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

The Effects of Wildlife-Livestock-Human Interactions on Habitat in the Meru Conservation Area, Kenya

LUCID Working Paper 39

By

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1. INTRODUCTION[1]

Kenya's policies on land use are normally well intended, but their limitations to narrowly defined sectors of the economy has often led to undesirable ecological and socio-economic implications for biodiversity conservation and livestock production in arid and semi-arid lands (ASALs). For instance, in an effort to address rapid increase in human population and the attainment of self-sufficiency in food production, the Kenya government has sought to increase the productivity of ASALs through dry land agriculture and intensified livestock production (ROK, 1994; Southgate & Hulme, 1996). This policy has provided agricultural communities occupying high potential agro-ecological zones with a perfect opportunity to seek alternative land for settlement and crop cultivation in the country's rangelands. Thus, over the past few decades, Kenya's Meru Conservation Area (MCA) has witnessed a steady immigration of agricultural households from nearby high potential agro-ecological zones into its buffer zones. The situation has subjected natural habitats that formerly served as communal grazing lands and wildlife dispersal areas to sustained fragmentation and alteration, as these migrant households take up land for settlement and crop cultivation. The most affected zones are the wetter margins of the western and southern buffer zones, which are also critical for livestock and wildlife, particularly in the dry season. The situation has led to a reduction in the livestock grazing range, a decline in the livestock/wildlife resource base, and increased resource competition among wildlife, livestock and agriculturalists. Consequently, the MCA has increasingly witnessed complex interactions between conservation and socio-economic needs and pursuits of households occupying its buffer zones. Some of the indicators of these interactions include land use related land cover changes and disputes arising from conflicts of interest among agriculturalist, pastoralists and conservationists with wildlife as the common ground of contention, particularly on the western, southern and northern boundaries of Meru National Park.

The MCA is therefore a classical case of Kenya's protected areas that are currently degenerating into 'island' national parks and reserves surrounded by increasingly reducing—hence largely degraded—pastoral grazing lands, and fast expanding smallholder farmlands (UNEP & KWFT, 1988). Since 65-80% of Kenya's wildlife occupy areas outside the formal boundaries of protected areas at any given time (Matiko, 2000), while pastoral livestock depend on the wetter margins of rangelands as dry season grazing reserves (Herlocker, 1999; Ekaya, 2001; Serneels, 2001), the situation in the MCA poses serious ecological and socio-economic implications for biodiversity conservation and livestock production in the Greater Meru Ecosystem. It is on this basis that this working paper seeks to review the link between Kenya's present policies on land use in ASALs, wildlife conservation and utilization, and human population growth and distribution; as they affect land use in rangelands. Finally, as a case study, the paper presents an in-depth analysis of the effects of wildlife-livestock-human interactions on habitat in the MCA as a consequence of the above policies; and the implications for biodiversity conservation and livestock production in the region.

2. CHARACTERISTICS OF KENYA'S ASALS

2.1 The physical and socio-economic environment

In Kenya, like other East African countries, arid and semi-arid lands (ASALs)—also referred to as rangelands—(Herlocker, 1999), are characterised by low, erratic and unreliable rainfall, high temperatures, low humidity, low soil fertility and poor drainage (Southgate and Hulme, 1996; Ekaya, 2001). They have marginal agricultural productivity with livestock production and wildlife management as the principal land use types. Kenya's ASALs are therefore largely uncultivated areas that support grazing and browsing animals, with vegetation and water as the most critical natural resources (Pratt and Gwynne, 1977; Herlocker 1999; Serneels, 2001)

[1] This report is derived from a M.Sc. thesis written by the author from the University of Nairobi Department of Zoology.

ASALs make up 87% of Kenya's total land area (Pratt and Gwynne, 1977). These areas support over 25% of the country's total human population, 52% of the total livestock population and 90% of the country's wildlife resources (Maalim, 2001). With not less than 4 million Kenyans engaged in full-time pastoralism and several more millions deriving the bulk of their sustenance from livestock production, ASALs are important in supporting both rural and urban livelihoods (Wekesa, 2001). For instance, it is currently estimated that the total value of livestock in Kenya's ASALs is more than Kshs 70 billion, which accounts for about 90% of the pastoral economy and 10% of the Gross Domestic Product (Wekesa, 2001; HPI, 2002). ASALs are also important for the country's tourism industry, through which Kenya earns about Kshs 50 billion annually, based largely on viewing of wildlife in protected areas (UNEP and KWFT, 1988; Herlocker, 1999).

2.2 Land use in Kenya's ASALs

In the pre-colonial era, Kenya's ASALs supported nomadic pastoral communities and large wildlife populations (Southgate and Hulme, 1996). The pastoral livestock production system was a largely subsistence economy based mainly on milk production, although other products, such as meat, blood, hides and skins were also important (Williamson and Payne, 1978). Livestock played a very important role in the pastoral culture: they not only provided social status, but were also used as reserves of family wealth; they also were a form of social capital and an insurance against disaster (Williamson and Payne, 1978; Bekure *et al.,* 1991). To ensure survival in the face of frequent and often extreme environmental fluctuations, the pastoral livestock production system was characterised by such coping mechanisms as high mobility and flexibility, a milk-based diet, herd splitting, use of dry season grazing reserves, stocking herds with a high proportion of breeding females and use of a social security system of stock loans and redistribution. This system was labour intensive, and valued large and often diverse herds (Herlocker, 1999; Ekaya, 2001).

A striking feature of the pastoral livestock production system was its success for thousands of years. Pastoralists and their livestock were in dynamic equilibrium with the range environment. Rangeland degradation seldom occurred because the growth of human and livestock populations was constrained by such factors as disease, raiding between tribes and limited supplies of water. Thus, except during drought, the availability of forage was seldom a problem (Thurow *et al*., 1989).

Though pastoralists still apply these coping mechanisms, so much has changed. In an effort to address rapid increase in human population and the desire for self-sufficiency in food production, Kenya's post independence governments have formulated profit oriented and ill-informed technocratic land use policies in ASALs that tend to promote intensified livestock production, dry land agriculture and wildlife-based tourism (Southgate and Hulme, 1996). These policies have tended to ignore the perceptions and notions of indigenous pastoral groups on ASAL resource management—which have been shaped by their experience and familiarity with the constraints of the rangeland environment over several years.

Notable effects of these policies include the gradual overshadowing of pastoral community governing councils by the influence of a central government, the continued spread of agricultural communities into rangelands from high potential agro-ecological zones, and the subsequent introduction of a market economy into ASALs which has necessitated the need for physical and macro-economic infrastructure (roads, markets, administrative facilities etc.), which are still largely lacking in Kenyan rangelands (Coppock, 1994; Herlocker, 1999).

The situation has not only introduced land use change in Kenya's ASALs, but also resource competition to the pastoral livestock production system. This has raised fears of a collapse of pastoral livestock production in rangelands, a situation that would render the 4 million Kenyan pastoralists jobless and deny the country about 10% of it Gross Domestic Product (Lado, 1992; Southgate and Hulme, 1996; Wekesa, 2001; HPI, 2002).

3. LAND USE CHANGE AND ASAL LAND USE POLICY IN KENYA

Historically, Kenya's ASALs have received low priority in the allocation of development resources. This was for a long time justified on economic grounds and the need to maximise the productivity of areas with known and proven economic potential (GOK, 1992). For instance, since the British colonised Kenya in 1895, policy for development of ASALs has been to expand agriculture, resulting in the social and economic marginalization of pastoral groups (The Swynnerton Plan, 1953; Wamicha & Mwanje, 2000). The situation has not been made any better by post independence governments, which have also tended to promote land use policies that undermine traditional ASAL land use practices, a situation which has brought agriculturalists, wildlife and pastoralists into conflict (Southgate and Hulme, 1996).

Land use policy in ASALs has revealed a mismatch between the indigenous pastoral groups' perception of resource management and the market economy approach adopted by the government (Southgate and Hulme, 1996). ROK (1994) reported that both the colonial and post-colonial authorities believed in addressing rapid increase in human population and the attainment of self-sufficiency in food production by increasing the productivity of ASALs through intensified livestock production and agriculture. The report states that with only 8.6 million hectares of Kenya's 44.6 million hectares regarded as having medium or high potential for rain-fed agriculture, irrigated cultivation in the more arid areas is regarded as an important means of increasing food production. According to the report, about 10% of the 540,000 hectares of ASALs regarded as potentially irrigable is currently under irrigation, while an additional 2,500 hectares is to be brought under irrigation each year under the current Development Plan (*Resource Mobilization for Sustainable Development)*. Government policy, under this development plan, has been to favour small-holder irrigation by virtue of its low implementation and operational costs, and its relatively successful record when compared to centrally-managed large scale irrigation schemes. Concerns have, however, been expressed with regard to irrigable land in ASALs. The proximity of such land to water is in most cases quite close, which makes their value to both wildlife and pastoral populations critical both as water points and dry season grazing reserves (Southgate and Hulme, 1996; Herlocker, 1999; Serneels, 2001).

Thus, the absence of a land use policy that recognises the role of pastoral livestock production as an ideal land use type in Kenyan rangelands has contributed to the spread of agriculture into high potential areas of ASALs, making these areas to increasingly become the locus of resource competition in rangelands (Southgate and Hulme, 1996; Lorot, 2002). Some of the reasons attributed to the failure to comprehensively incorporate the pastoral livestock production system into Kenya's ASAL land use policy include the following arguments:

(i) The colonial attitude and perception of nomadic pastoralism may still be influencing the policy of post-independence Kenyan governments. The extracts below illustrate the perceptions of Sir Charles Eliot, Kenya's second Governor:

"*I cannot admit that wandering tribes have a right to keep other and superior races out of large tracts merely because they have acquired the habit of straggling over far more land than they can utilize………..!*

"The only hope for the Maasai is that under intelligent guidance, they may gradually settle down and adopt a certain measure of civilization. Any plan of leaving them to themselves with their old military and social organization untouched seems to me fraught with grave danger for the prosperity of the tribe as well as for the public peace" (Eliot 1905, quoted in Southgate and Hulme, 1996);

(ii) That pastoralists were among the last groups to embrace formal education thus the current crop of policy makers are not informed on the pastoral thinking and their way of life. Proponents of this school of thought argue that these policy makers have tended to think that irrigation in rangelands would be a good way of making the largely uncultivated lands more productive and in

the process make pastoral communities more productive members of the society by settling down (Lorot, 2002); and

(iii) Pastoral livestock production has for a long time been placed under the Ministry of Agriculture where, as a legacy of colonial attitudes towards indigenous populations and their land use practices, land use policy in ASALs has been formulated along the following three principal objectives: to promote and maintain stable agricultural practices; to provide for the conservation of the soil and its fertility; and to stimulate the development of agricultural land. Thus, the ministry's land use policy has over the years tended to promote agricultural expansion at the expense of other competing sectors in Kenya's ASALs (Southgate and Hulme, 1996).

Going by the arguments of Darkoh (1990); Said *et al.* (1997) and Ekaya (2001), land use change in Kenyan rangelands has introduced resource competition among pastoralists, agriculturalists and wildlife, thereby weakening pastoral traditional responses to hazards, the effects of which would be severe consequences for Kenya's ASALs with regard to habitat degradation, biodiversity losses and increased poverty. The situation has been attributed to the absence of a coherent and comprehensive policy on the environmental and the institutional capacity to support the same (Southgate and Hulme, 1996); lack of land zoning in areas of conservation concern (Serneels, 2001) and agriculturally-induced land tenure reform programmes in areas where livestock production and wildlife management remain the principal land use types (Smucker, 2002). Efforts should therefore be made towards formulating a comprehensive policy on land use and land tenure in Kenya's ASALs if the country's ASALs are to be spared of habitat degradation, loss of biodiversity and increased poverty among pastoral communities (UNEP and KWFT, 1988; Said *et al*., 1997; Herlocker, 1999; Ekaya, 2001). It is hoped that the recent establishment of NEMA is expected to bring together comprehensive legislative and institutional environmental policy framework to replace the present *limitations of narrowly defined sectors in dealing with the total environment* (Bragdon, 1992; Southgate and Hulme, 1996).

4. WILDLIFE CONSERVATION AND MANAGEMENT POLICY IN KENYA

4.1 Wildlife conservation: A historical perspective

According to Nyeki (1992), formal conservation began with a group of explorers at a historic campfire in Yellowstone, USA in 1870. Two years later, the US government passed a bill authorising the setting apart of certain areas as conservation areas, and the words "National Park" came into official use. Many other countries followed this example: Canada established formal protection for the mining springs at Banff in 1885, which later became the Banff National Park; Britain founded the National Trust of Great Britain in 1895; and Sweden established the Laponia National Reserve in1909. The first protected area on the African continent was the Sabi Game Reserve founded by President Kruger of South Africa in 1892, which later became the world famous Kruger National Park. In 1900 the East African Game Regulations were developed, and this lead to the creation of the Kenya Game Department in 1907.

In 1937 an Ordinance was passed in Kenya strengthening the laws relating to the protection of game animals and birds (Nyeki, 1992). Consequently, the government appointed the Game Policy Committee in 1938 to study and recommend where and how to establish a system of national parks. Thus, Ordinance No. 9 of 1945, referred to as the National Parks Ordinance, was developed and a Board of Trustees appointed to administer areas of land to be designated as national parks and reserves. This led to the establishment of Nairobi National Park in 1946 and Tsavo National Park in 1948 (Nyeki, 1992). The Ordinance later became the Royal National Parks of Kenya Ordinance, which was changed further to the National Parks of Kenya Act. It is under this Act that most of the existing 56 protected areas (26 national parks and 30 reserves) were established (KWS, 1994), including Meru National Park in 1966 (KWS, 1998), bringing the total protected conservation area to 44, 720 km2—which is 7.7 % of Kenya's total land area (Nyeki, 1992).

4.2 Post–independence wildlife conservation policy in Kenya

Nyeki (1992) reported that after the 1945 changes in Ordinance, two government institutions were established to administer wildlife policies, namely: the Kenya National Parks Organization; and the Game Department. The Kenya National Parks Organization was charged with the protection and administration of national parks and national reserves. This included developing them as tourist resorts for the benefit and enjoyment of the general public.

On the other hand, the Game Department administered and controlled all wild animals outside the authority of national parks, including those on private land. The department advised and assisted local county councils to establish game reserves where hunting of wild animals was forbidden. Consequently, the various game reserves under county councils were officially declared hunting blocks where only licensed hunting was allowed under the control of the department.

To encourage local people to understand and appreciate the need for wildlife conservation, and develop good relations between the department and the local people, the Game Department often gave financial assistance to local authorities. These grants were for the construction and development of public utilities such as primary schools, dispensaries and cattle dips. The councils were also expected to use these grants to pay compensation for loss of property caused by wildlife.

In 1976, an Act of Parliament (*The Wildlife Conservation and Management Act, 1977*) merged the two wildlife institutions into one government department, the Wildlife Conservation and Management Department, under the Ministry of Tourism and Wildlife. The new department brought together all matters concerning wildlife conservation in the country and became the only overall wildlife authority on state land, trust land and private land. It was responsible for conserving and managing all wildlife resources in the country and ensuring that the resource gave back the best possible returns to individuals and the nation in terms of cultural, aesthetic and economic gains. Such utilization was intended to be carried out in a way that was not harmful to conservation principles.

Licensed hunting, however, was not well coordinated, and poaching continued to destroy wildlife on a large scale. This situation forced the government to ban all hunting of wild animals and handling and/or trading in game trophies in 1977 and 1978 (Legal Notice No. 120 of May, 1977; Legal Notice No. 181 of August, 1979). Though the ban led to the closure of professional hunting companies and curio shops dealing in game trophies, it did not solve the poaching problem. Poaching continued to reduce the population of certain animal species, especially the elephant and rhino. For instance, the elephant and rhino populations declined by 85 % and 97 % respectively between 1976 and 1990. Thus, in the late 1980s, change of conservation and management policy had become essential if Kenya was to save her remaining stock of wild animals. Consequently, the Wildlife Conservation and Management Act was amended to create the Kenya Wildlife Service in 1989 (The Wildlife Conservation and Management Act, 1977; Nyeki, 1992).

4.3 Wildlife conservation under the Kenya Wildlife Service

KWS (1990) in its publication on *Conservation Policy Framework and Development Programme* in Kenya reported that the Kenya Wildlife Service was established by Act of Parliament in 1989 as a self-governing state corporation. Its mandate was to conserve Kenya's natural environment and its fauna and flora, for the benefit of the present and future generations both in Kenya and in the world. Its responsibilities included sustainable utilization of Kenya's wildlife resources for the country's economic development and for the benefit of the people living in wildlife areas. The organization was also charged with protecting the people and their property from damage by wildlife.

According to KWS (1990) and Nyeki (1992), the Parliamentary Act, which created KWS, empowered the Minister responsible for wildlife conservation and management to appoint a Board of Trustees to run KWS. The trustees, under the leadership of the Chairman of the Board, were

delegated the duty to make policies and regulations for the protection and management of wildlife in Kenya. These policies would then be approved and published in the Kenya Gazette by the Minister before they became law. In addition to this, the Board has the powers to declare, establish, de-gazette or close national parks/reserves and game sanctuaries. It can also change park / reserve boundaries, as it deems necessary. The KWS Director, who is the Secretary and Executive Officer of the Board, has general control of all wildlife affairs in the country. The Director also issues utilization licenses and consults with local authorities and communities about the conservation and management of wildlife in their areas.

The realization that 65-80% of Kenya's wildlife may be found outside the protected areas at any given time (Matiko, 2000), and hence the obvious limitations of the protected areas approach to conservation (Inamdar *et al.*, 1999), led KWS to found the Community Wildlife Service 1992 and the *Parks beyond Parks* programme in 1996 as community-based conservation (CBC) initiatives (Rutten, 1992; Southgate and Hulme, 1996). The CBC was intended to involve rural communities, particularly those sharing habitats with wildlife, as an integral part of its wildlife conservation policy. The CBC has three objectives: the conservation of biodiversity, the sustainable use of natural resources, and the equitable sharing of benefits arising from activities related to conservation (Hackel, 1998).

The CBC approach has been quite popular as it is perceived to be an effective mechanism for addressing problems of social injustice. However, its success on the ground has been limited due to several complex factors, such as its requirement of huge financial investment, highly skilled staff, a realistic long-term period, and full involvement of local communities in the formulation and implementation of policies (Serneels and Lambin, 2001). Thus, to succeed it requires long-term commitment to funding, strong local participatory links, clear, precise and achievable objectives, and careful evaluation of the cost and benefits of project components at the household level, which have been lacking in CBC (Stocking and Perkin, 1992).

In addition to this, changing land use in areas surrounding protected areas has also made it difficult for CBC to succeed. These areas are experiencing the expansion of small-holder cultivation in wildlife dispersal areas. The situation has been reported to reduce animal home ranges, leading to increased human-wildlife interaction, which may degenerate into human – wildlife conflicts (Little, 1994; KWS, 1994; Said *et al*., 1997; Serneels, 2001).

4.4 Human-Wildlife conflicts in Kenya

KWS (1994) defined human-wildlife conflicts as *"any and all disagreements or contentions relating to destruction, loss of life or property and interference with rights of individuals or groups that are attributable directly or indirectly to wild animals*". This definition also recognises those conflicts that arise from clashes of interest between competing or polarised parties with wildlife being the common ground of contention.

KWS (1994) reported that the basic premise is that in recent years wildlife-human conflicts have escalated because of (a) changes in land use especially the expansion and intensification of arable farming and sedentarization of pastoralists in rangelands, (b) inadequate wildlife control, (c) ban on hunting and capture of wildlife, and (d) natural increase in animal numbers.

Conflicts related to wildlife conservation policies and laws include the liberalization of wildlife management and utilization outside protected areas, which tends to operate on vague, contradictory and outdated policies on land use, hunting, game farming, trade, compensation, stakeholder rights, responsibilities and participation (KWS, 1994). For instance, it is contradictory to proceed with consumptive utilization of wildlife resources at the commercial scale for the benefit of landowners under the present conditions of prohibitive legislation. Some of the prohibitive legislation include the Presidential Directive prohibiting all hunting and animal capture of 1984; the ban on hunting (Legal Notice No. 120 of May, 1977); and the ban on trade in wildlife and wildlife products (Legal Notice No. 181 of August, 1979).

Conflicts related to KWS' operational strategies are largely management challenges. These range from poor law enforcement to ineffective community mobilization mechanisms, poor animal control and revenue sharing strategies (KWS, 1994).

Conflicts related to socio-economic issues include increase in human population in ASALs, land use change, the demand for land reform programmes which has led to increased demand for resources, particularly among livestock keepers and wildlife. The situation has led to increased wildlife-human interactions and degenerated into human-wildlife conflicts, such as loss of human life and destruction of property by wildlife (KWS, 1994).

5. HUMAN POPULATION POLICY IN KENYA

Kenya has a population policy concerned with the growth rate and distribution of human population. Some of these policies have had a positive effect on land use in ASAL environments, while some have contributed indirectly to land use change in ASALs (UNEP and KWFT, 1988). For instance, the primary goal of Kenya's *National Population Policy for Sustainable Development* contained in Sessional Paper No. 1 of 1997 is the implementation of appropriate policies, strategies and programmes, which take into account the relationship between human population and availability of natural resources (ROK, 1999). Some of the programmes undergoing implementation under this policy include the transformation of family planning programmes into reproductive health care policies, the promotion of education and training of women and the girl-child on their role in achieving the desired decline in fertility rates, and the promotion of policies regulating the distribution of human population, particularly rural to urban migration (ROK, 1999).

The promotion of family planning to limit family size through education and reproductive healthcare policies have lowered Kenya's fertility rate from an estimated 8.1 lives births per woman in 1978 to 4.7 live births in 1998. This has reduced Kenya's annual population growth rate from 3.8% in 1979 to an estimated 2.5% in 1998 (ROK, 1999), thereby indirectly lowering the number of people migrating to ASALs from high potential agro-ecological zones. On the other hand, the policy discouraging rural to urban migration has a direct effect in influencing the increase in human population density in high potential agro-ecological zones, which eventually leads to their migration to ASALs as a response to human pressure on land and the need for alternative land for settlement and crop cultivation (UNEP and KWFT, 1988).

Thus, indirectly population policy can influence how the public interacts with wildlife and other natural resources. The public can contribute to conservation through influencing the birth rate and migration into wildlife areas. For instance, families can limit family size, taking into account the growth of population and the resources available. In addition, reports on population growth and land use trends in specific wildlife areas can be the basis for education which can be used to raise individual and community consciousness about the impact of population on the environment (UNEP and KWFT, 1988). However, the difficulty of communicating the wisdom of family planning in wildlife areas must be appreciated, given traditional values, the labour-intensive pastoral lifestyle and the social insecurity associated with most subsistence livelihoods (UNEP and KWFT, 1988; Ekaya, 2001).

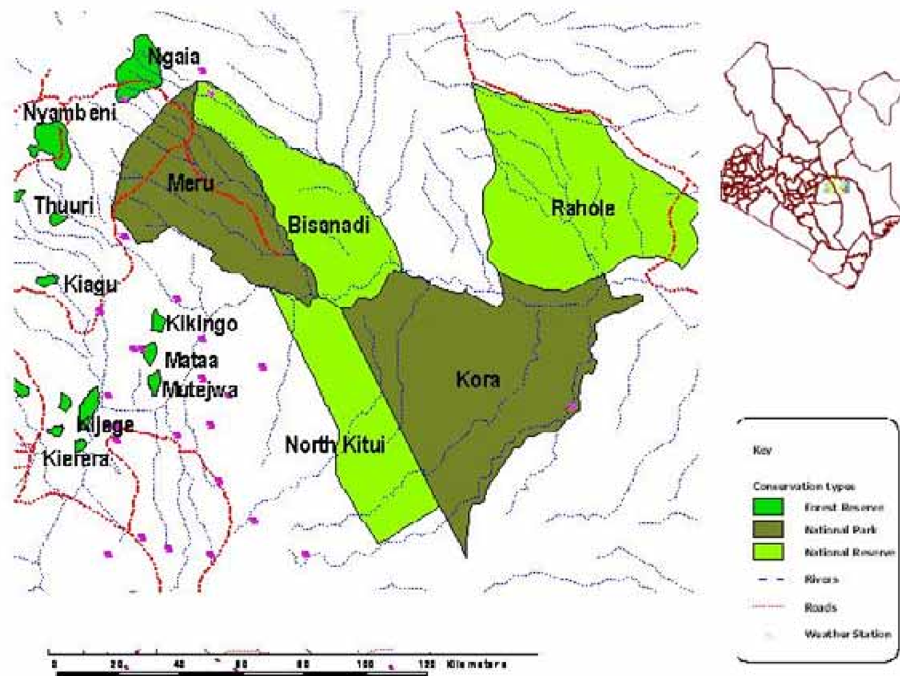
6. MATERIALS & METHODS

6.1 The Study area and study site

The MCA comprises Meru National Park, Kora National Park, Bisanadi National Reserve, Mwingi National Reserve and the adjoining community land. The conservation area is the second largest protected area in Kenya after Tsavo National Park. It is approximately 370 km North West of Nairobi and lies on the equator between 0° 20' and 0° 10' South, 38° 00' and 38^{0} 25' East

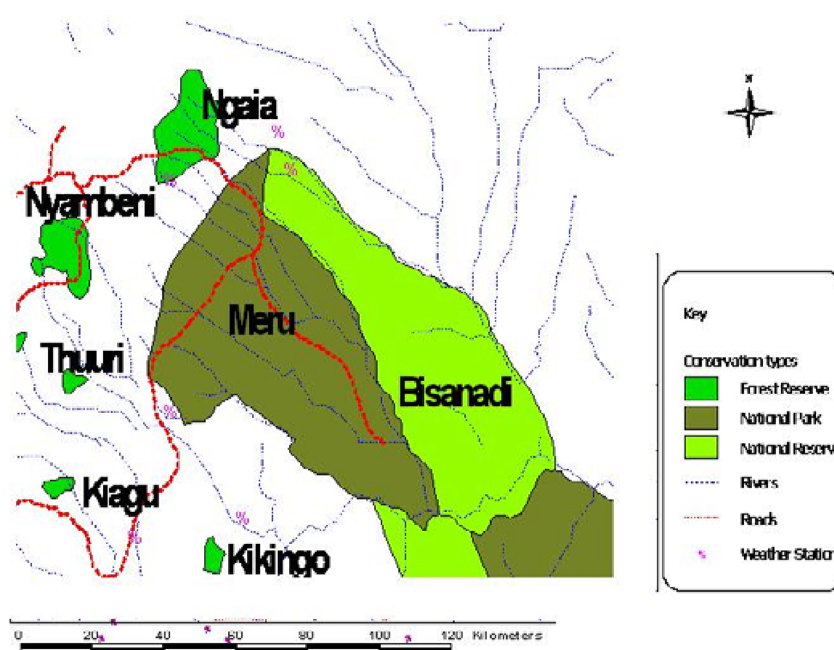
(Munyugi, Ruhiu and Warutere, 1996). Figures 1 and 2 below show the MCA and the study site respectively.

Figure 1. The Meru Conservation Area



Source: prepared from topographic sheets

Figure 2. The Study Site



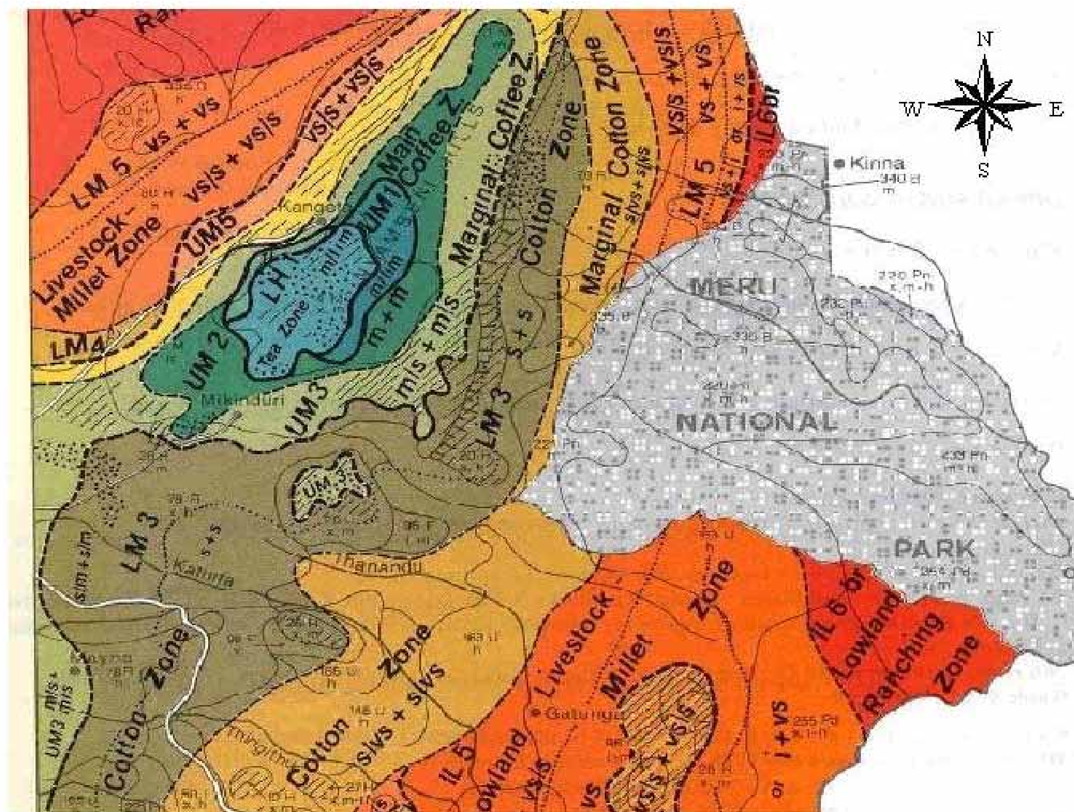
Source: prepared from topographic sheets

The area is semi-arid eco-climatic zone (Pratt and Gwynne, 1977). It has a bimodal rainfall pattern, which ranges from 380mm to 1000mm per year. The long rains come in the months of

March through June, while the short rains come in October through December. Day temperatures are consistently above 30° C and do not fall much below 20° C at night, especially in the dry season (Pratt and Gwynne, 1977; Jaetzold and Schmidt, 1983). Pratt and Gwynne (1977) described three main vegetation types in this eco-climatic zone, namely: open *Acacia* wooded grassland, *Acacia-Commiphora* bushland and *Combretum/Cordia/Grewia* shrubland vegetation.

The MCA is a gazetted protected area with wildlife management as the principal conservation activity. Owing to a marginal potential for rain-fed agriculture the adjoining community land has traditionally been under agro and pure pastoralism, although the continued immigration of agricultural communities in the area is increasingly putting the wetter margins exclusively under crop cultivation. Commonly cultivated crops include legumes, maize, millet and sorghum, but the area has also a potential for cotton, particularly in the western buffer zones and southern Tharaka area. Commonly kept livestock types include cattle on the western Meru National Park boundary; cattle, goats and donkeys in the southern Tharaka area; and cattle, goats, sheep and camels in the northern pastoral lands. Figure 2 below shows the agro-ecological zones bordering Meru National Park to the western and southern boundaries.

Figure 3. Agro-ecological zones around Meru National Park



Source: Jaetzold and Schmidt, 1983

6.2 Characterization of wildlife-livestock-human conflicts and causes of conflict

A household questionnaire survey was conducted in the buffer zones of Meru National Park and Bisanadi National Reserve (0-10km from the protected area boundary) in January 2003. The questionnaire was pre-tested among a section of the target population in October 2002. The actual survey, conducted through stratified random access method (Campbell *et al*., 2003), interviewed 42 agro-pastoralists, 30 agriculturalists and 8 pure-pastoralists to form a total of 80 households out of 5,291 households—distributed in the western, southern, and northern buffer zones of the study site. The questionnaires were distributed in each of these zones on the basis of proportional number of households.

The survey was intended to gather the following information:

i). Changes in human population within households in the MCA's buffer zones between 1980 and 2000,

ii). Residential status of households with regard to the duration of stay in the MCA's buffer zones, and the distance of the homestead from the protected area,

iii). Factors contributing to immigration to the MCA's buffer zones, particularly for households which migrated to the area between 1980 and 2000,

iv). Land use types and patterns of land use change in the MCA between 1980 and 2000,

v). Potential indicators of increased interactions between conservation and socio-economic needs and pursuits of communities neighbouring the MCA, such as wildlife-livestock-human conflicts and habitat changes,

vi). Wildlife-livestock-human conflict types in the MCA,

vii). Causes of the above conflicts,

viii). Wildlife-livestock-human conflict zones of the MCA, and

ix). Methods of mitigating wildlife-livestock-human conflicts.

Using the *t*-test for paired proportions (Sokhal and Rolf, 1981), the sample data was tested for the significance of change in human population in the MCA's buffer zones between 1980 and 2000.

i.e.

$$t_{df} = \frac{| X_{1980} - X_{2000} |}{\sqrt{(SE_{1980})^2 + (SE_{2000})^2}}$$

Where: t_{df} = *t*-test at a given degree of freedom
X_{1980} = sample population mean in 1980
X_{2000} = sample population mean in 2000
SE_{1980} = standard error of the 1980 population mean
SE_{2000} = standard error of the 2000 population mean

The study obtained demographic data from the Central Bureau of Statistics to determine changes in human population density and the spatial distribution of human population in the MCA between 1980 and 2000. This was done using ARCVIEW 3.2 GIS package (Eastman, 1999) to develop GIS maps showing human population densities and distribution in the western, southern and northern buffer zones of the MCA in 1979 and 1999 respectively.

6.3 Characterization of land use types and determination of land use change

The questionnaire survey characterised land use types in the buffer zones of the MCA, the relative popularity of each land use type among households, and the geographical distribution of various land use types within the MCA with regard to households. The survey determined possible land use changes in the various geographical localities between 1980 and 2000. The survey also reviewed land ownership among households with regard to possible land tenure reforms between the pre-independence era and 2000, particularly in the southern and western buffer zones of Meru National Park. The essence of this was to determine the implications of possible land use-land cover changes for pastoral livestock production and wildlife management.

6.4 Wildlife-livestock-human conflicts

Using the Chi-square test for the goodness of fit (Sokhal and Rolf, 1981), the study determined the significance of the difference between expected and observed cases of wildlife-livestock-human conflicts in the MCA.

i.e.

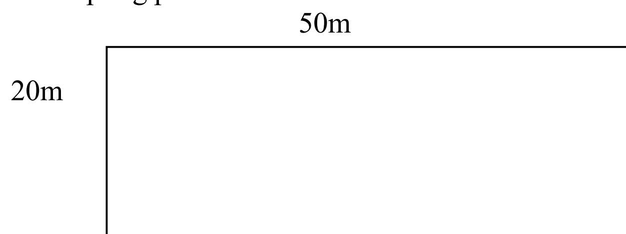
$$\chi^2_{df} = \frac{(O - E)^2}{E}$$

Where: χ^2_{df} = Chi-square at a given degree of freedom
O = observed frequencies
E = expected frequencies

6.5 Vegetation description
A reconnaissance trip was made to the study site in October 2002 to develop a general understanding of the vegetation types in Meru National Park and Bisanadi National Reserve. Ament's (1975) preliminary description of vegetation in Meru Nation Park was useful for the reconnaissance trip. Actual vegetation description began in January 2003 and the aim was to collect descriptive details, organize the vegetation data for statistical analysis and come up with physiognomic classes.

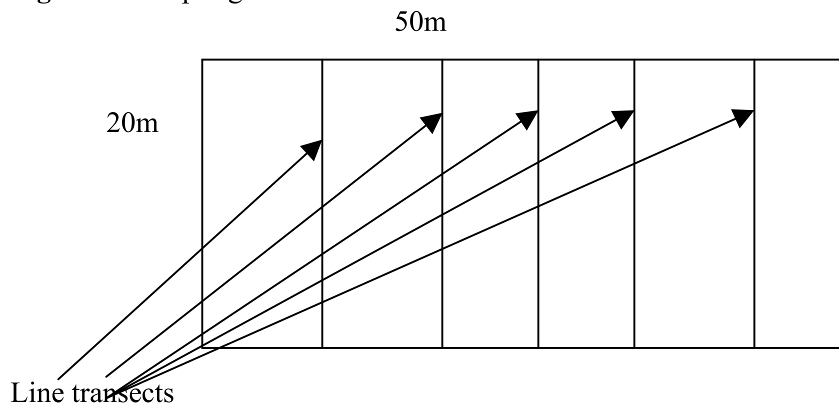
The vegetation description was hierarchical and it employed both physiognomic and floristic classification methods (Kent and Coker, 1992). The first step was to divide the whole vegetation into distinct physiognomic classes on the basis of recommendations by the East African Range Classification Committee (Pratt and Gwynne, 1977). The following physiognomic features were used to describe and classify the vegetation:
i). Plant life form: This involved describing whether the vegetation was made up of trees, shrubs or herbs/grass,
ii). Stratification: The height in metres of each life-form class was recorded, using a clinometer, and
iii). Basal and canopy: Cover estimation was done through the point-intercept method (Kent and Coker, 1992). In each physiognomic category, sampling plots measuring 20 × 50m were delineated using a measuring tape and string. The cover type was recorded as closed, open or sparse vegetation community.

Figure 4. Sampling plot



Using a measuring tape and a string, five transects, spaced 10m apart, were laid perpendicular to the baseline, along which point frames were placed for cover estimation. Four point frames, spaced at a 5-metre interval, were placed along each transect. Cover was estimated by recording 'hits' by cover category (life form class) and plant species on a cover data form.

Figure 5. Sampling transects



The percent cover of each species per transect was determined by summing up the hits for that species, dividing the hits by the total number of points along the transect, and multiplying by 100 (Kent and Coker, 1992; NPS, 2003).
i.e.

$$\text{Percent cover}_{sp} = \frac{\text{Hits}_{sp} \times 100}{\text{Points}}$$

Where: $\text{Percent cover}_{sp}$ = percent cover of a species in a transect
Hits_{sp} = number of points on which a species occurs
Points = total number of points on a transect

The total percent cover for the species in the physiognomic category was determined by adding together all the transect cover values for the species and dividing by the number of transects (NPS, 2003).

The total vegetation cover in the physiognomic category was calculated by adding the cover percentages for all plant species. This was followed by the determination of the relative cover with regard to life form classes. This involved dividing the total percent cover for each life-form class with the total vegetation cover for the physiognomic category, multiplied by 100 (NPS, 2003).
i.e.

$$\text{Relative cover}_{life\text{-}form} = \frac{\text{Percent cover}_{life\text{-}form} \times 100}{\text{Percent cover}_{total}}$$

Where: $\text{Relative cover}_{life\text{-}form}$ = relative cover of a life-form class within a physiognomic category
$\text{Percent cover}_{life\text{-}form}$ = total percent cover of life-form class within a physiognomic category
$\text{Percent cover}_{total}$ = total percent cover of all species in a physiognomic category

With the various physiognomic categories described with regard to life-form and relative cover, but the dominant species in each category being different, all species in a physiognomic category were listed for constancy. Constancy refers to the level of occurrence of a plant species in a vegetation community relative to other species (Kent and Coker, 1992). Species were ranked downwards from high to low constancy on the basis of their commonness or rarity in a physiognomic category. This involved determining the sum occurrence of a plant species in all transects divided by the total number of transects in a physiognomic category, multiplied by 100.

$$\text{Constancy}_{sp} = \frac{\text{Occurrence}_{sp} \times 100}{\text{Transects}_{total}}$$

Where: Constancy_{sp} = the constancy value of a plant species in a physiognomic category
Occurrence_{sp} = the sum of all occurrences of a plant species in all transects in a physiognomic category
Transects_{total} = the total number of transects in a physiognomic category

These constancy values were used to determine the dominant species in each physiognomic category leading to the description of species composition in each category.

A GIS map was then developed using ARCVIEW 3.2 (Eastman, 1999) to illustrate the location and distribution of the various vegetation communities described in the Meru National Park and Bisanadi National Reserve.

6.6 Determination of habitat changes

The study was originally intended to determine habitat changes in the MCA by analysing 1980 and 2001 Landsat Thematic Mapper images. However, there were no cloud-free satellite images captured in the wet season between 1980 and 1986. The study therefore used 1987 and 2001 satellite images. The analysis involved three remote sensing processes:

6.6.1 Image processing

The MCA's Landsat Thematic Mapper images for 1987 and 2001 (1:100,000) were obtained and processed using ARCVIEW-GIS Version 3.2 (Eastman, 1999). This involved correcting the images for errors generated by satellite sensors, atmospheric scattering, and geometric distortions associated with satellite movements, earth's curvature and rotation (Wilkie and Finn, 1996). Geometric correction involved image co-registration in order to overlay known landscape features (from scanned topographic sheets) to corresponding satellite image pixels, using the ground control points (GCP) method (Eastman, 1999).

Supervised classification was then carried out, by converting the spectral data contained within the satellite images directly into thematic land-cover information. This involved identifying homogeneous regions within the image that represented unique known landscapes, also referred to as *training sets.* Training sets were identified on the basis of spectral characteristics, the researchers' knowledge of the landscape features captured within the image, field visits and topographic maps of the area. With each training set representing a characteristic spectral response, digital classification was done to match the spectral signatures of each pixel in the image to a given training set signature (Wilkie and Finn, 1996).

6.6.2 Ground truthing

Ground truthing involved visiting sites that represented the land cover classes (training sets) identified in the image. It was done through stratified random access method with emphasis being placed on identifying spectral characteristics associated with each land cover class (Rush *et al.,* 1985). Ground truthing was intended to identify the size, shape and distribution of features in each land cover class as well as the variations represented between classes in the spectral image (Wilkie and Finn, 1996).

Each geographical site was located using a global positioning device (GPS) (Michener *et al.,* 1992) and topographic maps of the study area, in order to ensure a level of precision appropriate to the imagery pixel size on the ground (Wilkie and Finn, 1996). The land cover features recorded in each spectral class included the geographical location of each sample plot in Universal Transverse Mercator (UTM) co-ordinates using a GPS; percent landscape cover by each life-form class, including bare ground and areas under cultivation, using a modified Braun-Blanquet method (Kent and Coker, 1992); dominant plant species within each life form class; and the approximate maximum height for each life-form category, measured using a clinometer. The topographic features at each site, such as slope, rivers (seasonal and permanent), swamps, hills, and roads, were recorded. The land use type at each site was also recorded.

Vegetation data that was collected during ground truthing was done concurrently with vegetation description discussed above. In addition to these, photographs of the sample plots were taken to validate the data.

6.6.3 Image analysis

Using both the normalised difference vegetation index's (NDVI) subtraction method (Wilkie and Finn, 1996) and visual interpretation (Campbell *et al*., 2003), image analysis was done on the 1987 and 2001 satellite images to determine specific habitat changes. This involved viewing the remote sensing data as single-band and colour composite images in order to differentiate the spatial and spectral details available within specific land cover classes in the 1987 and 2001 satellite images (Wilkie and Finn, 1996), using the GIS package, IDRISI Version 32 (Eastman, 1999).

The observed differences were tested for significance using the *t*-test of one sample (Sokhal and Rolf, 1981).

i.e.

$$t_{df} = \frac{| X - Ц |}{SE}$$

Where: t_{df} = *t*-test at a given degree of freedom
X = sample mean
Ц = expected mean

The results were analysed alongside the human population density maps to determine the relationship between habitat changes and changes in human population densities and land use between 1987 and 2001.

7. RESULTS

7.1 Human population dynamics in the MCA between 1980 and 2000

According to the questionnaire survey, 70% of the households occupying the buffer zones surrounding the MCA were migrant communities who came to the area after 1980. Majority of these were agricultural communities from nearby high potential agro-ecological districts, such as Meru Central, Nyeri, Murang'a and Kiambu in Central Province. However, there were also groups, which migrated to the MCA from relatively drier districts, such as Kitui, Garissa and Marsabit.

Majority of the immigrations by agricultural households into the MCA's western and southern buffer zones led to permanent human settlements. Some of the factors that made the western and southern buffer zones particularly popular with agriculturalists included their high rainfall gradient (Jaetzold & Schmidt, 1983), and the fact that they were still largely open areas that served as wildlife dispersal areas and pastoral communal grazing lands in the 1980s (KWS, 1998). In addition to these, the conclusion of land tenure reforms in the southern Tharaka Area and parts of the western buffer zones in the 1990s, which culminated in land adjudication, effectively replaced the authority of clan elders on land issues with that of the central government (Smucker, 2002). Thus, individual landowners became increasingly empowered to sell off their land to migrant agricultural households without any requirements for clan approval. Table 1 below illustrates household immigration patterns in the MCA before and after 1980.

Table 1. Household immigration patterns in the MCA

Duration of residence in the MCA	No. of households	%
Households which immigrated before 1980	24	30
Households that immigrated between 1980 and 2000	56	70
Total	**80**	**100**

Source: prepared from the questionnaire survey

The survey recorded an 83% increase in human population in the MCA's western, southern and northern buffer zones, from 391 people in 1980 to 717 people in 2000 among 80 households. This corresponded closely to the 86% increase in human population reported in the 1999 Household Census by the Central Bureau of Statistics (ROK, 2001) in the six districts bordering the MCA, which indicated that human population increased from 1.56 million in 1979 to 2.90 million in 1999. This information is summarised in Table 2. From the data contained in Table 2, the *t*-test for paired proportions indicated a significant increase in human population (t_{178}; $P<0.05$) in the buffer zones surrounding the MCA between 1980 and 2000.

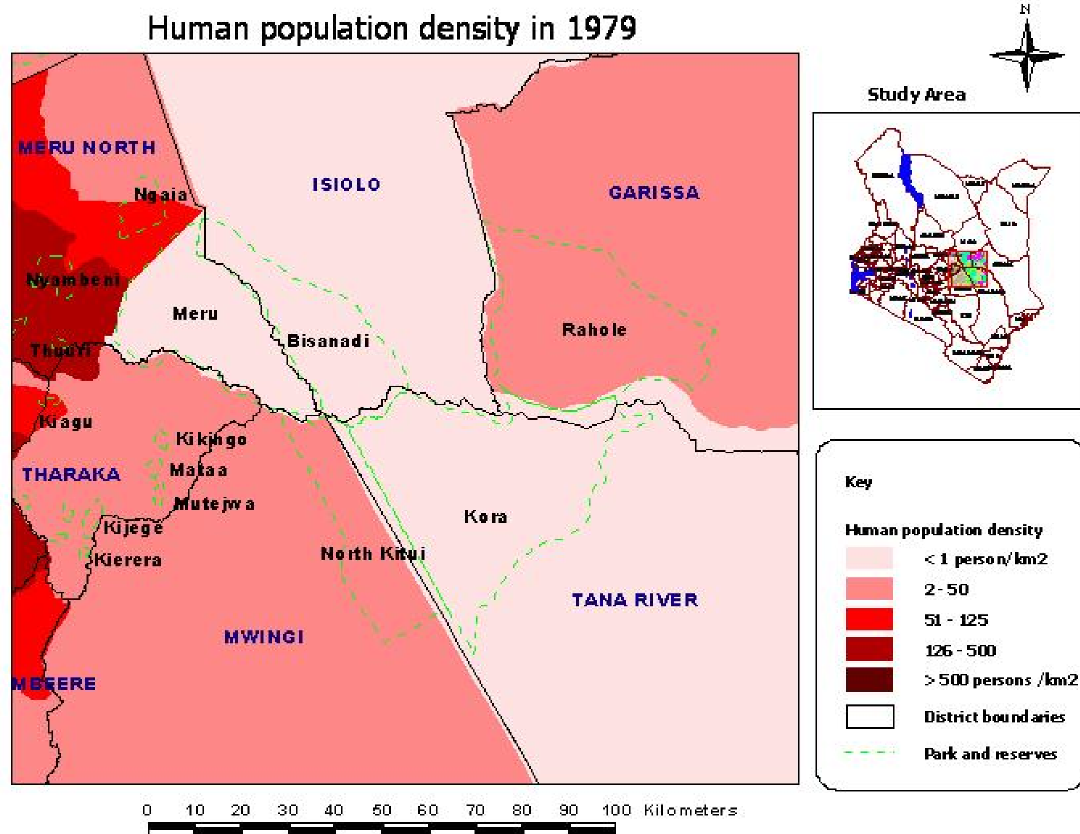
Table 2. Human population changes in the MCA between 1980 and 2000

	Sample population in 1980	**Sample population in 2000**
Sample size (n)	80 households	80 households
Sample population	391 people	717 people
Mean (X)	4.89 people per household	8.96 people per household
Std deviation (SD)	4.435	5.295
Std error (SE)	0.496	0.592

Source: prepared from the questionnaire survey

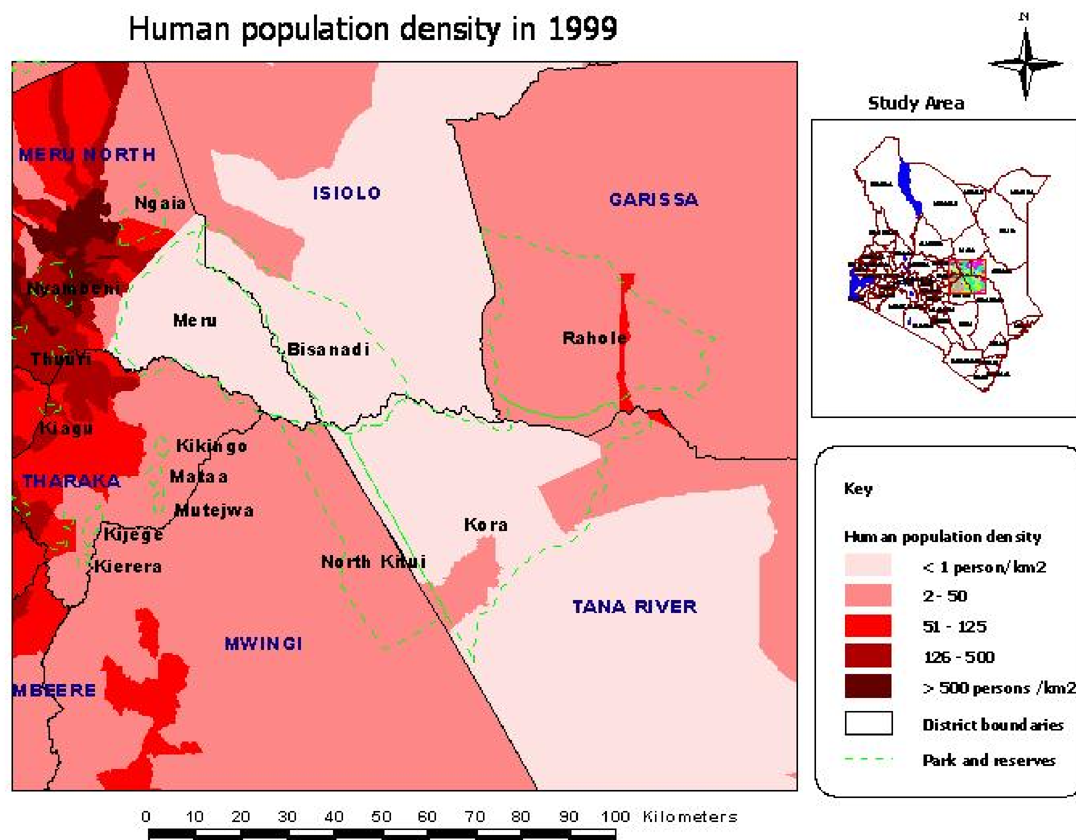
The study observed a significant increase in human population density in areas bordering the MCA between 1979 and 1999, particularly in localities with higher agricultural potential. Human population density in the southern buffer zones increased from an average of 2-50 people per km^2 to 51-125 people per km^2, and an average of 126-500 people km^2 to over 500 people per km^2 in the western buffer zones. This is illustrated in Figures 6 and 7 below using GIS maps prepared from human population data obtained from the Central Bureau of Statistics (1979 and 1999 Household Census).

Figure 6. Human population density in the MCA in 1979



Source: Prepared with demographic data from ROK (2001).

Figure 7. Human population density in the MCA in 1999



Source: Prepared with demographic data from ROK (2001)

7.1.1 Drivers of human immigration to the MCA

On the basis of weighted means, factors driving human immigration to the MCA were ranked as shown below, with decreasing level of importance. These factors were identified to act independently but simultaneously, while some operated synergistically.

i). High human population pressure on land in high potential agricultural zones and the subsequent need of alternative land for human settlement and crop cultivation,

ii). Limiting pasture and water resources in the drier parts of northern Kenya hence immigration in search of pasture and water, particularly during periods of drought,

iii). Prevailing security in the MCA's buffer zones relative to the northern bandit-prone areas, which makes areas bordering the conservation area more secure for pastoralists,

iv). Informal employment opportunities in the conservation area, which attracts potential employees to the MCA before they eventually find themselves settling in the conservation area's buffer zones, and

v). The presence of social amenities such as schools and dispensaries in the buffer zones of the MCA, which attracts households that may be living not very far way from the conservation area.

7.2 Land use in the MCA

The study identified three principal land use types in the MCA, namely: agriculture, agro-pastoralism and pure-pastoralism. Table 3 below illustrates the principal land types in the MCA and their geographical distribution in the areas bordering the conservation area.

The survey indicated that 35% of the households interviewed in the buffer zones of the MCA practiced agriculture. Majority of these households occupied the relatively wetter (1000mm of rainfall year^{-1}) western buffer zones of the conservation area. Cultivation was mainly subsistent

and commonly cultivated crops included sorghum, maize and peas, but the area has also a potential for cotton cultivation (Jaetzold and Schmidt, 1983).

Table 3. Land use types in the MCA

Land use type	**No. of households**	**Relative percentage**	**Geographical distribution in the MCA**
Agriculture	30	35	Western and southern buffer zones
Agro-pastoralism	42	55	Southern, western and northern buffer zones
Pure-pastoralism	8	10	Northern pastoral lands
Total	**80**	**100**	

Source: prepared from the questionnaire survey

Agro-pastoralism was practised by 55% of the households interviewed. These households mainly occupied the southern Tharaka area of the MCA, but a few agro-pastoral households were also encountered in the northern pastoral lands and the western agricultural zones. An inverse relationship was observed between the number of livestock kept among agro-pastoralists and the rainfall gradient with regard to crop cultivation. For instance, agro-pastoralists in relatively wetter areas such as the western buffer zones (850-1000mm of rainfall $year^{-1}$), kept fewer livestock than those in relatively drier areas (400-600mm of rainfall $year^{-1}$) such as the Tharaka and Kinaa areas in the southern and northern buffer zones respectively. The survey recorded a livestock population of 2,214 among 42 agro-pastoral households, which on average translated into 52 livestock heads for every household. However, agro-pastoral households occupying the western and southern buffer zones kept hardly 15 and 35 heads of livestock respectively, while those found in the northern pastoral zones kept well over 200 heads of livestock. The type of livestock kept by agro-pastoralists also varied with geographical location. For instance, those occupying the western buffer zones kept cattle mainly, but in the southern areas cattle, goats and donkeys were all kept. Agro-pastoral groups in the northern zones kept cattle, goats, sheep and camels.

About 10% of the households interviewed practised pure-pastoralism. These households, which consisted mainly of the Borana pastoral community of the MCA's Northern Dispersal Area, occupied the northern pastoral lands, but owing to lack of formal boundaries in their grazing patterns, they could be spotted in the communal grazing lands and wildlife dispersal areas of the western Meru National Park boundary towards the southern Tharaka areas particularly in the dry season. A livestock population of 4,653 was recorded among 8 pure-pastoral households, translating into an average of 582 heads of livestock for every pure-pastoral household. Their livestock types included cattle, goats, sheep and camels.

7.2.1 Livestock population dynamics in the MCA, between 1980 and 2000

According to the survey, the agro-pastoral households interviewed experienced a combined 12.7% reduction in the livestock population, while pure-pastoral households witnessed a combined livestock population increase of 97.7% between 1980 and 2000. This led to an increase of about 41.6% in the total livestock population in the MCA. Table 4 below illustrates the survey data on the livestock population dynamics in the MCA, between 1980 and 2000.

The study could not establish the reason for a very high increase in livestock population among pure-pastoral households, while the decline in livestock population among agro-pastoral households was attributed to several factors. Some of these factors included livestock deaths from diseases, livestock attacks by wildlife, and livestock thefts. Livestock diseases were the principal factor affecting livestock production, particularly in the western and southern buffer zones of Meru National Park. The survey found rinderpest and trypanosomiasis to be most important diseases, but foot-and-mouth disease and East Coast fever were also occasionally reported.

Table 4. Livestock population changes in the MCA between 1980 and 2000

	Agro-pastoralism	**Pure-pastoralism**	**Total no. of livestock in the MCA**
No. of households	42	8	
No. of livestock in 1980	2496	2353	4849 (in 1980)
No. of livestock in 2000	2214	4653	6867 (in 2000)
Average livestock per household in 1980	59.4	294.1	
Average livestock per household in 2000	52.7	581.6	
Percentage change in livestock population	**-12.7%**	**97.7%**	**41.6%**

Source: prepared from the questionnaire survey

Two arguments featured to explain the reason agro-pastoralists appeared to be more vulnerable to these diseases than pure-pastoralists: during the long period of interaction between pure-pastoralists and their environment, they have learnt to manage livestock diseases through ethno-botanical skills (Herlocker, 1999); and pastoralists tended to avoid habitats within the MCA that were frequented by buffaloes and other species that were considered potential carriers of trypanosomiasis.

7.2.2 Communal grazing lands and wildlife dispersal areas

The survey observed the existence of communal grazing lands and wildlife dispersal areas in the MCA's buffer zones. Their sizes were, however, found to be on a general decline, particularly in areas currently experiencing expanding crop cultivation in the western and southern buffer zones of Meru National Park. The reduction in their sizes was attributed mainly to the continued encroachment of human settlements and the fragmentation of land into smallholder cultivation units. The newly arriving communities in the western buffer zones were mainly agriculturalists, majority of who were migrating from nearby higher potential agro-ecological zones. Thus, they tended to target areas of the MCA with relatively better soil and water conditions, such as Murera, Kanjoo and Nguyuyu on the western buffer zones.

7.3 Wildlife-livestock-human conflicts in the MCA

The study categorized wildlife-livestock-human conflicts in the MCA into conflicts affecting communities bordering the MCA, and conflicts affecting wildlife.

7.3.1 Conflicts affecting communities bordering the MCA

The destruction of crops by wildlife was one the most common conflict types in the MCA. This conflict type was season dependent, and was commonly reported in the wet season when wildlife, such as elephants, buffaloes and baboons dispersed from the protected areas into the neighbouring community land. Cases of crop destruction were most prevalent in the western and southern buffer zones of Meru National Park. The most affected crops included maize, and legumes—mainly peas, which these communities cultivated in the wet season mainly for subsistence. Farms that were commonly invaded by wildlife were in most cases quite close to the park boundary, in some instances as close as 10 metres. The farm shown in Figure 8 below was situated 200m away from the western boundary of Meru National Park. It belonged to one of the agricultural households that were experiencing frequent cases of crop destruction by wildlife in the MCA's western buffer ones.

In the northern buffer zones, occupied by pastoral communities, livestock attacks by wildlife was the most frequently reported conflict type. Cattle were the livestock species most affected by this conflict type, though goats were also occasionally attacked. This conflict type was prevalent in Kinna, Rapsu and Kubresa. Animals that commonly attacked livestock were mainly the larger herbivores, such as elephants and buffaloes, but a few cases of carnivores such as lions and leopards were also reported.

Figure 8. Farmland situated on the western boundary of Meru National Park

Photo by John Otuoma, 19th January 2003

Human attacks by wildlife was also a common conflict type, particularly in the western zones of Murera and Kindani, and the northern pastoral areas of Kinna and Rapsu. In most cases wildlife attacks resulted in human deaths. For instance, 5 people were killed by lions in 1997 in Murera alone, while in January 2003 alone two cases of human deaths were reported in the Kinna and Rapsu. Incidents of human and livestock attacks by wildlife were more prevalent in the northern pastoral lands because the larger herbivores of the area were endemic species of this buffer zone, thus they live in the area with pastoralists. The picture shown in Figure 9 below was taken at the Kinna Ranger's Post after a crisis meeting of pastoral community leaders and Kenya Wildlife Service rangers. The meeting followed a near park invasion by the pastoralists when an elephant killed a local villager as he walked along the road in the nearby Kinna area at 6.30am.

Figure 9. Kinna Ranger's Post, Meru National Park

Photo by John Otuoma, 20th January, 2003

Forage and water resources were common causes of conflict in the MCA. Forage was particularly limiting in the northern pastoral lands in the dry seasons, thereby compelling pastoralists to encroach into the protected area for the same. Given the large number of livestock kept by pure-pastoral households, any single incidence of encroachment often led to marked change in the herbaceous cover of the vegetation within the protected area, while and a season-long encroachment would lead to significant changes in the vegetation pattern within a community. Thus, pastoralists and conservationists were in constant conflict in the dry seasons over forage utilization. This situation was exacerbated by the fact that entry into the protected area remains illegal, but pastoralist never appeared to respect this law.

Conflicts over water were observed mainly in the southern Tharaka zone, particularly between wildlife and agro-pastoralists. There were often claims and counter-claims of water utilization rights by KWS and the communities living along rivers that formed common boundaries. The

local communities depended on the water for both domestic use and irrigation of farms, while KWS regarded these rivers as the protected area boundary whose water they needed for utilization by wildlife. Other conflicts related to water utilization were observed in the western buffer zones, where agriculturalists dammed water upstream for irrigation, thereby interfering with water flow to the protected area downstream.

Disease transmission from wildlife to livestock was another common wildlife- livestock conflict reported by pastoral and agro-pastoral communities in the MCA. The most affected areas were the western, southern and northern buffer zones of the MCA. However, there was a lack of agreement between livestock keepers and KWS staff on whether it was wildlife transmitting diseases to livestock or vice versa. The most prevalent diseases included rinderpest and trypanosomiasis, but east-coast fever and foot-and-mouth disease were also occasionally reported. The lady in blue in Figure 10 below recounted how her family had been losing cattle to livestock diseases since their migration to the western Meru National Park boundary in 1992. Her homestead was 10m from the park boundary, where her livestock picked diseases from tsetse flies and ticks, originating from buffaloes and other game in the park. She had no livestock left at the time of the interview in January 2003. She complained also of crop destruction by wildlife, particularly baboons. The crops in the background belonged to her household.

Figure 10. Agriculturalists occupying the western Meru N. Park boundary

Photo by John Otuoma, 21st January, 2003

In order to establish the level of significance of each conflict type, the survey ranked wildlife-livestock-human conflicts affecting communities bordering the protected area on the basis of percentage frequency values. This is illustrated in Table 5 below.

It was observed that all respondents had at some point been exposed to wildlife-livestock-human conflicts, but the level of exposure was found to differ among different households. This depended on factors such as distance of homestead or land use activity from the protected area boundary, the type of conflict with regard to geographical location, land use type, and strategies used by different households to mitigate conflicts. Table 6 below illustrates the level of exposure of various households to wildlife-livestock-human conflicts in the MCA.

From the data contained in Table 6 below, the Chi-square test for the goodness of fit indicated a significant difference (χ^2_2; P< 0.05) between expected and observed levels of household exposure to wildlife-livestock-human conflicts among communities bordering the MCA.

Table 5. Conflicts affecting local communities in the MCA

Conflict type	**% level of significance**	**Area of prevalence**
Crop destruction by wildlife	27%	Western and southern buffer zones
Livestock attacks by wildlife	25%	Northern pastoral zones
Human attacks by wildlife	25%	Experienced in all buffer zones of MCA, but more common in the north zones
Disease transmission from wildlife	23%	Prevalent in northern pastoral zones, but also common in the southern borders

Source: prepared from the questionnaire survey

Table 6. Household exposure to wildlife-livestock-human conflicts in the MCA

Level of exposure to conflicts	**No. of households**	**Relative percentage**
Highly exposed	67	84
Least exposed	13	16
Total	**80**	**100**

Source: prepared from the questionnaire survey

7.3.2 Conflicts affecting wildlife in the MCA

Three main conflict types were observed to affect wildlife in the MCA, namely: the encroachment of pastoral livestock into the protected area for forage and water in the dry season, the fragmentation of areas surrounding the protected area into human settlements and farmlands, and poaching of wildlife.

Pastoralists encroached into the protected area mainly for forage and water in the dry season. This occurred when areas available to them in the northern zone were depleted of forage and a solution had to be sought to prevent the death of livestock from drought. Water was also limiting during this period because most permanent rivers in the MCA flow in the western and southern buffer zones before joining the Tana River further east. Thus, pastoralists had to move south in order to secure water resources.

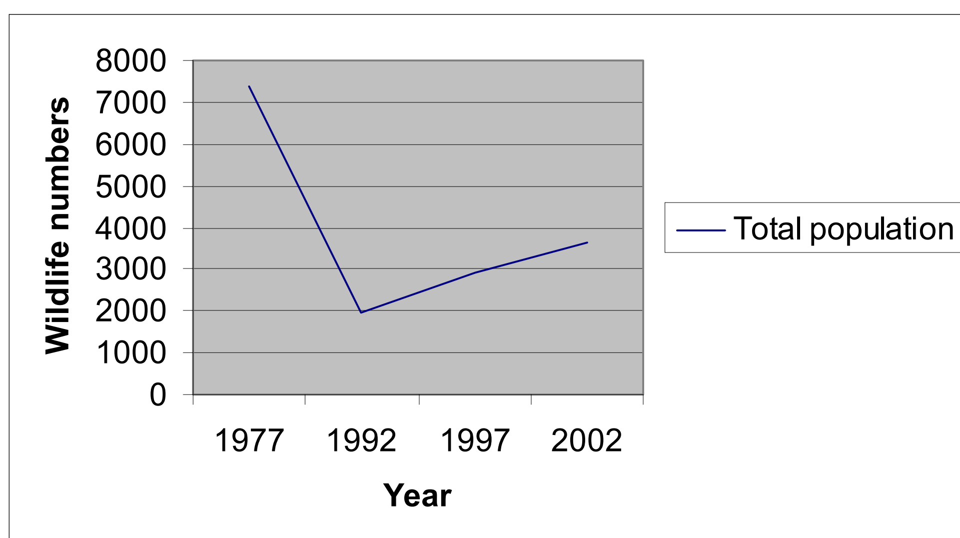
The continued immigration of agricultural communities into the western and southern buffer zones of the MCA, has led to the sustained fragmentation and alteration of wildlife dispersal areas and communal livestock grazing land, thereby rendering them unavailable for utilization by wildlife.

According to KWS, poaching was prevalent in the Northern Dispersal Area of the MCA in the late 1970s and early 1990s, but incidents of this conflict has gone down in recent times and this was attributed to improved security prevailing in the conservation area since the late 1990s. Figure 11 below illustrates changes in the total elephant, buffalo and giraffe population in the MCA between 1977 and 2002.

7.4 Causes of wildlife-livestock-human conflicts in the MCA

Wildlife-livestock-human conflicts in the MCA were attributed to three main causes, namely: causes related to land use change and Kenya's ASAL land use policy; causes attributable to wildlife conservation and utilization policy; and those associated with KWS' ineffectiveness in wildlife management.

Figure 11. Wildlife population changes in the MCA between 1977 and 2002



Source: KWS' wildlife translocation report, 2002

7.4.1 Causes related to land use change and Kenya's ASAL land use policy
According to the questionnaire survey, agricultural communities who migrated to the MCA between 1980 and 2000 cited human pressure on land and the subsequent demand for alternative land for settlement and crop cultivation in their former homes in high potential agro-ecological zones as the major factor underlying their migration to the MCA. They targeted the MCA because it was largely uninhabited at the time of their immigration.

Majority of agricultural households indicated that most of the land in wetter margins of the MCA was under pastoral grazing and wildlife conservation at the time they purchased the parcels of land they were occupying. Over time, more arrivals of agriculturalists were witnessed as the natural habitat underwent fragmentation, the grazing range and wildlife dispersal areas gradually reduced, and the livestock / wildlife resource base diminished. Thus, wildlife-livestock-human interactions increased as agriculturalists, agro-pastoralists and pure-pastoralists sought access to limiting resources, a situation which led to wildlife-livestock-human conflicts in the MCA's buffer zones. For instance, chances of wildlife finding themselves in homesteads and farmlands rose significantly, and led to an increase in incidents of crop destruction and human attacks by wildlife especially in the wet season. Pastoralists, on the other hand, increasingly found it difficult to keep to the northern buffer zones left to them, thus they ended up encroaching into the protected area whenever their zones were depleted of forage, particularly in dry season.

This type of conflict, though directly attributed to land use change through the introduction of cropping and the subsequent competition for resources among wildlife, livestock and agriculturalists, had a strong bearing on ASAL land use policy in Kenya. The study found the existing ASAL land use policy to promote dry land agriculture at the expense of pastoral livestock production and wildlife management, a situation that has contributed to the on-going conversion of wetter margins of rangelands to farmlands (ROK, 1994; Southgate and Hulme, 1996; Lorot, 2002).

7.4.2 Causes related to wildlife conservation and utilization policy
According to the survey, most respondents found it difficult to engage in community-based wildlife conservation, as a conflict mitigation strategy, when the existing legislation bans all forms of utilization of wildlife resources. Some of the prohibitive legislation which they cited include the Presidential Directive of 1984 prohibiting all forms of hunting and capture of wildlife; the ban on hunting (Legal Notice No. 120 of May, 1977); and the ban on trade in wildlife and wildlife products (Legal Notice No. 181 of August, 1979). Other issues that were identified to be

contentious under the present wildlife conservation and utilization policy were lack of compensation for damage to property by wildlife, low level of compensation (Kshs 30,000) for human deaths arising from wildlife attacks and the long duration for compensation to be effected.

7.4.3 Causes related to KWS' ineffectiveness in wildlife management

The study found the population of wildlife occupying the buffer zones of the MCA to be appreciably high, particularly on northern Meru National Park boundary. Thus, there were frequent cases of wildlife attacks on human beings and livestock, which often led to deaths and injuries. However, KWS' conflict mitigation strategies were rather unpopular with the local communities. For instance, community-based wildlife conservation, which was frequently mentioned by KWS staff, existed more as a tool for raising awareness on conflict management rather than a programme with tangible socio-economic benefits for the community. Schools and dispensaries, which were a common feature of community-based wildlife conservation in the MCA, are basic amenities that can be located in every part of Kenya according to the country's policy on tackling poverty, illiteracy and health related challenges. Thus in the absence of consumptive forms of wildlife utilization, these communities perceived wildlife not only as a killer and destroyer, but also as a competitor for resources, such as land, forage and water.

It was also observed that KWS tended to have a reactive approach to conflict management, a situation that often made local communities view wildlife as the property of KWS and the government. For instance, when these communities killed an animal as a response to wildlife menace, KWS would come in full military gear to deal with the culprits. The same was noted when KWS came in to kill a "culprit" elephant for having killed a human being. This management style was noted to revolve around law enforcement as opposed to consensus building. Thus, the relationship between KWS and local communities in the MCA appeared to have strained over the years largely due to KWS' management of human-wildlife contentions.

7.5 Mitigation of wildlife-livestock-human conflicts in the MCA

The survey noted measures by both KWS and local communities to prevent and reduce wildlife-livestock-human conflicts in the MCA. These measures ranged from fencing, to guarding of property, practising 'convenient' forms of resource utilization, and community-based wildlife conservation.

7.5.1 Fencing

Both KWS and local communities applied fencing to reduce wildlife-livestock-human conflicts in the MCA. KWS erected an electrified fence round Meru National Park and Bisanadi National Reserve, which was intended to provide a barrier that stops wildlife from dispersing into the buffer zones that were being taken up by communities for human settlements and crop cultivation. Electrified fencing was also intended to keep pastoral livestock from encroaching into the protected area. Local communities, particularly agriculturalists and agro-pastoralists, used non-electrified barriers such as live fences and barbed wire fences to keep away wildlife, and occasionally livestock, from intruding into their homesteads.

7.5.2 Guarding farmlands and livestock

Guarding farmlands and livestock from destruction/attacks by wildlife was the most practised method of preventing wildlife-livestock-human conflicts in the MCA. Guarding involved using both weapons and deterrents, such as drum beating, fires, shouting and scarecrows to scare away wildlife. This method was, however, found to be labour-intensive and time-consuming. For instance, guarding was done both during the day and at night, particularly in the wet season. In some households, it compelled school-going children to participate depending on the size of farmland and/or livestock herd.

7.5.3 Practising 'convenient' forms of resource utilization

The use of a resource such as water was observed to be largely contentious in the MCA's western buffer zones. Agriculturalists had the tendency to dam water for irrigation, while KWS expected

the same resource to flow down stream for utilization by wildlife in the protected area. Thus, in order to reach a win-win situation, KWS had to let these communities use the resource while the community had to resort to cropping practices that utilize the least amount of water.

7.5.4 Community-based wildlife conservation
The arrangement under community-based conservation in the MCA was meant to recognise local communities as an integral part of wildlife conservation. This was intended to ensure the safety of wildlife in areas outside the protected area boundary, where they interact with these communities. However, the survey failed to observe any revenue-sharing arrangements from which local communities could benefit for the inconvenience suffered in hosting wildlife on their land.

7.6 Vegetation description
The study described six physiognomic classes with various floristic attributes. These classes included *Acacia-Chloris & Combretum-Sehima* open wooden grassland; *Acacia-Combretum-Chloris* shrub grassland; *Acacia-Commiphora* bushland vegetation; *Phoenix-Hyphaene-Raphia-Sporobolus* riverine vegetation; *Hyphaene-Phoenix-Chloris* impeded drainage vegetation and *Xerophyta-Euphorbia-Albizia* inselberg vegetation. The description of each vegetation type is given below:

7.6.1 Open wooded grassland
This vegetation community comprised grassland with scattered trees. The woody species were conspicuous with a canopy cover of about 30%. Two types of open wooded grassland vegetation were recorded in Meru National Park, namely: *Acacia-Chloris* open wooded grassland and *Combretum-Sehima* open wooded grassland.

7.6.1.1 *Acacia-Chloris* open wooded grassland was dominated by such woody species as *Acacia tortilis* and *A. senegal*. Other woody species associated with this community included *A. mellifera A. seyal, Balanites aegyptiaca, Terminalia brownii, T. spinosa,* and *Tamarindus indica*. The grass species *Chloris gayana* was dominant, but *Chrysopogon roxyburghiana, Chrysopogon plumulosus, Aristida adscensionis* and *Sehima nervosum* were also represented. Some *Acacia* species of this vegetation type were of shrubby habit. Woody species rose to a height of 6-10 metres, while grass species grow to a maximum height of about 1 metre.

Figure 12. *Acacia-Chloris* open wooded grassland

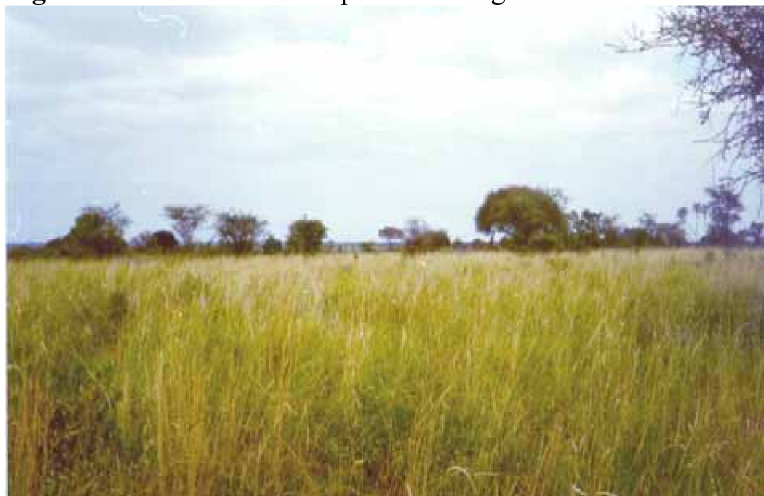


Photo by J. Otuoma

7.6.1.2 *Combretum-Sehima* open wooded grassland with *Combretum aculeatum* as the dominant woody species. *Combretum collinum, C. fragrans, C. hereroense, and C. volkensiia* were also common. *Sehima nervosum* was the dominant grass species throughout most of the *Combretum* wooded grassland. However, *Themeda triandra, Aristida adscensionsis* and

Chrysopogon plumulosus were also represented. Woody species rose to a height of 8-10 metres, with grasses rising to a maximum height of 1 metre.

Figure 13. *Combretum-Sehima* open wooded grassland

Photo by J. Otuoma

7.6.2 Bushland vegetation

This vegetation community comprised trees and shrubs. Mainly plants of shrubby habit dominated the vegetation, but trees were always conspicuous forming a single layered canopy cover of about 20% with a height not exceeding 10 metres except for occasional emergents. The vegetation community was represented in Meru National Park and Bisanadi National Reserve as *Acacia-Commiphora* bushland. Dominant species included *Acacia senegal, A. tortilis, A. mellifera* and *Commiphora africana*. Other species included *Commiphora campestris, Barleria taitensis, Bauhinia tomentosa, Hibiscus micranthus, Combretum collinum* and *Combretum aculeatum*. The bush was generally dense with open ground spaces that remained bare of vegetation throughout the year. Small patches of grass such as *Rhynchelytrum repens, Tetrapogon tenellus,* and *Hyparrhenia* species were also encountered.

Other bushland vegetation types in Meru National Park and Bisanadi National Reserve included *Combretum-Commiphora* bushland, dominated by *Commiphora africana, Combretum aculeatum, Combretum collinum, Acacia mellifera, Cenchrus ciliaris* and *Sericocomopsis hildebrandtii;* and *Combretum-Lawsonia* bushland, dominated by *Combretum aculeatum, Lawsonia inermis,* and *Chrysopogon plumulosus*. The bushland vegetation of Meru National Park and Bisanadi National Reserve generally shed leaves in the dry season.

Figure 14. *Acacia-Commiphora* bushland vegetation. Photo by J. Otuoma.

7.6.3 Riverine vegetation
The riverine vegetation community varied across Meru National Park with the rainfall gradient (Ament, 1975). The palms *Phoenix reclinata, Hyphaene coriacea* and *Raphia farinifera* were dominant with a copy cover of 50% and a height of about 10 metres, more so on the western zone where there were relatively more rivers. Other species included *Sporobolus pyramidalis, Schoenefeldia transiens, Pupalia lappacea* and *Ficus sycomorus*.

Figure 15. *Phoenix-Hyphaene-Raphia-Sporobolus* riverine vegetation

Photo by J. Otuoma

7.6.4 Impeded drainage vegetation
These are areas of Meru National Park, which were experiencing either permanent or seasonal flooding and supporting various plant life-forms, such as reeds, sedges, trees or shrubs. *Hyphaene coriacea, Phoenix reclinata* were the most representative woody species with a height of about 12 metres, while *Chloris virgata* was dominant with a basal cover of 80%. *Combretum hereroense, Combretum aculeatum, Acacia tortilis, Harrisonia abyssinica, Eragrostis superba, Sehima nervosum, Sporobolus iclados, Stripomoea laniflora and Cenchrus ciliaris* were also common.

Figure 16. *Hyphaene-Phoenix-Chloris* impeded drainage vegetation

Photo by J. Otuoma

7.6.5 Shrub grassland
This vegetation community was grassland with a basal cover of 85% with scattered or grouped shrubs of about 3 metres in height interspersed within it. This vegetation type extended from the northern parts of Meru National Park into Basanadi National Reserve, extending further into the Northern Dispersal Area.

The vegetation was dominated by *Chloris roxyburghiana,* but *Hyparrhenia filipendula, Aristida adscensionsis* and *Blepharis ciliaris* were also represented. Shrubs, most of which were woody

species of shrubby habit, included *Acacia seyal, A. mellifera, A. senegal, Combretum aculeatum, Bauhinia tomentosa, Truimfetta rhomboidea, Tephrosia hildebrandtii, Combretum volkesiia, Boscia angustifolia, Grewia tenax, Cordia sinensis.*

Figure 17. *Acacia-Combretum-Chloris* Shrub grassland

Photo by J. Otuoma

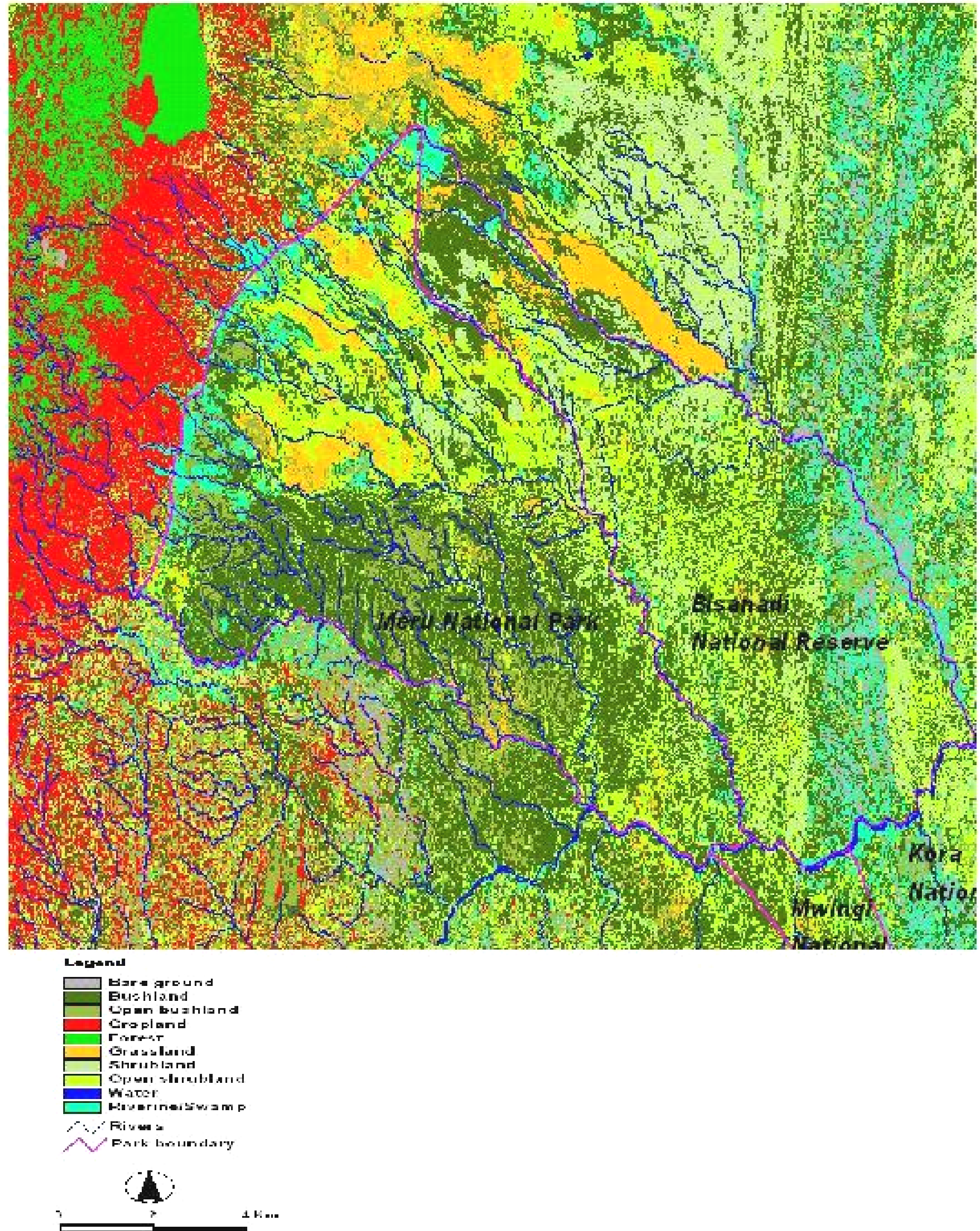
7.6.6 Inselberg vegetation

This refers to vegetation communities found on the rocky summits in Meru National Park (Ament, 1975), such as Mughwango Rocky Summit, the rocky projections of Leopard Rock and the Shifta Rocks. They were generally represented as bushes of *Xerophyta spekei, Euphorbia nyikae* and *E. candelabrum. Albizia tanganyicensis* and *Sterculia africana* were also common, with shrubs typical of *Acacia/Commiphora* bushland. Figure 19 below illustrates the location and distribution of the vegetation communities described above.

Figure 18. *Xerophyta-Euphorbia-Albizia* Inselberg vegetation

Photo by J. Otuoma

Figure 19. The MCA's Vegetation communities (land cover in 2001)

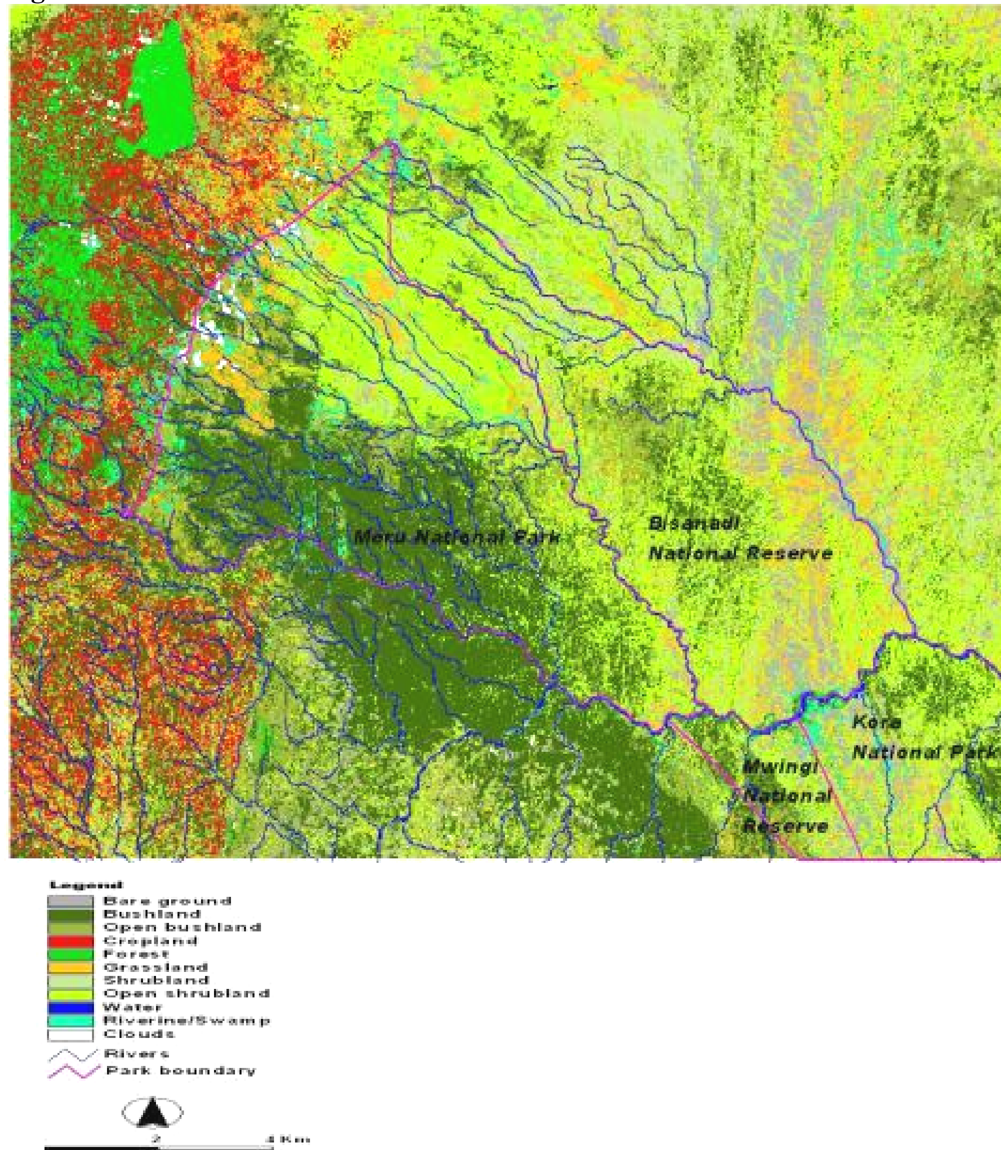


Source: prepared from Landsat TM images (2001) and topographic sheets

7.7 Habitat changes in the MCA

Remote sensing analysis of 1987 and 2001 Landsat TM images reported significant land cover changes in the MCA ($t_{1987/2001}$; $P<0.05$), particularly with regard to increase in the area under crop cultivation. Overall habitat changes are illustrated in Figure 19 above and Figure 20 below; while specific land cover changes are illustrated in subsequent Figures.

Figure 20. MCA Land Cover in 1987



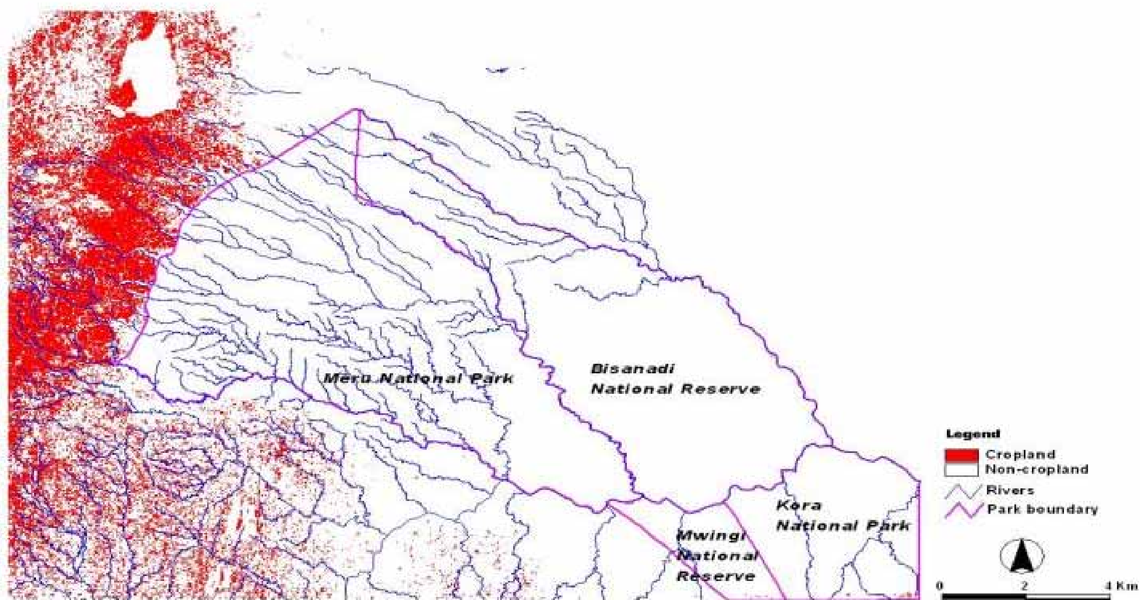
Source: Prepared from Landsat TM Image (1987) and topographic sheets

Image analysis indicated a considerable increase in the area under crop cultivation, particularly on the western and southern buffer zones of Meru National Park. The 1987 Landsat TM image had 35,054 ha under cultivation compared to 61,853 ha in the 2001 image. Thus, 26,799 ha of open wooded grassland were converted to farmlands and homesteads in the western and southern buffer zones of Meru National Park during this period. The changes in the area under cultivation are illustrated in red in Figures 21 and 22 below:

Figure 21. Area (35,054 ha) under crop cultivation in the MCA in 1987

Source: Prepared from Landsat TM Image (1987) and topographic sheets

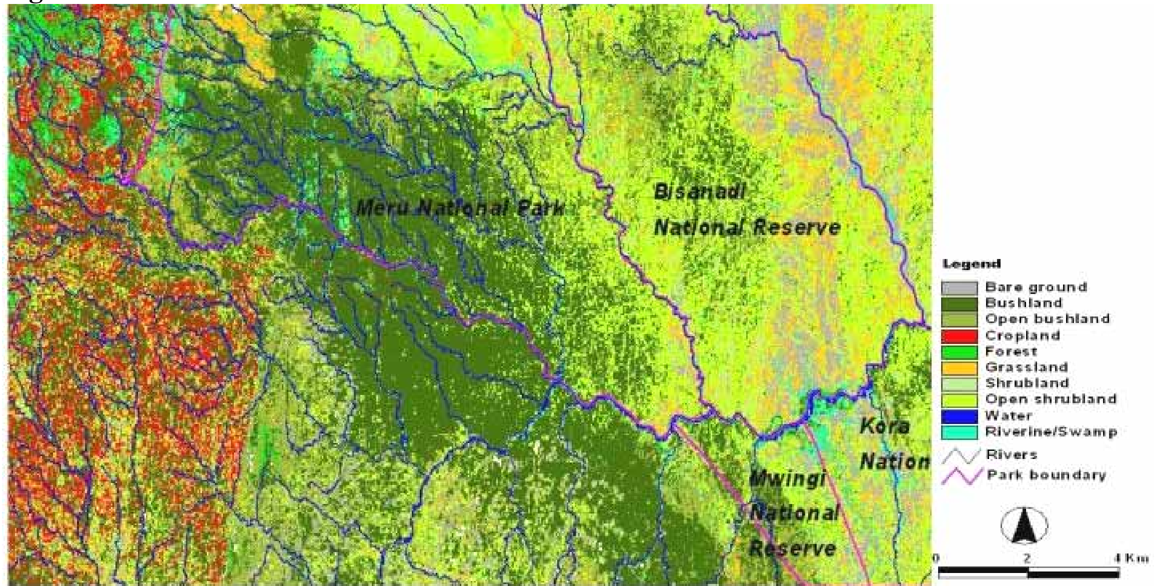
Figure 22. Area (61,853 ha) under crop cultivation in the MCA in 2001



Source: Prepared from Landsat TM Image (2001) and topographic sheets

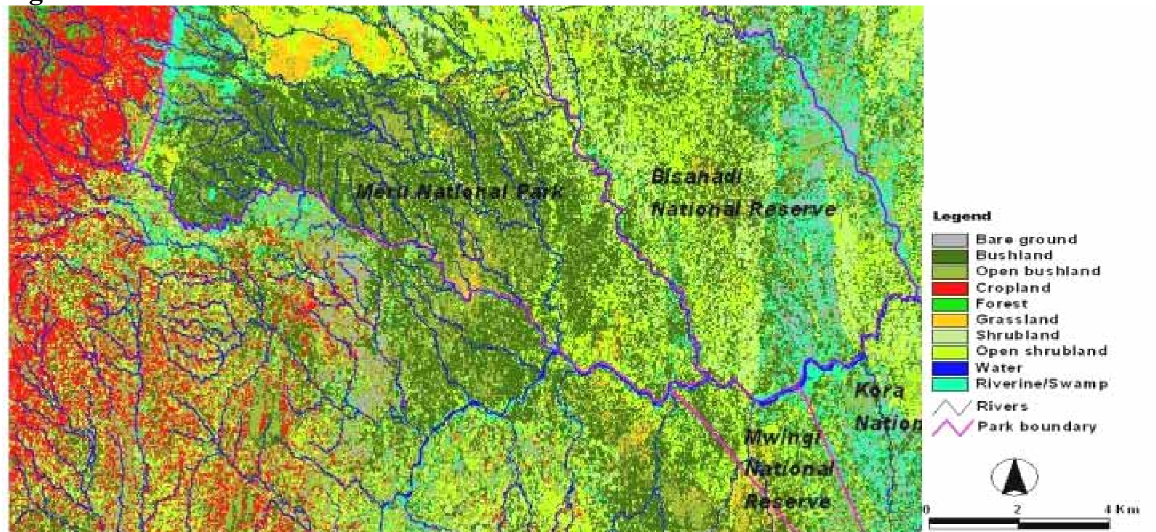
In the southern Meru National Park boundary, the dense *Acacia-Commiphora* bushland vegetation cover of 1987 had changed significantly to sparse bushland thickets within which were interspersed farmlands. A striking feature of this change was the lack of change in the same vegetation inside the park. These changes are illustrated in Figures 23 and 24 below.

Figure 23. Land cover in southern MCA in 1987



Source: Prepared from Landsat TM Image (1987) and topographic sheets

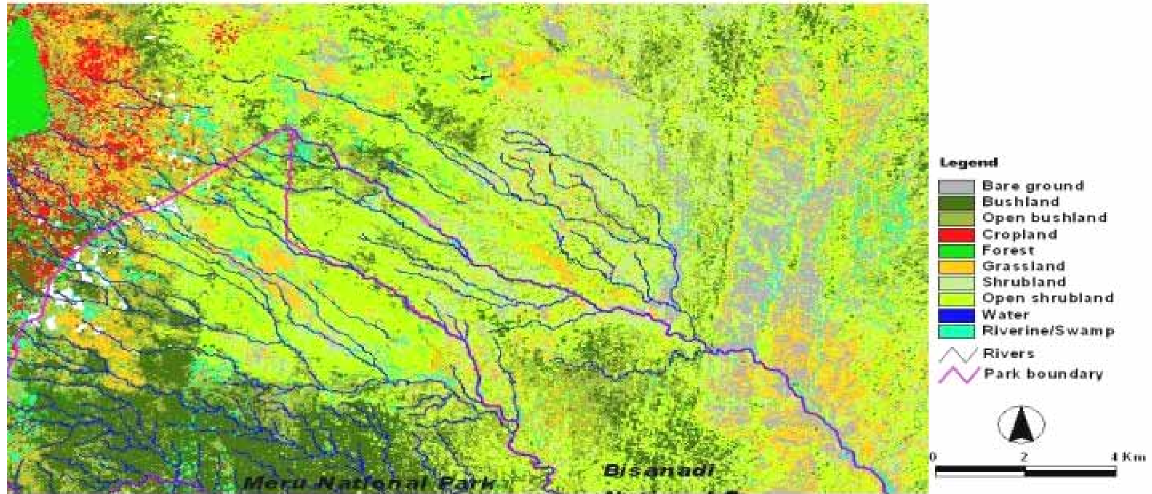
Figure 24. Land cover in southern MCA in 2001



Source: Prepared from Landsat TM Image (2001) and topographic sheets

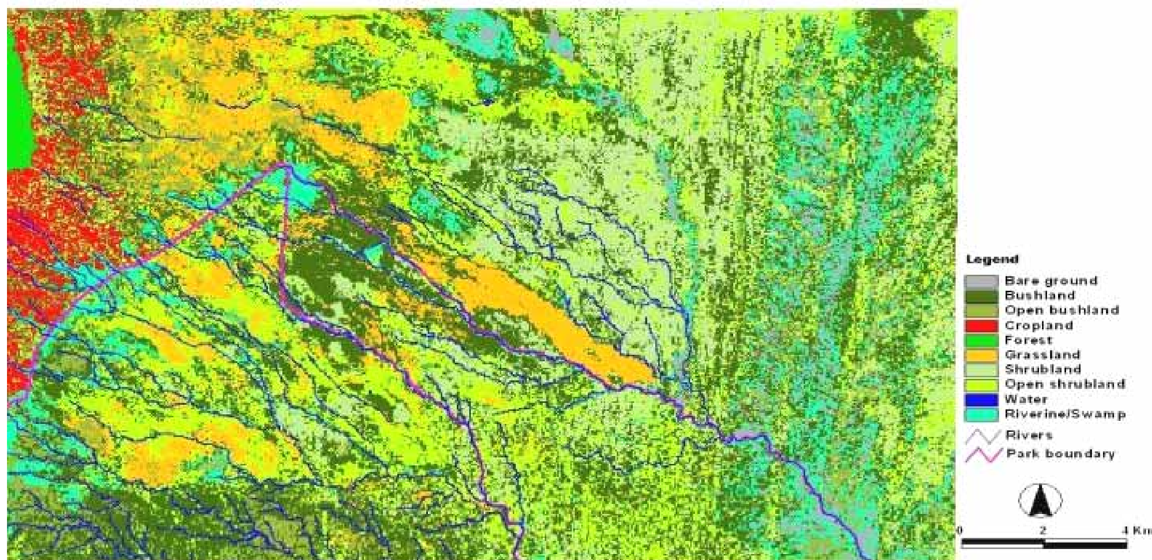
In the northwestern and northern parts of Meru National Park towards Bisanadi National Reserve, there appeared to have been bush and shrub encroachment, which replaced the shrub grassland vegetation of 1987. Bush encroachment was also noted in the eastern parts of Meru National Park and Bisanadi National Reserve where shrubland vegetation had been replaced in certain places by open bushland. These changes are illustrated in Figures 25 and 26 below.

Figure 25. Land cover in northern MCA in 1987



Source: Prepared from Landsat TM Image (1987) and topographic sheets

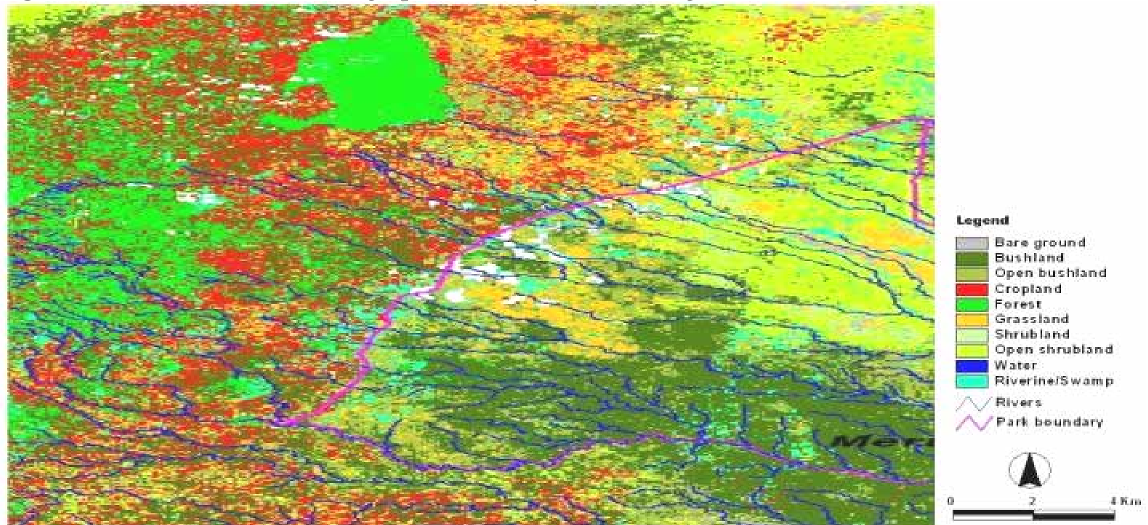
Figure 26. Land cover in northern MCA in 2001



Source: Prepared from Landsat TM Image (1987) and topographic sheets

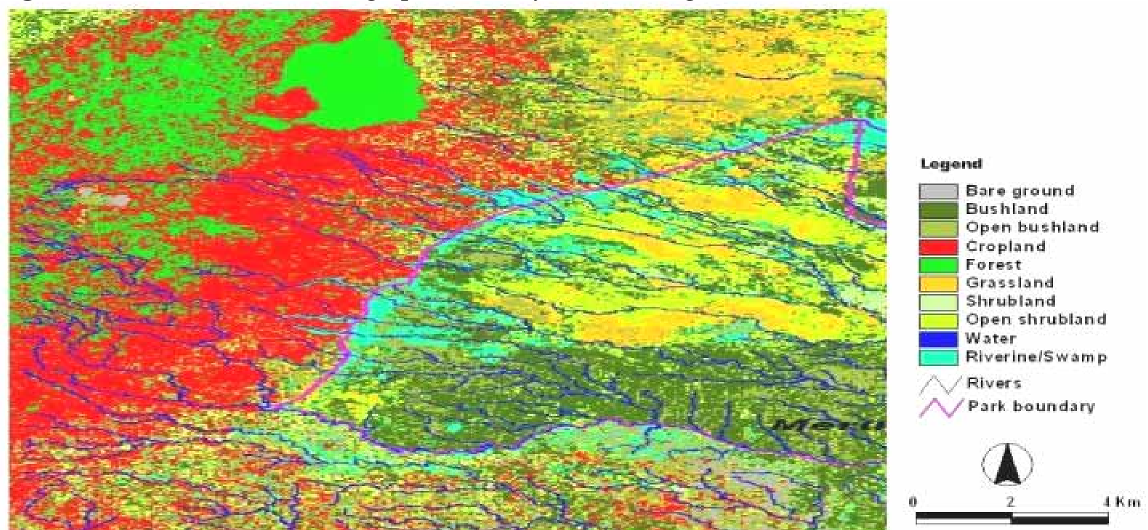
In the high potential agricultural zones bordering Ngaya Forest to the west, image analysis reported significant reduction in the woody cover, and an increase in the area under human settlement and crop cultivation. These changes are illustrated in Figures 27 and 28 below.

Figure 27. Land cover in the high potential Nyambene ranges in 1987



Source: Prepared from Landsat TM Image (1987) and topographic sheets

Figure 28. Land cover in the high potential Nyambene ranges in 2001



Source: Prepared from Landsat TM Image (2001) and topographic sheets

8. DISCUSSION

8.1 Wildlife-livestock-human interactions in the MCA

This study was the first of its kind to determine the effects of wildlife-livestock-human interactions on habitat in the MCA. The study focused on how land use/land cover changes that the conservation area experienced between 1980 and 2000 affected patterns of resource access among pastoralists, agriculturalists and wildlife, and led to interactions between conservation and socio-economic needs and pursuits of communities bordering the protected area. The study related its findings to present policies on land use in (ASALs), wildlife conservation and utilization, and human population growth and distribution; and the likely implications for biodiversity conservation and livestock production in Kenya.

It was observed that wildlife-livestock-human interactions seemed to have increasingly enhanced in the MCA between 1980 and 2000. The most notable indicators of these interactions included wildlife-livestock-human conflicts (Table 5) and land cover changes in the western, southern and northern buffer zones of Meru National Park and Bisanadi National Reserve (Figures 21-26).

These conflicts, as demonstrated by KWS (1994), were common disputes relating to resource access, with wildlife as the common ground of contention. Land cover changes, on the other hand, involved the fragmentation and/or alteration of natural habitats in the MCA's buffer zones, which led to identifiable changes in the vegetation pattern (Figures 19 and 20).

8.1.1 Factors driving wildlife-livestock-human interactions in the MCA

According to the survey, factors that were likely to drive the observed wildlife-livestock-human interactions in the MCA included an increase in wildlife population, an increase in livestock population, and the expansion of land under human settlement and crop cultivation in the MCA's buffer zones. It was observed, however, that the MCA experienced a breakdown in law and order between the 1970s and 1990s (KWS, 2002), which led to a marked decline in the wildlife population (Figure 11). Thus, change in large wildlife numbers was a very unlikely factor driving increased wildlife-livestock-human interactions in the conservation area between 1980 and 2000.

On the other hand, the increase in livestock population between 1980 and 2000, though found to be significant (Table 4), may only have been a minor factor driving wildlife-livestock-human interactions in the conservation area. This is depicted from the fact that conflicts involving livestock and wildlife were reported mainly in the dry season when forage is expected to be limiting, while crop destruction by livestock, which would have been expected as a conflict involving pastoralists and agriculturalists, was not observed at all.

It appeared that the main factor driving increased wildlife-livestock-human interactions in the MCA was the expansion of the area under crop cultivation and human settlement in the western and southern buffer zones of Meru National Park (Figures 19, 20, 21 and 22), which subsequently led to the fragmentation and alteration of natural habitats that formerly served as communal grazing lands and wildlife dispersal areas. This argument tends to explain the observed reduction in the size of communal grazing lands and wildlife dispersal areas in the western and southern buffer zones of Meru National Park (Figures 19 & 20).

The expansion of land under human settlement and cropping agriculture in the MCA's buffer zones was traced to the immigration of agricultural households into the conservation area from nearby high potential agro-ecological zones (Table 1). As demonstrated elsewhere in Kenya (Said *et al*., 1997), areas most targeted for cultivation in the conservation area were the MCA's wetter margins, such as the western and southern buffer zones, which were also critical for wildlife and livestock, particularly in the dry season (Herlocker, 1999). Indeed, these were also the conservation area's zones that witnessed some of highest cases of wildlife-livestock-human conflicts (Table 5), thereby representing a possible case of land use competition between the newly introduced cropping agriculture and traditional land use types, namely: livestock production and wild management (Serneel, 2001).

8.1.2 Land cover changes in the MCA

A close pattern tended to emerge between land use and land cover changes in the MCA. The most notable observation was made in parts of the western and southern buffer zones where open wooded grassland vegetation that served as communal grazing lands and wildlife dispersal areas in 1987 had been largely transformed into subsistent farmlands in 2001 (Figures 21 and 22). The expansion of the area under cultivation from 35,054 ha in 1987 to approximately 61,853 ha in 2001 represented a 76% increase in the fragmentation and alteration of the former livestock/wildlife habitat, thereby potentially rendering it unavailable for pastoral/wildlife utilization (Kamugisha & Stahl, 1993).

Also noted was the transformation of the dense *Acacia-Commiphora* bushland vegetation of 1987 in parts of the southern Tharaka zone bordering Meru National Park (Figure 23) to sparse bushland thickets in 2001 (Figure 24) only in areas outside the protected area, which was also attributed to increased anthropogenic influence, particularly the introduction of shifting cultivation. This argument was supported by the observed increase in human population density in

the southern buffer zones from 50 people per km^2 in 1979 (Figure 6) to about 500 people per km^2 in 1999 (Figure 7).

A similar trend was observed in the northern pastoral zones where open wooded grassland and shrub grassland vegetation of 1987 had transformed into bush and shrub thickets in 2001 (Figures 25 and 26). Two possibilities emerged to explain the vegetation changes in the northern pastoral lands: the fragmentation and alteration of natural habitats in the western and southern buffer zones through settlements and crop cultivation may have greatly reduced the pastoral grazing range and led to an increase in the pastoral livestock density in the northern buffer zones, which led to increased forage utilization (Kamugisha & Stahl, 1993); and that pastoralists were observed not to practice periodic burning of vegetation, thereby giving shrubs and woody species a competitive advantage over the herbaceous layer (Hoag & Clements, 1993). This argument is supported by the fact that the vegetation patterns inside the protected area, where periodic burning of was practiced, remained largely unchanged except for the northern parts of Meru National Park and Bisanadi National Reserve, which were often encroached by pastoral livestock. The two possibilities partly explain the observation that pastoral livestock were finding it increasingly difficult to survive periods of drought without encroaching into the protected area for forage and water.

Thus, as Figures 19 and 20 indicate, most of the natural habitats that traditionally served as communal grazing lands and wildlife dispersal areas in the MCA's buffer zones are increasingly coming under active crop production (UNEP & KWFT, 1988), while the continued immigration of agricultural households into the conservation area (Table 1) remains a potential threat to what may be left as patches of natural vegetation, in the wetter margins of the protected area (Serneels, 2001).

8.1.3 Wildlife-livestock-human conflicts in the MCA

The study grouped wildlife-livestock-human conflicts in the MCA into three categories, based on conflict causes. These categories include conflicts related to land use change in the MCA, conflicts attributed to Kenya's wildlife conservation and utilization policy, and conflicts associated with KWS' wildlife management systems in the MCA.

Like in a number of protected areas in Kenya (Said *et al*., 1997; Serneels *et al*., 2001), the introduction of cropping agriculture in the wetter margins of the MCA, such as the western and southern buffer zones, led to the fragmentation and alteration of habitats that once served exclusively as communal grazing lands and wildlife dispersal areas. The situation caused a decline in the wildlife/livestock resource base, which led to increased resource competition, enhanced wildlife-livestock-human interactions, and degenerated into conflicts related to resource access.

Some of the wildlife-livestock-human conflicts related to land use change in the MCA included (Table 5):

i). Crop destruction by wildlife especially in former wildlife dispersal areas, which are currently experiencing the encroachment of small-holder cultivation, such as the western and southern buffer zones of Meru National Park (Figures 21 and 22). This conflict type was commonly mainly during the wet season when wildlife migrated from the protected area to the community land bordering the MCA, a time when these communities also took advantage of the rains to cultivate crops,

ii). Livestock attacks by wildlife especially in the MCA's north western and northern pastoral areas. These attacks were attributed to increased interaction between livestock and wildlife as a result a reduction in the pastoral grazing range in the western and southern buffer zones, which led to increased livestock density in the northern pastoral lands. Some of these attacks were, however, reported in the protected area, particularly in the dry season when it is encroached by livestock for forage and water,

iii). Human attacks by wildlife in parts of the MCA's buffer zones, which witnessed human immigration and the expansion of settlements and farmlands between 1980 and 2000. Some of the attacks occurred in the northern pastoral lands, particular around the pastoral settlements of Kinna and Rapsu into which wildlife often dispersed in the wet season. Most human attacks by wildlife often led to human deaths,

iv). The Encroachment of pastoral livestock into the protected area for forage and water in the dry season, particularly in the northern parts of Meru National Park and Bisanadi National Reserve. Depending on the duration of encroachment, which was determined by the period of drought, the situation often led to marked changes in the vegetation pattern,

v). Exchange of diseases between wildlife and livestock, transmitted either when livestock encroached into the protected area or when wild animals dispersed into the buffer zones. Discussions on disease transmission were, however, controversial with claims and counter-claims between pastoralists and conservationists on whether it was wildlife transmitting diseases to livestock or vice versa,

vi). Livestock-wildlife competition for forage and water, particularly in the dry season. This conflict type arose mainly from loss of pastoral grazing reserves (Herlocker, 1999) and wildlife dispersal areas (Serneels, 2001) as a result of habitat fragmentation and alteration in the MCA's western and southern buffer zones. Thus, a reduced wildlife/livestock resource base enhanced chances of wildlife and livestock competing for common resources such as forage and water. This competition often occurred in the protected area in the dry season when livestock encroached into it as a response to the depletion of forage and water in the northern pastoral lands,

vii). Human-wildlife competition for water in the MCA's western and southern buffer zones. This occurred particularly in the wet season when agricultural communities dammed water upstream for irrigation, a resource that wildlife depended upon in the protected area downstream.

Thus, considering the causes and nature of the interactions that led to the above conflicts types, land use change comes up as the major factor contributing to their occurrence i.e. these conflicts appeared to have arisen from increased competition for resource access, which seemed to have been caused by a diminishing wildlife/livestock resource base.

Conflicts attributable to Kenya's wildlife conservation and utilization policy include those conflicts that arise from local community perceptions and attitudes towards wildlife (KWS, 1994). Kenya's wildlife conservation policy documents produced after 1992 have encouraged communities bordering conservation areas to participate in community-based wildlife conservation (Rutten, 2002) as a way of protecting about 65-80% of the country's wildlife resources, which can be found outside the formal boundaries of protected areas at any given time (Matiko, 2000). This policy has, however, been unpopular on the basis of its inability to address clear revenue-sharing guidelines between KWS and local communities (Serneel, 2001; Rutten, 2002), while the wildlife utilization policy remains prohibitive (KWS, 1994). Some of the existing prohibitive legislation include the ban on hunting (Legal Notice No. 120 of May 1977), the ban on trade in wildlife and wildlife products (Act No. 5 of 1978, Legal Notice No. 181 of August 21st 1979), and the Presidential Directive prohibiting all hunting and animal capture (1984). Under these conditions, it has become increasingly difficult to commit local communities to community-based wildlife conservation, when the only way in which they seem to benefit is through viewing of wildlife on their land (UNEP & KWFT, 1988; Southgate and Hulme, 1996). Thus, local communities not only consider wildlife as a competitor for resources, but also as government property that is superior to ordinary citizens of Kenya (KWS, 1994, 1998).

As part of the wildlife conservation and utilization policy, KWS has over the years promoted a misconceived policy of constructing schools and dispensaries as a form of benefit to communities living with wildlife (KWS, 1994). It should, however, be understood that such social amenities are

the government's responsibility to all Kenyan taxpayers including those bordering conservation area. Thus, it amounts to blackmail for KWS to consider such social amenities a wildlife-related benefit to these communities. If the wildlife conservation and utilization policy is upheld in its present form without an alternative source of livelihood for these communities, they are only likely to engage in land use practices that put them in conflict with wildlife.

Conflicts associated with KWS' management include conflicts that arise from the failure of KWS to seek consensus with local communities on contentious issues relating to human-wildlife conflicts (KWS, 1994). For instance, it was observed in the MCA that local communities do not consider law enforcement as an appropriate conflict resolution measure even when they are on the wrong. This arises from the feeling that wildlife belongs to the government, which is elected into office to care for the common good of the people; hence wildlife remains a resource that should be utilized to address the socio-economic well being of local communities (KWS, 1998). It is the failure by KWS to implement this feeling and hence lack of consensus building with local communities in resolving wildlife-livestock-human conflicts that has led to conflicts related to the management of wildlife resources.

The reactive approach of KWS to wildlife-livestock-human conflicts in the MCA has been demonstrated by KWS (1994) as a problem common to the human-wildlife conflict in most protected areas in Kenya. The situation has been attributed to KWS' being both ill-equipped and under-staffed to effectively address human-wildlife conflicts (KWS, 1994). Perhaps, it is time that KWS became more proactive in addressing human-wildlife conflicts, particularly by promoting schemes intended to improve community perception of wildlife. Such schemes, however, would require land use-related benefits to these communities.

8.1.4. Mitigating wildlife-livestock-human conflicts in the MCA

No single or combination of mitigation methods was found to be fully effective against wildlife-livestock-human conflicts in the MCA. As illustrated by Ngure (1995) and Walpole (2001), one of the principal problems with direct mitigation methods such as disturbance and guarding is that wildlife often habituate to deterrents such as drum beating, fires, shouting and using statues such as scarecrows. Another problem that was observed with some of the conflict mitigation methods is the requirement for close proximity with wildlife in order to effectively scare them away, but this in most cases entails considerable danger to the public (Walpole, 2001).

Non-electrified fencing by communities bordering the MCA, though expensive to construct and maintain, was also observed to be of little effect in preventing wildlife from encroaching into farmlands and homesteads, particularly large herbivores such as elephants. Live fences were the least effective, while wire and pole fences had some level of protection.

Electrified fencing by KWS around Meru National Park and Bisanadi National Reserve was fairly effective in stopping wildlife from leaving the protected area for neighbouring community land, and keeping pastoral livestock way from the protected area. Fencing the protected area, however, encouraged human encroachment into wildlife dispersal areas in the buffer zones because it created a sense of security from wildlife attacks (Ngure, 1992). On the other hand, fencing off a relatively small protected area like Meru National Park and Bisanadi National Reserve was observed to hold severe consequences for biodiversity conservation with regard to a possible increase in wildlife population in the absence of external interference, and the likelihood for subsequent resource competition, habitat degradation and a collapse of biodiversity conservation.

KWS came up with the Community Wildlife Service in 1992 in order to promote community-based wildlife conservation programmes, through which communities bearing the cost of living with wildlife are intended to benefit (Rutten, 2002). In the MCA, like most other conservation areas in Kenya, community-based wildlife conservation has had little success, mainly because it generates some unrealistic expectations without clear revenue-sharing guidelines (Shackly, 1996; Rutten, 2002). Some of the problems observed with community-based conservation in the MCA

included the current legislation that prohibits the utilization of wildlife resources by local communities; lack of compensation for property damaged by wildlife; low level of compensation (Kshs 30,000 currently) for human deaths arising from wildlife attacks; and the long duration that it takes for payment to be effected (UNEP & KWFT, 1988).

It has also been argued that community-based wildlife conservation schemes have failed in Kenya primarily because they do not address the actual problem, but its indicators. For instance, compensation only addresses cases of human deaths that have already occurred, which in most cases are claims that are difficult to evaluate, while funds are also insufficient (Hoare, 1995).

One of the most effective solutions to wildlife-livestock-human conflicts in the MCA would be proper land use planning backed by community-based natural resource management (Walpole, 2001). For instance, replacing cropping agriculture in the conservation area with land use types, which are more compatible with wildlife management and livestock production could discourage the encroachment of agriculture and human populations into the MCA's buffer zones. One of the solutions could be to include wildlife-related land use options, such as tourism and hunting, which would provide direct benefits for local communities while conserving biodiversity (Walpole, 2001). By generating benefits from wildlife to offset the cost of living with them, community attitudes and tolerance towards wildlife would certainly improve (UNEP & KWFT, 1988).

8.2 Causes of land use change in the MCA

Whereas the survey indicated the immediate cause of wildlife-livestock-human conflicts in the MCA to be primarily land use change, which led to the reduction in the livestock grazing range and loss of wildlife dispersal areas through their fragmentation and transformation into smallholder cultivation units, the underlying causes were identified to be Kenya's ASAL land use policy, regulations governing land ownership, and wildlife conservation and management policy (KWS, 1994; Southgate & Hulme, 1996; Seneels, 2001). As illustrated by Southgate & Hulme (1996), present ASAL land use policy in Kenya has revealed a mismatch between the indigenous pastoral perceptions of resource management in rangelands and the market economy approach advocated by the government. For instance, since 1994, the Kenya government's strategy in addressing rapid increase in human population and the attainment of self-sufficiency in food production has been to increase the productivity of ASALs through the expansion of dry land agriculture and intensified livestock production (ROK, 1996).

Given that most of Kenya's high potential agro-ecological zones are currently experiencing a rise in human pressure on land (UNEP & KWFT, 1988), this ASAL land use policy has provided the much needed opportunity to seek alternative land for settlement and crop cultivation in rangelands. Thus, the wetter margins of Kenya's rangelands, such as the MCA's western and southern buffer zones, have continued to experience the immigration of agricultural households from nearby high potential agro-ecological zones (Serneels, 2001). The 70% immigration rate observed in the MCA between 1980 and 2000 (Table 1) supports this argument, particularly the fact that majority of these households were agriculturalists from the nearby high potential Mt. Kenya region.

As demonstrated elsewhere in Kenya (Serneels, 2001), the MCA is a good example of the Kenya government's failure to enforce regulations governing land ownership and land use rights in areas bordering protected areas. For instance, land tenure reforms that were recently concluded in the MCA's southern Tharaka zone and parts of the western buffer zones (Smucker, 2002) have effectively replaced the authority of clan councils on land rights with those of the central government, thereby changing ownership from communal to individualised holdings, which individual households are free to sell without prior consultation with clan elders. This has made it relatively easier for migrant agricultural households to acquire land from native owners, a situation that has introduced cropping agriculture in areas that were largely under livestock rearing about two decades ago (Smucker, 2002). Thus, the MCA, like most other conservation areas in Kenyan rangelands, is increasingly degenerating into an 'island' protected area surrounded by fast

reducing communal grazing lands and increasingly expanding smallholder farmlands (UNEP & KWFT, 1988).

Habitat changes and wildlife-livestock–human conflicts in the MCA have been exacerbated by Kenya's wildlife conservation and management policy. There exists some policy support for public participation in wildlife management and utilization in Kenya's key wildlife policy documents (The Wildlife Act, 1977), but the existing prohibitive legislation has prevented communities bordering conservation areas from utilizing wildlife resources. The Wildlife Act (1977) states that "the prime objectives of wildlife conservation should be to ensure that wildlife is managed and conserved so as to yield to the nation in general and to individual areas in particular optimum returns in terms of natural, aesthetic and scientific gains as well as such economic gains as are incidental to proper wildlife management and conservation, and which may be secured without prejudice to such proper management and conservation." However, since the Presidential Directive prohibiting all hunting and animal capture in 1984; the ban on hunting (Legal Notice No. 120 of May 1977), and the ban on trade in wildlife and wildlife products (Legal Notice No. 181 of August 1979), the public has only been able to benefit from wildlife through viewing and photography (UNEP & KWFT, 1988). Thus, committing local communities to wildlife conservation under these conditions has tended to be unpopular.

8.3 Implications for biodiversity conservation and pastoral livestock production
The fragmentation and alteration of natural habitats in the wetter margins of the MCA—the western and southern buffer zones—has not only led to the loss of dry season grazing reserves, but also a reduction of the animal range. The situation has led to increased livestock density in the northern pastoral lands, which has subjected these areas to heavy forage utilization. Thus, pastoralists have increasingly found it unavoidable to encroach into the protected area for forage and water, particularly in the dry season when areas available to them are depleted of forage. The situation has led to increased interaction between livestock and wildlife. One of the notable impacts of these interactions has been disease transmission from wildlife to livestock, which has often led to great losses for livestock keepers in the MCA.

The on-going efforts to fence off the protected area are likely to reduce livestock-wildlife interactions, thereby significantly controlling disease transmission. However, the situation would lead to pastoralists losing their access to the protected area, which would destabilise their coping mechanisms in the dry season and increase their vulnerability to drought (Ekaya, 2001). It was also noted that fencing off the protected area has tended to create a sense of security among communities bordering the MCA, thereby attracting more households to the conservation area's buffer zones. This has contributed to further fragmentation and alteration of what would be remaining as communal livestock grazing land and wildlife dispersal areas in the wetter margins of the MCA (UNEP & KWFT, 1988; Serneels, 2001).

In addition, as a mitigation method intended to reduce human-wildlife conflicts, fencing remains ecologically questionable. In the absence of external factors limiting wildlife population growth, their numbers are likely to increase and lead to severe resource competition and habitat degradation. Under these conditions, wildlife population may crash leading to loss of biodiversity and a possible collapse of the conservation area.

It is currently estimated that 4 million Kenyans are engaged in full-time pastoral livestock production in ASALs, while several more millions derive their livelihoods from the livestock sector (Wekesa, 2001). On the other hand, about 90% of Kenya's wildlife resources occupy ASALs, of which 65-80% can be located in community land neighbouring protected areas (Matiko, 2000; Wekesa, 2001). Thus, a collapse of pastoral livestock production would not only make the 4 million pastoral population lose their source of livelihood, but also generate the demand for their absorption into alternative sectors of the economy (Wekesa, 2001). A collapse of wildlife conservation in Kenya's conservation areas would not only lead to loss of an annual earning of Kshs 50 billion for the country, but also loss of world heritage sites (Herlocker, 1999).

8.4 Conclusion & Recommendations

The MCA is a classical case of protected areas in Kenyan rangelands that are currently experiencing increased wildlife-livestock-human interactions due to a diminishing resource base induced by land use change, particularly in localities with more favourable conditions of soil and water. This situation, which arises from the introduction of crop cultivation in areas where the principal land use remains livestock production and wildlife management, is generally characterised by intense resource competition and wildlife-livestock-human conflicts related to resource access.

Though the situation has been attributed mainly to human pressure on land in high potential agro-ecological zones and the subsequent demand for alternative land for settlement and cultivation, this study noted that it is to a larger extent influenced by existing ASAL land use and land tenure, conservation and population policies. Present ASAL land use policy has been demonstrated to favour cropping agriculture over livestock production. The situation is exacerbated by land ownership under cropping agriculture, which tends to promote individualised tenure as opposed to the communal pastoral tenure, a case that has increasingly made the wetter areas of rangelands loci for resource competition. Thus, policy support is necessary to uphold wildlife/livestock habitats as communal habitats, and the buffer zones surrounding protected areas delineated exclusively as wildlife dispersal areas and communal grazing fields, from which human settlements and cropping agriculture are prohibited.

On the other hand, making conservation policies more proactive to local community interests would lessen the burden of wildlife conservation, which currently lies fully with the government and donor agencies. To succeed, however, the question: *who conserves wildlife and who benefits?* Must be addressed. Given that 65-80% of Kenya's wild animals are roaming outside the formal protected area boundaries at any given time, local communities should not continue to bear the cost of wildlife migrations under the existing legislation, which prohibits all aspects of wildlife utilization except viewing and photography. Proper revenue-sharing arrangements should be made between KWS and local communities under the existing community-based wildlife conservation programmes. This way, these communities are likely to recognise the value of wildlife on their land and take the responsibility for conserving wildlife and wildlife habitats, thereby reducing the burden of conservation on the government and donor agencies.

Finally, the Kenya government's efforts at controlling human population growth rate through family planning and reproductive health programmes has considerably reduced the birth rate, from 3.8% in 1979 to 2.5% in 1998. However, its policy on the distribution of human population, particularly its strategies to discourage rural to urban migration, has indirectly influenced the number of people migrating to ASALs from high potential agro-ecological zones, thereby contributing to land use change and resource competition in Kenyan rangelands. Since the wisdom of communicating family planning has not had much success among communities occupying rangelands given their labour-intensive land use systems, traditional values and the general insecurity of subsistence livelihoods, efforts must be made to limit the continued spread of agricultural communities into ASALs in order to avert a collapse of pastoral livestock production and wildlife conservation in Kenyan rangelands. This may involve formulating policies that recognize the ecological and socio-economic potential of ASALs and seek to protect the same.

REFERENCES

Ament, J. G. (1975). The vascular plants of Meru National Park, Kenya. J. East Africa Natural History Society and National Museum. No. 154.

Atieno, F. O. (2000). Land use and land cover changes in the Greater Amboseli Ecosystem, Kajiado District, Kenya, between 1988 and 1998. MSc. Thesis, University of Nairobi, Kenya.

Baker, R. and D. N. Kinyanjui (1980). Recommendations on the Institutional Framework for Environmental Management in Kenya. School of Development Studies, University of East Anglia, Norwich.

Bekure, S., De leeuw, P. N., Grandin, B. E. and P. J. H. Neate (1991, eds). Maasai herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya. International Livestock Centre for Africa (ILCA), Systems Study 4. Addis Ababa, Ethiopia.

Bragdon, S.H. (1992). Kenya's Legal and Institutional Structure for Environmental Protection and Natural Resource Management: An anaylsis and agenda for the future. Robert S. McNamara Fellowship Program, World Bank, Washington D.C.

Campbell, D. J.; Lusch, D.P.; Smucker, T. and E. E. Wangui (2003). Root causes of land use change in the Loitokitok Area, Kajiado District, Kenya. LUCID Working Paper No. 19.

Campbell, D.J. (1993). Land as ours, land as mine: economic, political and environmental marginalization in Kajiado District. In: T. Spear and R. Waller, eds, *Being Maasai*. London: James Currey. Pp 258-72.

Chapman, S. B. (1976, ed). Methods in plant ecology. Brackwell Scientific Publications, Oxford, England.

Coppock, D. L. (1994, ed). The Borana Plateau of southern Ethiopia: Synthesis of pastoral research, development and change, 1980-91. International Livestock Centre for Africa (ILRAD), Systems Study 5. Addis Ababa.

Darkoh, M.B.K. (1990). Kenya's environment and environmental management. Journal of Eastern African Research and Development. Vol. 20, 1-40.

Eastman, J.R. (1999). Idrisi 32 tutorial. Clark Labs, Clark University, Worcester, MA, USA.

Ekaya, W. N. (2001). An overview of the structural and functional elements of pastoralism in eastern Africa. In: a media handbook for reporting food security and drought in pastoral areas. Indigenous Information Network, Nairobi, Kenya.

Ellis, J. E. and D. M. Swift (1988). Stability of African pastoral systems: alternate paradigms and implications for development. J. Range Management. 41, 450-459.

Gichohi, H., Gakaku, C. and E. Mwangi (1996). Savanna ecosystems. *In:* McCanahan, T. R. and T. P. Young (eds), East African Ecosystems and their conservation. Oxford University Press, N. Y.

Government of Kenya (1992). Development Policy for the Arid and Semi-arid Lands. Government Printer, Nairobi, Kenya.

Graetz, D. (1994). Grasslands. In: Meyer, W. B. and B. L. Turner (eds), Changes in land use and land cover: a global perspective. Cambridge University Press, Cambridge.

Groombridge, B. (1992, ed). Global biodiversity: status of the earth's living resources. Chapman and Hall, London.

Hackel, J. D. (1998). Community conservation and the future of Africa's wildlife. Conservation Biology 13, 726-734.

Hary, I., Schwartz, H. J., Pielert, V. H. C. and C. Mosler (1996). Land degradation in African pastoral systems and the destocking controversy. Ecological Modelling, 86(2-3): 227-233.

Heifer Project International (2002). Livestock project report, Nairobi, Kenya.

Herlocker, D. (1999, ed.) Rangeland resources in eastern Africa their ecology and development. GTZ, Nairobi, Kenya.

Hoag, T. and A, Clements (1993). How vegetation types change. In: Parks & people; pastoralists and wildlife. Proceedings from a seminar on environmental degradation in and around Lake Mburo National Park, Uganda. Regional Soil Conservation Unit, SIDA, Nairobi, Kenya.

Inamdar, A., H. de Jode, K. Lindsay, and S. Cobb (1999). Capitalising on nature: protected area management. Science, 283, 1856-1857.

Indigenous Information Network (2001). A media handbook for reporting food security and drought in pastoral areas. Nairobi, Kenya.

Jaetzold, R. and H. Schmidt (1983). Farm management handbook of Kenya. Vol. II: Natural conditions and farm management information. Part C, Eastern and Coast Provinces. Ministry of Agriculture.

Kamugisha, J. R. and M. Stahl (1993, eds.). Parks & people; pastoralists and wildlife. Proceedings from a seminar on environmental degradation in and around Lake Mburo National Park, Uganda. Regional Soil Conservation Unit, SIDA, Nairobi, Kenya.

Kent, M. and P. Coker (1992). Vegetation description and analysis; a practical approach. John Wiley & Sons.

Kenya Wildlife Service (1994). Wildlife / human conflicts in Kenya. Report of the 5-person review group, Nairobi, Kenya.

Kenya Wildlife Service (1998). Conflict resolution plan for Samburu, Isiolo, Meru, Nyambene, Kora and Mwingi; Nairobi, Kenya.

Kenya Wildlife Service (1990). A policy framework and development programme, 1991-1996. Nairobi, Kenya.

Kenya Wildlife Service (2002). Animal translocation proposal. Meru National Park. Nairobi, Kenya.

Kiss, A. (1990, ed). Living with wildlife: wildlife resource management with local participation in Africa. World Bank Tech. Dept. Series Tech. Paper No. 130. Washington D. C.

Lado, C. (1992). Problems of wildlife management and land use in Kenya. Republic of Kenya, Wildlife Conservation and Socio-economic Development in the 1980s. Proceedings of the First All Africa Wildlife Conference, KICC, Nairobi, Kenya, 13-19th July 1980.

Little, P. (1994). The link between local participation and improved conservation: a review of issues and experiences. In: Western, D. and R. Wright (eds.) Natural connections: perspectives in community-based conservation. Island Press, Washington D. C.

Lorot, A. (2001). Agriculture, land and desertification. A report on civil society review of the implementation of Agenda 21 in Kenya. Kenya NGO Earth Summit 2002 Forum.

Maalim, M. (2001). A media handbook for reporting food security and drought in pastoral areas. Indigenous Information Network, Nairobi, Kenya.

Matiko, N. L. (2000). Perspectives on sustainable utilization of wildlife resources in Kenya. M. Sc. Thesis, Durrell Institute of Conservation and Ecology, University of Kent at Canterbury, United Kingdom.

Michener, W.K.; Jefferson, W. H.; Karinshak, D.A. and W. Xiang (1992). An integrated Geographic Information System, Global Positioning System and Spatio-statistical

approach for analysing ecological patterns at landscape scales. In: GIS / LIS Proceedings, 10-12th Nov. 1992, San Jose, California. Vol.2.

Munyugi, J. W. M., J. M. Ruhiu and J. K. Warutere (1996). Monitoring of elephant situation in Eastern Region with special reference to Meru National Park/Bisanadi National Reserve, Meru, Isiolo, and Samburu Districts. Eastern Region Biodiversity Department, Kenya.

Ndikumana, J., Stuth, J., Kamidi, R., Ossiya, S., Marambii, R., P. Hamlett (2000). Coping mechanisms and their efficacy in disease-prone pastoral systems of the Greater Horn of Africa. Effects of the 1995-97 drought and the 1997-98 El Nino rains and the responses of pastoralists and livestock. ILRI Project Report, Nairobi, Kenya.

Nyeki, D. M. (1992). Wildlife conservation and tourism in Kenya. Kenya Wildlife Service, Nairobi, Kenya.

O'Neill, K. M. (1996). The international politics of national parks. University of California, Los-Angeles, California. In: Human Ecology, Vol. 24: No: 4.

Pratt, D. J. and M. D. Gwynne (1977, eds.). Rangeland management and ecology in East Africa. Hodder and Stoughton, London, England.

Republic of Kenya (1994). Development Plan 1994-1996. Government Printer, Nairobi, Kenya.

Republic of Kenya (1977). The Wildlife Conservation and Management Act. Sessional Paper No.3, Parliament of Kenya, Nairobi, Kenya.

Republic of Kenya (1999). Statement by Honourable Elijah K. Sumbeiywo, M.P. and Assistant Minister Office of The Vice President and Ministry of Planning and National Development, at the 21st Special Session of the United Nations General Assembly, July 2nd 1999, New York.

Republic of Kenya (2001). The 1999 population and housing census. Vol. 1. Central Bureau of Statistics, Ministry of Finance and Planning, Nairobi, Kenya.

Riley, B. W. and D. Brokensha (1988). The Mbeere in Kenya, Vol. 1: Changing rural ecology. Lanham, University Press of America

Rutten, M. (1992). Selling wealth to buy poverty: The process of individualization of land ownership among the Maasai pastoralists of Kajiado District, Kenya. Verlag Breitenbach, Saarbrucken.

Rutten, M. (2002). Parks beyond parks: Genuine community-based wildlife eco-tourism or just another loss of land for Maasai pastoralists in Kenya. Issue Paper No. 111.

Said, M. Y., W. K. Ottichilo, R. K. Sinange and H. M. Aligula (1997). Population and distribution trends of wildlife and livestock in the Mara Ecosystem and the surrounding areas. A study on the impact of land use on wildlife and environmental indicators in East African Savannah. Department of Resource Surveys and Remote Sensing, Kenya.

Serneels, S. (2001). Drivers and impacts of land use/land cover change in the Serengeti-Mara Ecosystem: a spatial modelling approach based on remote sensing data. PhD dissertation, Universite Catholique de Louvain, Belgium.

Serneels, S. and E. F. Lambin, 2001). Impact of land use changes on wildebeest migration in the northern part of the Serengeti-Mara Ecosystem. Universite Catholique de Louvain, Place Louis, Louvain-la-Neuve, Belgium.

Serneels, S., M. Y. Said and E. F. Lambin (2001). Land cover changes around a major East African wildlife reserve: the Mara Ecosystem, Kenya. Int. J. Remote Sensing, 2001, Vol. 22, No. 17, 3397-3420.

Shackley, M.L. (1996). Wildlife tourism. Business Press, London.

Smucker, T. (2002, ed). Land tenure reform and changes in land use and land management in semi-arid Tharaka, Kenya. LUCID working paper no. 11, International Livestock Research Institute, Nairobi, Kenya.

Southgate, C. and D. Hulme (1996). Environmental management in Kenya's arid and semi-arid lands: an overview. Rural Resources Rural Livelihoods Working Paper Series, No. 2. Institute for Development Policy and Management, University of Manchester, Manchester.

Sprugel, D. G. (1991). Disturbance, equilibrium, and environmental variability: what is 'natural' vegetation in a changing environment? Biological Conservation, 58: 1-18.

Stocking, M. and S. Perkin (1992). Conservation with development: an application of the concept in Usambara Mountains, Tanzania. Transactions of the Institute of British Geographers. N. S. 17, 337-349.

Swift, D. M., Coughenour, M. B. and M. Atsedu (1996). Arid and semi-arid ecosystems. In: McClanahan, T. R. and T. P. Young (eds). East African ecosystems and their conservation. Oxford University Press, N. Y.

Swynnerton, R.J.M. (1953) . A plan to intensify the development of African Agriculture in Kenya. Ministry of Agriculture, Nairobi, Kenya.

The making of a framework (2001). Environmental law in Kenya. United Nations Enviroment Programme (UNEP) and African Centre for Technology studies (ACTS), Nairobi, Kenya.

Thurow , T. L., Herlocker, D. J. and A. A. Almi (1989). Development projects and Somali pastoralism. Rangelands 11 (1): 35-39.

UNEP and Kenya Wildlife Fund Trustees (1988). People, parks and wildlife. Guidelines for public participation in wildlife conservation. Case studies in Kenya.

Wamicha W.N. & J. I. Mwanje (2000). Environmental management in Kenya: Have the national conservation plans worked? Environmental Forum Publications Series, no. 2. 62 pp.

Wekesa, M. (2001). Improved livestock production marketing as a strategy for poverty reduction among pastoral communities in Kenya. In: a media handbook for reporting food security and drought in pastoral areas. Indigenous Information Network, Nairobi, Kenya.

Wilkie, D. S. and J. T. Finn (1996). Remote sensing imagery for natural resources monitoring. Columbia University Press, New York.

Williamson, G. and W. J. A. Payne (1978). An introduction to animal husbandry in the tropics. Longman, London.