Implications of trends in land use change for livestock systems evolution in East Africa: Lessons from the LUCID Project

Jennifer M Olson

ILRI

Discussion Paper No. 4 (Draft)
Targeting and Innovations

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
Implications of trends in land use change for livestock systems evolution in East Africa: Lessons from the LUCID Project

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Based on working papers and articles of the Land Use Change, Impacts and Dynamics (LUCID) Project

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Table of Contents

I. Introduction 1

II. Land use change patterns and driving forces 2
   A. Spatial and temporal patterns of land use change 2
   B. Driving forces of change 4
   C. Implications for livestock 8

III. Change in the agro-pastoral system 11
   A. Patterns of change 11
   B. Impacts of sub-division of land on livestock intensification 13
   C. Commercialization of cattle and crops 14
   D. The economics of livestock versus crops versus wildlife land uses 15
   E. Issues for livelihoods 18
   F. Impacts on livestock 20
   G. Conclusion 22

IV. Change in the mixed-crop livestock system 24
   A. Patterns of land use change 24
   B. Trends in intensification 25
   C. Impacts on livelihoods and livestock 29

V. Future trends 30

Annex: Trends in crop and livestock production 33
Bibliography 35
Boxes

1. Extensification and intensification in semi-arid lands 3
2. Droughts as catalysts of change 13
3. Conditions for sustainable intensification? 26

Tables

1. Intensification continuum for higher potential zones in East Africa 7
2. Optimal land use strategies in normal and drought years for Loitokitok Division, Kajiado District, Kenya 16

Figures

1. Rainfall gradient and land cultivated in Kajiado District, Kenya 4
2. Land use change between 1961 and 2001 in the Kiritiri area of Mbeere District, Kenya 5
3. Kibale National Park and surrounding areas land use/cover, Uganda 10
5. Manure application and change in soil fertility by wealth class in Embu and Mbeere Districts, Kenya 27
6. Extensification and soil management 28
7. Results of econometric model of land rents for rainfed agriculture and livestock in Loitokitok, Kajiado District, Kenya 31
8, 9 and 10. Rural, urban and total population projections, 1950 to 2030 for Kenya, Tanzania and Uganda 32
1. Introduction

The mixed crop–livestock system and the agro-pastoral systems have evolved rapidly over the past 50 years in East Africa. Livestock was and continues to be a major component of each system. The role of livestock has evolved, however, as well as the relative importance of each of the systems. The evolution is related to broad forces such as changing markets, population growth and migration, changes in land tenure and other policies, economic factors, and environmental conditions. These driving forces have led to rapid land use change particularly reflecting the growth of mixed cropping–livestock system at the expense of pastoralism, as well as major changes within the systems. The changes have allowed many more people to live on the land, 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. Despite the rapid evolution, rural poverty is common and key environmental resources such as water and grazing land are becoming increasingly scarce, contested and/or degraded. Poverty, poor land management and land degradation are much more common and persistent in marginal environments, especially, the remote, semi-arid zones.

This report summarizes over 20 years of research on land use change patterns and processes in case study sites across Kenya, Tanzania and Uganda to provide information on the evolution of livestock in the systems. Many of the case study sites cross-ecological gradients, from the Highlands to the lowland savannas, and offer a glimpse of how the mixed crop–livestock, the agro-pastoral and the pastoral systems have evolved in relation to each other. The purpose of this report is to highlight major trends in relation to livestock; additional information on each of the case study sites, the research methodology employed and on particular components, such as the root causes of land use change, trends in changing biodiversity and land degradation, as well as regional socioeconomic and environmental syntheses, can be found in the over 40 working papers of the Land Use Change, Impacts and Dynamics (LUCID) project. The LUCID working papers from which this report is drawn were authored by scientists and students in six institutions in East Africa, and by scientists and students in the US and France. Their contribution to this report is gratefully acknowledged and, when directly used, cited. This report is drawn particularly from LUCID Working Paper 47, the East Africa regional syntheses of land use change (Olson et al. 2004b). We would also like to acknowledge the financial support to LUCID of the United Nations Environment Programme and the Global Environment Facility.

This report consists of a description of land use change trends and driving forces, provides a summary of implications of these changes for livestock in mixed crop–livestock and in agro-pastoral systems, and then discusses processes that may affect future trends in land use systems.

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1. LUCID working papers can be downloaded in Adobe pdf format free of charge from www.lucideastafrica.org. Paper copies can be obtained by request to the LUCID Coordinators, Theme 1, International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya.
II. Land use change patterns and driving forces

The East Africa region is 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 a high degree of spatial and temporal variability, common spatial patterns of land use change are found across the region.

A. Spatial and temporal patterns of land use change

The spatial pattern of land use change over the past 50 years has been characterized by increasingly intensively managed landscape except in protected areas or in extremely marginal environments. The pattern occurred at an uneven pace across the region depending on historical conditions and varying driving forces. The most important land use conversions in terms of amount of land 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 cropping 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, most of the secondary towns in the study sites also grew rapidly, if not as rapidly as the primary cities. The relatively small size of local and regional towns belies their economic role in rural households, and the impact of off and non-farm activities on rural land use and land management.

The most significant land use and cover change that occurred in the region since the 1960’s has been the expansion of cultivation from the more humid, higher potential areas into the sub-humid zones and then into the semi-arid bush. The driving forces include demographic changes (local population growth and migration), economic changes (higher relative returns to labour and land in crops than livestock), policies (e.g. land privatization, support for export crops), and changing quality of and access to services and infrastructure. 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 1).
Box 1. Extensification and intensification in semi-arid lands

1950’s: Economy based on livestock herding.

   In some areas, shifting cultivation was practiced.

1970’s: Expansion of cultivation into the grasslands by frontier farmers and by local agro-pastoralists. Sedentarization of agro-pastoralists in many areas.

1980’s: Land tenure changes, including a general shift from communally 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 into grazing areas.

   Intensification of the agricultural system with more permanent cropping and shorter distance livestock herding. Some soil management, but land degradation is severe and rapid. Rainfed crops bring only limited income.

   Along streams and in wetlands in areas near markets, high-input irrigated cropping expands.

Current: Rate of expansion of rainfed cropping has slowed in several areas, perhaps because available land is too dry for cropping. Livestock herds are smaller, are grazed nearer homesteads.

   In poor areas, widespread short-term out-migration by husbands and long-term out-migration by children to seek income.

Source: Olson et al. (2004a).

The rate of conversion from grazing to cropping appears to be slowing in some areas (e.g. in the savannas east of Mt Kenya and below Mt Kilimanjaro on both the Kenyan and Tanzania sides) where the frontier of conversion is in drought-prone land. The reason for the slowing is probably related to the low potential of the remaining available land for crops (rainfall below 500 mm/year appears to be a limit for cropping) and/or the availability of better alternatives elsewhere for potential migrant farmers. Below 500 mm/year of rainfall, agriculture is really only practicable in small, intensively managed plots (Figure 2). In other study sites, the expansion of agriculture has either not yet slowed (e.g. around Kibale National Park in Uganda), or the conversion has not yet occurred (e.g. the predominately pastoral sites of Sango Bay and Kabale/Ntungamo in Uganda) (Mugisha 2002; Tukahirwa 2002; Mbonile et al. 2003; Campbell et al. 2004a; Olson et al. 2004a).
B. Driving forces of change

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 agro-pastoralism or even dominated by crops. In-migrating farmers obtained rights to former grazing land in a mixture of informal, familial land sharing agreements, to purchasing newly privatized land from its new owners, to being given the land in governmental settlement schemes. In some sites in Uganda, the in-migration of farmers to grazing areas has been limited by land tenure policies or local regulations (Mugisha 2002; Tukahirwa 2002; Mbonile et al. 2003; Campbell et al. 2004a; Olson et al. 2004a).

In Kajiado, Kenya, for example, immigrant farmers settled initially under informal arrangements with members of group ranches (GR). Fears that younger members of group ranches would be deprived of land rights, led to calls for subdivision of GRs to individual ranches by 1980. The profitability of farming in wetlands furthered this impetus to subdivide. Many GRs are now subdividing and herders are becoming herder-farmers alongside the immigrants. These changes in land tenure are affecting who has access to what land resources, such as along streams and in wetlands, dry season grazing, and wildlife migration corridors. These changes are leading to an intensification of land use and impact how livestock are raised, the viability of wildlife conservation, and result in social effects regarding the distribution of resources (Ntiati 2002; Campbell et al. 2004a).
In Mbeere District, Kenya, an abrupt conversion of land use from a mix of shifting cultivation (yellow) and grazing (beige) to permanent cropping that occurred in the 1980's following the implementation of a government land privatization, or adjudication, program (Figure 2). All the land that had been communally managed by clans was subdivided into farm plots and allocated to nuclear families. Fences were installed around the plots and bush was cleared to claim ownership, and free grazing was no longer possible. Herd sizes quickly declined and families then depended on cropping for most of their income. The Mbeere, who had considered themselves herders, became farmers within a span of a few years (Olson et al. 2004a)

Changes in land tenure arrangements by governments have been perhaps the most ‘shocking’ driving force of land use as administrative mandates were made for entire areas. Starting in the 1930’s and continuing until the 1960’s, parks were gazetted in land 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. 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. These changes are the result of a combination of government policies, local interpretation and implementation of those laws within the existing customary land tenure structure. The 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 privatization leads to improved land management, but it is definitely associated with an intensification of use. The role of livestock vis a vis crops thus changes with the land use changes, and with intensification (Table 1) (Olson 1998; Olson et al. 2004b).
<table>
<thead>
<tr>
<th>Factors, Indicators</th>
<th>I. Shifting cult 50 years ago</th>
<th>II. Permanent cult. Lake Mburu today</th>
<th>III. Intensification SW Uganda today</th>
<th>IV. Intensified Embu, Moshi today</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land tenure</td>
<td>Communal land holding.</td>
<td>Most land privately held.</td>
<td>Land privately held.</td>
<td>Land privately held.</td>
</tr>
<tr>
<td>Cropping system</td>
<td>Shifting cultivation, long fallows.</td>
<td>Permanent cultivation, short fallows important.</td>
<td>Consolidated, small farms.</td>
<td>Consolidated, small farms.</td>
</tr>
<tr>
<td></td>
<td>Low value food crops (sorghum).</td>
<td>Low/med value food crops (sorghum, beans).</td>
<td>Permanent cultivation, little fallowing. Low value food, med value cash crops (maize, tubers, coffee).</td>
<td>Permanent cultivation, no fallowing. Medium value food and high value cash crops (coffee, tea, vegetables, fruit, maize).</td>
</tr>
<tr>
<td>Trees in system</td>
<td>Needs met by wild sources.</td>
<td>Fuelwood deficit; plant fuelwood specially in woodlots and boundaries, fruit/medical specially near house.</td>
<td>Fuelwood needs met on-farm. Plant for local market (fuel, fruit, construction).</td>
<td>Plant for regional market (fruit, nuts, medicine) and for fodder.</td>
</tr>
<tr>
<td>Soil management</td>
<td>No inputs; crop residues burned.</td>
<td>Widespread use of crop residues, some manure used. Terraces used as boundary markers.</td>
<td>Crop residues and animal manure highly valued (moved within farm). Few chemical inputs (low cash returns). Soil conservation important.</td>
<td>On-farm manure used but not well managed. Off-farm manure and chemical fertilizer purchased. Erosion controlled.</td>
</tr>
<tr>
<td>Links with national/international economy, changes in terms of trade</td>
<td>National level growing in importance. Low value food products sold but little regional specialization.</td>
<td>Medium value export crop (e.g. coffee) and low value food crops traded.</td>
<td>Important in system: med/high value products sold, low value food products bought.</td>
<td>Important in system: med/high value products sold, low value food products bought.</td>
</tr>
<tr>
<td>Land, LABOUR, capital productivity</td>
<td>High labour prod.</td>
<td>Medium labour productivity</td>
<td>Low labour productivity</td>
<td>Medium labour prod.</td>
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<td>Low land productivity.</td>
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<td>Medium land productivity.</td>
<td>High land productivity</td>
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<td></td>
<td>Low capital prod.</td>
<td>Low capital productivity.</td>
<td>Medium capital productivity.</td>
<td>Medium capital prod.</td>
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<tr>
<td>Land Degradation</td>
<td>Low</td>
<td>Rapid degradation.</td>
<td>Degraded</td>
<td>Degradation reversed</td>
</tr>
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<td></td>
<td>Much grassland and fallowed land, patches of open woodland, scattered fields. Little out-migration, some for political or social reasons.</td>
<td>Much conversion to cropland, some fallow land, large patches of grass &amp; woods on marginal land.</td>
<td>Conversion to cropland almost complete; little fallow, few patches of grass or woods, increased planting of trees. Much long distance rural–rural to frontier land.</td>
<td>Landscape of densely planted crops and trees, increase in built-up land.</td>
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<td>Rural–urban increasing.</td>
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<td>Source: Adapted from Olson (1998).</td>
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</table>
C. Implications for livestock

Specific land use impacts on livestock include:

- **Fencing**: Fencing of the individual land units, to protect the newly privatized grazing resource and/or to protect crops and livestock against diseases, and against neighbours’ herds. It reduces the viability of large grazing orbits and large herds as access to land is lost. In some areas fencing has led to problems concerning wildlife migration corridors.

- **Smaller land management units**: The land management unit is declining in size and becoming increasingly fragmented 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. This reduces the amount of on-farm and of communal grazing land.

- **Loss of access to water and grazing in areas gazetted as parks and reserves.** In many cases, protected areas were chosen as key areas for wildlife hunting or viewing because they incorporated wildlife gathering points such as permanent watering sites. These same sites had been equally important to livestock. With the expansion of cropping often to park boundaries (e.g. Figure 2), the loss of these resources has become increasingly critical to livestock keepers especially in droughts.

- **Conversion of privatized land to crops.** A conversion of grassland that had been reserved as grazing 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 economically more productive under crops. In this process, often some people gain large land units or access to water whereas others loose. One outcome has been the sale of smaller, unproductive plots to outsiders or to large landholders, or the crisis sale of land during droughts or family emergencies leaving families near homeless.

- **Increased competition over key remaining communal resources.** The remaining communal key resources such as watering points, communal grazing areas, and woodlands or forests have become a focus of competition and conflict.

- **Intensification and a change in the role of livestock.** 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 manure and chemical fertilizers. In these areas, livestock (especially cattle) gain value as a source of high quality manure. Where dairy products can be marketed and where veterinary services are available, a switch to dairy cows can occur, in which case some land may be converted back from crops to forage. In cases without access to markets or without high-value commodities, intensification of cropping of use occurs with the shrinking of farm sizes but without sufficient investment in soil management to prevent degradation.
Although the general pattern across the region has been one of intensification as described in Table 1, intensification is not inevitable. Where conditions are favourable—stable government, governmental support for agriculture in the form of, for example, credit and extension, and favourable commodity prices and markets—the increase in population densities and economic development has led to successful intensification with sustained or increased per capita production and improved soil management. When conditions are not favourable—particularly during times of war, insecurity or economic declines—population increases have resulted in lower per capita production and to land degradation. Intensification is thus not inevitable and the process can reverse, as in Southwest Uganda during the years of civil unrest (Olson 1998; Olson et al. 2004b).

In summary, land use change in systems 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 expansion of crop agriculture into the rangelands have altered the viability of extensive livestock based livelihoods. This has been particularly evident in areas better connected to the national economy by a road network and markets. In more remote areas or where rainfall is very low, such as in northern Kenya, the pressures on the pastoralist systems are more related to low economic development, few government services, the lack of alternative income sources and population increases. These at times have been exacerbated by civil strife. In general, through, 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.

The most critical impact of land use change on livestock keeping has been the reduction in amount of grazing land, which has varied by ecological gradients:

- In the higher potential areas, much less grazing land available as most land is converted to cropping. Remaining livestock are fed on crop residues, grass found on roadsides or other small communal areas, and in the case of high value livestock like dairy cows, on produced feed and fodder.

- In the mid to lower potential areas, communal grazing land has shrunk as cropping has expanded and fencing has reduced access to what is left. Privatization of land has led to smaller land management units that are unsuitable for sustaining large herds and do not permit long grazing orbits. Sheep and goats (shoats), and other small livestock, become relatively more numerous than cattle. In many areas in East Africa, these zones are or will soon be completed converted to mixed crop–livestock zones. Former pastoralist households have become agro-pastoralists with changes in gender and age group roles.

- In the arid to semi-arid zones too dry for depending on rainfed agriculture, expeditionary agriculture is occurring but the rate of land use change is relatively slow. Nevertheless,
fencing and conversion will continue where land is privatized. Herders have lost access to former dry season grazing areas and drought retreats (usually wetlands or higher elevation zones), reducing their ability to maintain herds during droughts. In some places, herders have lost access to watering points for their livestock as these have been converted to irrigated cropping or have been enclosed within wildlife protected areas.

The implications of the land use changes for specific systems will be described further below. First described are changes in the agro-pastoral system in the arid and semi-arid lands, and then changes in the higher potential, mixed crop–livestock system.

Source: Mugisha (2002).

**Figure 3.** Kibale National Park and surrounding areas land use/cover, Uganda in 1955 (left) and in 2000 (right).
III. Change in the agro-pastoral system

A. Patterns of change

Agro-pastoral livelihood systems in Arid and Semi-Arid Lands (ASAL) are in flux. In the past 100 years, herding systems in East Africa have experienced chronic pressure to alter their land use as a consequence of multiple forces including government policy towards livestock, farming, and wildlife; in-migration and population growth; encroachment of crop agriculture; civil strife; a governmental bias against herders who were viewed as resistant to economic development; and extreme environmental circumstances, particularly droughts and floods. Meanwhile many farmers are recent migrants to ASAL and have had to adapt their cultivation systems in the face of recurrent drought, changes in access to water, rainfall variability and, in many areas, declining soil productivity. These pressures have resulted in reduced access by herders to vital grazing and water resources, competition over resources between herders and wildlife, sedentarization 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 decentralized 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 (Olson et al. 2004b).

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. For example in Loitokitok, Kajiado, Kenya, in 1979, 56% of farmers had more than 10 goats while in 2001, only 12% of farmers had more than 10 goats. 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 more remote rangelands. This has implications for soil stability, and for the biodiversity of flora, birds, and wildlife. There is evidence from the Loitokitok case site that those who remain in the traditional herding economy are poorer than those who have diversified into farming (Campbell 1999; Campbell et al. 2000; Campbell et al. 2004a).

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.

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 sedentarize. To reduce their vulnerability to droughts and other shocks, pastoralists like others have diversified their economic base. Droughts have acted as catalysts in the past 20 years spurring pastoralists to reduce their dependence on livestock by cultivating more crops and moving towards more non-farm income sources (Box 2). The extensive, purely 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 (Campbell 1999; Olson et al. 2004b; Campbell et al. 2005; Campbell 2006).
Box 2. Droughts as catalysts of change

Drought is recurrent in ASAL, occurring every 8-15 years. The potential impact has increased as the number of residents of ASAL has grown, and as access to key resources has become more competitive. During droughts, farmers and herders maintain a range of coping strategies including mobility and diversity of income sources. Droughts have been a catalyst of fundamental change, particularly where antecedent conditions have increased people’s vulnerability.

When combinations of driving forces are active, such as rapid in-migration, loss of access to water and grazing, and implementation of a different policy framework, droughts have pushed livelihoods over thresholds in their capacity to cope. Droughts became tipping points to fundamentally different livelihoods. Past droughts have triggered some pastoralists to adopt rainfed and irrigated cropping, migrate to towns, or invest in children’s education to reduce dependency on herding.

Source: Campbell (2006).

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 (Campbell et al. 2000; Tukahirwa 2002; Wangui 2003; Campbell et al. 2004a). 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).

The agro-pastoral production system changes have been accompanied by important shifts in culture and society, for example changes in gender roles and responsibilities. The increasing importance of crop income in former pastoralist households has led to a shift in labour responsibilities in Kajiado District, Kenya with men spending additional time on crop production (especially cash crops), and women spending actually more time than men in caring for livestock (women are herding livestock as well as conducting the traditional milking, care of sick animals and care of calves). A result is that livestock herds are being grazed closer to the compound, and that the long distance, seasonal grazing orbits to dry season grazing zones are becoming rare (Wangui 2003).

B. Impacts of sub-division of land on livestock intensification

In many ASAL areas in Kenya, governmental programs, and local economic and social pressures are leading to sub-division of land. These pressures will probably lead to sub-division in ASAL in other East African countries. In Loitokitok, Kajiado District, Kenya, the intensification of the livestock system is expected following the sub-division of land and while awaiting the

improvement of market networks for beef and dairy. The improvements may take some time, but a change is nonetheless inevitable because the potential rents (economic returns to land) to be captured are simply too large to be ignored.

Sub-division inevitably leads to a switch from extensive to more intensive methods of production. Once the economies of scale from extensive production are lost, both beef and dairy will require more intensive methods of production with fewer animals, higher inputs and improved pasture management. The same holds true for crop production which will become gradually more important in the farm economies.

In general, adjudication and sub-division promotes intensification of production and higher land rents. Within the smallholder cultivation sector of Kenya, data shows that freehold land is clearly more ‘developed’ than is unadjudicated land: population density is higher, as are growth rates; land rents are more than three times higher; cash crops are more important; livestock are less important but are managed more intensively managed; and transport and market networks are better.

Rents invariably rise after sub-division and along with them the value of the land – if only because it is now available in bite sized chunks rather than in huge swathes. Land values have soared following sub-division. In the decade between 1984 and 1994, they increased by some 800% at an annual rate of 24% per annum, a true gain of some 60% over the background rate of inflation.

Changes in land tenure regimes, improvements in market networks and adoption of better technology will all conspire to shift land rents upwards. There are significant gains in rents to be made, so large that it is inevitable that they will be captured. Wildlife rents can stem the tide of expanding cropping to some extent, but they are highly dependent on local entrepreneurial and managerial skills. Wildlife rents will remain low in the current Kenyan wildlife policy environment.

The socio-economic pressures to sub-divide land are irresistible and complete sub-division is inevitable. However, to maximise net returns it is vital that in the lower rainfall areas sub-division is not accompanied by large scale fencing. This will preserve to some extent the extensive nature of the livestock production system, thus easing the difficult transition to intensive production; it will also maintain wildlife populations and the conservation value of protected areas. The key to this is to raise livestock productivity (better markets, better technology) and to raise wildlife rents.

C. Commercialization of cattle and crops

For the last 25 years the pastoral areas of the arid and semi-arid (ASAL) Districts in Kenya have been undergoing a fundamental change in the patterns of production. The area under
cultivation has been growing at 8.6% per annum within the seventeen ASAL Districts with maize cultivation growing at some 4.9% per annum (Annex). While the area under cultivation is clearly showing a strong response to price (elasticity of 0.55%) maize cultivation shows little price sensitivity (elasticity of 0.043%). Maize cultivation may therefore be simply reflecting the rate of growth in the human population (+3.11%/annum).

The growth in livestock off-take shows a trend towards increased commercialization, as well. Between 1977 and 1994 the absolute numbers of both cattle and shoats have been variable but have shown no consistent trend. Off-take, however, has been growing steadily at 5.6% per annum and 3.2% per annum respectively—and is clearly price sensitive, especially with shoats. This demonstrates a radical shift in livestock production strategy, from a more traditional subsistence production towards one more integrated within the national cash economy. The final marked change in the ASAL Districts has been the decline in wildlife. A 3.3% per annum rate of loss suggests a total loss of 45% between 1977 and 1993, and a 55% loss by 2003.

It is against this national background that trends within Kajiado District can be interpreted. Kajiado is relatively near to the Nairobi markets, despite an unimproved road. Cultivated hectares and maize hectares are expanding faster, at 13.5% per annum and 6.9% per annum respectively, than in the ASAL Districts as a whole while the slightly stronger price elasticity for maize suggests a more market driven response. Livestock production in Kajiado broadly follows the national trends. The numbers of both cattle and shoats have remained effectively constant. Cattle off-take has grown firmly at 3.3% per annum over the last thirty years. However, in complete contrast the off-take of sheep and goats has shown a consistent decline of −5% per annum. Finally, in marked contrast to the ASAL Districts as a whole (apart from Laikipia District), wildlife populations in Kajiado would appear to be holding their own and if anything to be increasing.

These data suggest a fundamental structural change to ASAL production systems. Agro-pastoralists are capturing agricultural rents at an astonishing rate and are intensifying their livestock production strategy for increasing off-take from what is effectively a stable herd size. Along with a marked diversification of land uses and income streams, this process will eventually result in the full integration of what were previously subsistence economies into the national, and even the international, economies.

D. The economics of livestock versus crops versus wildlife land uses

The rapid expansion of rainfed cropping at the expense of grazing land for livestock and wildlife leads to the question of when, or where, the expansion will stop. Agro-pastoralists are clearing bush and planting crops in dry zones where the crop harvest is minimal. Norton-Griffiths analyzed a series of marketing, price, labour and other data to determine the potential economic returns to rainfed crops, livestock and wildlife by rainfall gradient for Loitokitok Division of Kajiado District in Kenya. His results, below, provide insights into current and

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Health and in the Ministry of Agriculture and Livestock Development (Norton-Griffiths 1995). 2002 data for Kajiado were obtained from recent District reports.

especially future trends in land use change as people respond to market opportunities in an area with frequent droughts. He does not consider in this analysis the impact of the loss of key water or other resources, or other environmental or social factors, on the various production systems as discussed above.

Table 2 shows the net returns to five potential land use strategies in Loitokitok Division for both normal and drought years at three levels of rainfall. Defining the optimal land use strategy as the one that gives the highest returns in both normal and drought years (defined as one standard deviation below average rainfall), it is clear that none of the single land use strategies (only crops, only livestock, only wildlife) do as well as the mixed strategies of crops with livestock, or livestock with wildlife.

Table 2. Optimal land use strategies in normal and drought years for Loitokitok Division, Kajiado District, Kenya

| Optimal Land use strategies for loitokitok division in normal and drought years |
|---------------------------------|-------|-------|-------|
| Mean Rainfall                  | 700mm | 500mm | 300mm |
| 1. Agriculture only           |       |       |       |
| Normal year                   | $39.6 | $24.7 | $9.6  |
| drought year                  | $13.6 | $9.6  | $5.1  |
| 2. Agriculture and Livestock no wildlife |       |       |       |
| Normal year                   | $54.5 | $33.4 | $12.6 |
| drought year                  | $18.0 | $12.6 | $6.6  |
| 3. Livestock only no wildlife |       |       |       |
| Normal year                   | $14.9 | $8.7  | $3.0  |
| drought year                  | $4.4  | $3.0  | $1.5  |
| 3. Livestock with wildlife    |       |       |       |
| Normal year                   | $22.5 | $18.3 | $14.4 |
| drought year                  | $15.4 | $14.4 | $13.4 |
| 4. Wildlife only (normal and drought years) | $1.4 | $12.4 | $12.4 |

Note: drought year defined as 1 st. dev below mean rainfall Livestock returns without wildlife increased by 48% (Table 6.10)
Wildlife returns = concession and access fees of $10.3 plus 3* $0.7 of low rent activities

Furthermore, in the wetter areas above 500mm mean annual rainfall, the best strategy is to maximise the net returns to livestock by eliminating wildlife and running a mixed crop and livestock production system. In contrast, the opposite is the case in drier areas, below 500mm mean annual rainfall, where the best strategy is to run a mixed livestock and wildlife production system. 500mm of rainfall represents a transition phase where the strategic decision to
maximise net returns to land is not clear cut: agriculture and livestock are best in normal years but livestock and wildlife are best in drought years. Here, the choice will depend largely on local factors and conditions.

Thus, in the wetter areas the transformation of pastoralism to mixed cropping and livestock production with the elimination of wildlife is inevitable and is already mostly occurred. In contrast, a mixed livestock wildlife production system is optimal in the lower rainfall areas of the Division, so long as wildlife rents continue as they are.

If wildlife rents fall, perhaps though a downturn in tourist numbers, the mixed cropping and livestock system will be optimal further down the rainfall gradient leading to additional elimination of wildlife. In contrast, if wildlife rents can be raised, either by better bargains between landowners and tour agents over existing concessions, by involving landowners more directly in the tourism industry, or by bringing back a wider range of options for capturing wildlife revenues (e.g. by reintroducing consumptive utilization), then the mixed livestock and wildlife production system will be optimal further up the rainfall gradient with increased gains for wildlife and conservation. It is simply a matter of differential returns.

Land use in Loitokitok Division is thus in a highly transitional phase. The most important structural influences are the strengthening of external (mainly urban) markets for agricultural and livestock produce; the gradual improvement in marketing networks and information flow about markets to producers; and the social pressures forcing changes in land tenure regimes from group ownership of large properties to single ownership of many much smaller properties. These will act synergistically to produce upward pressures on both land prices and on land rents. With sub-division comes a transformation from extensive production systems to more intensive production systems, with even further upward pressures on land values and rents. The improved technologies to achieve intensification are already available to landowners. There are significant gains in rents to be made, so large that it is inevitable that they will be captured – either by the local agro-pastoralists themselves, or by outsiders alienating land from them.
E. Issues for livelihoods

In summary, livelihood systems in ASAL are robust. They are characterized by flexibility that enables them to adapt to changes in socio-economic and environmental conditions, and by diversified economic options that reduce risk, a fact of life in ASAL where variable rainfall and recurrent drought affect food security. The number and intensity of some of the changes in local and external economic, social, demographic, environmental and political conditions over the past 30 years have tested the robustness of livelihood systems. Their most persistent challenge is to maintain access to land and water resources of sufficient quality and quantity to sustain the population from season to season and year to year. Nevertheless, the trends in land use change are leading to the critical issues described below.

1. Competition over Access to Perennial Water. 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. Meanwhile such well-watered areas are the focus of the expansion in crop production. Competition over access to water between and within land use systems, especially between cropping, and livestock and wildlife, is widespread. This has led to privatization of some water resources such as along streams or in swamps for cropping, reducing the amount and the quality of water for livestock, wildlife and household use.

2. Reduction in economic viability of pastoralism? A variety of factors has threatened the viability of extensive livestock production. These include the encroachment of farming reducing access to dry season water and grazing resources, the demarcation of national parks that enclosed perennial water and grazing, and highly variable rainfall and severe droughts. In addition, civil strife has disrupted livelihoods, altered access to land, and dislocated marketing systems. The relatively high profitability of the cropping systems that have encroached upon traditional herding resources has resulted in in-migration by non-herders, and many herders settling and diversifying into farming. Others continue their extensive herding systems, as in Uganda, where land tenure favours current landholders.

Where herders have diversified into farming they have become more sedentary, and their home herds tend include more sheep and goats and fewer cattle. There is evidence that that those who remain in the traditional herding economy are poorer than those who have successfully diversified into farming (Campbell 1999; Mugisha 2002; Tukahirwa 2002; Mbonile et al. 2003; Worden et al. 2003; Campbell et al. 2004a; Olson et al. 2004a; Olson et al. 2004b).

Despite the diversification into cropping, livestock continues to be an important livelihood strategy for earning income, as a hedge against drought or the need for large sums of cash, for food security, and to provide income diversification.
3. Land tenure policies as a driving force of change

The increase in the area under cultivation, both rainfed and irrigated, has been facilitated by changes in land tenure policy, both official and customary. The general trend has been towards land privatization, and fragmentation of former communal holdings (see section II. B above).


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. These investments or, more commonly lack of investments, have had important impacts on the economic growth of ASAL regions. Non-policy impacts of government such as civil unrest and corruption have also had major impacts on land use, particularly by affecting agricultural and non-agricultural economic costs and opportunities, and migration (Campbell et al. 2004a; Olson et al. 2004b).

5. Rainfed Cropping Expansion.

Under certain conditions of rainfall amounts, soil conditions, and availability of transportation, land and labour, economic returns to cropping have been shown to be higher than economic returns to livestock in ASAL. This has driven a large expansion of rainfed cultivation into former grazing areas—the largest land use conversion observed in the LUCID sites.

Many of the fields in the ASAL 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 ASAL 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 some sites.

6. Irrigated cropping.

Concurrently, the amount of land under irrigation has grown rapidly due to high returns. In the Kajiado, Kenya site, for example, irrigated land expanded from 245 to 4768 hectares between 1973 and 2000 (Figure 4), 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 aquifers. The crops, usually vegetables, are destined for both national and export markets. Some of these 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 environmental impacts especially on water quality and quantity are already negative in some areas. Water sources for livestock, wildlife and people have become scarcer and/or polluted (Mbonile et al. 2003; Campbell et al. 2004a; Githaiga et al. 2004; Reid et al. 2004).
F. Impacts on livestock

a. Pasture species and forage productivity. The influence of livestock on pasture is through the reduction of above ground biomass and cover, and through enhancing plant species diversity through the dispersal of seeds in their manure. LUCID results indicate that livestock grazing enhances plant species diversity richness at a local scale by providing opportunities for common species to establish. Conversely, grazing decreases diversity at a regional scale by removing the most grazing-sensitive rare species. Adequate frequency and intensity of grazing plays an important role in maintaining species diversity of rangeland plants. In the absence of grazing, woody shrubs gradually replace grasses except in the arid zones.

Land use change from bush to more intensive open grazing tends to reduce organic carbon content, soil moisture, pH, bulk density and nitrogen. This does not appear to affect forage productivity until grazing intensity reaches a certain level. Continuous grazing is apt to have a negative impact on soil, forage production and plant diversity. The contraction of grazing orbits and concentration of livestock occurring in some areas could thus lead to a degradation
of pasture and soil, continued shrinking of family herd sizes and poverty for those without alternative income sources (Kamau 2004; Maitima et al. 2004).

b. Change in livestock herd composition and size. The herd structure is changing towards fewer native cattle, and more sheep, goats and crossbred cattle. Household herds are getting smaller (though they are often grouped during grazing), and grazing orbits are shorter. In general, herds are staying closer to the homesteads. The rate of off-take of young animals for the market is rising.

c. Human–wildlife conflict. As competition for the available resources continues, there have been rising levels of human–wildlife conflict. This includes injury and loss of life, and crop damage. Many farmers have responded by fencing land. With increased individual tenure, the impact of fencing upon livestock management, and upon wildlife dispersal, will increase (Campbell et al. 2002; Githaiga et al. 2004; Reid et al. 2004).

d. Income distribution. The land use conversion to more cropping has led to higher land productivity per hectare 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 in the past. Competition over limited grazing and, increasingly, over water is of critical concern (Tukahirwa 2002; Mbonile et al. 2003; Campbell et al. 2004b; Olson et al. 2004b).

e. Other societal changes. In ASAL zones with significant in-migration, the ethnic composition of the population has changed significantly. For example, the Maasai are now a minority in Loitokitok, Kenya while other, mostly traditional farming groups make up over half of the population. Also, the diversification of income sources (see below) has led to a shift in labour invested in livestock keeping. In general, less labour is available for herding livestock, particularly for long grazing orbits. Gender roles, and probably age group roles, have changed with women taking up more responsibility for livestock (including for herding) (Wangui 2003).

f. Diversification of income sources

A key constraint to ASAL development has been that the vast majority of people are engaged in land-based livelihoods—herding, farming, crop–livestock mix, and to some extent wildlife-based. As long as most people remain dependent on the land, the prospect for depletion or degradation of land and water resources is amplified, and the vulnerability of a growing number of people to droughts and other climatic changes is significant. Some land-based activities have the potential for value-added through processing of crop and livestock products, processing that would provide local employment.

i. Crops. A significant response to the changing economy, land tenure regime, rainfall variability and population densities has been an increase in the numbers of people adopting a mixed crop and livestock system. These tend to promote more sustainable livelihoods through
diversification of economic opportunity, and reduced vulnerability to declines in production of one facet of production due to drought, disease or economic forces. They also address degradation/poverty linkages through allowing people a more balanced diet and diverse economic opportunities; and by providing for more effective land management through access to manure and in some cases animal traction (Campbell 1999; Campbell et al. 2004b; Olson et al. 2004b).

ii. Dairy. In some in former pastoral areas near markets or transport routes, the high value of milk and manure has resulted in the adoption of exotic species of dairy cows in systems of limited or zero grazing.

iii. Tourism. Revenues from tourism can be significant, but tend to be concentrated in selected localities. The main sources of tourism revenues to landowners are from governmental protected areas (revenue sharing from parks and reserves, and from conservation NGOs), and from private conservation ranches. Income is generated from both non-consumptive (access to land to view wildlife) and consumptive (bird shooting, wildlife farming and wildlife cropping) uses (Norton-Griffiths and Butt 2004).

The income earned by land owners and land users from tourism is highly variable, and depends on 1) the agreement between the landowner and the tour operator (e.g. on access fees, bed night fees, concession fees), 2) the abundance and diversity of wildlife, 3) the nature of the landscape, 3) the number of tourists, 4) the extent to which local employment is generated and 5) the policy environment (e.g. whether hunting is permitted).

iv. Processing of livestock products. There is renewed interest in developing decentralized slaughtering and associated industries to promote economic opportunities in ASAL. The meat industry has been centralized in a few large facilities that benefit from economies of scale. A decentralized meat industry located in ASAL towns would bring value added to the localities. Meat processing would provide direct employment in the plants and indirect employment through multiplier effects in the service sector and in activities using by-products such as leather and bonemeal. This would stimulate the local economy, offer off-farm employment, reduce the prospect for land degradation and stem rural–urban migration (Campbell et al. 2004b).

G. Conclusion

The LUCID research findings of past and current trends in ASAL indicate that improved productivity will require enhancing the inherent flexibility and diversity of the livelihood systems. Key issues related to sustainable livelihood and ecological systems include:

Dependable access to clean water supplies.

Enhanced diversification of income sources and livelihood strategies, e.g. promotion of local processing of livestock and crop products.
Intensification of the livestock system since less grazing land is available and since access to dry season/drought refuge water and grass is less common. Labour available for more intensive livestock keeping may be a constraint as people are involved in other activities.

Enhance the flexibility and adaptability of the ASAL livelihood systems to facilitate their ability to accommodate and respond to economic, policy, demographic, security and environmental variability and change.

A multi-scale participatory approach to ASAL management ensures that the decisions of individual farmers and herders sustain, not undermine, the system they live in.

Cross-sectoral approaches to address root causes. Sectoral strategies are likely to address symptoms, while system sustainability requires a cross-sectoral approach.
IV. Change in the mixed crop–livestock system

A. Patterns of land use change

In areas that were already cultivated in the 1950’s, land use changes have been less dramatic than in the ASAL. 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 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.

Driving forces of change in the mixed systems include economic, policy and other reasons behind migration and population growth, the availability of land for settlement, and non-farm opportunities. Young families seeking land have historically conducted an expansion. Their migration is usually short distance towards the edge of the area already cultivated or on land belonging to their group. Policies have tended to favour crops over livestock in terms of land policies, and in terms providing marketing, technical and financial support. Governmental land privatization or adjudication programs, for example, have resulted in a conversion to crops as grazing large herds was no longer possible. Economic returns to land in mixed crop–livestock systems tend to be higher than for pastoral livestock systems alone (Tukahirwa 2002; Mbonile et al. 2003; Campbell et al. 2004a,b; Norton-Griffiths and Butt 2004; Olson et al. 2004a,b).

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 evolution has been:

1. Early clearance of the forest for grazing livestock 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 fed crop residues, and 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. Manure was placed on the fields.
5. Continued intensification, including use of animal manure, soil conservation, and chemical fertilizers and pesticides.
6. Governments and large-scale private 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, income diversification and local population increases. For example, the amount of land under coffee diminished when coffee prices declined, and horticultural crops have emerged that are sold nationally or internationally. Bananas are becoming more of 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 (Olson et al. 2004b).

B. Trends in intensification

Soil management and the use of animal manure have evolved with the increased intensification. The LUCID study sites include two areas (there are others elsewhere in East Africa) with a long history of intensive agriculture and soil management that may portend what will happen elsewhere. 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 feed concentrate. Much of the milk was sold to a parastatal organization, and the highly valued manure was applied to the fields.
i. with less erosion and added manure and other organic materials, soil productivity improved though farmers say not to the same level as it was originally. Some farmers purchase manure from poorer regions to apply to their cash crops.
changes in crop mixtures and livestock production as markets for commodities (coffee and milk, for example) fluctuate with changing government programs and international markets. Farmers are experimenting with growing vegetables and other high value crops, for example, as coffee and tea prices are low (Olson et al. 2004b).

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 or Mt Kilimanjaro’s volcanic soils, cool climate and ties to national programs and markets will 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 (Box 3, Figure 1). 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 soil analyses (Gachimbi 2002), the fields in drier or lower elevation areas have significantly fewer nutrients and worse erosion. Within three years following bush clearance and cultivation, soil nutrients and organic matter content had declined significantly.

**Box 3. Conditions for sustainable intensification?**

A region that may be moving towards sustainable intensification is semi-arid Mbeere District, downslope of Mt Kenya and with a good road connection to Nairobi. The land around Kiritiri town experienced rapid conversion—78% changed from bush to fenced farms between 1961 and 2001, mostly following a land adjudication program (Map 1). Conversions that may have happened gradually with population growth and agricultural intensification occurred suddenly. Families could no longer maintain their large goat herds on the small holdings, and cleared their land for crops.

A field-level view reveals, however, that fields are left fallow due to low returns—only 40% of the land is cropped. Indeed, half of the husbands work primarily off-farm. The women-headed families left behind tend to stay poor, and not to increase their livestock holding or invest in land management. Ironically, labour is a limiting resource along with cash and land.

Many families are poor as farm sizes have shrunk, the prices of crops remain low, and land productivity is low. Crop loss to pests, diseases and low rainfall is frequent. Use of fertilizers, manure and other inputs is relatively low.

Farmers, meanwhile, are seeking to diversify their income sources by working off-farm, selling fuelwood, and trying new crops. They ask for higher-paying crop or livestock products, and are well aware of the productive soil management practices of their Embu neighbours on the upper slopes. Indeed, some sell manure to Embu farmers. The impression is that Mbeere farmers are more than interested in moving towards a higher-productive system, if conditions were right.

Source: Olson et al. (2004a).

Even in the most productive, highly managed zones, however, the variation between households in levels of land management and productivity is important. A common pattern
emerged of how the lack of household resources, particularly livestock, affects investment on the land. Poorer households make significantly fewer investments such as manure application due to the lack of labour and capital, and fewer farm and non-farm resources (Figure 5).

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 (Figure 6).

Source: Olson et al. (2004a).

**Figure 5.** Manure application and change in soil fertility by wealth class in Embu and Mbeere Districts, Kenya.
I. Shifting cultivation

II. Continuous cropping

III. Transition period

IV. Sustainable intensive system

What are the conditions for successful intensification?

Pressure on land

Soil management

Soil fertility

Source: Adopted from Olson (1998).

Figure 6. Intensification and soil management.

Government, parastatal or NGO programs have been influential in organizing erosion control measures, encouraging mulching and manuring, and supplying chemical inputs. In situations when programs stopped, such as due to civil unrest in Uganda, the collapse of parastatals in Kenya or structural adjustment in Tanzania, farmers have often ended practices. Chemical inputs that had been widely used were abandoned or their use confined to selected, marketed crops. Terraces were maintained in Southwest Uganda but became short since they were used as boundary markers rather than for erosion control. However, the application of manure and the planting of trees and fodder plants have continued perhaps because they require less capital and provide clearly realized benefits (Tukahirwa 2002; Mbonile et al. 2003; Campbell et al. 2004b; Norton-Griffiths and Butt 2004; Olson et al. 2004a; Olson et al. 2004b).

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 East Africa, 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.
C. Impacts on livelihoods and livestock

Issues for livelihoods in systems undergoing intensification and moving towards continuous cropping thus include:

a. *Low and declining soil productivity* in many fields.

b. *Land management and soil productivity vary widely* between areas and households. Poorer households with few animals and small farms make fewer investments and tend to have more soil degradation. Gender disparities and HIV-AIDS reinforce the situation of poverty. Areas with low-value crops, far from the market, or unreliable rainfall invest less in soil management. On the other hand, soil productivity is improving on farms and in areas that invest in the land.

c. *Small and declining farm sizes.* Some families are near-landless in all zones.

d. *The systems are in constant flux* with changing commodity markets and prices. Many farmers are switching from export crops to supplying urban markets for livestock and crop products.

e. *Livestock are highly valued.* Although the number of animals per household is low, most families continue to keep at least goats, if not a cow, and reserve land for producing fodder. Livestock are highly valued for their manure as well as their meat and milk. Parastatals and other government programs have had a large impact on the production and marketing of animal products.

f. *Governmental policy and programs* frequently changed. Those affecting the production system have included changing access to credit, price incentives, subsidies for fertilizers and pesticides, import policies, the strength of extension services, decentralization and centralization of land management, and changes in land tenure arrangements.

g. *Little community level land use planning* to optimize land resources: water, grazing, woodlands, soil and water conservation, etc.
V. Future trends

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. 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 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.

Trends in land use change portend a continuation of land use conversion from pastoralism towards agro-pastoralism in the future. Two major driving forces of change—economic factors and population growth—both point towards expansion of cropping into the ASAL.

Analyses of economic returns to differing land uses (livestock, crops, wildlife conservation) indicate that cropping is more profitable per unit land area than livestock, even in semi-arid areas (Figure 7). A combination of crops with livestock in the wetter ASAL areas, or livestock and wildlife in the most arid zones, provides the highest returns particularly in drought years (Norton-Griffiths and Butt 2004). This would indicate that the economic driving force of land use change from pastoralism to agro-pastoral will continue, particularly where markets and transport are available.

A spatial allocation model using population growth as a major driving force also indicates that expansion of cropping will continue into the next 10 years (for Kenya) to 15 (for Uganda) to 30 years (for Tanzania) until all available arable land is converted (Lei et al. 2005; Olson et al. in review). Population projections by the United Nations also indicate major changes in the proportion of the populations of Kenya, Tanzania and Uganda in rural and urban areas. In Kenya and Tanzania, rural population growth is expected to start to level off in the next few years. Massive migration particularly to the capital cities and lower overall population growth rates are expected to slow rural population growth. In Uganda, migration to the cities is expected to be less and the rural population will continue to grow at a rapid rate at least until 2030 (Figures 8, 9 and 10) (United Nations 2005).

The eventual leveling off of rural population numbers, and the large growth of urban markets for crop and livestock products, has significant implications for the evolution of agricultural systems. Presumably labour saving technologies, land productivity enhancements and higher producing crop and livestock technologies will become increasingly important.

In the meantime, however, the current situation is critical particularly in semi-arid areas—where the vulnerability of the human and environmental systems overlaps and is in the processes of worsening. This is where the mixed crop–livestock system is expanding, placing an increasing...
number of people at risk of productivity declines and highly variable rainfall. The higher
temperatures and more variable rainfall that are expected with climate change will exasperate
their situation. The flexibility and resilience that livestock bring will, however, ensure that they
continue to be a major component of the mixed crop–livestock, and agro-pastoral, systems.


Figure 7. Results of econometric model of land rents for rainfed agriculture and livestock in
Loitokitok, Kajiado District, Kenya.

**Figures 8, 9 and 10.** Rural, urban and total population projections, 1950 to 2030 for Kenya, Tanzania and Uganda.
Annex: Trends in crop and livestock production in ASAL districts, Kenya.6

<table>
<thead>
<tr>
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<tr>
<td>POPULATION GROWTH</td>
<td>% per annum growth rate</td>
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<td></td>
<td>+3.11 %pa^{(1)}</td>
<td>+5.41 %pa^{(4)}</td>
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<tr>
<td>ALL CULTIVATION</td>
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<tr>
<td></td>
<td>+8.6%pa^{(2)}</td>
<td>+13.5%pa^{(3)}</td>
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<td>AGRICULTURE</td>
<td>Maize ha: %pa change</td>
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<tr>
<td>MAIZE</td>
<td>Price elasticity</td>
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<td></td>
<td>+4.9%pa^{(4)}</td>
<td>+6.0%pa^{(5)}</td>
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<tr>
<td>CATTLE</td>
<td>Off-take: %pa change</td>
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<tr>
<td></td>
<td>Price elasticity</td>
<td></td>
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<td></td>
<td>-1.0%pa^{(6)}</td>
<td>+5.6%pa^{(7)}</td>
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<tr>
<td>LIVESTOCK</td>
<td>Numbers: %pa change</td>
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<tr>
<td>SHEEP&amp;GOATS</td>
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<td></td>
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<tr>
<td></td>
<td>-0.5%pa^{(9)}</td>
<td>+3.2%pa^{(10)}</td>
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<tr>
<td>WILDLIFE</td>
<td>Numbers: %pa change</td>
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<tr>
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<td>Off-take: %pa change</td>
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<tr>
<td></td>
<td>Price elasticity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-3.3%pa^{(12)}</td>
<td></td>
</tr>
</tbody>
</table>

(1) ln(cultivated hectares) = -0.397 + [dummy variables] +0.086*ln(year), n=216, r^2=0.86, t=8.812, p=0.000
(2) ln(cultivated hectares) = 8.768 + [dummy variables] +0.552*ln(year), n=77, r^2=0.89, t=3.216, p=0.024
(3) ln(cultivated hectares) = 5.316 + [dummy variables] + 0.049*year, n=253, r^2=0.95, t=10.504, p=0.000
(4) ln(cultivated hectares) = 7.021 + [dummy variables] + 0.043*ln(price), n=89, r^2=0.95, t=1.072, p=0.605
(5) ln(cattle numbers) = 11.927 + [dummy variables] -0.010*year, n=134, r^2=0.88, t=1.781, p=0.081
(6) ln(cattle off-take) = 1.738 + [dummy variables] + 0.056*year, n=271, r^2=0.70, t=6.147, p=0.000
(7) ln(off-take) = 3.692 + [dummy variables] + 0.751*ln(price), n=129, r^2=0.62, t=3.197, p=0.020
(8) ln(wholesale numbers) = 11.777 + [dummy variables] + 0.005*year, n=145, r^2=0.94, t=0.630, p=0.408
(9) ln(wholesale off-take) = 6.029 + [dummy variables] + 0.032*year, n=270, r^2=0.44, t=2.536, p=0.012
(10) ln(off-take) = 5.532 + [dummy variables] + 1.088*ln(price), n=118, r^2=0.47, t=3.57, p=0.001
(11) ln(wildlife numbers) = 7.072 + [dummy variables] -0.033*year, n=1311, r^2=0.61, t=5.336, p=0.000
(12) ln(demographic numbers) = 259.5 + 0.135*year, n=9, r^2=0.74, t=4.823, p=0.002
(13) ln(demographic numbers) = -327.96 + 0.069*year, n=20, r^2=0.81, t=3.053, p=0.000
(14) ln(demographic numbers) = 5.626 + 0.115*ln(price), n=5, r^2=0.88, t=5.543, p=0.012
(15) ln(demographic numbers) = 56.176 + 0.032*year, n=19, r^2=0.27, t=2.791, p=0.013
(16) ln(off-take) = 109.241 + 0.050*year, n=18, r^2=0.67, t=5.963, p=0.000

Note 1: The OLS regression analysis used here has the general form:
\[ \ln(y) = a + [\text{dummy variables}] + b\cdot x \] (or \( a + b\cdot \ln(x) \) for elasticities)
\ln(y) is used both to normalize distributions and so that \( b \) can be interpreted in terms of rates (% per annum) or elasticities (% change in y for a % change in x). Dummy variables, coded 0 or 1, absorb variation associated with individual Districts and/or individual livestock and wildlife species, thus revealing the pure time trend.


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6. Data on cultivation, on producer prices and on livestock off-take (slaughter and sales) in the 17 ASAL Districts in Kenya, for the period 1977–94, were obtained from District records and annual reports, and from internal records and reports in the Ministry of Health and in the Ministry of Agriculture and Livestock Development (Norton-Griffiths 1995). 2002 data for Kajiado were obtained from recent District reports.
Trends in cattle (top) and shoat (bottom) off-take in Kajiado District, Kenya. 7


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7. Data on cultivation, on producer prices and on livestock off-take (slaughter and sales) in the 17 ASAL Districts in Kenya, for the period 1977–94, were obtained from District records and annual reports, and from internal records and reports in the Ministry of Health and in the Ministry of Agriculture and Livestock Development (Norton-Griffiths 1995). 2002 data for Kajiado were obtained from recent District reports.
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