between zones. A common pattern emerged across zones of how the lack of household resources affects the levels of investment of labour and capital on the land. Poorer households make significantly fewer investments on the land, such as manure, chemical fertilizers and to some extent soil and water conservation techniques. This is due to the lack of capital to invest, fewer farm resources including animals, and a labour shortage. The labour shortage is due to especially male members working outside the farm, an inability to hire labourers, and the household's low social capital in the community that might otherwise assist. These farms tend to produce low value commodities, so have less incentive and less cash to invest in the land. The variability between households is closely related to household composition—the number of adults, and the gender of the acting head of household. The variables—household size and composition, and resources, are highly associated conceptually and correlated statistically, but in summary the findings are:

a. the combination of agricultural wealth factors—farm size, number of animals and number of workers (family and especially hired in)—is more important than any single of these. This agricultural wealth combination is closely associated with degree of soil management, particularly application of manure, but also the application of fertilizers and use of soil conservation measures.
b. Household composition is a critical variable explaining variability in soil management and fertility. It is associated with agricultural wealth but provides a critical explanatory factor. Widows are the poorest of all categories with the least amount of land or other resources. They apply the least amount of manure, and have declining soil fertility. In other, usually young households where the husband is living and working away from the farm, the absence of the husband affects farm resources such as labour and farm size, and is closely linked to poverty. Husbands leave very small farms because the family needs non-farm income, but once the husband has left, farm sizes or other signs of agricultural wealth do not increase. This group has the worst declining soil fertility. Finally, those households where the husband is living on the farm but who has an outside source of income is the wealthiest group, has the highly levels of soil management, and highest levels of improving soil fertility. In general, then, there is often an overlap between female-headed households and the poorest households, especially in the younger and older age brackets. Gender disparities reinforce the already precarious situation of poverty. The poorest households tend to sell off their assets, including land, in times of emergency, resulting in a growing

percentage especially in poorer communities of near-landless households whose farms are often characterized by degraded soil.

c. Off-farm income is therefore critical to the general wealth of the farm household. Employment that has a higher return appears more likely to be invested in maintaining the farm. The presence or absence of the husband, however, is more important than the type of employment indicating that any outside income is less likely to be invested in the farm if the husband is absent.
d. Soil management and land degradation also varies between communities in similar agro-ecological zones in different countries (e.g., comparing high elevation areas in Rwanda, Uganda and Kenya). In countries in which the agricultural sector is not as profitable, or where other problems such as insecurity affects the local economy, farmers invest significantly fewer resources in their land, and the effects are reflected in lower productivity and in worse soil degradation.
e. The apparent spiral relationship between poverty and degradation is not irreversible. Over time, as the agricultural sector becomes more profitable and other conditions become more favourable, farmers start to increasingly invest in soil management after a short lag period (observed in Uganda and Kenya). Policies and programs may have a large impact during this transition period, when returns to investment in the soil may be met in the short to medium term.

The poverty/ degradation relationship is, therefore, complex but real. Poverty, poor land management and land degradation are much more common and persistent in marginal environments—in this study, the remote, semi-arid zones. Even in higher potential zones, however, the poverty/ degradation relationship follows a similar pattern. Those households with fewer farm and non-farm resources are those who cannot apply soil inputs or otherwise invest in their land, and their fields are more likely to have declining soil fertility. Household composition, especially the absence of the husband in poor households, is a compounding variable negatively affecting land management. These, the poorest of the poor, cannot easily reverse their fortune to find the labour and other resources to invest in their farm and reduce the soil's degradation.

4. Evolving Land Management in Grazing Systems

a. Herding Systems

Since the colonial period, herding systems in East Africa have experienced chronic pressure to alter their land use pattern as a consequence of multiple forces including government policy towards livestock, farming, and wildlife; population growth; encroachment of crop agriculture; civil strife; a governmental cultural bias against herders who were viewed as resistant to economic development; and extreme environmental circumstances, particularly droughts and floods. These pressures have resulted in reduced access by herders to vital grazing and water resources, competition over resources between herders and wildlife, sedentarisation of pastoralists, and increases in the intensity of resource use in areas where water and grazing remain accessible.

Critical to the sustainability of livestock based livelihoods is access to sufficient water and pasture at critical periods – during the annual dry seasons and recurrent droughts. During wet seasons, herders disperse their livestock over wide areas of savannah landscapes, while in dry seasons and droughts they retreat to mountain slopes and to riverine and swamp areas in the lowlands where water is available perennially.

In the past, grazing intensity was distributed such that pasture was not depleted except during periods of drought. National level colonial reports charged that overgrazing was chronic and widespread, but district reports disputed this pointing out that degradation of pasture was limited to periods of drought. Nevertheless policy makers in both the colonial and independence periods adopted policies that assumed that mismanagement of rangeland resources was the norm.

Only recently has policy come to respond to the reality that herders do not indiscriminately degrade their resources, and in Kenya there is renewed interest in developing decentralised slaughtering and

associated industries to promote livestock-based economic opportunities in semi-arid areas. However, a variety of factors has reduced the viability of extensive livestock production and these will need to be assessed in any livestock development strategy. These include the encroachment of farming into the riverine and swamp areas and on the mountain slopes reducing access to dry-season resources, the demarcation of national parks that enclosed perennial water and grazing for the almost exclusive use of wildlife, and severe droughts. In addition, civil strife has disrupted livelihoods, altered access to land, and dislocated marketing systems.

In consequence livelihood systems for many herders have become less sustainable. They have been forced to adapt to altered access to water and pasture. The relative wealth of the cropping systems that have encroached upon traditional herding resources has resulted in many herders settling and diversifying into farming. Others continue their extensive herding systems. Where civil strife has occurred, as in Uganda, systems are under reconstruction and adjusting to altered socio-economic and political conditions.

Herd size and composition have altered. There is evidence that in the extensive systems, herders who depended on access to areas now under cultivation have reduced the size of their herds. Where this is the case grazing intensity declines, and there may be a reduction in setting of fires such that grassland is diminishing and bush/tree vegetation is increasing in the rangelands. This has implications for soil stability, and for the biodiversity of flora, birds, and wildlife. There is evidence from the Loitokitok Case Study in Kenya that those who remain in the traditional herding economy are poorer than those who have diversified into farming.

Where herders have diversified into farming they have become more sedentary, and the shoat-cattle ratio in their home herds has changed to include more shoats. With the income from irrigated or rainfed crops, some have purchased additional cattle that are managed off-farm. Around the homestead, grazing intensity has increased and access to water is a problem as riparian areas are cultivated.

The viability of both the extensive and the more sedentary livestock systems is affected by restrictions on movement of animals to pasture and water due to an increase in fencing of fields. Such fencing is a response to crop damage by wildlife and by livestock. As land adjudication proceeds to provide for private ownership rather than open-access or group ranches, the impact of fencing upon livestock management, and upon wildlife dispersal, will increase.

In many farming areas, the value of livestock as producers of milk and manure has resulted in the adoption of exotic species of dairy cows in systems of limited or zero grazing.

b. Wildlife

While the gazetting of national parks and reserves has afforded protection of wildlife for decades, in many areas dispersal into adjacent areas is necessary to sustain wildlife populations. Socio-economic situations in areas adjacent to parks and reserves thus have implications for wildlife conservation management. Some such developments, such as civil unrest, have resulted in the decimation of wildlife herds. More widespread is a chronic problem of increasing human-wildlife conflict resulting from wildlife predation on cattle, shoats and other livestock, and damage to crops.

This is associated with the extension of farming into areas formerly part of the wildlife resource base. As with herders, wildlife has experienced reduced access to some grazing and water resources. These have in some cases been resolved by wildlife moving elsewhere, while in others they persist and conflict with people ensues.

A variety of solutions to human-wildlife conflict have been proposed and implemented but the issue remains vital. Many now argue that conservation of wildlife will depend either upon aggressive restrictions on human land use, or that people living adjacent to wildlife populations must be provided sufficient financial incentives for them to accept and protect wildlife. The proponents of

each position are vigorous and tend to be oppositional. Conservation of mammal biodiversity under these circumstances is a highly political issue.

In summary, land use change in East African livelihoods that include livestock production has been dynamic for the past century. Initially such change was driven by land alienation for colonial settlement. Livestock systems found themselves restricted in area, and in the quality and quantity of water and pasture resources available. Over the past 50 years, and particularly since independence, the creation of parks and reserves, and the extension of crop agriculture in to the wetter margins of the rangelands have altered the viability of extensive livestock based livelihoods. In some areas this has been exacerbated by the consequences of civil strife. Economic returns to mixed herding-cropping systems are greater than to herding alone. Many herders have become poorer, while others who have successfully diversified have become wealthier. Under both systems patterns of land use have changed with implications for grazing intensity, the structure of vegetation, and the distribution of wildlife, again illustrating the importance of the poverty/ degradation relationship.

V. DISCUSSION AND CONCLUSION

1. Pattern of Extensification and Intensification of Land Use in East Africa

In summary, the most significant land use and cover change that occurred in the East Africa region since the 1960's has been an expansion of cultivation from the more humid, higher potential areas into the sub-humid zones and then into the semi-arid bush. The landscape of the semi-arid zones has changed from one dominated by bush savannah used for grazing by pastoralists, to one of a mix of cultivation and bush (Box 2). The conversion from bush to farmland was precipitated in many places by governmental land tenure policy that altered the land management and ownership structure from a more communal to a private, individualized system. The change in land tenure, combined with migration push factors elsewhere, led to in-migration by farmers and the transformation of the land use system from one dominated by pastoralism to one of mixed agro-pastoralism. In several sites, the transformation from pastoralism to farming reflected the lack of economic and political power of pastoralists relative to farmers—especially where pastoralists have little national-level power, they lost their control of the land to large scale land users, including parastatals, and to small scale farmers. Many pastoralists took up agriculture as their total grazing land shrank, as they lost access to key dry season and drought period water and grazing resources, and with economic and social pressures to sedentarise. To reduce their vulnerability to droughts and other shocks, pastoralists like others have diversified their economic base. The extensive, nomadic pastoral land use system has greatly changed in all the study sites, although this system remains important in more remote, insecure or arid landscapes of East Africa.

Many of the rainfed crops in the drier zones are not intensely cultivated, however, due to low returns to labour. The crops are of low value, and risks of drought and pests are high. The semi-arid zones appear to be in danger of worsening soil degradation and poverty due to this expansion of cropping into environmentally fragile and climatically risky areas. Indeed, there are signs of farmers switching to crops more tolerant of degraded soils, and the rate of expansion of cropping into semi-arid zones has slowed in the Kenyan and Tanzanian study sites. The contraction of grazing orbits and concentration of livestock occurring in some areas could also lead to a degradation of pasture and soil, continued shrinking of family herd sizes and poverty for those without alternative income sources. Out-migration is common among men of the poorest families especially in these semi-arid areas. In some study sites, the husbands in over half of the households are not working their own land; but the additional income they earn does not necessarily bring their families out of poverty.

Box 2. Pattern of extensification and intensification in semi-arid zones

1950's: Economy based on livestock herding.
In some areas, shifting cultivation was practiced.
1970's: Expansion of cultivation into the grasslands by farmers and agro-pastoralists. Sedentarisation of agro-pastoralists in many areas.
1980's: Land tenure changes, including a general shift from communally managed land by clans, to more privately managed land (e.g., to commercial ranches, or to family land holdings). Much in-migration by farmers from more densely populated areas.
Extensification of cropping. In some areas, rapid clearance of bush.
1990's: Further extensification of cropping.
Intensification of the agricultural system with more permanent cropping and shorter distance livestock herding. Some field soil management, but land degradation. Rainfed crops bring only limited income.
Along streams and in wetlands in some areas, intensive, market-driven cropping expands.
Current: Rate of expansion of rainfed cropping has slowed in several areas.
Livestock herds are smaller, stay nearer homestead.

In contrast, another land use conversion in semi-arid areas has led to an important new source of income—crops grown in wetlands or under irrigation and sold on national and international markets. In select areas with available water and near transport routes, both small and large scale producers have developed schemes to produce vegetables, fruit, flowers, rice and sugar cane using large amounts of water, chemical fertilizers, pesticides and fungicides. Many of these intensive, high input systems have been developed by large scale producers from outside the area or by the government, while others by wealthy locals. The benefits are often concentrated in a few hands, however, and the medium term environmental impacts especially on water quality and quantity are negative. The intensification of this system has come at the expense of other land use systems in the same area, as water sources for livestock, wildlife and people have become scarcer.

The wetter, more productive land and water sources are therefore increasingly less available to livestock and wildlife for dry season grazing and drinking. The land use conversion has led to higher land productivity in monetary terms but these gains are offset by the reduced productivity of livestock and wildlife systems. The people who are gaining may thus be different from those who had depended on the resources. Conflict over limited grazing and, increasingly, over water is of critical concern. Wildlife is also greatly affected when the new cultivation is placed along a migration corridor. The wildlife species requiring frequent access to water are particularly vulnerable to loss of access to watering sources (Worden et al. 2003).

On the other hand, the humid to sub-humid areas, most of which are densely populated, appear to represent an intensification success story. The intensification theory addresses how small scale farmers are expected to adopt their farming system to increasing population densities and associated reduction in farm sizes by increasing their application of labour, capital and land saving technologies. In many places, intensification occurs only after people have settled in new areas and exhausted any available land, and so land becomes scarce. In the sub-humid zones in East Africa, conversion of land use from mostly grazing to cropping occurred in the 1960's and 1970's. The extensification of cropping was then dramatic and wholly converted use of land. Where marketing and environmental conditions were conducive, this was followed by intensification and development of a productive, market-oriented system. An example of temporary intensification was the arrival then departure of high-input cotton within a 15-year period. Staple food crops replaced cotton, and eventually maize and beans for the market became the dominant crops.

In the humid, highland zones, highly productive agricultural systems with intensive soil management support many people and sell a large amount of food and cash crops—an intense use of the land. Governmental and parastatals programmes were instrumental in the earlier development of the tea and coffee sectors. Farmers have been forced, however, to respond to changing economic circumstances by modifying their farming system as international coffee and tea prices declined precipitously and as governments privatised production and marketing structures. Many farmers eventually removed their coffee bushes to plant more marketable, if less remunerative, crops, representing a de-intensification of land use. Land fragmentation and land shortage is a major problem. Responses have included purchasing land in or migrating to semi-arid zones, but especially by reducing dependency on the land. Families have focussed their investments on their children's education so that they learn a trade other than farming, many people seek non-farm employment (in some cases leaving their farms vacant), and, in the Mt. Kenya site, birth rates and population growth rates have declined rapidly.

The pattern of land use and cover change appears to have followed a non-linear path of intensification and extensification, therefore, with variations in rate and with reversals. The pattern for the semi-arid areas, summarized in Box 2, includes an initial intensification of the livestock system (sedentarisation and shrinkage of grazing land), followed by extensification of agriculture, and then intensification of agriculture with increased use of inputs and labour. Where marketing and environmental conditions are marginal, however, the initial conversion to crops has been followed by low and in some cases declining intensity of use. In the more humid areas, farming systems have evolved with shifts in types of crops and trees being grown and livestock management, and soil management practices.

2. Political and Other Forces of Change

The examination of intensification and extensification above reveals the variety of influences affecting the rate and direction of intensification besides population increases and land scarcity. In East Africa, the intensification/extensification process has been greatly modified by wider socio-economic conditions and local events that often overwhelmed the general pattern. Many of these influences are included in the political ecology framework.

Across the region, land tenure programmes and other policy shocks have greatly influenced how and when agro-pastoral land use systems have changed. Agricultural intensification and extensification patterns were closely affected by national and international policies including structural adjustment at the international level, and economic structures at the national level (Table 1). Examples of changes in governmental policy that affected land use include:

- Change from centralized to decentralized (and visa versa) governmental management of communal or governmental land;
- Change in enforcement of restricted use of protected areas;
- Nationalisation or privatisation of production and marketing structures;
- Subsidizing, and removing subsidies, on agricultural inputs and commodity prices;
- Moving farmers to villages and communal farms (villagisation);
- Land ownership or access rights to small holder land changing between the national government, the local government, the leadership of clans or ethnic groups, and private individuals;
- Other changes in land tenure, including settlement schemes, and which groups have rights to settle on a piece of land.

In addition to these often abrupt changes in government policy, more gradual if similarly influential government decisions have affected land use such as: regional and temporal variations in government investment in road infrastructure, agricultural extension, primary education and health care. Non-policy impacts of government such as civil unrest and corruption have also had major impacts on land use in East Africa, particularly by affecting agricultural and non-agricultural economic costs and opportunities, and migration.

Economic forces of change were mentioned throughout the above discussion of intensification and extensification. In East Africa, these economic forces have been particularly linked to policy and programs. For example, intensification processes and rates are affected by household level decisions on how to most effectively produce using existing land resources. The major shift that occurred in the sub-humid sites is that crops overtook herded livestock as the most profitable use of household land and labour, and sedentarisation and intensification rapidly occurred. Why household circumstances changed to cause this shift to crops was due to non-economic circumstances at different levels including land privatisation programmes and large family sizes. Markets and prices of livestock and crop commodities played a large role in affecting decisions on crop/ livestock mix and crop choice, yet these economic factors have been greatly influenced by national and international policies and programmes. A governmental decision to delay paving a road, for example, has major reverberations in the ability of farmers and pastoralists to market their products. Similarly, agricultural subsidies in developed countries and the growing international supply for former East African export products has greatly affected farm gate commodity prices and land use decisions at the household level. Diversification of food and income sources has become a critical response to the risk and uncertainty associated with agriculture.

3. The variety of agents

The land use changes that occurred in East Africa went beyond the expected agricultural system processes associated with small scale farmers adapting to changing circumstances. Governments were also active agents of land use change, and large scale land managers had a major impact on the landscape. Both of these latter groups have often been overlooked in explaining or predicting land use change by political ecology studies, and by the wider land use/ cover change literature.

In addition to the land policies mentioned above, a huge impact of government on land use and land cover in the sites was their management of protected areas. The gazetting of large expanses of land with protected area status occurred during the colonial administration with the delimiting of parks and reserves. During the post-independence period examined in this study, however, governments have de-gazetted some of this land especially for large-scale agricultural projects, but also to settle small scale farmers. More commonly, governments have varied their enforcement of restrictions on the use of the land—varying from at times from being highly restrictive, to allowing small patches to be cultivated, to permitting large areas to be cut and cultivated or grazed. These variations in enforcement have come with changing pressure put on governments by international and national conservationists, perceptions of the importance of conservation, and degrees of governance strength and levels of corruption. International tourist income, the main economic benefit of protected areas, has been highly variable over time and between parks. With increasing pressure on the protected areas from neighbouring communities, often limited benefits accruing to the communities from the parks or reserves, and the high agricultural potential of many of the protected areas, use of these lands will probably continue to shift with the varying forces.

The other large scale land managers in the studies sites are private, institutional or parastatal ranches, plantations and farms. Examples are irrigated rice and sugar cane schemes, tea and tree plantations, flower farms and cattle ranches. These large scale managers tended to use and to change their use of the land differently from small scale users—their initial installation caused major, rapid changes, and changes afterwards were infrequent but, when they did happen, were abrupt. The amount of land managed by large scale holders expanded during the study period as wealthy farmers purchased land, and as institutions or parastatals were allocated land by governments. Many use a high degree of agricultural inputs such as water for irrigation, which is causing conflict with other land users in some areas.

Although land use change by large scale land users, particularly governments, may be difficult to predict, the land they occupy is not only large but often encompasses critical resources for other groups.

UNDERLYING DRIVING FORCES	DIRECT DRIVING FORCES	KEY PROCESSES
Policies/ government Land policies (e.g., tenure, property rights, gazetting of protected areas, settlement schemes, villagisation) and how enforced Ag. policies: parastatals, cooperatives, plantations, support & marketing of crops and technologies Investment in education, health, infrastructure (where and how much) Industrial and urban policies Centralization/ decentralization of government Structural adjustment programmes: liberalization of markets, subsidy removals, institutional and monetary reforms International environmental protocols, organisations Donor assistance Level of corruption, good governance Stability, elections, war Changing power relations between groups, regions *Economic changes* Declining international prices and terms of trade for agricultural commodities, minerals, timber Growing national demand for maize, other food Fluctuations in growth of non-agricultural sectors Increasing/ decreasing private traders *Regional characteristics* Relative wealth, availability of jobs Land availability Protected areas, tourism Agro-ecological potential Diseases (animal, plant, people) Ties to markets, national economy Existing land ownership, use and cover *Individual or household characteristics* Wealth/ poverty, education, employment Age, gender of head of household Ethnicity Social ties/ networks	*Demographic factors* Variable in and out migration, labour migration (related to conditions in source and destination): Birth & death rates (related to health care, disease, household economics, education, culture) Growing population size and increasing density *Local economic factors* Changing price, marketability and production costs of crop, animal and tree products Ag. technological change: animal traction, tractors, irrigation system and pumps, soil & water conservation, fertilisers and pesticides, crop and animal species and varieties Changing crop choice: less coffee, cotton, millet and bananas, and more maize, beans, vegetables, flowers Non- and off-farm income diversification Land scarcity: lack of pasture, small farm sizes Large scale public and private land managers Privatisation of former communal land (informal, adjudication, sub-division of ranches, etc.) *Cultural factors* Inheritance and tenure system Acceptability of selling land Changing role and power of clans, chiefs Traditional livelihood strategy (e.g., Chagga home gardens, cropping, pastoralism, trading) Value placed on home land, sacred forests *Social factors* Changing distribution of land, wealth, power Commercialisation of labour, water, land and tree resources Competition / cooperation between groups Changing gender roles and responsibilities *Environmental factors* Soil degradation/ improvement, pasture degradation/ imprv. Droughts, rainfall variability Diseases (human, animal, plant), wildlife (as resource, conflict with)	*Agricultural system processes* Sedentarisation of people conducting shifting agriculture, pastoralism Extensification of cropping especially to former pastoralist land, adjacent to protected areas Intensification of crop-livestock systems, higher input of labour and capital per unit of land, changing technologies and soil management (has at times reversed due to economic, political situation) Fragmentation of land holdings with inheritance, selling parcels Re-distribution of land holdings between generations, households, groups Von Thunen: land use affected by distance to road, market, and the price and perishability of product *Other processes* Urbanisation, and rural-urban linkages Rural income diversification National economy evolution from agriculture to industry, commerce and services Gravity & other migration models: rural-rural migration with land availability as economic factor, temporary and permanent migration to urban centres

Table 1. Driving Forces of Land Use Change in East Africa

4. Policy implications

The overriding finding of the LUCID land use changes analyses is how rapidly farming systems and land use have changed. Small-scale farmers and pastoralists have changed their entire farming system several times since the 1950's. New land uses have been developed, and existing land uses have been transformed. In general, the changes have allowed many more people to live on the land as farmers and agro-pastoralists, and the farming systems have shown flexibility and adaptability in face of changing international and national economic and political structures. Diversification, towards a mixture of crops and livestock, cash and food crops, and farm and non-farm income, has been a critical means for households to reduce their risk in face of these changes.

Nevertheless, rural poverty is common and key environmental resources are becoming increasingly scarce, contested and/ or degraded. Approaches to these environmental issues need to address access to resources and economic benefits for communities, and the role of large-scale landholders.

These rapid changes in land use link to critical issues of sustainable livelihoods, land degradation and biodiversity that are different from one production/livelihood system to another, resulting in a need for policy to be more focussed to address their particular needs.

Livestock Grazing:

Implications of changes in access to land and grazing orbits (loss of dry season hill grazing and of wetlands/ water) include:

- Increased poverty of pastoralists,
- Increased grazing intensity,
- Pasture and soil degradation, and
- Decreased biodiversity (plant species, birds, wildlife).

Rain fed cropping in semi-arid areas:

This is the most critical issue from all LUCID sites. These sites:

- Are often economically marginal,
- Usually are remote, and not well linked to national economy,
- Have many women-headed households who are especially vulnerable to poverty and external shocks.

Land use change in these areas is associated with:

- Severe soil degradation,
- Heightened climatic risk to households,
- Insufficient water conservation in soil and water conservation efforts.

These semi-arid farming areas need:

- Drought resistant crops, and
- Higher value crops and the means to market agricultural products;
- Ways to diversity income sources locally, such as processing of commodities.

Wetlands and irrigated agriculture:

The increased intensity of land use in wetlands represents one of the critical recent changes in land use, and has implications for sustainability of wetland resources and of livelihood systems dependent upon them.

Irrigated systems have:

- Disrupted the pre-existing distribution and mobility of herding and wildlife activities,
- Affected access to water resources for people, livestock and wildlife,
- Reduced water quality and quantity for many users, and
- Increased socio-economic disparities by concentrating economic benefits among some.

Policy options include:

- Increased attention to issues of water quality, quantity, flow, and distribution among user groups, and
- Promote traditional water management practises, for example, the Chagga system for community sharing of water and upkeep of canals.

Farming-livestock mixed system:

In both semi-arid lowlands and hill slope areas there has been an increase in the numbers of people adopting mixed crop and livestock production systems. There is evidence that these promote more sustainable livelihoods through:

- Diversification of economic opportunity,
- Associated reduced vulnerability to declines in production of one facet of production due to drought, disease, and economic forces.

They also address the degradation / poverty linkages through:

- Allowing people a more balanced diet and diverse economic opportunities; and
- Providing for more effective land management through access to manure and in some cases animal traction.

The potential of these mixed production systems would be enhanced by policies that facilitate:

- Consistent commodity prices,
- Reliable commodity markets,
- Access to inputs and credit,
- Improved infrastructure, and
- Options for employment in processing and marketing activities based on local production of crops and livestock.

Examination of Issues at a Broad Scale

Broad policy issues that underlie the development of all areas and livelihood systems include:

i) For land use generally, a broader scale view of land management, that includes community participatory management with government representatives, especially
   - In marginal lands, in particular the semi-arid lands,
   - Where poor people are living,
   - Where there is competition over limited water or land resource, and
   - Where land use affects others (e.g., watersheds, stream or pipe water collecting).
   - Participatory management needs to specifically include various groups including women, and "squatters" or tenant farmers.

ii) Strengthen non-farm income sources and opportunities, in urban *and* in rural areas. As discussed above, these might include options for employment in processing and marketing activities based on local production of crops and livestock.

iii) Improved transportation infrastructure, roads and railroads, to assist commodity transport, permit better competition with international markets.

iv) Strong educational and health facilities in rural areas.

Science in the Interest of Society: Enhancing Linkages between Policy-Makers and The Research Community

A number of activities of the LUCID Project have involved interactions among the scientists of the LUCID Project and policy-makers in East Africa. These activities have led to lively discussions regarding the definition of research problems, and the application of results, to issues of contemporary policy concern.

Among the conclusions is that there needs to be increased opportunity for:

- Policy-makers and scientists to meet and discuss issues of common concern; and

- Policy-makers from different sectors of government need opportunities to meet to discuss issues that cut across the spheres of responsibility of different ministries.
- Consolidation of results of research in each country.
- Depositing and sharing data sets, information, reports and articles produced by government agencies, NGOs, research institutions (such as universities, government laboratories, and national and international research centres) and individual researchers, subject to concerns of privacy and intellectual property.

Specific actions that could facilitate these objectives include:

- Researchers, both national and expatriate, should be strongly encouraged to share the results of their analyses within the host country.
- National universities, research institutes and similar organizations should consider coordinating a formal "seminar series" to bring together scientists and policy-makers on a regular basis to debate contemporary policy issues and related research findings.
- Results of research and related data/information should be collected, consolidated, and distributed.
- A government agency such as one concerned with environmental management, a national library, or a national university could be given responsibility for data management.

An Integrated Cross-Sectoral Approach to Policy in which Policy is identified as a Key Driver of Land Use Changes.

The analyses of the LUCID Team have demonstrated the complexity of interacting societal and biophysical processes that contribute over time to land use change, and implications for land degradation and biodiversity. The ability of the LUCID team to conduct its analysis was enhanced by the adoption of a comprehensive conceptual framework, political ecology. This framework not only enabled identification of key drivers, and the importance of temporal and spatial interactions, but it also forced consideration of systemic effects of particular drivers through their interactions and feedback.

Thus a key conclusion of the analyses is that the adoption of a comprehensive conceptual framework that stresses system interaction and feedback between societal and biophysical processes is important to scientific assessment.

In a similar vein, the results of the analyses also have implications for policy formulation. Policy is shown to be an active and important driver of land use change. Policies have generally been devised and implemented through sectoral structures with sectoral objectives. The analyses have demonstrated that over the longer term unintended outcomes often emerge as the policy effects reverberate through the system. This suggests that policy-making would also be enhanced by the adoption of such a comprehensive conceptual framework, and multi-sectoral discussion of policy objectives, design and strategy.

In particular, policy-making needs to recognize and actively examine the positive and negative effects of past policies:

- Do not assume that the current situation is not the result of policies, many of which are probably still in place.
- There is a tendency for people to focus on population, environmental and maybe economic causes and solutions without acknowledging the role of past and current policies. Any proposed policy or program will probably affect the situation similarly to past ones, so we can learn from the past.
- Policies are frequently developed and implemented in sectoral rather than integrated contexts. While in the short- to medium-term desirable outcomes may ensue, longer-term outcomes resulting from impacts on complex societal-biophysical systems may have negative or even contrary outcomes.

- A critical consideration should be to encourage rather than constrain flexibility in future options for livelihood systems as there is much uncertainty resulting from system dynamics, and from unanticipated shocks in environmental and societal conditions.

This discussion has indicated that there is a great potential for more effective communication and dialogue between scientists and policy-makers over issues of common concern. This potential can only be realized where there is genuine interest on both sides, and where each respects the contribution of the other to the common goal of improving the sustainability of livelihood systems, while at the same time maintaining biodiversity and reducing land degradation. The LUCID Project has provided a venue for such interactions, and the lessons learned point towards options for a more integrated approach to science and policy.

REFERENCES

Biot, Yvan, Piers M. Blaikie, Cecile Jackson, and Richard Palmer-Jones. 1995. Rethinking Research on Land Degradation in Developing Countries. World Bank Discussion Paper 289. Washington, D.C.: World Bank.

Blaikie, Piers. 1985. *The Political Economy of Soil Erosion in Developing Countries*. Essex: Longman Group Limited.

Blaikie, Piers, and Harold Brookfield. 1987. *Land Degradation and Society*. London: Methuen & Co., Ltd.

Boserup, Ester. 1981. *Population and Technological Change: A Study of Long-Term Trends*. Chicago: The University of Chicago Press.

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. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 18. Nairobi: International Livestock Research Centre.

Campbell, David J. 1998. Towards an Analytical Framework for Land Use Change. In *Carbon and Nutrient Dynamics in Tropical Agro-Ecosystems*, edited by Bergstrom and Kirschmann. Wallingford, UK: CAB International.

Campbell, David J., David P. Lusch, Thomas A. Smucker, and Elizabeth Edna Wangui. 2004. Root causes of land use change in the Loitokitok Area, Kajiado District, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 19. Nairobi: International Livestock Research Institute.

Campbell, David J., Salome B. Misana, and Jennifer M. Olson. 2004. Comparing the Kenyan and Tanzanian Slopes of Mt. Kilimanjaro: Why are the adjacent land uses so distinct? Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 44. Nairobi: International Livestock Research Institute.

Campbell, David J., and Jennifer M. Olson. 1991a. Environment and development in Kenya: Flying the Kite in Kajiado District. *The Centennial Review* XXXV (2):295-314.

———. 1991b. Framework for Environment and Development: The Kite. CASID Occasional Paper 10. East Lansing: Center for Advanced Studies in International Development, Michigan State University.

Chira, Robert. M. 2004. Changes in Wildlife Numbers and Conservation in Embu and Mbeere Districts, Eastern Province, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 37. Nairobi: International Livestock Research Institute.

Ewel, K.C. 2001. Natural resource management: the need for interdisciplinary collaboration. *Ecosystems* 4:716-722.

Gachimbi, Louis N. 2002. Technical Report on Soil Survey and Sampling: Embu - Mbeere Districts. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 9. Nairobi, Kenya: International Livestock Research Institute.

Geertz, Clifford. 1963. *Agricultural Involution: The Process of Ecological Change in Indonesia*. Berkeley: University of California Press.

Grigg, David. 1980. *Population Growth and Agrarian Change: An Historical Perspective*. Cambridge: Cambridge University Press.

Kinzig, A.P. 2001. Bridging disciplinary divides to address environmental and intellectual challenges. *Ecosystems* 4:709-715.

Mbonile, Milline J., Salome Misana, and Cosmas Sokoni. 2003. Land use change patterns and root causes of land use change on the southern slopes of Mount Kilimanjaro, Tanzania. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 25. Nairobi: International Livestock Research Institute.

Mugisha, Samuel. 2002. Root causes of land cover/use change in Uganda: An account of the past 100 years. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 14. Nairobi: International Livestock Research Institute.

Noe, Christine. 2003. The Dynamics of land use changes and their impacts on the wildlife corridor between Mt. Kilimanjaro and Amboseli National Parks, Tanzania. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 31. Nairobi: International Livestock Research Institute.

Ntiati, Paul. 2002. Group ranches subdivision study in Loitokitok Division of Kajiado District, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 19. Nairobi: International Livestock Research Institute.

Olson, Jennifer M. 1998. A Conceptual Framework of Land Use Change in the East African Highlands. Paper read at Earth's Changing Land: Joint Global Change and Terrestrial Ecosystems and Land Use and Land Cover Change Open Science Conference on Global Change, at Barcelona, Spain.

Olson, Jennifer M. , Bilal Butt, Fred Atieno, Joseph Maitima, Thomas A. Smucker, Eric Muchugu, George Murimi, and Hong Xu. 2004. Multi-scale analysis of land use and management changes on the Eastern Slopes of Mt. Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 20. Nairobi: International Livestock Research Institute.

Otuma, John. 2004. The Effects of Wildlife-Livestock-Human Interactions on Habitat in the Meru Conservation Area, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 39. Nairobi, Kenya: International Livestock Research Institute.

Peet, R., and M. Watts. 1996. *Liberation Ecologies: Environment, Development, Social Movements*. New York: Routledge.

Rocheleau, D., B. Thomas, and E. Wangari. 1996. *Feminist Political Ecology : Global Issues and Local Experiences*. New York: Routledge.

Smucker, Thomas A. 2002. Land Tenure Reform and Changes in Land Use and Land Management in Semi-arid Tharaka, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 11. Nairobi, Kenya: International Livestock Research Institute.

Tiffin, Mary, Michael Mortimore, and Francis Gichugi. 1994. *More People, Less Erosion: Environmental Recovery in Kenya*. Chichester: John Wiley & Sons.

Tukahirwa, Joy. 2002. Policies, people and land use change in Uganda: A case study in Ntungamo, Lake Mburo and Sango Bay sites. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 17. Nairobi: International Livestock Research Institute.

Turner, B.L II, Goran Hyden, and Robert W. Kates, eds. 1993. *Population Growth and Agricultural Change in Africa*. Gainesville: University Press of Florida.

Wangui, Elizabeth E. 2003. Links between Gendered Division of Labour and Land Uses in Kajiado District, Kenya. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 23. Nairobi: International Livestock Research Institute.

William, Christopher M. 2003. The Implications of Land Use Change on Forests and Biodiversity: A Case of the "Half Mile Strip" on Mount Kilimanjaro, Tanzania. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 30. Nairobi: International Livestock Research Institute.

Worden, Jeffrey, Robin Reid, and Helen Gichohi. 2003. Land-Use Impacts on Large Wildlife and Livestock in the Swamps of the Greater Amboseli Ecosystem. Land Use Change Impacts and Dynamics (LUCID) Project Working Paper 27. Nairobi: International Livestock Research Institute.

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.

———. 2000. The Reworking of Conservation Geographies: Nonequilibrium Landscapes and Nature-Society Hybrids. *Annals of the Association of American Geographers* 90 (2):356-369.