



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

**Ecological Gradients as a Framework for
Analysis of Land Use Change**

LUCID Project Working Paper 45

By

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July 2004

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The Land Use Change, Impacts and Dynamics Project
Working Paper Number 45

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I. INTRODUCTION

Many livelihood systems in Africa are organized to take advantage of the resources afforded by diverse ecological conditions. In many cases these may be represented as ecological gradients. Such gradients may be defined as encompassing a range of ecological conditions from higher rainfall (potential) to lower rainfall (potential) where land use and livelihood systems interact across the zones. This definition limits the geographical extent of the gradient to the land use of wildlife and human livelihood systems in terms of their interactions across zones and/or between livelihood systems. They can be both “vertical” as on mountain slopes, and “horizontal” as for example across ecological zones in the West African desert-sahel-sudan zones. The vertical gradients on mountains, caused by orographic rainfall and temperature differences, are more spatially condensed.

Interactions across gradients may occur within land use or livelihood systems, for example where wildlife and livestock herders use wetter areas in dry seasons/drought and drier areas in wet seasons such as the Maasai in East Africa (Spear and Waller 1993, Bernard et al. 1989) and the Touareg (Nicolaisen 1963) and Peul/Fulani (Dupire 1962; Boutrais 1988) in West Africa. Similarly, there are examples of cultivation systems where farmers use hilltops, hillsides, and valleys allowing production of a variety of crops and thus mitigating risks such as total crop failure. Examples include the pre-colonial Kikuyu in Kenya (Ruthenberg 1980), the Chagga on Mt. Kilimanjaro (Moore 1977; Bart et al., 2003), the Mafa in north Cameroon (Boutrais, 1973; Boulet, 1975) and the Kofyar in Nigeria (Netting, 1968). Cross-gradient interactions may also exist between livelihood systems. The most important of these interactions are at the junctions between zones – e.g. between savannas and the rain fed crop systems where upland farmers have economic, social, and ecological exchange relationships with lowland herders.

Gradients also display socio-economic characteristics that vary both within livelihood systems, and between them in terms of trade, social relations, and access to resources. Power relations often determine the processes defining such characteristics and access to resources. For example in pre-colonial times greater power rested with herders in the dry lands and less with adjacent farming groups. In most cases this power relationship was reversed with colonial rule, except in areas that were distant from state authority.

Thus, for our purposes a gradient is effectively defined both by ecological conditions and interactions within and between livelihood systems. Their principal characteristics include:

- There are distinct ecological conditions at the extremes of gradients.
- There are distinct uses of resources at the extremes of gradients. These may be different livelihood systems (e.g. farming and herding) or uses within livelihood systems – wet season/dry season grazing.
- Usually land use systems (e.g. livelihoods and wildlife) will interact across the different ecological zones of the gradients.
- Interaction implies that the functional extent of a gradient is defined by the spatial interactions between or within land use/livelihood systems.
- The boundary zone is a lower potential resource for those located in higher potential lands of gradient, and higher resource potential for those in the lower potential lands of gradient.
- Land use in higher potential lands of gradients can flourish without access to boundary zone. This is less/not true of the livelihood systems at the drier end of the gradient.
- The boundary zone between land uses is vulnerable to land use change, competition, and conflict between land use systems, and between people within livelihood systems.
- The boundary zone is zone of potential exchange and mutual benefit between livelihood systems across the gradient and a zone of potential conflict between them, particularly over

access to water.

- Access to water (rain fed, stream, swamp) for cultivation, domestic, livestock and wildlife is often the critical issue in interactions between gradients, with common questions of what are the rights and limitations for user groups?
- The level of exchange, competition, and conflict across the gradient is determined by the relative power of different livelihood systems – military, institutional/political, economic, technological – that is the local expression of the broader, national socio-economic-political system.

The LUCID Project examines a number of case studies of land use change in Kenya, Uganda and Tanzania. They were selected as they exhibit characteristics of gradients and this commonality allows for the processes of land use change and implications for land degradation and conservation of biodiversity to be compared and contrasted using the gradient as a common organizing framework.

II. CHARACTERISTICS OF EAST AFRICAN GRADIENTS

In East Africa various ecological gradients can be observed. This paper examines the altitudinal gradients along the slopes of Mt. Kilimanjaro and Mt. Kenya.

II. A. Biophysical Characteristics

The ecological gradients on the slopes of Mount Kilimanjaro in Tanzania and Kenya, and on Mt. Kenya represent important ecosystems that have unique resources and many opportunities for the development of their people. These can be illustrated by the southern, Tanzanian gradient on Mt. Kilimanjaro. This gradient has five distinct ecological zones: the lowland zone, reaching an altitude of about 900-1000 m.a.s.l.; the cultivated belt (Coffee-banana belt) extending up to 1700-1900 m.a.s.l.; the montane forest zone, which includes the half mile strip along the southern edge of the forest and the Kilimanjaro Forest Reserve extending to 3500-3700 m.a.s.l.; Heath land occurring in the alpine and sub-alpine zones at altitudes exceeding 3,500 m.a.s.l., and the alpine desert (the summit) dominated by bare rock and ice (Mbonile et al., 2003).

II. A. 1. Agro-Ecological Potential

In terms of agro-ecological potential, the lowland zone (below 1000 meters above sea level) is characterized by rainfall that is variable both within and between seasons. Drought is recurrent. Average annual temperatures are more than 30°C. Until recently, extensive livestock keeping (mainly traditional cattle) by the Maasai people dominated this zone, which also provided the habitat for large and varied wildlife populations. Over the past 40 years the lower slopes and adjacent plains in both Kenya and Tanzania have witnessed increased cultivation due to smallholder farmers moving down the gradient, and significant investment in irrigation. The annual crops include maize, sorghum, and cassava. Paddy and sugarcane are grown in the formal irrigation schemes on the Tanzanian side of the mountain, while horticultural crops dominate in the smallholder schemes on the Kenyan side.

The middle zone (1000-1600 m.a.s.l.) is characterized by a high population density and a high rainfall, with temperatures ranging between 25 and 30°C. In Tanzania the main group is the Chagga who practice intensive farming of coffee, grown under bananas. In the coffee/banana belt, improved dairy cattle and also the traditional cattle are kept under zero grazing. This system is necessitated by the fact that farm holdings are very small (average 1 hectare) so that there is no spare land for grazing. The lower edge of this zone is climatically similar to the lowlands and people engage in cattle production and the growing of annual crops, mainly maize and beans.

While the Maasai herders have long grazed their livestock in the lowlands, differences in settlement history exist among the farmers on the Kenyan and Tanzanian slopes of Mt. Kilimanjaro. That in Tanzania can be traced back for centuries, while in Kenya settlement is more

recent, beginning in the 1930s, expanding after 1960 and continuing today (Campbell et al., 2003).

A similar gradient, also characterized by a variety of livelihood systems is found on Mt. Kenya (Bernard et al., 1989). According to Gachimbi (2002), Embu and Mbeere Districts, Kenya, on the eastern slopes of Mt. Kenya represent a range of ecological conditions. Embu District has a good climate and fertile soils ideal for small scale farming of annual and perennial crops, while Mbeere District is of marginal agricultural potential.

II. A. 2. Climate

Despite the fact that East Africa has an average rainfall ranging between 500 mm per annum in the lowlands it to about 2,500 mm pa in the highlands such as Mounts Kilimanjaro and Kenya, and the Lake Victoria Islands. However, the region experiences fluctuations of rainfall resulting in periodic drought. These rainfall fluctuations in East Africa have been occurring in well-established cycles of about ten years. Some of the droughts that have been clearly remembered by several East African households have been the droughts of 1974, 1983 and the most recent one of 1994. These drought periods were punctuated by abnormal climatic conditions like those of El Nino in 1997 that turned out to be a disaster rather than a blessing. In fact both dry and extremely wet conditions have a big impact on the land management in East Africa. This is because drought has led to the invasion of wetlands both by farmers and pastoralists simply because water in wetlands takes a long period to dry. Besides farmers and pastoralists drought attracts wildlife and the area near the wetlands are heavily eroded. On the other hand, spells of heavy rainfall lead to the destruction of already established biomass (Wangui, 2003:5; Mbonile et al., 2003).

Another natural factor that has influenced land management in East Africa is climatic change such as global warming that has increased the intensity of heat and reduced the reliability of rainfall and glaciers on the slopes of Mount Kilimanjaro and Mount Kenya. Since these high mountain systems are some of the main sources of rivers in East Africa the retreat of glaciers pose a great threat to the ecosystem and particularly biodiversity in the region (Mbonile et al., 2003).

II. A. 3. Vegetation

Generally, at a gradient level, on the two mountains species diversity and richness increases with decrease in altitude. This implies that the lowlands, including the scrubland and the shrub land, which were used as pastureland were much more diverse having a number of grass species and shrubs which were not encountered anywhere in the highlands. In Tanzania, the notable shrubs included *Commiphora africana*, *Boscia angustifolia*, *Croton pseudopluchellus*, *Grewia burtii*, *Solanum incanum*, *Hyptis suaveolens* and *Ocimum suave*. Such species may serve to indicate overgrazing in the area. A number of palatable annual grasses in this vegetation type include *Eragrostis superba*, *Pennisetum polystachion*, *Heteropogon contortus* and *Eragrostis aethiopica*. Thus, with a decrease in altitude, the lowlands were favorable for grazing activities and to some extent cultivation of cereal cash crops such as maize, rice and a number of vegetables (Misana et al., 2003).

Vegetation patterns on the slopes of Mount Kilimanjaro and Mt. Kenya have been completely altered. For example, on the southern, Tanzanian slopes a large proportion of the forest, particularly towards the lower edge, now consists of secondary vegetation. On the northern side the Tanzanians have maintained a forest reserve that is largely intact despite some incursions, but across the border in Kenya only a small remnant remains. A belt of cultivated grassland and cropland has replaced virtually the entire lower part of the montane forest belt. Much of what used to be scrub, bush and lowland forest have been converted to cropland or grassland. A similar pattern of vegetation is found on the slopes of Mt. Kenya, and similar land uses have emerged on the lower and upper slopes of the mountain (Olson et al. 2004).

II. A. 4. Soil Resources

The properties of soils influence the choice of both cash crops and food crops grown along transects. For example, a detailed study conducted on the Tanzanian slopes of Mount Kilimanjaro

indicates that most soils located on the upper and middle zone are inherently fertile as compared with soils located on the lower zones (Majule, 2003.). Major factors attributing the difference include high soil fertility management levels in the Kihamba system whereby large amount of organic residues is added. On the other side there are significant soil erosion control practices including trash grass and terraces. Soil fertility degradation is common in the lower zone due to poor management practices such as excessive application of artificial fertilizers in rented fields, and transfer of biomass from the lowlands to the highlands (Misana, et. al., 2003:22). Overgrazing is also a serious problem in the lower zone leading into soil erosion (Majule, 2003).

The survey conducted by Gachimbi (2002a) on the Kenyan slopes and Majule (2003) on the Tanzania slopes of Mt. Kilimanjaro also demonstrated the natural fertility of volcanic soils, but warned of a decline of soil fertility is associated with land degradation, and poor application of chemical fertilizers. Similar conclusions have been reached by studies of soils and soil management on Mt. Kenya (Gachimbi 2002b).

II. A. 5. Pests and Diseases

All case study sites have been suffering from pests such as armyworms, locusts, grasshoppers, cutworms, and moles. Besides pests there are diseases like Coffee Berry Disease (CBD) that spread very quickly from Kenya to Tanzania in the 1970s and 1980s. Also a disease like the banana weevil spread quickly from one country to another. There is also sleeping sickness and nagana that has affected land use patterns (Bourn et. al. 2001). The major outcome of these diseases and pests has been the reduction in the outputs of crops like coffee leading to farmers changing their cropping systems by shifting to annual crops like beans, tomatoes, maize and rice. The presence of nagana has reduced the number of livestock and so turning pastoralism being less sustainable. In the end the pastoralist have been compelled to revert to farming or as stated out-migrate to other parts of the country (Mbonile, et al. 2003).

II. A. 6. Wildlife

Wildlife is an important component of the landscape in all study sites. Wildlife conservation, including the demarcation of national parks and reserves, and related tourism activities contribute to the dynamics of land use, and to the economies of Tanzania and Kenya.

The distribution of land uses and of wildlife species across the gradient often results in conflict when wildlife grazes crops or predate livestock. In Kenya such conflict is long-standing though the specifics of such encounters have changed over time as a result of changing patterns of human-wildlife competition and conflict over an extended period of time. The differences over years lie in the complex processes of socioeconomic change and their interplay with the environment. The driving forces are institutional, and ecological, cultural, economic and political.

In the Loitokitok case study, for example, the interaction between people and wildlife differed from one area to another. The greatest number of conflicts with any species of wildlife is found in the swamps (Campbell et al., 2003). The principal land use practice in the lowlands in the late 1800's was pastoralism (Thompson, 1962). Over the past 75 years the Maasai herders (original pastoral land managers) have relinquished to wildlife and farming their control over resources fundamental to their herding economy. Farming on the northern Kenyan slopes of Mount Kilimanjaro began in the 1930's. Since the mid-1970's land use changes have occurred in the area between Amboseli and Tsavo West national parks. Cultivation has expanded at the expense of forest on Mount Kilimanjaro, and riparian vegetation along rivers and around swamps in the lowlands. Also the government is encouraging establishment of tourist facilities on group ranches adjacent to parks. Today the land uses compete for access to resources particularly grazing land and water, and many people are now located where their economic and personal security are vulnerable to threats from wildlife. Decreasing wildlife populations have been observed with increase in human population (Worden et al., 2003), as a result of habitat destruction. Escalating crop raiding conflicts resulting in erection of barriers and other protective measures that have contributed to disruption of wildlife as observed in Embu District, Kenya (Chira, 2003).

Wildlife, similar to traditional herding systems, has depended on the water and grazing resources along gradients to maintain their flexibility and resilience to climatic extremes. During dry seasons and droughts, elephants and grazing animals have moved upwards to the higher elevation forests or towards other more humid areas to find food, while during rainy seasons they migrated down to graze the grasses of the dryland savannas. With land use change, including expansion of cultivation in the upper highlands and into the midlands disrupting their former migration routes, and new cultivation around dryland water sources reducing their access to drinking water, their flexibility and critical food sources have declined.

Distinct ecological zones, reflected in rainfall, soils, vegetation and the distribution of wildlife, characterize the gradients. These zones while discrete merge one into the other. The distribution of resources along the gradient influences the pattern of land use by different livelihood systems.

III. DYNAMICS OF SOCIO-ECONOMIC CHARACTERISTICS OF GRADIENTS

The patterns and processes of land use across ecological gradients in Africa have changed dramatically over the past 150 years since the advent of colonial powers. There have been changes in the power relations that determined access to and control over the diverse resources of the gradients, and these have altered the sustainability and vulnerability of livelihood systems. These dynamics will be discussed in terms of themes that illustrate the principal driving forces of land use change, power, land adjudication, demography, and environmental conditions.

III. A. Pre-Colonial Past

Access to water was, and remains, an essential component defining livelihood systems in areas where gradients encompass savanna and rainfed cropland. Important sources of water are rain, which is more reliable in the uplands of East Africa where farmers historically predominated and where herders sought refuge in times of drought, and along rivers and around swamps in lowlands where herders raised their livestock. Wildlife was tolerated as part of the total land use system, and wildlife were selective of habitats on the gradient by season and by species.

Herders needed to assure that their livestock could be watered throughout the year, and access to the variety of resources provided by the ecological gradient was critical in areas where rainfall was seasonal and droughts recurrent. Herders accomplished this through the exercise of political power, and by force if needed. In wet seasons the savanna plains were lush and surface water was plentiful. In dry seasons and particularly during droughts however the herders would move their animals up the gradient into the wetter areas where water and pasture was available. Were this to bring them into contact with farmers, the military power of the herders would ensure access if necessary.

Historical evidence suggests that the mountain slopes of East Africa have been occupied for over 2000 years (Hamilton 1982). The ancestors of the contemporary inhabitants probably moved to these areas as part of the Bantu migrations, being attracted by fertile volcanic soils and reliable rainfall. The principal crops grown were sorghum and sweet potato, and many kept livestock, including cattle and goats. For example, the Chagga who have resided on the southern slopes of Mt. Kilimanjaro since the 1600s developed an intricate land use system, the Kihamba or home gardens characterized by multi-purpose trees intercropped with food crops, mainly bananas, finger millet and beans, and the shamba land (small fields in-between the different vihamba) with food crops like maize, beans, yams, sweet potatoes, finger millet and grass for livestock (Anderson, 1982). This agroforestry farming system is supported by a sophisticated indigenous irrigation system. The farmers also own livestock, some being stall fed, and applied manure from the livestock. The farmers of the uplands throughout East Africa traded with adjacent herding groups, such as the Maasai around Mt. Kilimanjaro and the Mbeere on the eastern slopes of Mt. Kenya. The Chagga also participated in the regional trade from the coast inland to Lake Victoria.

There were significant interactions between and within livelihood systems. The interaction was

affected by the power distribution between groups. The pastoralists held more power than the cultivators in many areas during this period. The interactions included:

- Lowland-upland mobility seasonally by herders, and valley-hill diversification of land use by farmers.
- Lowland products such as meat, milk and hides were exchanged for upland crops.
- Nutrients were transferred across the gradient as livestock brought manure to fields, and was in some cases “mined” in areas where livestock were corralled and manure sold to cultivators.
- Cattle were the expression of wealth and would be purchased by farmers to demonstrate their status.
- Inter-marriage between groups was frequent.

The majority of interactions occurred at the boundary between the upland farming systems and those of the herders in the lowlands. The boundary zone is that of highest potential for the latter, while it is relatively unimportant for the former who can manage without access to boundary zone. This is not the case for the livelihood systems at the drier end of the gradient for which it represented the best of the resources easily accessible to them. This zone was of mutual benefit to the livelihood systems across the gradient through exchange of products and cultural interaction, and also a zone of potential conflict between them, particularly over access to water.

III. B. Colonial Times to the Present

A number of processes contributed to change in the nature and distribution of livelihood systems since the colonial period. These included a disruption of pre-colonial power and authority structures, economic development, population growth, land alienation, and land consolidation in high potential lands. These processes created a land shortage in many high potential areas leading to out-migration of farmers. They moved to lower potential areas including to areas adjacent to existing settlement, to high potential “islands” in drylands such as river valleys and swamps, and to the lower slopes of mountains.

III. B. 1. Power

The most important impact of colonialism on cross-gradient interaction emanated from the loss of military and political power by herding groups, and the transfer of authority, under indirect rule, to farming societies. As herders lost power and their dominance of access to water in dry seasons and during droughts, farmers expanded into the wetter margins of the rangelands, including into river valleys and swamps formerly controlled by herders (Campbell, 1981).

The colonial policy favoured farming relative to nomadic, extensive livestock production. Political power shifted from herders to farmers, and the latter become more integrated with the state in terms of political and institutional power, access to infrastructure and markets, and the processing and marketing of their commodities. The British in Kenya chose to restrict access to the lucrative cash crop and commercial livestock sectors to settlers in the “White Highlands”. The colonial authorities imposed taxes on the indigenous population and Kenyan smallholders in the central highlands, including Mt. Kenya. To obtain cash for taxes farmers were encouraged to produce grains for sale in the expanding administrative and market towns, as well as for subsistence. The British imposed a system of chiefs who were responsible for collecting taxes and assuring labour for terracing of the slopes to improve soil conservation. Colonial investment in the highlands, particularly in and close to administrative headquarters such as Embu town, included extension services, roads, schools and medical facilities.

In Tanganyika, the Germans saw great potential in the production systems on the slopes of Mt. Kilimanjaro. They established coffee estates, and Moshi developed as a market and administrative centre linked by rail to the coast. After World War I the British assumed authority and they encouraged the Chagga to grow coffee and vegetables for sale in Moshi and the coastal towns. The home gardens intensified, and an increase of population led to a decline in access to swidden lands.

The expansion of coffee production led to the conversion of the grazing areas in the uplands, which necessitated stall-feeding (Soini, 2002a). Among the Chagga some of the small fields (shambas) where food crops were grown and *Dracaena* groves, areas set aside for burials and sacrifices were also converted to home gardens. In contrast to the situation in Kenya, the livelihood systems on the mountain slopes were integrated into the colonial economy. Increased wealth led the Chagga to create producer cooperatives, and to invest in roads, education, and medical facilities.

Colonial investment was, by and large, restricted to high potential areas that were accessible to the infrastructure of the colonial economy. The more remote areas were essentially disregarded. Thus although the Kenyan slopes of Mt. Kilimanjaro had agricultural potential it was not developed due to geographic isolation from the selected centres of the colonial economy and its transportation infrastructure. Similarly the lowland zones adjacent to the mountains were left largely beyond the realm of British colonial interest, except for the posting of district officials to ensure administrative compliance. Herders could no longer maintain access to water or dry season grazing by force, except where the power of the state was limited by conflict or isolation and herding groups remained mobile and in effective authority.

The change in the distribution of livelihood systems affected wildlife migrations and distribution. In the East Africa wildlife conservation policy, a systems of parks and reserves was established which affected lowland livelihood systems' access to resources. In some areas this was also true of upland systems where upland parks were demarcated such as on Mt. Kilimanjaro in Tanzania, and Mt. Kenya and the Aberdares in Kenya. A significant outcome of conservation policy was that issues of compatibility, competition, and/or conflict arose between wildlife and adjacent livelihood systems (Campbell et al. 2000).

III. B. 2. Land Adjudication Policy

Land ownership and user rights are critical issues in determining access to humid areas that support rainfed cropping and to water along rivers and around swamps. The colonial authorities implemented policies that had a significant impact upon African society. The process of demarcating land as national parks and reserves for the conservation of wildlife was one facet of colonial land policy. A second was to allocate land to settlers, as with the coffee and sisal estates in Tanzania, and the "White Highlands" in Kenya. In the central highlands of Kenya it contributed to severe disruption of established land use systems. This included land consolidation that reduced valley-hill crop diversification across the gradient, thus increasing the risks associated with drought and crop diseases. These policies of appropriation of land from the indigenous systems, and land consolidation were resented by the African population and provided the impetus for the Mau Mau revolt against the British.

Since the mid-1950s on Mt. Kenya, the British and subsequently the independent government have enforced land adjudication programmes that transferred land tenure from communal land organized by clans to private farm land organized by individual families. The focus was initially upon the high potential agricultural lands, including the rain fed slopes of Mt. Kenya. Land adjudication has stimulated a land market with the potential for redistribution of rights of access. Land became a commodity and replaced cattle as the measure of wealth. The policy was later applied to the drier lower slopes of the gradient and is now being applied to the rangelands.

The gradient on the northern slope of Mt. Kilimanjaro in Kenya has experienced land adjudication programmes since the mid-1950s. Initially land on the wetter slopes was allocated as Individual Ranches and that in the lowlands as group ranches. The Individual Ranches were quickly subdivided into small farms. Some of these were farmed by Maasai who had married wives from farming groups such as Kikuyu, Kamba, and Chagga. Others were sold to immigrant farmers who had experienced land shortage elsewhere in Kenya, such as on the slopes of Mt. Kenya. (Campbell 1993). Over time, with population growth in the area, and with continuing immigration, farming spread down the gradient into the drier slopes, and eventually extended to irrigated riparian areas along rivers and around swamps in the Group Ranches. Those farming in these areas did not have

formal rights to land, and many settled as sharecroppers with Maasai members of Group Ranches, or farmed as day labourers. Population growth, ambiguity as to land rights among younger members of Group Ranches, the increase in farming, and the lucrative returns to irrigation, have culminated in contemporary demands for subdivision of the group ranches. The implications of a subsequent land market for the herding and wildlife-based economies of the area are uncertain (Ntiati, 2002).

Similar uncertainties face the people in the lower reaches of the eastern gradient on Mt. Kenya. Land adjudication is recent and ongoing among the Tharaka and the Mbeere and both traditional and modern land allocation procedures are involved in distribution of land titles (Smucker, 2003; Olson et al., 2004).

In Tanzania, the land tenure system particularly in the upper and middle zones on the slopes of Mount Kilimanjaro is traditional with the dominant system being the Kihamba system (Mbonile, 2003). With increased population, agriculture and settlement increasingly spread to steep river valleys and down the slopes to the lowlands, with cultivation of food crops being pushed to the lower slopes. The lower slopes that bordered settled areas and the plains were mostly covered by woodland and bush land (Holland, 1996). The Chiefs allocated lowland plots (shambas) to upland farmers from the 1940s to 1960s so that a farmer would have a kihamba (home garden) in the upland for coffee/banana production and a shamba in the lower slopes/lowlands for food crop production (Maro, 1974). Also, additional coffee estates were established in woodland and bush land zones in the upper lowlands (Soini, 2002a).

Land adjudication is a response to economic development and to the perception that it is a necessary precondition for sustainable land management. It is also driven by population growth and migration. Each of these has a specific relationship with the land potential exhibited across the gradient. The upper reaches have greater economic potential, a higher land value, population densities are elevated, and in the absence of conservation measures, the potential for land degradation is high. The lower slopes, in contrast, have less remunerative production systems, and lower population densities. Recent trends in down-gradient migration are resulting in an intensification of land use, with an associated potential for land degradation.

III. B. 3. Population Dynamics

The pattern and intensity of land use across the gradients is reflected in demographic characteristics. The slopes of both mountains where the rainfall is more than 1,000 mm per year have high population density exceeding 600 people per km² in some districts like Embu, in Kenya and Moshi Rural in Tanzania. On the other hand, in the lowlands and on the leeward slopes of these mountains where the rainfall is below 500 mm pa the population densities have been low until very recently when farmers settled to form clusters of dense population especially in well watered areas (Campbell, 1999; Olson and Maitima, 2002).

Population densities on the Tanzanian slopes of Mt. Kilimanjaro have changed dramatically during the last 60 years and illustrate patterns of change similar to those of the slopes of Mt. Kenya (Maro, 1975; Mbonile, 1999:18). The population increased from about 267,700 in 1948 to about 840,000 in 1988 and to 1,053,204 in 2002. There is also a high in-migration to local urban areas. However, this high population growth is slightly reduced by the heavy out-migration of population to other regions in Tanzania as well as abroad (Mbonile, 1999:5). A number of reasons explain these rapid changes of population dynamics in Tanzania. First, the introduction of traditional irrigation systems enabled the farmers to grow crops throughout the year and increased the productivity of staple foods like bananas. Secondly, there was a change in the cropping system with the introduction of coffee as cash crop, combined with improved health care and hygiene. The cash enabled the population to buy foods from other places and support the high population density. Third, the increase of population mobility between the lowlands and the highlands increased the area that could be cultivated. In addition, people are tapping resources like grass and crop residues, transporting them to the highlands where they enrich the soil by making compost manure, and feeding them to livestock that in turn produce manure.

A similar trend of population growth was observed in the northern slopes of Mount Kilimanjaro where population growth has been very rapid during the post independence period. In Kajiado District, Kenya it increased from 85,000 in 1969 to nearly 259, 000 in 1989. The major cause of rapid growth rate exceeding 5.5% pa has been the migration of agrarian ethnic groups from the densely populated central highlands dominated by Mount Kenya. These agrarian groups have migrated to cultivate the well-watered and fertile slopes of Mount Kilimanjaro and the Ngong Hills near Nairobi and where subsistence farming and livestock keeping dominate the economy. The other economic activities in this area include horticulture and wildlife based tourism in the lowlands (Campbell, 1999).

Rising human populations along with much land tenure change and expansion of cultivation have squeezed pastoralists onto land areas that are too small to be viable for pastoral production particularly in the driest zones. This has led to an untenable situation where pastoralists can no longer depend on their livestock as the sole basis of their livelihood, while opportunities for livelihood diversification are few. Furthermore, livestock populations have tended to be stable rather than expanding because of disease epidemics and livestock starvation associated with recurring drought. The result is a rising human population dependent on a stable or declining livestock population.

Thus, the general pattern has been the movement of farmers and farming down the gradient towards the more arid lands. This has led to an intensification of land use as agriculture replaces herding at the wetter margins of the rangelands, but has resulted in the grazing and watering options of herders being reduced and they concentrate on the limited remaining sources. With more intensive cropping, the possibility of land degradation is enhanced. There are also questions about the impact on biodiversity. The gradients had supported a diversity of ecological resources – biodiversity of soil, flora, and fauna. With the change in land use is the biodiversity of the gradient altered, conserved, enhanced, or depleted? And does “Natural” biodiversity give way to biodiversity derived from activities of livelihood systems?

IV. CONCLUSION

This paper has discussed the ecological gradient as an organizing framework to assist understanding of the complex interactions between societal and ecological processes underlying land use change in East Africa. It has drawn on detailed case studies on the gradients of the slopes of Mt. Kilimanjaro and Mt. Kenya to show how land use change is responsive to the dynamics of both local and external driving forces.

The study has shown that the distinct ecological conditions at the extremities of gradients are associated with specific land uses. These may be different livelihood systems (e.g. farming and herding) or uses within livelihood systems – such as for wet season and dry season grazing. Access to water (rain, stream, swamp) for cultivation, domestic uses, livestock, and wildlife is critical in determining the nature and distribution of livelihood systems.

Land use systems (e.g. livelihoods and wildlife) interact across the different ecological zones of the gradients, and thus a gradient is characterized by vigorous spatial, cultural, and economic interactions, sometimes conflictual, between or within land use/livelihood systems.

The level of exchange, competition, and conflict across the gradient is determined by the relative power of different livelihood systems – ethnic, military, political, economic, technological – to control access to key resources. What has occurred on the East African gradients has been local expressions of the broader, national socio-economic-political system.

The dynamic nature of gradients is evident in the case studies. The major land use changes have been the expansion of cultivation down the slopes and the replacement of natural vegetation by cultivated land. In the uplands, there has been encroachment on the forest for agriculture and in some areas exotic trees have replaced the indigenous trees. In the lowlands, including the plains,

agriculture has expanded into areas formerly used for watering animals, grazing and wildlife conservation.

A key issue is whether the changes in the cross-gradient interactions have increased or reduced the sustainability of livelihood systems and the natural resources upon which they depend. There is strong evidence that the upper gradient, the areas of higher economic potential that were the focus of colonial economic and infrastructural investment, remain advantaged compared to areas lower on the gradient that were geographically and perceptually distant from colonial investment. Post-colonial policy has generally reinforced the geography of colonial development.

With high and increasing population densities, upland areas have however failed to provide sustainable livelihoods for many, and rural-urban and rural-rural migration has ensued. Some of those who have failed to prosper upslope have moved down the gradient. Much of this migration has been to the wetter margins of the adjacent lowlands, to riparian lands along rivers and around swamps where formal or informal irrigation has developed. Lack of security of access to land, and competition over land and water resources is a contemporary characteristic of many such areas, and thus the long-term future of the migrants remains in question.

This study has illustrated the importance of gradients to livelihood systems in East Africa. The ecological characteristics have influenced their activities and distribution. There are important interactions between them in terms of trade, social relations, and access to resources. These interactions have changed over time as power relations between groups have altered access to resources, and as external economic and political processes have shaped options available to different livelihood systems. These changes have had an impact on the sustainability of the resource base across the gradient, and future patterns of land use will reflect the ability of the resources to support them.

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