Human-elephant Conflict in the Masai Mara Dispersal Areas of Transmara District

By

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Abstract

This thesis is based on a field study of human-elephant conflict (HEC) in the Masai Mara dispersal areas of Transmara District, Kenya, during 1999 and 2000. The district experiences high HEC because it supports a small resident elephant population and receives elephants that disperse up the escarpment seasonally from the Masai Mara. The study examines attitudes and perceptions of people towards elephants, land use changes, changes in elephant distributions and densities, types and patterns of HEC, and the success of different mitigation methods.

Attitudes and perceptions towards elephants were determined using participatory workshops and questionnaire surveys. Land use patterns were examined using aerial photo surveys, secondary data and field surveys. Elephant abundance and distribution were determined from secondary data and ground surveys. Vegetation plots were established to measure seasonal changes in natural forage, and changes in elephant diet were examined through dung analysis. Conflict data were obtained from KWS records and daily monitoring, including interruption of learning in schools. Data were analysed at fine scale using a Geographical Information System, and appropriate statistical tests were used to determine which of many variables most determined prevailing levels of HEC, and the success of mitigating HEC.

Forestland was increasingly converted to cultivation, which in turn reduced elephant range and confined resident elephants to the remaining forest and to group ranches. Corridor usage by elephants increased with migration of wildebeests into the Masai Mara. Seasonal and spatial patterns in the occurrence of crop raiding incidents were determined by the maturity of maize, the area under farming, distance from the road and distance from the market centres. The success of crop protection measures depended on using a combination of traditional methods. Men who are drunk most risk being attacked by elephants. Elephants may also directly and/or indirectly interfere with learning in schools, but pupil performance was mainly determined by distance from school, absenteeism and tribe. The local community fosters negative attitudes towards elephants from which they currently receive no benefits. The future for elephants in Transmara District is bleak unless a benefit sharing, compensation and active problem elephant control programmes are implemented. Effective land use planning and participation of the community in conservation could help achieve these goals. The findings of this study have important implications for the future of elephant conservation in the face of competing human needs, both in Transmara District and elsewhere in Africa.

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CHAPTER ONE

General Introduction

1.1 Introduction

This thesis investigates the issue of human-elephant conflict (HEC) in the Transmara (TM) District of Kenya. TM District lies on the north-western edge of the greater Serengeti-Mara ecosystem and adjacent to the Masai Mara National Reserve (MMNR), Kenya (Figure 2.1). Across its range, the African elephant (*Loxodonta africana* Blumenbach 1797), faces three major threats that are detrimental to its survival, namely: poaching; habitat loss; and, conflict with humans. As land use patterns change and human and elephant populations increase, competition for resources is inevitable (Dublin *et al* 1997). In such a situation, human-related activities stand to succeed (Hardin 1968), especially where the elephant is viewed as a liability and where people harbour negative attitudes towards elephants. Because of the threats faced by elephants, there has been considerable interest in its plight in the light of escalating conflict between man and the elephant. The elephant is indeed a very fascinating animal which Sukumar (1989) described as:

> *an object of worship; a target of hunters; a beast of burden; a burden to the people; gentle in captivity; dangerous in the wild; the pride of kings; the companion of mahouts; a machine of war; an envoy of peace; loved; feared; and, hated (Sukumar 1989).*

Certainly, for any elephant conservation programme to succeed, it must complement other forms of land use. This can only be achieved by understanding and applying the repertoire of knowledge possessed by the local and indigenous communities on natural resource conservation and utilisation. Any land development strategies necessitated by increasing human populations have negative implications for elephant numbers and distribution. Without access to private land in the dispersal areas outside formalised protected areas, wildlife populations will crash (Western 1998).

Hence, this study attempts to determine the types and patterns of conflict arising as a result of changing land use patterns, and their implications for the elephant in TM District. In the remainder of this chapter, I review the management of, and conservation practice relating to, the African elephant, to set the scene for this study. In particular, I concentrate on the changing socio-cultural and economic status of man, the arising conflict and possible mitigation strategies from a wider perspective.

1.2 Elephant ecology and habitat

The social system of elephants is based around a matriarch, who leads a herd of related females cows and their offspring (Moss 1988). The matriarch decides when and where the herd will eat, rest and travel. The males either live on their own or in bachelor herds. The large body size (6,000 kg) of elephants require 100-300 kg of food each day and around 250 l of water. The herd can cover a long distance in a day provided it is never far from water. Due to the biological necessities of their immense body size, elephants have a key ecological role that is defined by their need for great quantities of food, water and habitat. Encroachment on their ranges therefore has serious implications for their management.

Elephants show a preference for secondary re-growth and are strongly associated with "wet" habitats such as swamps, marshes and seasonally inundated forests (Lahm 1993). Forest elephants feed heavily on fruits (Wing & Buss 1970) and the type of food available determines their range of movement. For effective conservation and management of elephant populations, an understanding of their movement patterns is important because it is in the course of moving between areas that they cause problems. Elephants may be sedentary (Douglas-Hamilton 1971) or nomadic (Leuthold 1977, Viljoen 1989, Lindique & Lindique 1991). Elephant home ranges show considerable variation in size (Sikes 1971, Laws *et al* 1975). Elephants in Lake Manyara have the smallest range of 42 km^2 described so far (Douglas-Hamilton 1971). Home range sizes increase to 3,744 km^2 in Tsavo (Leuthold 1977); 5,800 to 8,700 km^2 in Namibia (Lindique & Lindique, 1991); and, 102 to 5,527 km^2 in Laikipia-Samburu (Thouless 1996). Variation in home range size is attributed to differences in rainfall, land use patterns, pasture availability, forage quality and water sources, and illegal killing (Thouless 1994, 1995).

1.3 The value of the elephant

From the socio-cultural, ecological and economic point of view, the elephant is valued as an important wildlife species. However, the value differ among different communities due to socio-cultural differences. The introduction of protected areas and policy changes denied the local communities living with wildlife from continued use. This has caused resentment and local communities now view elephants as a liability and its conservation has been highly politicised. Nevertheless, the contemporary conservation strategies are geared towards community participation in natural resource management while deriving benefits based on sustainable use.

1.3.1 The socio-cultural value

In the African culture, elephant ivory was used for decorations and as a symbol of power. Representations of elephants were important in traditional art (Ross 1992). Many traditional beliefs portray an elephant as a wise and powerful king. Among some people, it is widely believed that the relationship between man and elephant is so close that man take up residence in an elephant body after death or even while still alive. According to a Maasai myth, resembling the Biblical story of Lot's wife, an elephant descended from a Maasai woman who looked back at the forbidden sight of her old home, was turned into an elephant. According to

Mbano and Nyanchuwa (1996), the name 'elephant' was used to refer to big things such as 'Rupia Tempo' clans, which means large clan. The elephant was also used in customs to honour rulers. Elephant meat is popular in some communities but many avoid it because of widespread taboos (Bousquet 1978, Peters 1993, Tchamba 1995). Bile stones are believed to have medicinal and magical properties while fat from the heart help in conception (Sikes 1971). Politically, a number of African nations (Botswana, Central African Republic, Guinea, Ivory Coast, Swaziland, Tanzania and Zaire) depict elephants or their tusks on their national flags or coats of arms.

1.3.2 The ecological value

The elephant, is a "keystone" species that plays a pivotal role in structuring both plant and animal communities (Laws 1970, Western 1989, Shoshani 1993, Dublin *et al* 1997) and dominates the biomass in the habitat it occupies (White 1995). The impact of the elephant on its habitat can be both beneficial (Ruggiero & Fay 1994) and destructive (Tchamba & Mahamat 1992). The differential use of habitats by elephants can alter significantly the structure of plant communities (Laws 1970, Field 1971, Thomson 1975, Dublin 1986). Utilisation patterns are influenced by forage preference and availability (Leuthold & Sale 1973, Western & Lindsay 1984, Thouless 1995) and external factors such as extreme weather conditions (Confield 1973), human settlement and cultivation (Lamprey *et al* 1967, Laws 1970, Lamprey 1985) and poaching activity (Dublin & Douglas-Hamilton 1987). Studies have found a diversity of viable seeds in elephant dung, suggesting a key role for elephants in seed dispersal. For instance, in Tai forest, Ivory Coast, the elephant dispersed about 30% of the large tree species while *Balanites wilsonian* depends on the elephant for dissemination. The paucity, or absence of regeneration in some primary forest plant species, is attributed to the disappearance of the elephant (Kortland 1984). Other ecological roles include formation of waterholes (Cumming 1982), discovery of water (Viljoen 1988), redistribution of nutrients into bare areas, nutrient cycling (Anderson & Coe 1974, Coe 1977, Coe 1978) and making additional food available to smaller browsers (Viljoen 1988).

1.3.3 The economic value

Meat from culled elephants in Zimbabwe is sold to local communities, city markets or crocodile farms (Martin *et al* 1992), or sold to restaurants in South Africa (Hall-Martin 1990). Elephant skins are used to make boots, briefcases, handbags, luggage and golf bags (Child & White 1988). For instance, Zimbabwe earned between US$ 0.9–2.8 million from skins in 1990 (Cumming 1991). Elephant ivory is used to make sculptures and ornaments (Scullard 1974) and carvings, piano keys, billiard balls and name-seals (Parker & Amin 1983). Indeed, the largely illegal export of ivory from Africa between 1979-1989 earned over US$ 500 million (Cobb 1989). Other values of the elephant include sport hunting (Craig & Gibson 1993, Protected Areas and Wildlife Management Programme 1993), which earned Zimbabwe over US$ 500,000 in 1989 (Bond 1995), and tourism (Walker 1992, Garai 1994, Mendelssohn 1995). Despite all its values, the elephant is experiencing a number of conservation and management problems arising mainly from habitat loss, poaching and HEC.

1.4 Threats facing African elephants

The elephant once roamed most of the continent (Cumming *et al* 1990) but today its range is scattered, fragmented populations south of the Sahara desert in 37 range countries (Said *et al* 1995). Numbering approximately 1.5 million in 1978, today they are reduced to about 600,000. This is due to changing land use patterns because of increasing human population, poaching, desertification, different approaches to tourism, among others. However, Parker and Graham (1989a), argue that the declining elephant population is due to complex historical processes between humans and elephants, involving competition for fertile land and water but not simply as a result of human greed and the rising price of ivory.

1.4.1 Habitat loss

1.4.1.1 Changing land use and cover types and elephant conservation

Many African elephants live outside protected areas (PAs), which alone cannot sustain elephant populations. Therefore, elephants depend on areas outside PAs often on a seasonal basis. With increasing human populations, different land use and cover types are evolving that are not compatible with elephant conservation. USDA Forest Service (1989) defines land cover as what covers the ground, especially vegetation, water bodies or physical structures. They define land use as the predominant purpose for which an area is employed, which may include agriculture, forestry, range, urban development, communication corridors and many more. One or more uses may take place on the same piece of land. Land use is dynamic and responds to prevailing ecological and socio-economic conditions (Kwame 1996). Land use patterns refers to the systematic arrangement (or distribution) of distinct land use types over space (Kwame 1996).

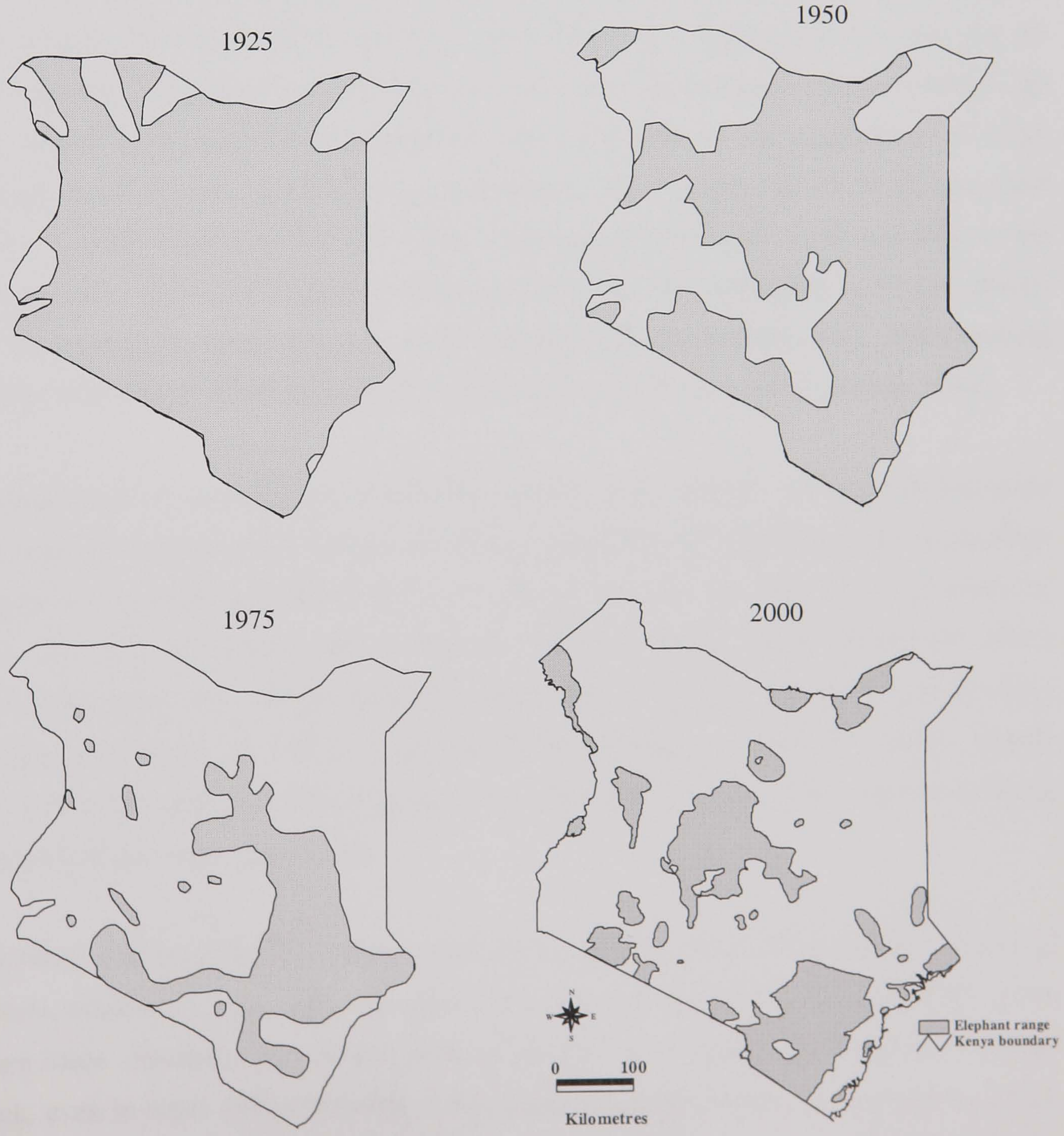
The economic analysis of land use options, land tenure and wildlife conservation by Norton-Griffiths (1998) in different scenarios suggest important wildlife management approaches. Kenya lost over 44% of its wildlife between 1977 and 1994 (Norton-Griffiths 1998) because of rapidly changing land use patterns, as the economics of conservation cannot be realised by land owners. However, because of the special protection status afforded to elephants by the government, habitat loss remains the biggest threat. Ngure (1992) underscores the need to review land use policy and planning and to attain an understanding of the current land use practices. Multiple land use strategy is often recommended as the best elephant management option to minimise conflicts, which is a slow process in Kenya.

Pastoralism is a land use strategy that is generally compatible with conservation (Western 1989), but is dying as a result of increased human population and reduced ranges for livestock movement. While pastoralists co-existed with wildlife harmoniously because of lack of capital and technology and low human population (Norton-Griffiths 1998), their increased population and raised social and economic expectations have brought about gradual changes in land use patterns and increased productivity per unit area of land. Hence, elephants stand to lose more of their elephant range because of increased net benefits from crop production.

1.4.1.2 Changes in elephant range in Kenya

Elephant range in Kenya has contracted markedly (Figure 1.1) over the years (Steward & Steward 1963, Laws *et al* 1975, Graham & Parker 1989a, Said *et al* 1995), largely as a result of competition with man for essential resources.

Figure 1.1 Change in the range of the African elephant in Kenya, from 1925, 1950, 1975 (adapted from Parker & Graham 1989b) and 2000 (KWS Elephant Programme).



The rising human population encroaches on the elephant ranges, converting them into cultivation. Parker & Graham (1989b) predict elephant extinction on the fertile East African soils at a human density of 82.5/km^2. Therefore, the once continuous elephant range in Kenya has become highly fragmented. There were 11 fragments in 1975, but today 26 fragments cover an area of 139,185 km^2. The largest such fragment in the central part of the country cover Meru, Laikipia, Mt Kenya region and is 44,732 km^2, while the second largest is Tsavo ecosystem covering 40,754 km^2. Fifteen of the 26 fragments form part of existing PAs while 11 have no contiguous connection to existing PAs. At this rate, elephants might eventually be displaced from their dispersal areas and be confined to the PAs.

1.4.1.3 Evolution of Maasai agriculture in TM District

Typically, the Maasai ideology regarded pastoralism as easy and rewarding. In contrast, the Maasai regarded cultivation negatively and viewed farmers as people with 'palms of leather' (*en-dap e-'ŋjon*) who always toil and have no time for pleasure and relaxation. Furthermore, agriculture was viewed as destructive and produced less desirable food than livestock products (Galaty 1982). However, various factors have influenced the evolution of agriculture among the Maasai, namely: (a) the migrant population; (b) existing government policies; and, (c) the market economy. The expropriation of Kipsigis land as tea plantations by colonial settlers in the 1930's created a migrant peasant population. The consolidation and registration of fertile Maasailand land with titles also attracted more migrants. The migrants influenced the pastoralist Maasai to take up farming as a viable option, made agricultural inputs more accessible to the Maasai, provided labour to till Maasai farms and/or leased land belonging to Maasai (Kituyi 1990). The technological advancement of developing a drought resistant and a quick ripening Katumani maize variety allowed farmers to cultivate areas with low rainfall (Sindiga 1984).

The expropriation of agriculturally suitable Maasailand by the colonial government during the 'Maasai moves' diminished the traditional Maasai pastoralism and cut off avenues of exchange with agricultural neighbours (Kituyi 1990). This created the need for local production which led to cultivation by both migrants and the Maasai. The 1902 Special District Ordinance, which declared Maasailand as a closed district, reduced the importation of agricultural practices encouraging the Maasai to venture more into farming (Kituyi 1990). Other reasons include provision of credit facilities, official government statements on food policy and emphasis on development of dry areas (GoK 1979).

Consolidation and registration of land under private title has also influenced the growth of agriculture, because the legal right to exclusive use of a parcel of land with its title deed serves to secure loans. Similarly, agricultural services receive more support from government than livestock, even in areas where livestock is the single most important economic activity (GoK 1985). The increased involvement of the Maasai in a free market economy and the realisation that the calorific value of grain is cheaper to achieve than a similar calorific value from livestock, increased the Maasai use of agricultural foods (Kitching 1980). Finally, dramatic increase in the prices of cereals and modest gains in livestock prices has further reduced livestock while agricultural expansion has increased. The increased prices of cereals are due to the ready market created by rapid urbanisation. Improved communication between urban and agricultural areas provides new, more lucrative markets instead of modest pastoral markets, and government policies favouring agricultural produce. Grain traders also demand much higher prices from the pastoralists than the national averages (Kahaerby 1976, Hjort 1981). Subsistence agriculture is a means of supplementing the pastoral diet and the only realistic path towards economic security and self-reliance, rather than the commercialisation of the pastoral economy (Arhem 1984). The changing land use patterns in Maasai land can in part be attributed to the changing patterns of land tenure among other reasons.

1.4.2 Poaching and its implications for elephant conservation

Poaching is a term used to refer to illegal killing of wildlife for their trophies. The demand for the elephant tusks has cost the lives of many elephants. As a result of poaching, the elephant population in Kenya declined by 67% from 130,570 animals to 19,749 in 1987 (Swara 1988). At the CITES CoP in Kyoto, Japan, the elephant was listed on Appendix 1. Population of the elephant was moved to Appendix II during the CITES Cop in Harare, Zimbabwe in June 1997. For the southern African countries of Botswana, Namibia and Zimbabwe, limited trade in elephant products was allowed but only between certain countries and under very strict laws. However, the Kenyan elephant was still fully protected under Appendix I.

In 1992, KWS established Elephant Mortality Database to monitor elephant deaths. Elephant poaching declined in the 1990s and by 1996, there were more elephants outside protected areas than inside due to re-establishment (Waithaka 1998). Kenya's elephant population benefited from protection by what was then, one of the best financed and run wildlife department on the continent (Dublin *et al* 1995). Elephant range in Kenya is now 135,005 km^2 or 22.70% of the total land surface and elephant numbers have grown from 19,000 to 27,000 in 1989 and 1997 respectively (Waithaka 1998). A large proportion of Kenya's elephant range lies outside PAs and elephants frequently migrate between both protected and non-protected areas. Expanding human popuiation and increased cultivation in marginal, non-protected areas of elephant range have escalated conflicts between humans and elephants competing for land and access to water (Thouless 1994, Kiiru 1995, Ngure 1995).

1.4.3 Human-elephant conflict (HEC)

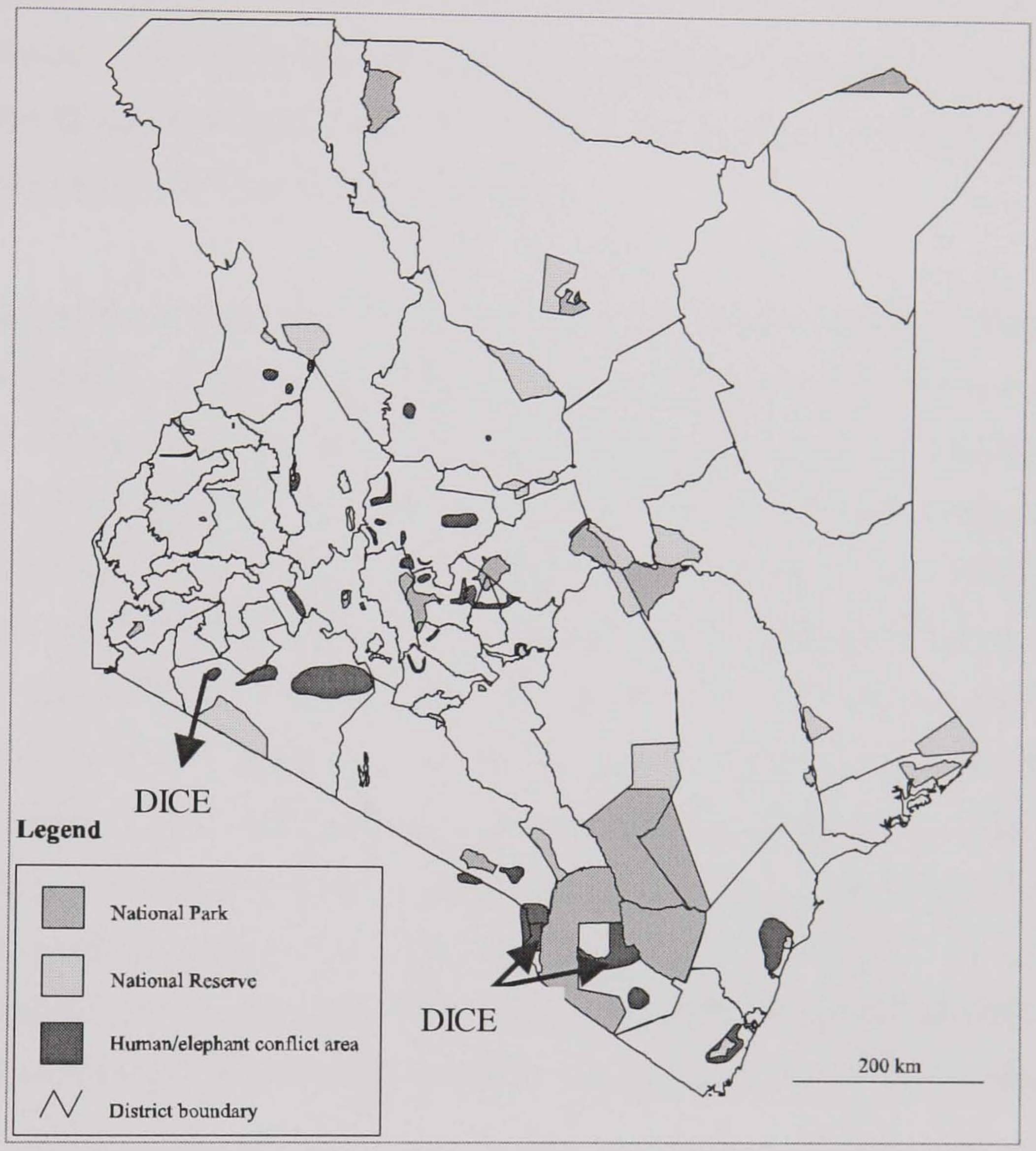
This study defines HEC as all disagreements or contentions relating to destruction, loss of life or property, interference with rights of individuals or groups that are attributed directly or indirectly to the elephant and man. HEC is a contemporary management crisis that is being experienced in all elephant ranges. All elephant ranges in Kenya have been marked as HEC areas (Figure 1.2) and TM is one of the key areas (KWS 1994). More general studies on elephants have been conducted in the Mara ecosystem (Omondi 1994, Sitati 1997, Kimanzi 1998) which provides information for further research. Unlike most studies where researchers focused their study on the negative impact of the elephant, this study attempts to give a balanced review of the impact of both man and the elephant to each other. The increase in HEC is attributed to the changing socio-economic and cultural aspects of the local communities resulting from population explosion.

KWS have mapped 31 HEC areas in Kenya, and Narok District has the most sites (Figure 1.2). Nine areas are attached to PAs, and 22 areas are away from PAs, all on private land. The Durrell Institute of Conservation and Ecology (DICE) has supervised HEC studies in Tsavo (Kasiki 1998, Low 2000) and this study in TM District apart from other studies (Kailas 2000) for comparison. Two types of HEC are exhibited: (a) direct conflicts, including, killing or injuring of man or elephant, property destruction such as of crops and infrastructural facilities, and/or competition for natural resources such as grass, trees, salt licks, and water; and, (b) indirect conflicts including disruption of the social and economic activities, such as school attendance, increased walking distance to bypass elephants, and reduced night activities. Others include temporary migration, building strong 'bomas' to keep elephants away and fencing fields. The conflict affects elephant ecology (Tchamba 1995) and migratory behaviour (Whyte 1993), and also human ecology. Elephants are often mentioned as the major source of human-wildlife conflicts (Omondi 1994, KWS 1994, Sitati 1997). This was summarised by a community representative to the members of human-wildlife conflict task force:

> *"Let animals on private and communal lands be granted to be the property of the local people so people can plan how best to maintain and use them. Furthermore, if the elephants and lions could be kept in the National Parks then people would be happy to have and own all other animals on their lands"* ***(KWS 1995: quote from a community representative, Bura, Taita District).***

Most conflicts occur in agricultural areas which were formally uninhabited by humans, presenting a difficult challenge to conservationists (Kangwana 1995). Lahm (1996) attributes this to the rural exodus of villagers and changes in village organisation and institutions that have resulted in less cohesive, fragmented societies where traditional communal practices, which united villagers have been abandoned (Lahm 1993). There is a need for defined management objectives for both protected and non-protected areas of elephant range. This is because the status of HEC varies significantly across its range, and its long term survival is more threatened in some areas than others. Areas that are vulnerable to crop raiding include the widely dispersed plantations, unprotected farms, farms far from villages and farms located near elephant infested areas like forest edges, parks and reserves. With increasing HEC, and no compensation or no benefits from wildlife activities to the local communities, elephant poaching has emerged as the only economic benefit to some community members. Because of the increasing threats directed towards elephants, their plight has been highlighted by many institutions and organisations.

Figure 1.2 Locations of HEC in Kenya (Source: Smith & Kasiki 2000).



1.4.4 The plight of the elephant

The elephant is a highly politicised wildlife species that has drawn much concern both from the local, national and international communities. Indeed, the elephant debate has often dominated CITES Conference of the Parties. Unlike other wildlife species, elephants have proved to be very expensive to manage and conserve due to their ever-changing behavioural ecology and many projects have been established to determine the best management options. Berhad of Malaysia, in collaboration with the Malaysian Wildlife Department, started "New Homes for Elephants" Trust Fund in which individuals or corporate owners are sought to "adopt" a translocated elephant. Similarly, the Society for Conservation Biology (SCB), supports a project in Malaysia, focusing upon finding solutions of HEC using satellites.

TRAFFIC monitors the illegal activities involving animal products, including elephants, all over the world. The African and Asian elephant specialist groups have been established to monitor and update the trends in elephant conservation activities. This includes the Human-Elephant Conflict Task Force (HECTF) of the African Elephant Specialist Group (AESG), and the Asian Elephant Specialist Group (AsESG). Many symposiums and workshops have been held on human-elephant conflict, such as the 1998 symposium on "Finding solutions to the human-elephant conflict in Asia" at the 1998 Society for Conservation Biology Annual meeting in Sydney, Australia. Other important elephant related databases established include, Monitoring system for the Illegal Killing of Elephants (MIKE), the Elephant Trade Information System (ETIS), and Bad Ivory Database System (BIDS).

Special journals exist for elephants, *Pachyderm* (thick skin) for the African elephant and *Guraja* for the Asian elephant, are produced three times a year to disseminate information on elephant conservation and management. The Academy of Natural Sciences in Philadelphia's yearly exhibitions on elephants shares the concern, while the Elephant Managers Association (EMA) in India is devoted to the transfer of knowledge on veterinary, care, training, treatment, behavioural studies, breeding and habitat enrichment for elephants. Ringling Brothers and Barnum and Bailey (RBBB) centre, a US$ 5 million facility is dedicated to the conservation, breeding and study of the Asian elephant. The International Union for Conservation of Nature (IUCN), the mother of all conservation principles and policies, is also very concerned with the problem facing elephants. CITES was established to protect the elephant and other endangered and threatened wildlife species. The Friends of National Zoo (FNZ) have set up an adoption scheme of elephants in Thailand after many of the domesticated elephants became unemployed after logging was banned and the elephant owners could no longer maintain elephants (Sukuma 1990).

Save the Elephant (SE) "eyes in the sky " project in Kenya monitors problem elephants in Amboseli. The KWS's Elephant Program monitors and identifies other options for management of the elephant. The KWS Elephant Research Trust Fund (ERTF), supports elephant related research projects in Kenya of which this project was a beneficiary. African Conservation Centre (ACC), Kenya have initiated the project, "human-elephant conflict: Taking the initiative" aimed at facilitating all experts from Africa and Asia researching the elephant to exchange ideas and suggest strategies for conflict management. The list of elephant projects is endless and sends a signal of increasing concern towards elephant conservation. The whole problem revolves around conflicting policies of conservation and development.

1.5 Mitigation of human-elephant conflict

Many different approaches have been used to mitigate conflict between elephants and people at different levels. The increasing conflicts and therefore increasing pressure on governments by local communities has forced some governments to come up with policies on conflict mitigation. However, conflicting policies is the major stumbling block to elephant management and conservation both at local, regional and international scale. Nevertheless, historically, the management of problem elephants has evolved from brutal and inhuman towards careful approach.

1.5.1 History of problem elephant control (PEC) in Kenya

Conflict between elephants and humans has existed in Kenya as long as crops have been grown. About 30 elephants were shot every year in early 1900's (Melland 1938). After realising that sustained control shooting had adverse effects on elephant populations, a protectionist approach was adopted and electric fences were established in Nairobi, Tsavo and Aberdares NP in 1950's but were failures (Jenkins & Hamilton 1982). Moats were used in the Aberdares, Meru NP, Tsavo, Laikipia and Maralal. Elephants in Tsavo have learned how to go through the moats, while the Aberdare moats succeeded only after modifications. Moats in Maralal were ineffective because they were broken by pastoralists to allow passage of livestock, while the Laikipia moat was shallow and ineffective. Most moats failed because of lack of maintenance. High tensile steel fences were constructed along Meru NP and the Loita wheat scheme in 1980's. The once effective Meru fence was weakened by lack of maintenance and vandalism, while wheat farming spread to both sides of the fence rendering it useless. In 1987, electric fences were erected in Nakuru NP, Nairobi NP, Aberdares NP and Ngulia Rhino Sanctuary and they have been effective because of community support and the high voltage (KWS 1992).

Melland (1938) highlighted some of the crude methods used by some communities to control problem elephants in early 1900s:

(a) A weighted spear slung from a tree and released by a trip wire;
(b) Pit falls with a sharpened pole that stabbed the elephant to death;
(c) Ringing a herd with fire and burning it to death;
(d) Poisoned arrows, causing a lingering death lasting weeks;
(e) Hap-stringing and bleeding to death;
(f) Shooting with muzzle-loading guns, which only wounded around 90% of elephants;
(g) Foot snares with anchors, which caused wounding and bleeding to death; and
(h) Blinding and spearing to death.

Non-lethal methods such as thunder flash can only be used during the rainy season owing to the likelihood of starting un-proscribed fires. Some success is evident but the wet vegetation hinders the operation. PAC in Kenya varies depending on the intensity and type of conflicts, as well as the area in which it occurs. Delayed authorisation may result in the killing of innocent non-raiding elephants (Kangwana 1995). There is a need for local management to ensure rapid responses to problem elephants which involve public relations and local villagers in local elephant management. However, conservationists think that by minimising elephant crop destruction problems, further human encroachment on elephant ranges is likely (Ngure 1992). Because of increasing conflict and inability to control, elephant translocation has emerged as another possible conflict reduction strategy.

1.5.2 Elephant translocation

Elephant translocation strategy involves the removal of problem elephants from high conflict zones especially farming areas to no farming areas or reduction in elephant numbers in conflict areas. Historically, elephants from Ruma NP in Lambwe Valley were driven out to the Mara in 1948 by the local community because of increased conflicts. The first elephant translocation programme by KWS was in 1995, when elephants were moved from Mwea NR to Tsavo East NP to ease pressure and reduce conflicts. Subsequent elephant translocations followed (Table 1.1). A total of 76 elephants have so far been translocated at a cost of Ksh 17.0 million (US$ 212,500). All were bulls except one female that had been identified as a notorious crop raider. Nine elephants died in the course of translocation. Elephant translocation is not only expensive but may not be the long term solution since all elephant ranges are encroached and are under cultivation. As a result, erection of barriers such as fences have also emerged.

Table 1.1 Elephant translocation in Kenya (Source: KWS elephant programme).

Year	From	To	Distance (km)	No. / Sex	Cost (Ksh)	Deaths	Reasons
1995	Mwea	Tsavo	400	21 bulls	7.0 m	5	Conflict / habitat damage
1997	Lewa Downs	Kora	400	10 bulls	3.0 m	2	Habitat damage
1998	Lewa Downs	Meru	200	5 bulls	1.5 m	None	Conflict / habitat damage
1998	Mwaluganje	Tsavo	400	30 bulls	5.0 m	2	Conflict / habitat damage
1999	Imenti	Meru	200	1 bull	*	None	Conflict
2000	Laikipia	Meru	250	9 bulls & 1 cow	0.5 m	None	Conflict

* *Figure not available*

1.5.3 Fencing

Various forms of fencing have been tried to prevent elephants from conflicts with people (Table 1.2). The electric fence, considered as a possible solution to HEC, is very expensive and has its ecological repercussions. In 1990, Taita Taveta District administration proposed a 54 km electric fence to mitigate elephant crop damage problems in areas adjacent to Tsavo NP, this being the first fencing exercise by KWS (Ngure 1992). The project failed to meet its objectives and was subsequently suspended because of lack of thorough information on HEC. Despite the increased food production and reduced conflict, fencing also causes additional management problems. Fencing cannot really solve the conflict problem, because a large proportion of elephants is found outside PAs (Daily Nation 1998a, Waithaka 1998). Other electric fences have been erected around Kabiruini forest by Singare ranch (Daily Nation 1998c) and another 300 km fence costing about Ksh 500 million (US$ 5,000,000) around Aberdares NP (Daily Nation 1998e) to reduce HEC. However, rogue elephants that are notorious for fence destruction or crop raiding are often shot.

Table 1.2 The costs and lengths of some of the established electric fences in Kenya to minimise human-wildlife conflict (Source: KWS elephant programme and Fencing unit).

Year	Park / Area	Length (km)	Cost (Ksh)	Other notes	Effectiveness
1997	Mwea	16	17.5m		Effective
1997	Meru (Naari)	9	6.7m	Community project	Effective
1998	Kimana	61	36.4m	People fenced in	Effective
1996	Tsavo	60	19.6m		Not effective
1999	Shimba Hills	17	39.3m	Elephants fenced in	Effective
*	Shimba Hills	87	*	Elephants fenced in	Effective
*	Aberdares	80	*	Rhino Sanctuary	
*	Ngulia Sanctuary	30	*	Rhino Sanctuary	
*	Nairobi N.P.	40	*	Rhino Santuary	Effective
*	Nakuru N.P.	74	*	Rhino Sanctuary	
*	Marsabit	30	*		
*	Mt Elgon	18	*		
*	Laikipia	22	*		
*	Ngare Ndare	40	*		
*	Siapei	4	*	Experimental fence	Not effective
*	Sangare	2	*		

* *Information not available*

1.5.4 Shooting of problem elephants

Shooting of problem elephants began as early as 1912 when rifles were issued to keep down elephant population. For instance, in Uganda between 1917 and 1921, 3,992 elephants were killed and many were injured (Melland 1938). In 1936, 2,674 and 228 elephants were killed in Tanganyika and Kenya, respectively. The situation worsened as wounded elephants were more troublesome and vicious and a new approach was sought. Elephants learned and abandoned the danger zones and migratory routes. The scheme was subsequently abandoned and restarted recently. Problem animal control (PAC) unit was established by KWS when elephant problems started to escalate. However, the approach of killing problem elephants is seen as wasteful and uneconomical in Kenya since it involves loss of life and considerable costs incurred in terms of manpower and material resources in destroying the problem elephant. Edible meat is given to the local people while the tusks are recovered, but the skins and inedible meat are wasted.

1.5.5 Establishment of elephant sanctuaries and wildlife trusts

Some communities recognised elephants outside PAs and have supported the establishment of sanctuaries and ranches on their land for conservation purpose and benefits. For instance, Mwaluganje Elephant Sanctuary was established with the objective of ensuring that elephants in Mwaluganje and Shimba Hills are free from attacks by local residents due to crop raiding and for the local people to derive benefits directly from tourism earning from gate taking and earnings from campsites (Daily Nation 1998b). Others include the private land Lewa Downs Wildlife Conservancy and Impala Sanctuary while many communities around PAs are forming wildlife trusts as a way of minimising conflict.

1.5.6 Community conservation programmes

Community conservation is a participatory process between people and organisers who have rights and responsibilities affecting conservation. It leads to better planning and more benefits for communities, which encourages more interest and participation in conservation. Traditionally, managers of PAs concentrated on law enforcement to protect natural resources. The government restricted resource use by the local communities and controlled revenue from tourism. However, this approach suffered a major set back since the communities that live around PAs have often developed a negative attitude towards conservation due to competition for resources like water, land and pasture. The long term survival of PAs depends on the approval and good will of the local communities. The principle behind community conservation programmes is to try to integrate the use of natural resources with rural development by channelling some benefits from resource use to socio-economic development of local communities. Local communities should hence participate as partners in the management of the natural resources both within and outside PAs.

For conservation efforts to succeed, they must embrace the socio-economic and cultural values of the local community. The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) programme in Zimbabwe actualises community based wildlife use and management policy. However, its successful implementation has been hindered due to poor management reducing its ability to meet its set objectives. In Zambia, the Administrative Management Design (AMADE) was established to administer wildlife and improve the living standards of people in wildlife areas. Other community programmes include Luangwa Integrated Resource Development Project (LIRDP) and the Zambia Wetlands Project (ZWP).

Uganda has Community Conservation Unit that tries to address the needs of the local people while Namibia has a new conservancy policy that seeks to grant the community the rights over the management and use of natural resources.

In Kenya, KWS established Community Wildlife Service (CWS) to involve local communities in the management of wildlife. The KWS policy of sharing 25% revenue collected from gates with local communities remitted Ksh 18 million (US$ 600,000) in 1991, Ksh 13.4 million (US$ 470,000) between 1992 and 1993 and Ksh 36 million (US$ 1,200,000) in 1993 and 1994 (Norton-Griffiths 1998). Game farming of ostrich, crocodiles, guinea fowls, and insects is being encouraged and overseen by KWS, but is hampered by the existing outdated and contradictory wildlife policies. However, according to a ban of hunting (Legal Notice No. 120 of 20 May 1977), trade in wildlife and wildlife products (Parliamentary Act No. 5 of 1978; Legal Notice No. 181 of 21 August 1979) and Presidential Directive prohibiting hunting and capture in 1984, the pilot wildlife utilisation being implemented under CWS is technically illegal.

1.5.7 Other methods employed in problem elephant control

(a) In the past, there was not much response reports of elephant disturbances, an approach referred to as "wait and see". Nature took its course as there was fairly peaceful co-existence between elephants and humans. This approach seems to take centre stage until the outcry by locals is loud enough for action to be taken.

(b) Culling of excess animals occurs for some animal species, but is not applied to elephants. The Kenya Government has always resisted culling elephants even when over-abundant, mainly for ethical and humanitarian reasons. However, Kenya might in future "mentally tip-toe" towards the idea of culling, given increasing encroachment on elephant ranges and a recovering elephant population.

(c) Local game scouts are employed in some areas to assist KWS in carrying out control work. The scouts are trained by KWS in handling ammunition and general wildlife management principals .

(d) The local community may be compensated for losses and injury caused by wildlife (GoK 1977). This is in accordance with the Wildlife Act of 1979 Section 62 (1). However, this scheme has never succeeded due to limited funds, dishonesty and inefficiency in the assessment process and in submission of compensation claims. The compensation scheme for crop damage was therefore abolished in 1989. The compensation for injury is Ksh 15,000.00 (US$ 214) and human death is Ksh 30,000.00 (US$ 428). This has been very controversial as the figures are just too low creating a lot of resentment from the local people (KWS 1995). The government is working out the formalities of increasing compensation to Ksh 1.0 million (US$ 14,286) for loss of human life. However, compensation schemes have had little success in Cameroon (Tchamba 1995) and in Kenya (Ngure 1995). The African Wildlife Foundation (AWF) elephant project in Amboseli pays a higher consolation fee for loss or injury of livestock by elephants. In Namibia, Game Products Trust Fund (GPTF) was established to reduce tension between elephants and people through fencing and installation of water points.

(e) Kenya has been trying to channel some of the earnings from tourism and wildlife industries into the local communities (Parkipuny 1996). Some projects pay grazing fees to ranches outside PAs for areas used by wildlife such as in Amboseli, Tsavo and Chyulu Hills. In Masai Mara, the local community receive revenue for development of tourist camp sites or lodges on their land. Before hunting was banned in 1977, the hunting concessions were used to benefit local communities. Therefore, increasing HEC has necessitated studies on HEC in order to understand the arising complex interaction between man and elephants.

1.6 Previous research on human-elephant conflict

HEC is the current management crisis facing wildlife managers and conservationists, and should be given priority for action (WWF 1997). More general studies have also mentioned the importance of HEC (Caughley 1976, Bell 1984, Hoare 1992, Anon 1997). Further, specific studies have increased in number and sophistication in recent years and have documented extensive conflict scenarios and complex systems of conflict management. Such studies have been conducted in Cameroon (Tchamba 1995, Ekobo 1996); in Zimbabwe (Hawkes 1991, Jones 1992, Osborn 1992, Hoare & Mackie 1993, Hoare 1995, Osborn & Rasmussen 1995, Wunder 1996); in Gabon (Lahm 1994, 1996); in Namibia (O'Connell 1995); in Malawi (Deodatus & Lipiya 1991, Simons & Chirambo 1991, Bhima 1997); in Ghana (Opuku 1988, Asika 1994, Nchanj 1994, Barnes *et al* 1995, Sam *et al* 1997); in Tanzania (Nicholson 1968, Vessey-Fitzerald 1968, Matzke 1975, Newmark *et al* 1994); in Central Africa (Thouless & Tchamba 1992, Hillman-Smith *et al* 1995, Mubalama & Hart 1995, Barnes 1996); and, in Uganda (Kinloch 1972, Naughton-Treves 1998). Many studies have also been conducted in Kenya (Allaway 1979, UNEP 1988, Pool 1990, Irigia 1990, Ngure 1992, 1994, 1995, Sakwa 1992, Waithaka 1993, Litoroh 1994, Thouless 1994, Western 1994, Omondi *et al* 1994, KWS 1994, Kangwana 1995, Kiiru 1995, Thouless & Sakwa 1995, Kasiki 1996, 1998). This large list of references shows a burgeoning of studies since 1992, an indication that the issue of HEC is of increasing concern. However, because of differences in the methods and type of data collected, more generalised recommendations have been derived which have proved less useful to long term conflict resolution. Therefore, there is a need for a standard format to monitor conflict. While the quality of the research has been improving over time, based on earlier recommendations and refined study methodologies and analyses, it has become apparent that spatial and temporal patterns of conflict must be understood with the use of Geographical Information System (GIS), which is increasingly becoming an important tool in HEC studies (Kailas 2000, Smith & Kasiki 2000, Low 2000). Equally, remote sensing techniques help in understanding human encroachment on elephant range, while indigenous knowledge can be used to give a clear understanding of the historical evolution of conflict and traditional mitigation strategies. This is the first study to consider most recommendations of previous research in its study.

1.7 The role indigenous knowledge, GIS and remote sensing in elephant conservation

The use of indigenous knowledge has of late been considered an important way to bridge a "missing link" in natural resource management (Chambers 1992). Research on natural resources is the key interface between local and scientific knowledge (Blaikie *et al* 1996). However, local knowledge can only be equitably negotiated between local and external actors through the participatory approach (Biggs 1989). This knowledge elicits important information that can now be scientifically tested to arrive at some unique explanations. This study adopted this approach.

Participatory approaches are a way of gathering information for use by community and conservation agencies. Therefore, community participation is the key to correct elephant conservation and management problems. The participatory approach is an important process in developing interaction with the local community and in gaining more information. Rapid Rural Approach (RRA) was the first participatory methodology developed in the 1970s, while Participatory Rural Appraisal (PRA) was developed in the 1990s (Chamber 1992). RRA was started in Thailand at University of Khon Kaen while PRA evolved in Kenya to develop a Village Resource Management Plan in Machakos (Kabutha & Ford 1988). The two approaches differ considerably (Table 1.3). RRA study has spread to other universities such as University of Phillipines in Phillipines, Egerton University in Kenya, Obafemi Awolowo University in Nigeria, University of Zimbabwe in Zimbabwe and several universities in Australia (Bawden *et al* 1984, Ampt 1988, Voyce 1989, Ampt & Ison 1988 & 1989, Ison 1990, Dunn & McCmillan 1991, Dunn 1991). In Australia, RRA study has been linked with soft systems theory (Checkland 1981) and contextual science (Russell & Ison 1991). This study adopted RRA methodology as a learning process and to avoid high expectations from the community members since the study was academic, and to understand the historical evolution of factors determining conflict in TM District.

GIS as a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data from the real world for a set of particular purposes (Maguire *et al* 1991, Scolten & Van der Vlugt 1996, Martin 1996, DeMers 1997, Burrough & McDonnell 1998). It is a system consisting of hardware, software, data processing and a proper organisational context, which compiles, stores, manipulates, analyses, models and visualises spatial data to solve planning and management problems. The use of GIS is becoming increasingly widespread in the fields of resource management and indeed it has become an important tool in solving ecological problems (Walpole 2000). In elephant conservation, GIS has been used to study home ranges and factors affecting their size and location (Thouless & Dyer 1992, Hillman-Smith *et al* 1995, Thouless 1996, Barnes *et al* 1997, Gibson *et al* 1998, Verlinden & Gavor 1998). GIS data can be complimented by remote sensing data and other spatial data, in order to understand the interplay of the many variables in elephant conservation.

Table 1.3 Comparisons between RRA and PRA (Source: Chambers 1992).

	RRA	**PRA**
1. Establishment	Late 1970s, 1980s	Late 1980s 1990s
2. Major innovation	Universities	NGO's
3. Main users	Universities / Aid agencies	NGO's / Government departments
4. Key resource earlier overlooked	Local peoples knowledge	Local peoples capability
5. Main innovation	Methods	Behaviour
6. Predominant mode	Elicitive, extractive	Facilitating
7. Ideal objectives	Learning by outsiders	Empowerment of local people
8. Long term outcomes	Plans, projects, publications	Sustainable local action and institutions
9. Outsiders role	Investigation	Facilitation
10. Information owned, analysed and used by	Outsiders	Local community

1.8 Land issues and wildlife conservation

1.8.1 Land issues and wildlife conservation in Kenya

In Kenya, the ongoing rapid agricultural revolution does not auger well for elephant conservation. The British colonial administration in the 1890's enacted some of the earliest game protection legislation in Kenya (Saibull 1996) to promote sustainable hunting as opposed to the high level hunting that threatened wildlife species to the brink of extinction. Protected areas were set up in the 1940's and by 1975, the Kenya government released a new wildlife policy. This was followed by wildlife management conservation Act in 1976 and the National Parks and Game department amalgamated to form the Wildlife Conservation and Management Department (WCMD). WCMD was to integrate wildlife conservation with the welfare of the local communities and a wildlife planning unit was set to provide the relevant planning support to protected areas (Western 1982). The KWS superseded the WCMD in 1989 (Lusiola 1996). KWS manages National Parks on behalf of the central government while National Reserves are managed by County Councils. KWS provides national policy guideline and gives regular advice and technical support to National Reserves. However, the County Councils have a great deal of autonomy over the affairs of their respective reserves (Parkipuny 1996). More than a half of the 47 protected areas in Kenya are National Reserves under the jurisdiction of the County Councils.

1.8.2 The evolution of land tenure system in Maasai land

The Maasai lost most of their land to the British government when Kenya was colonised in 1895. Their land was replaced with a colonial export-oriented economy dominated by plantation agriculture and beef ranching. The 1902 Special District Ordinance declared Maasailand a closed area, protected from external pressures and left alone to develop along its own lines. Between 1910 and 1913, an agreement was signed to keep Maasais off Laikipia and some were moved to Kilgoris in TM District (Kituyi 1990). The National Parks Ordinance of 1945 resulted in the creation of the MMNR and the Maasais lost salt licks, seasonal pastures and permanent water sources. In the 1950's, the British hurried through policies to create an African middle class to have a stake in the economic system and protect the British interests in the colony after the Mau Mau revolt. This led to radical changes in land tenure where private titles were issued and private ranches created as well as exclusive rights granted over lands within the reserve. For instance, the Swynnerton Plan of 1954 led to the development of a policy to generate a rural-based African middle class directed towards property rights and development (Swynnerton 1955). Equally, the World Bank and the Lawrence Commission on land consolidation and registration pushed for the creation of ranches for securing development credit (Lawrence Report 1966, Leys 1977). A policy on free access to willing buyers after independence and the repeal of the 1902 Special District Ordinance into Masailand led to major influxes of migrants into TM District (Kituyi 1990). Settlement, a premise for the campaign of development, the provision of credit facilities to farmers by government agricultural credit agency, and statements of official policy led to increased farming practices (GoK 1980, Sindiga 1984).

Kilgoris is a Kipsigis name while Maasais call it '*Oltanki*', the place with the water tank (Kituyi 1990). The Kipsigis were heavily defeated during the battle of Ngoino when they raided the Kisiis in an effort to steal some cattle, and were driven out of the Kilgoris area and the north of Oloololo escarpment. Since the Kisiis were primarily an agricultural community, the conquered rangeland area was not important to them. Hence, it was soon under Maasai use and officially granted by the British government as part of the Maasai Reserve. These traditional relations partly explains the migration of Kipsigis into TM District.

The 1968 Land Group Representative Act led to the setting up of group ranches meant to discourage communal ownership of land and subsistence oriented livestock rearing. Instead, it advocated sedentary commercial livestock production. It was also meant to enable the pastoralist community to acquire land titles so that they could access loans for range and livestock, and for improvements, in order to enter the commercial livestock sector (Halderman 1972). The group ranches were intended to prevent further alienation and retention of communal access to range resources over areas large enough for viable extensive livestock rearing. The Maasais were hence attracted by the opportunity to increase water facilities, dips and salt licks that were part of the group ranch legislation development programmes (Parkipuny 1996). The development programmes were stopped and a sense of identity within the boundaries was created, encouraging a more sedentary way of life. However, group ranch members still hold large numbers of livestock, which are supposed to be collectively sold off to limit stock holdings and are now clamouring for sub-division, a process that has already began. The changing land tenure patterns have resulted in more incompatible land use strategies, that have in turn increased HEC.

1.9 Transmara District as an important elephant range

TM District has a high potential for agricultural activity due to fertile soils and high rainfall (Thurrow 1996). These have attracted immigrants from the adjacent districts resulting in increased cultivation and human population, which are incompatible with elephant conservation. TM District supports an elephant population whose numbers have not been clearly established due to the forest nature of the habitat and the seasonal movement of elephants from the adjacent Narok District (Wamukoya *et al* 1997). TM District was documented as one the areas in Kenya experiencing intense conflict with wildlife (KWS 1994). Increasing cases of conflict are a threat to wildlife species and particularly elephants, which are regarded as the most problematic animal species. Finally, in order to safeguard people and elephants in TM District, there was a need for a thorough investigation on the status of changing land use patterns, elephant density and conflict and how these have influenced peoples' attitudes towards elephants.

1.10 Justification for this study and study questions

The elephant species scores highly on the following first cut criteria on the value of animal species in social, economic and ecological aspects (WWF 1997). These criteria include wildlife species that (a) are highly visible nationally and internationally, (b) are highly attractive to tourists; (c) are potentially dangerous to life and property; (d) are mobile and require large areas to satisfy their needs, (e) compete directly for space with other land use; (f) occur in large numbers outside the protected areas; and, (g) present management challenges to wildlife managers and agencies.

The study provides vital input to Masai Mara management plan and TM District land use plan. With good and workable plans, elephant and the remnant forest conservation will be assured while minding peoples needs. At the same time the Kenyan Government may benefit from this study since loss of life, property, injuries, and costs of mitigation measures involve a substantial amount of money, which contributes to draining the national budget through non-existent compensations for human deaths and injury. This study examines HEC from both social and ecological perspectives and tries to identify factors affecting patterns of conflict (Figure 1.3). The study will contribute to realising elephant conservation, a positive attitude towards elephants and increased local development.

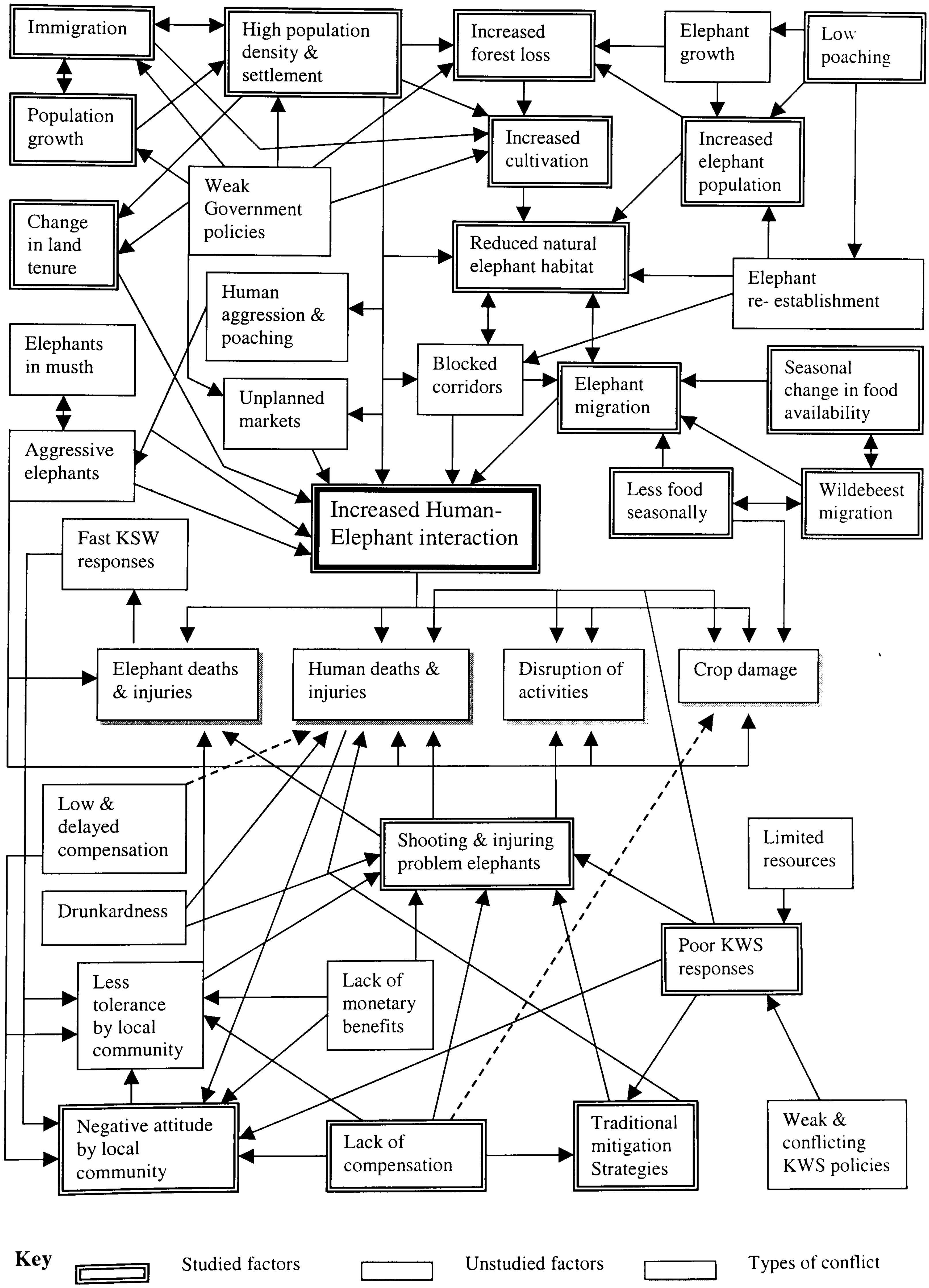
The main questions investigated in this study are;

- What is the history of human-elephant interaction in TM District?
- What is the attitude and perception of the local people towards elephant conservation?
- How has land use and habitat coverage changed over time in TM District?
- How has the density and distribution of elephants changed over time in TM District?
- What conflicts arise between elephants and the local people?
- What factors determine the seasonal patterns of conflict?
- What factors determine the spatial patterns of conflict?
- What protection measures are used by the local people and how successful are these measures?
- How can these conflicts be mitigated?

1.11 Thesis organisation

Chapter 1 has provided a brief background information on concepts surrounding human-elephant conflict, elephant conservation and management, and the aims of this study. Chapter 2 describes the biophysical and socio-economic features of the study area and the general methods used in the study. The historical background of the elephant interaction with the people, ranges, important areas, elephant related themes and activities and conflict mitigation measures are discussed in Chapter 3. Chapter 4 describes socio-economic profile as well as attitudes and perceptions of the local communities towards elephant conservation. The changing land use and cover types that are related to conflicts are described in Chapter 5. Chapter 6 describes current elephant densities, distribution and habitat use in the study area. Chapter 7 explains the types and patterns of HEC in TM District. Factors determining seasonal patterns of crop raiding and factors affecting spatial distribution of crop raiding are discussed in chapters 8 and 9 respectively. Chapter 10 describes protection measures and other farm based factors affecting crop raiding. Finally, suggestions for conserving the elephant while minimising its conflict with the people are made in Chapter 11.

Figure 1.3. A theoretical framework of the types and factors that cause HEC.



CHAPTER TWO

Study area and General methods

2.1 Introduction

Transmara (TM) District is an important wildlife dispersal area for the resident elephant population in the Mara Triangle (MT) of the Masai Mara National Reserve (MMNR), and also enjoys unique and diverse biophysical features. Being a zone of high agricultural potential, increased cultivation threatens the future of the elephant through increased conflict. This chapter highlights detailed background information on biophysical attributes and provides a socio-economic profile of the study area that directly or indirectly influences elephant conservation and management. The general study methods are briefly discussed, while detailed and more specific methods of data collection and analysis are presented in the appropriate chapters.

2.2 Location

Transmara lies between latitude $0^0 50'$ and $1^0 50'$ South and longitude $34^0 35'$ and $35^0 14'$ East. It is bordered by seven districts, namely: Kuria and Migori to the west; Kisii, Gucha, Nyamira and Bomet to the north; and, Narok to the east. To the south lies the Republic of Tanzania (Figure 2.1). The TM District now covers an area of about 2901 km^2, having been carved from Narok District in 1994. It has five administrative divisions, namely: Lolgorian, Kilgoris, Pirrar, Keyian and Kirindoni; and 54 sub-locations. Of these, the present study only covered an area of about 1611 km^2, comprising 26 sub-locations (Figure 2.2). Currently, elephants move within 19 sub-locations either permanently or seasonal.

2.3 Biophysical features

2.3.1 Climate

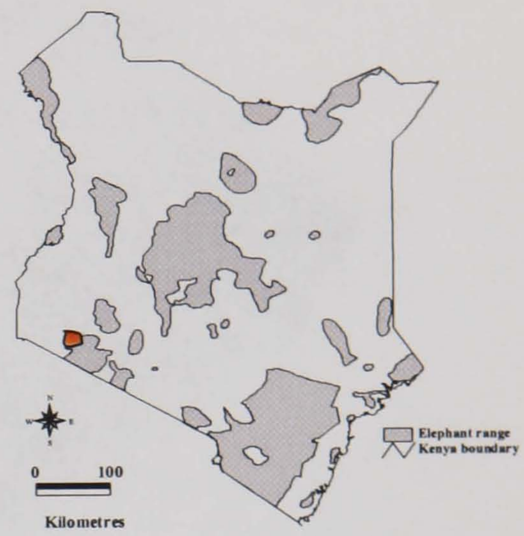
The temperatures of TM District are moderate due to its high altitude, and range from 14.8^0 to 20.3^0 C. The mean annual temperature ranges from 15^0 C in the north to 17^0 C in the south. The highest temperatures occur in February, while June and July are the coolest months. The average temperature generally reduces from east to west apart from the projection to the western part of the District, which has high temperature because of low ground (Figure 2.3).

Rainfall in TM is influenced by the Inter-Tropical Convergence Zone (ITCZ) giving it a bimodal pattern. The breeze from Lake Victoria causes convectional rainfall, which is further, influenced by altitude. Long rains occur between February and June, while short rains occur between November and December. The mean annual rainfall is about 1500 mm. There is a north-south gradient with some 1000-1200 mm of rain falling around the Oloololo escarpment, and some to 1800 mm falling above the hills surrounding Kilgoris town (Figure 2.3). Keyian and the highlands to the west and north of Kilgoris, receive the highest rainfall. Similarly, hailstorms fall in the west and northern highlands of the District.

Figure 2.1 Location of TM District, showing (a) position of Kenya (shaded) in Africa, (b) position of TM (red) in Kenya, and (c) the boundaries of divisions of TM, and its neighbouring districts and the MMNR.

(a) Map of Africa

(b) Map of Kenya



(c) Map of TM District

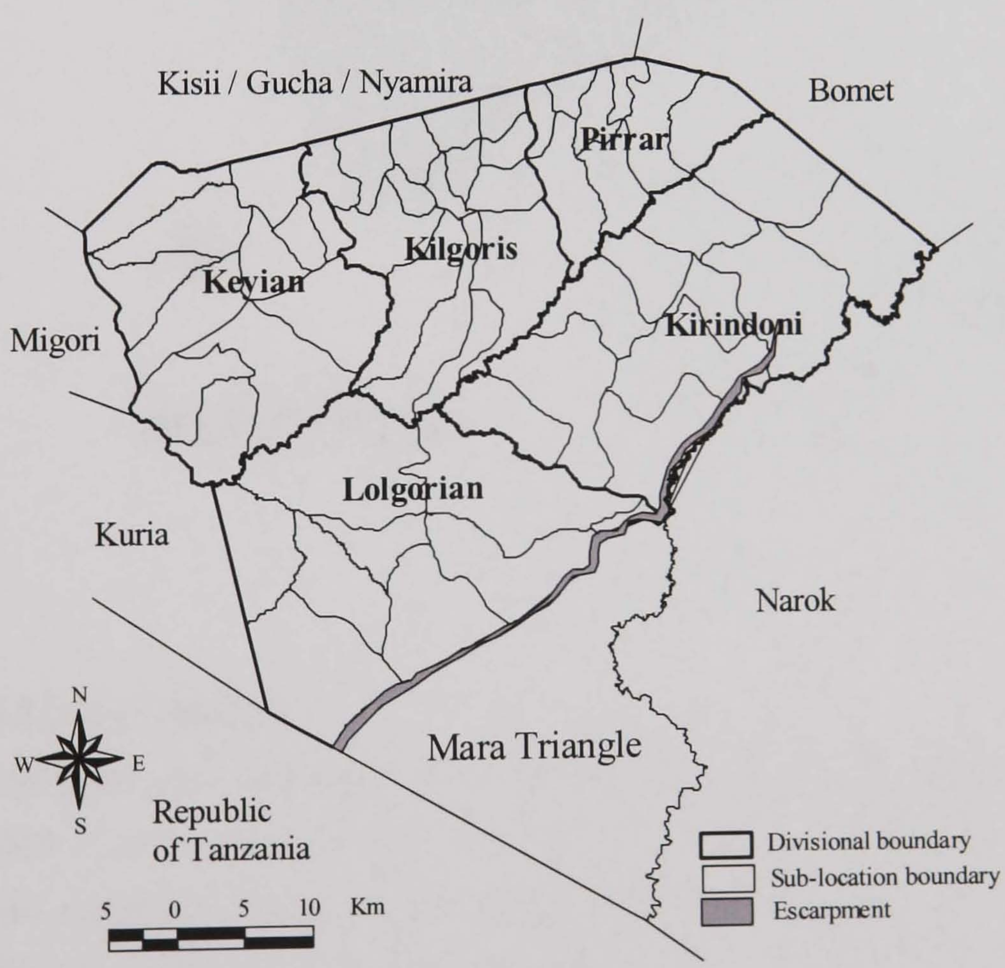
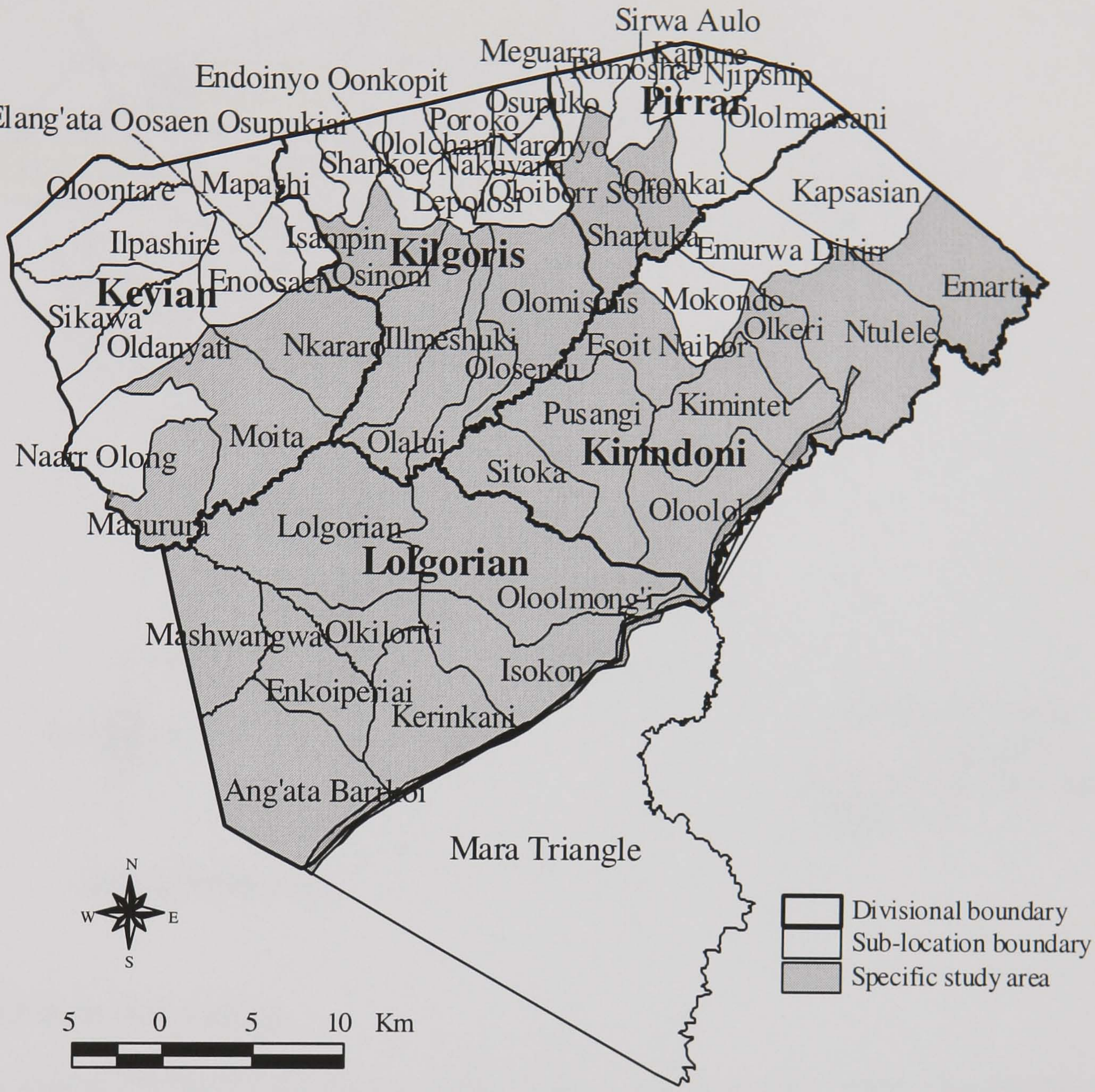


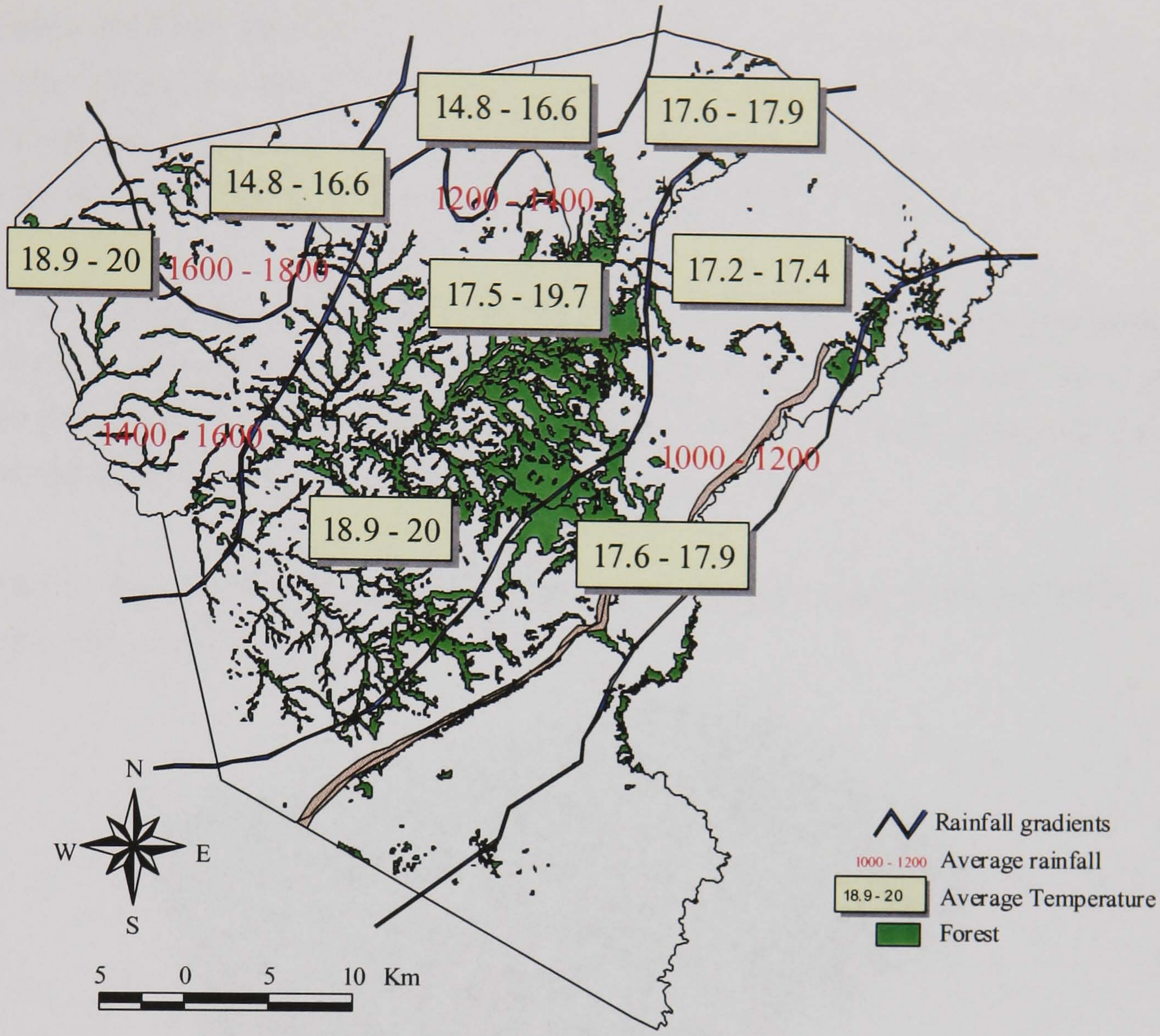
Figure 2.2 Map of TM District showing the specific sub-locations (shaded) in which the study was conducted and MMNR.



2.3.2 Topography

TM District has two major topographical categories: (i) the highlands lying between 2200 and 2500 m above sea level (a.s.l); and, (ii) the plateau which rises between 1500 to 2200 m a.s.l. The highlands consist of the Osupuko, Kapune, Meguarra and Shankoe Hills in Pirrar and Kilgoris divisions, and Keyian and Nkararu Hill in Keyian Division. The plateau covers the eastern part of Kirindoni and south of Lolgorian Divisions. The Oloololo or Siria Escarpment, meaning in Maasai "corner of the earth" (Glover & Trump 1970), falls away sharply down to the Mara River and the MMNR. The escarpment resulted from faults in old metamorphic rocks (Williams 1964). It rises to 1900 m above the level of the Mara River at 1560 m a.s.l. and its formation diverted the Mara River from its ancient and more direct route to Lake Victoria (Williams 1964). The escarpment plays a major role in the distribution of wildlife (Taiti 1973) especially of elephants, due to the existence of natural corridors along and up its length.

Figure 2.3 Map showing the spatial distribution pattern of rainfall (mm) and temperature (°C) in TM District (based on Jaetzold & Schmidt 1986).

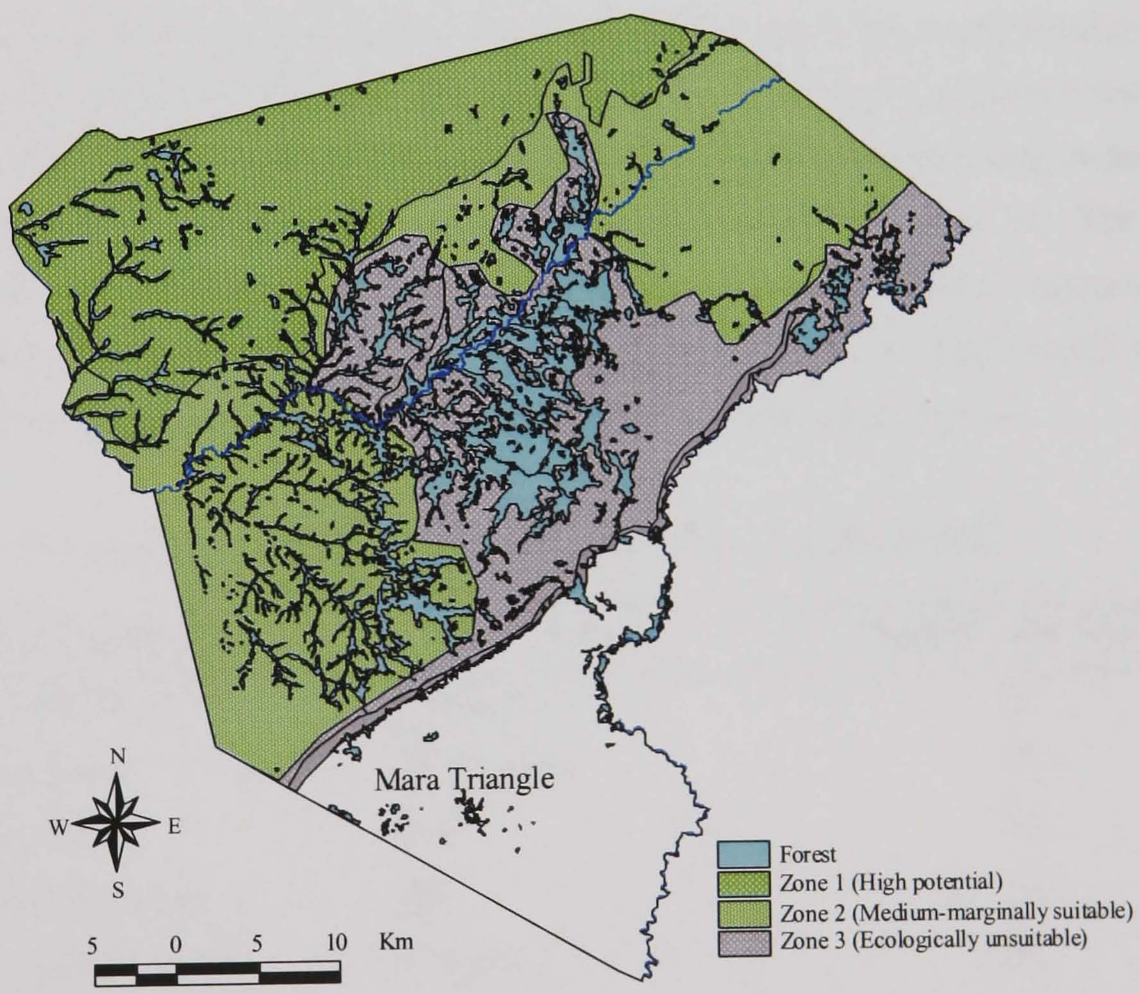


2.3.3 Soils and geology

The soils in TM District are diverse in both texture and structure due to physical deposition with differing levels of suitability for farming (Figure 2.4). Most of the TM District has eroded steep hills and deposits of alluvial soils on the valley bottoms. The remaining eastern part of the district has sandy soils and a significant percentage of clay. According to the Kenya Soils Survey map, 43 different soil types exist in the TM District. However, seven predominant units, based on similar attributes and management implications, were identified and delineated (TDP1994). Lolgorian Division has one soil unit (4), ranging from dark grey to brown soils that are fairly shallow with low nutrient content but good drainage. These soils can support crop farming. Kirindoni Division has three soil units (5, 6, 7), ranging from black to dark reddish brown clay loam, that are deep with moderate nutrient hence suitable for crop farming, and occurring in the area overlooking MMNR. However, grey to brown loams that are deep with moderate nutrients cover almost all of the remainder of the Division. The shallow, poorly drained, sandy clay that is susceptible to erosion and not suitable for crop farming is found in the Emarti sub-location. The remaining three divisions each have 3 soil units (1, 2, 3). Keyian Division is dominated with 2 soil units (1, 2) that are dark reddish and brown soils with clay to sandy clay texture. Therefore, the soils are suitable for agriculture, but are limited by their poor capacity to retain nutrients. The dark, shallow reddish clay loams that are rich in nutrients are found in a section of Kilgoris Division and in Olandare of Keyian Division. Finally, most of Kilgoris and Pirrar divisions have poorly drained, dark grey clay loams, which are fairly deep and less productive. Olalui, Kilae and the central part of Lolgorian Division have soils deficient in P, Mg, Zn, Cu, Fe, B, N and Ca (MOA 1997). The same areas, which lie within the core elephant range, are being turned into cultivation, in turn resulting in conflict.

The MT is based on phenolite rock from tertiary volcanic activity. There exist many flat-topped rocky hills (inselbergs) such as Ol Doinyo Lolamutiek that are of volcanic origin. They support a bushland type of vegetation, due to fire resistance offered by the rocky slopes and the free drainage of the soils (Denise & Popp 1978).

Figure 2.4 Classification of soil suitability for large-scale maize and wheat farming in TM District (based on TDP 1999).



2.3.4 Vegetation and flora

2.3.4.1 On communal lands (CLs)

Vegetation is a product of annual rainfall, soils and topography. Natural forests and bushlands cover about 38% of the land of TM District. However, four main vegetation associations occur outside MMNR (Kiyiapi *et al* 1996). They include:

- small remnant patches of Afro-montane forest on a few isolated hills such as Olenkapune to the west. This association is dominated by *Podocarpus latifolius, Olea africana, O. capensis* and *Apodytes dimidiata;*
- semi-deciduous or semi-evergreen forests in the low lying and central areas like Nyakweri, Olomismis and Mogor. This association is dominated by *Olea capensis, Diospyros abyssinica, O. africana, Warburgia ugandensis* and *Manilkara butugi;*.
- dry deciduous forests occurring in the central and western areas like Ntulele, and Olonkolin. It is the most widespread association found in TM District and dominated by *Elaeodendron buchananii, Manilkara butugi, Warburgia ugandensis, Olea africana, O. capensis, Diospyros abyssinica, Euclea divinorum* and *Trichocladus ellipticus;* and,
- savannah woodland interspersed between all three previous. This woodland is dominated by *Acacia gerrardii, A. abyssinica, A. mellifera, Combretum* spp., *Erythrina abyssinica, Euclea divinorum, Combretum molle* and *Albizia coriara.*

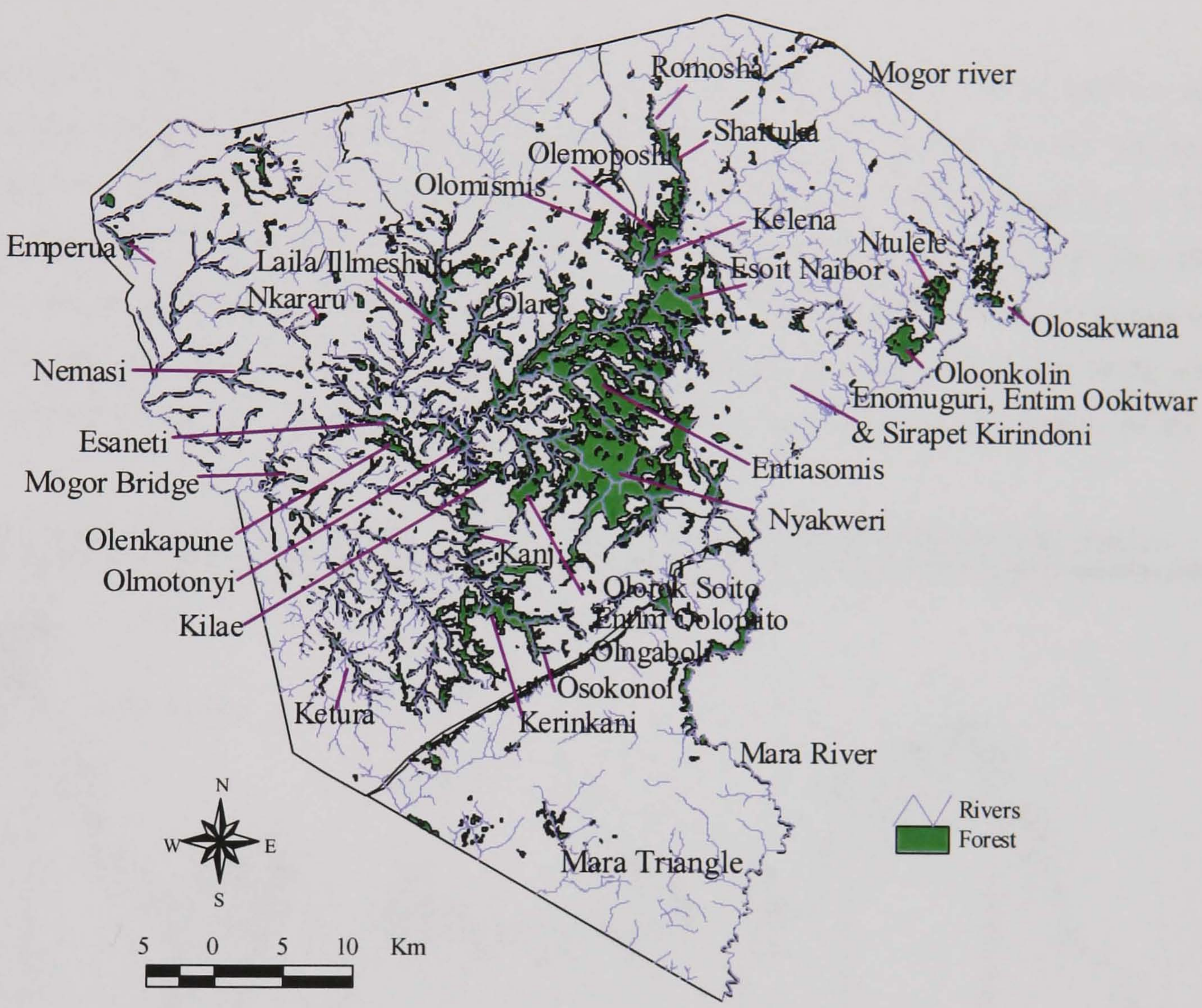
The forests are closed and consist of several trees and a shrub layer, whereas the woodland and savannah woodlands are more open and less structured. The unprotected indigenous forests in the TM District cover an area of over 300 km^2 (DDP 1997). Forest ownership falls under three categories: communal or group ranch; County Council; and, individual (Table 2.1). The forest area under the control of group ranches is largely intact, but is slowly being encroached by charcoal burners (Figure 2.5). The individually owned forests and the County Council forests are threatened with indiscriminate clearing for agricultural land and other purposes.

Table 2.1 The ownership and size of forests in TM District (based on DDP 1997).

Forest ownership	Forest	Approx. size (km^2)
Kimintet Group Ranch	Nyakweri	50
Moyoi Group Ranch	Olenkapune	20
Olalui Group Ranch	Laila	30
Olomismis Group Ranch	Hill	10
Transmara County Council	Emperua	150
Individually owned	-	40
TOTAL		300

The indigenous forest plays an important role in the Maasai socio-cultural and economic life. The forest is an important wildlife dispersal area and a dry season grazing ground for both livestock and wildlife, especially from Narok District. The trees also provide shade for the council meetings of Maasai elders. The other uses include fuel, medicine, timber, shafts for spears and arrows, walking sticks, charcoal and fencing poles. Currently the major threat to the forest is the "slash and burn" operations where forestland is converted to agricultural production. Pit sawing is occurring on a low scale (Kiyiapi, *et al* 1996). The Government is advocating the establishment of small-scale milling and wood carving industries to sustainably exploit the forest resources.

Figure 2.5 Drainage patterns and spatial distribution of forest fragments in TM District (based on Kiyiapi *et al* 1996).

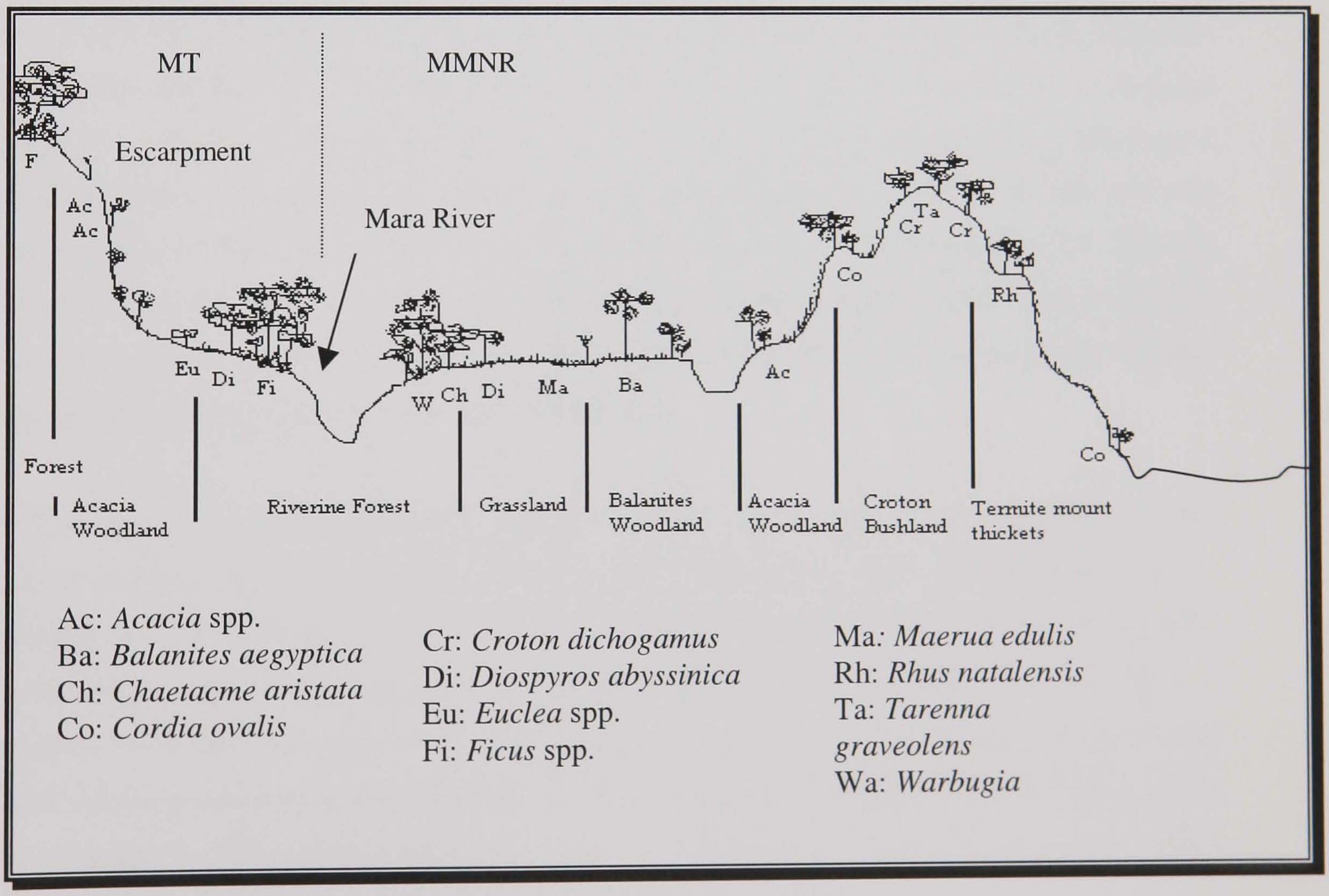


2.3.4.2 Mara Triangle of Masai Mara National Reserve

The name 'Mara' derives from a Maasai word meaning patchy distribution of vegetation (Denise & Popp 1978). The Mara has a vast mosaic of different plant communities. Irregular patches of bush growing along drainage lines break great open expanses of grassland. The ridge tops and hillsides are covered by dense bushland, while lush green forest lines the Mara River and its major tributaries. The boundaries between plant communities are gradual or abrupt and an ecotone is formed in some cases. Taiti (1973) recorded 69 grass species in the Mara that are derived in nature and seven species of *Acacia*. These include: *A. drepanalobium; A. brevispica; A. gerradii; A. hockii; A. senegal; A. seyal* var *fistula*; and, *A. xanthophloea*. The young leaves and pods are rich in proteins and highly preferred by elephants. *Rhus natalensis* and the sand paper tree, *Cordia ovalis*, are common on the termite mounds and favoured by elephants. The *Acacia* woodlands along the escarpment harbour many tsetse flies (*Glossina swynnertoni*). The desert date, *Balanites aegyptiaca,* woodland is evenly and widely spaced, with single trees whose crowns are composed of tangled mass of thorny branches, interspersed with Themeda grass, which covers the entire plain of the Mara Triangle (MT). *Balanites* occur on heavy, dark, cracking clay soils (Herlocker 1974). Elephants prefer the sweet pulp and dry fruits of *Balanites* (Melland 1938). *Balanites* have long roots that assist in exploiting water at very deep level and therefore enable them to withstand being pushed over by elephants. However, the browse line has now been shaped beyond the reach of further browsing by elephants.

Riverine forests occur along Mara River and its tributaries, and in isolated pockets along streams (Figure 2.6). The forest is dominated by *Warbugia ugandensis* and *Diospyros abysinica,* whose fruits are preferred by elephants. *Diospyros* is highly priced for its black heartwood. Forest size has declined because of fires (Glover & Trump 1970, Herlocker 1974) and elephants (Darling 1960). Today forests occur only on sites provided with protection from grass fires and with a good supply of ground water. Also, seven species of fig tree of the genus *Ficus* have been reported and generally the forest is rich in flora and fauna (Herlocker 1974).

Figure 2.6 A generalised profile of habitat types in the MT showing different plant species.



2.3.5 Drainage

TM District is well drained, and its highland areas are the source of permanent and seasonal rivers. The Mara and Mogor rivers are the major rivers (Figure 2.5), and their main tributaries include Enkare onkituak, Shartuka, Operai, Keshuro and Sitet. The Mogor River bisects the area from north-east to south-west. The Mara River flows on the eastern side. The major rivers have the potential for hydroelectric power and irrigation. Most of these streams dry up during severe drought. The surrounding grassland areas in the MT are flooded during seasons of heavy rains due to impeded drainage of the black cotton clay soils. The riverine forests of the two major rivers form an important permanent habitat for the elephant population both on communal lands (CLs) and protected areas (PAs).

TM District has the potential for sub-surface water that is not fully exploited. Only four areas have been drilled, namely Kilgoris Catholic Mission, KWS station at Lolgorian, Kichwa Tembo Safari Camp and Oloololo Gate of MMNR. The moderate, and almost year round rainfall in the district could provide adequate water sources for domestic, livestock and wildlife use, with construction of pans and dams. TM District has three dams located at Mutengwarr, Kawai and Masurura, where elephants seek access mainly at night.

2.3.6 Wildlife and tourism resources

2.3.6.1 Wildlife resources

MMNR is the northern-most extension of the 25,000 km^2 Serengeti-Mara ecosystem. The exact area and evolution of MMNR as a protected area is rather unclear in the available literature. Originally, MMNR was established as a wildlife sanctuary but it was declared a National Reserve in 1950 covering an area of 647 km^2. In 1974, over 1,700 km^2 was gazetted as a National Reserve but the recent boundary modifications reduced it to 1,510 km^2. The MT was carved off into TM District in 1994. The Mara River separates it from Narok District. The MT covers about 18% of the Trustland in Lolgorian Division. Transmara County Council (TMCC) now manages this portion of the MMNR. The MMNR generates a lot of revenue from wildlife-based tourism to the TMCC and the local community.

TM District has a great diversity of wildlife and bird species and it is also an important dry season grazing area for migratory wildlife, which moves up from the MMNR and over the escarpment during the dry season. It also has resident population of elephant, buffalo, giraffe, zebra, rhino, wildebeest, eland, topi and impala. There are several corridors that are critical to wildlife movements (Kiyiapi *et al* 1996) through which wildlife spreads out onto communal land. Most corridors have been blocked, while the remaining central corridor that links group ranches and the MT is also threatened by human settlement and farming. However, the highest concentration of wildlife occurs on the top part of Siria Escarpment.

Wildlife in TM District is declining as a result of increasing pressure from livestock, agriculture and poaching activities (Sommerlatte 1997). The reduction of rangelands results in increased competition between livestock, wildlife and humans for the remaining resources such as water, grazing, and mineral salts, among others. As a result, according to Macalla (pers. comm.), many areas in the TM District have been poached clean of buffalo, topi and giraffe. Sommerlatte (1997) reported 3,680 head of wildlife in TM District based on a 1997 rainy season aerial survey, with a density of 2.6 animals/km^2 and a biomass of 330.3kg/km^2 (Table 2.2). Little or no wildlife is found in the north or north-east of TM District, due to the great extent of cultivation and human settlement. Wildlife also decreases towards the south-west where small scale farmers exist. However, no elephants were recorded during the survey but are known to inhabit parts of the main forest block, especially riverine forests bordering the Mogor River. During this study, other wildlife species were seen which are not included in Sommerlatte's surveys. These include: eland (*Tragelaphus taurotragus*); lion (*Panthera leo*); and, leopard (*Panthera pardus*).

Table 2.2. Wildlife population estimates and density in TM District during 1997 (from Sommerlatte 1997).

Animal species	Population estimate	Population density (km^2)
Buffalo (*Syncerus caffer*)	31	0.02
Giraffe (*Giraffa camelopardalis*)	61	0.04
Hippo (*Hippopotomus amphibius*)	46	0.03
Impala (*Aepyceros melampus*)	2,300	1.65
Thomson gazelle (*Gazella thomsonii*)	61	0.04
Topi (*Damaliscus lunatus*)	284	0.20
Wildebeest (*Connochaetes taurinus*)	54	0.04
Zebra (*Equus burchelli bochemi*)	843	0.60
Total	3,680	2.60

2.3.6.2 Tourism activities

The MT, covering about 480 km^2 of the MMNR, has a diversity of wildlife species that attracts tourists. The Oloololo or Siria Escarpment also provides a magnificent viewpoint that is ideal for filming. For instance, it is the area where the famous film "Out of Africa" was shot. Tourists also come to view the traditional Maasai houses or *manyattas* and learn about their culture and traditions. This has made the Mara ecosystem an important tourist destination, and tourist numbers have been rising over the years (Sindiga 1984, Sitati 1997), but fell again during the 1992 and 1997 political unrests.

TM District has six tourist hotels that are of international standards. The Little Governors and Mara Serena Lodge fall within the MT while Kichwa Tembo, Olonana, Mpata Club and Olkuruk are located on the group ranches (Figure 2.7). The lodges and the MMNR provide employment to both the local community and to other tribes in different sectors such as catering, administrative, tour operations, and game rangers, among others. The local community also generates income from the sale of food products to lodges and of Maasai cultural items such as embroidery and woodcarvings to tourists. Therefore, the tourism industry is an important base for economic growth in the TM District, which improves the living standards of the community. However, the TM community has not established a wildlife association unlike the Maasai community on the Narok side.

Figure 2.7 Tourist Lodge located within MMNR next to River Mara.

2.4 Socio-economic profile

2.4.1 Demographic characteristics

According to the 1989 census, the TM District population was 136,204 with 4.1% growth rate per annum and population density of 47/km^2 (DDP 1997). The high population growth rate is attributed to improved health care services, increased child immunisation, high immigration and cultural beliefs and values. The population was projected to rise to 231,459 in 1997, to 264,270 in 1999, and to 294,319 in 2000. Nevertheless, there was an over-projection of the population by 135,595 based on the 1999 census (Figure 2.8). The under-projection could have been due to inter-tribal fighting. Nevertheless, the human population in TM District is very unevenly distributed, based on the population density per division (Figure 2.9). The youth forms the largest percentage of the population. Consequently, the future impact on resources will become heavier when youths reach their reproductive age.

The Maasai are the largest pastoral ethnic group in East Africa and occupy the whole of the eastern and northern frontier of Serengeti National Park and MMNR. Their institutionalised age-set structure is important for recruiting the youth and the whole community for development and conservation purposes (Parkipuny 1996). The elephant population has been displaced in areas occupied by non-Maasai.

'It is not a mere accident of history that many of the most spectacular wildlife protection areas in East Africa are found in territories previously part of Maasailand' (Parkipuny 1996).

Figure 2.8 Changes in the human population in TM District, from 1948 to 1999.

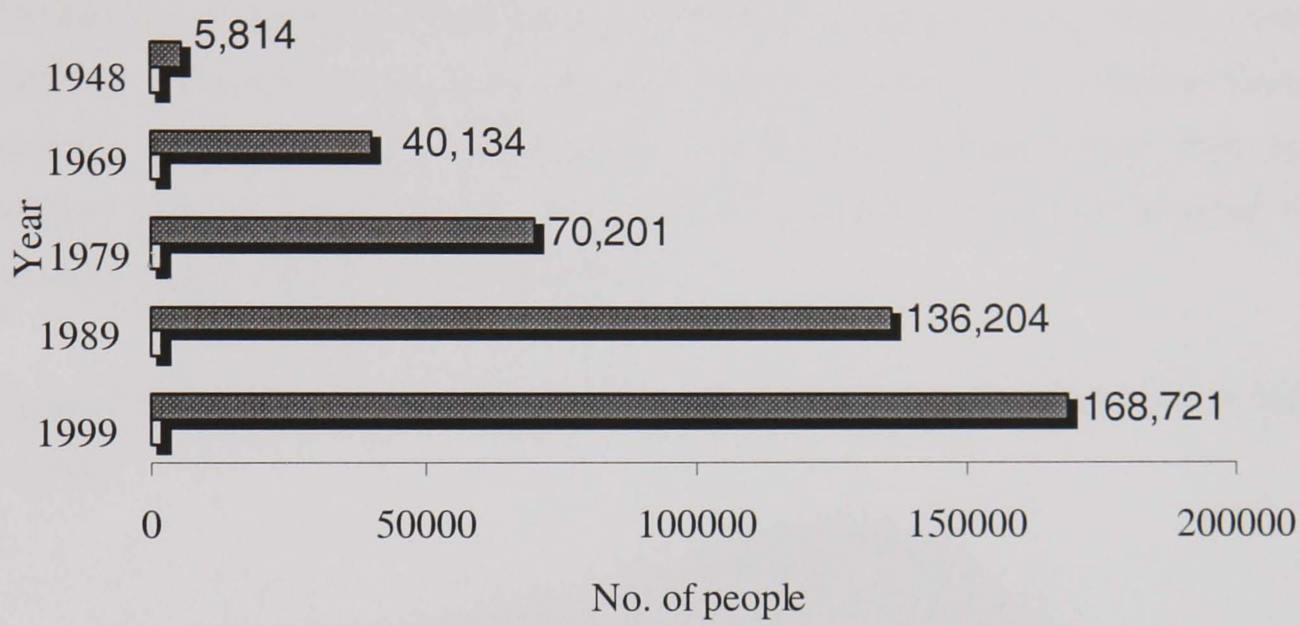
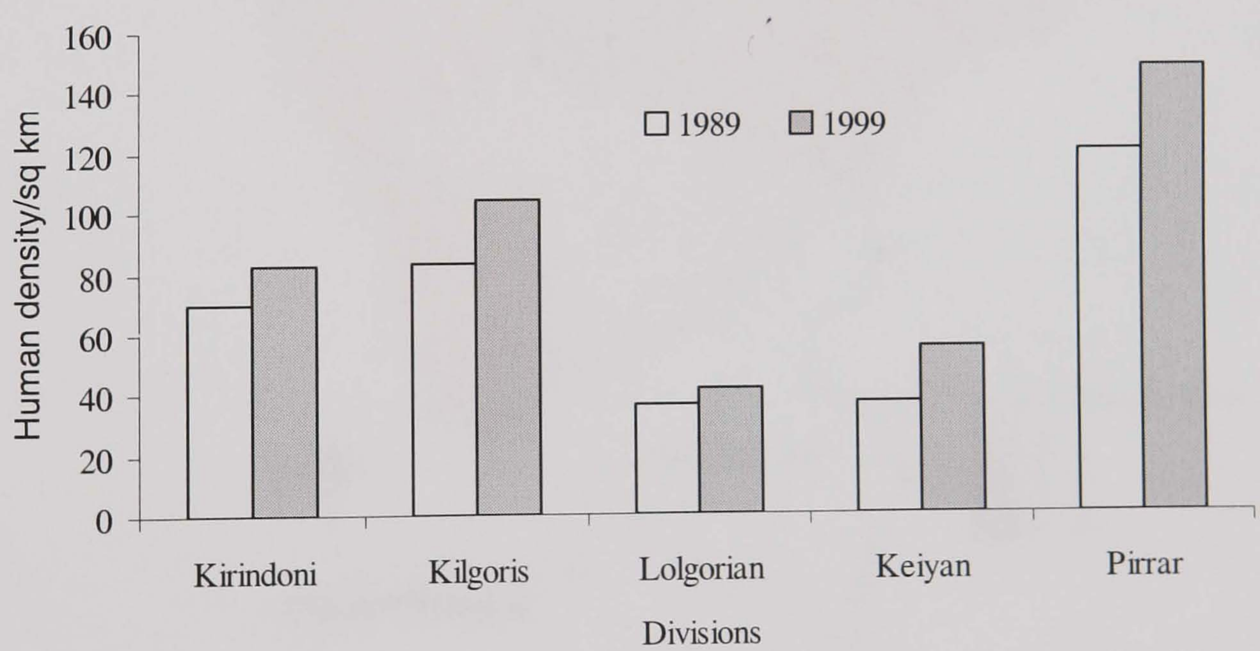


Figure 2.9 Changes in population density across divisions in TM District in 1989 and 1999.



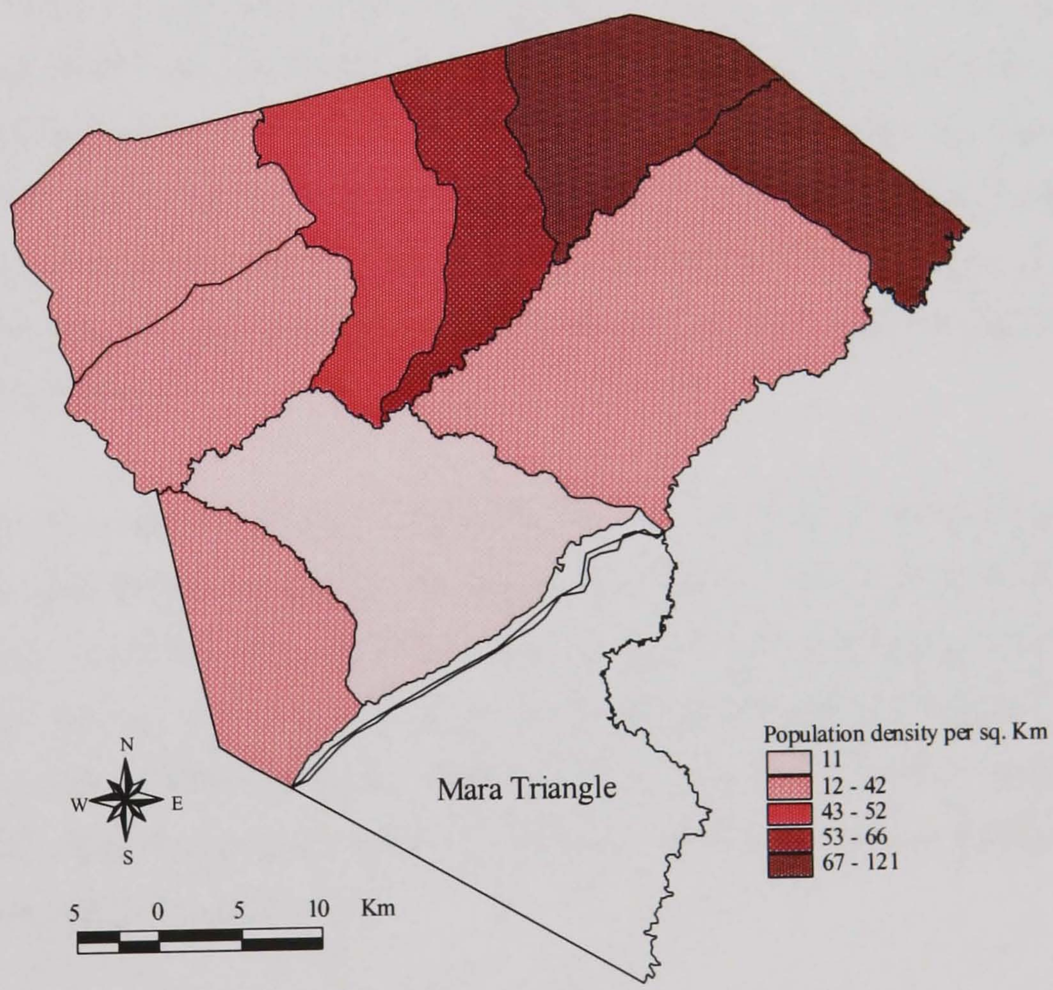
2.4.2 Human distribution

The TM District has dense settlement to the north and less dense settlements to the west and south (Figure 2.10). This is due to the heavy influx of the non-Maasai people from adjacent densely populated districts. Distribution and settlement patterns have an effect on elephant conservation, that is discussed in detail in Chapter 5. Nevertheless, below I briefly discuss the three Maasai clans of Siria, Moitanik and Uasin Gishu, as well as the other ethnic groups in TM District. Distribution by other ethnic groups is presented in Chapter 5.

2.4.2.1 Siria

The Siria were the first Maasai clan to have settled in TM District and claim to be the official owners of TM. The Siria clan had been forced out of TM during the war with Loita Masai clan and took refuge in Luo Nyanza, but settled back in 1910. The Siria have been moved slowly from the high potential agricultural zone to the present low potential rangeland. The Siria are the only Maasai clan not to have been heavily influenced by other tribes, and are still rooted in their traditions. Livestock keeping is still the main economic activity and pockets of farming have started to supplement their dietary changes. The Dorobo, a sub-clan of the Siria, have since changed from hunter-gatherers to pastoralists through gradual stocking of livestock. The Siria presently occupy about 44% of TM District.

Figure 2.10 The density pattern showing human distribution based on locations in TM District in 1989.



2.4.2.2 Moitanik

The Moitaniks first started moving into TM District in the 1940s from the western part of Kenya. The Moitaniks who intermarried with the Luhyia tribe, settled in the northern part of TM District. The second and third groups of Moitaniks settled in 1950 and 1953, respectively, all with cattle. The last generation is still migrating, but without cattle, mainly to acquire land. Most of their land has been put under cultivation because of the influence of the farming Luhyia tribe. The clan is the most literate and has abandoned most of its Maasai culture. Their settlement, together with the Uasin Gishu, has had an insignificant impact on pastoralist habits of the Siria because of their low population (Pander 1995). The Moitanik presently occupy only about 13% of TM District.

2.4.2.3 Uasin Gishu

The Uasin Gishu clan first migrated to TM in 1954 and settled in the northern part of TM District. They arrived from the present Uasin Gishu District, and highly intermarried with the agro-pastoral Nandi community. Most of their land is being put under farming because of intermarriage and they have discarded most of their Maasai culture and traditions. The Uasin Gishu have since then expanded their area and presently occupy about 16% of TM District.

2.4.2.4 Other tribes

There are five non-Maasai tribes in TM who have either acquired land and settled, or are venturing into business in urban areas and market centres. The Kipsigis form the majority and have migrated from the adjacent Bomet and Kericho districts to settle in the northern and southern portions of TM District. The Kurias from Kuria District have settled in the south. The Kisiis from Kisii District have settled in the west. Due to their high density, the Kisiis have put most of their land under crop farming. Many have moved into deeper parts of Maasailand in order to hire land for farming, charcoal burning and pit sawing. The Kikuyus and Luos have settled in urban areas, to engage in business and small-scale farming. The non-Maasais occupy about 27% of TM District.

A distinct transition zone has emerged between the Maasai community and the Kisii and Kuria tribes. This zone has remained unsettled for many years, but now acts as a battleground between these tribes, given constant cattle raids by the Maasai to restock, following major livestock loss through drought, disease or raids, and given the ideological notion of original ownership bestowed by the divinity onto the Maasai (Hollins 1905). However, the zone is getting smaller and smaller with increasing pressure of land. The Kisiis lease some of this portion and other parts for growing maize (Figure 2.11).

2.4.3 Agriculture

TM District heavily relies on agriculture and livestock keeping as its main economic activity. This is due to the moderate climatic conditions and moderately fertile soils. These conditions support the production of cash and food crops, as well as fodder for livestock. Both the highlands and the plateau permit crop farming and livestock activity (Figure 2.12). The district has considerable potential for agricultural activity based on its agro-ecological zones (Jaetzold & Schemdt 1986). The upper midland (coffee-maize zone) covers 54% of TM District followed by upper midland (semi-arid) with 15%, upper midland (transitional) with 10%, and the remaining zones cover less than 10% of TM District. The national food production strategy emphasises crop farming because foreign exchange earnings accrue largely from crop exports.

Also, the national perception of rural development is formed and defined under the dominant influence of crop farming, while livestock production and pastoralism remain neglected (Parkipuny 1996).

Figure 2.11 Farming on (a) the borderline between the Maasai and Kisii tribes which appears like "no-mans-land" and on (b) the Mogor Riverine forest. Notice the dense population on Kisii side and the lack of settlement on Maasai land.

(a) (b)

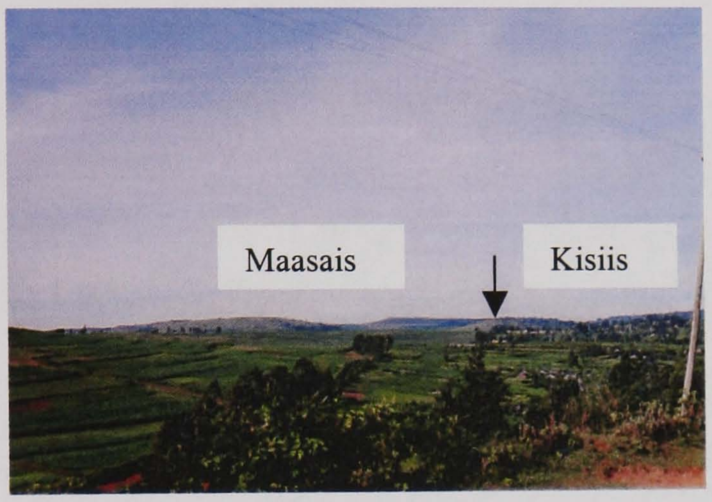
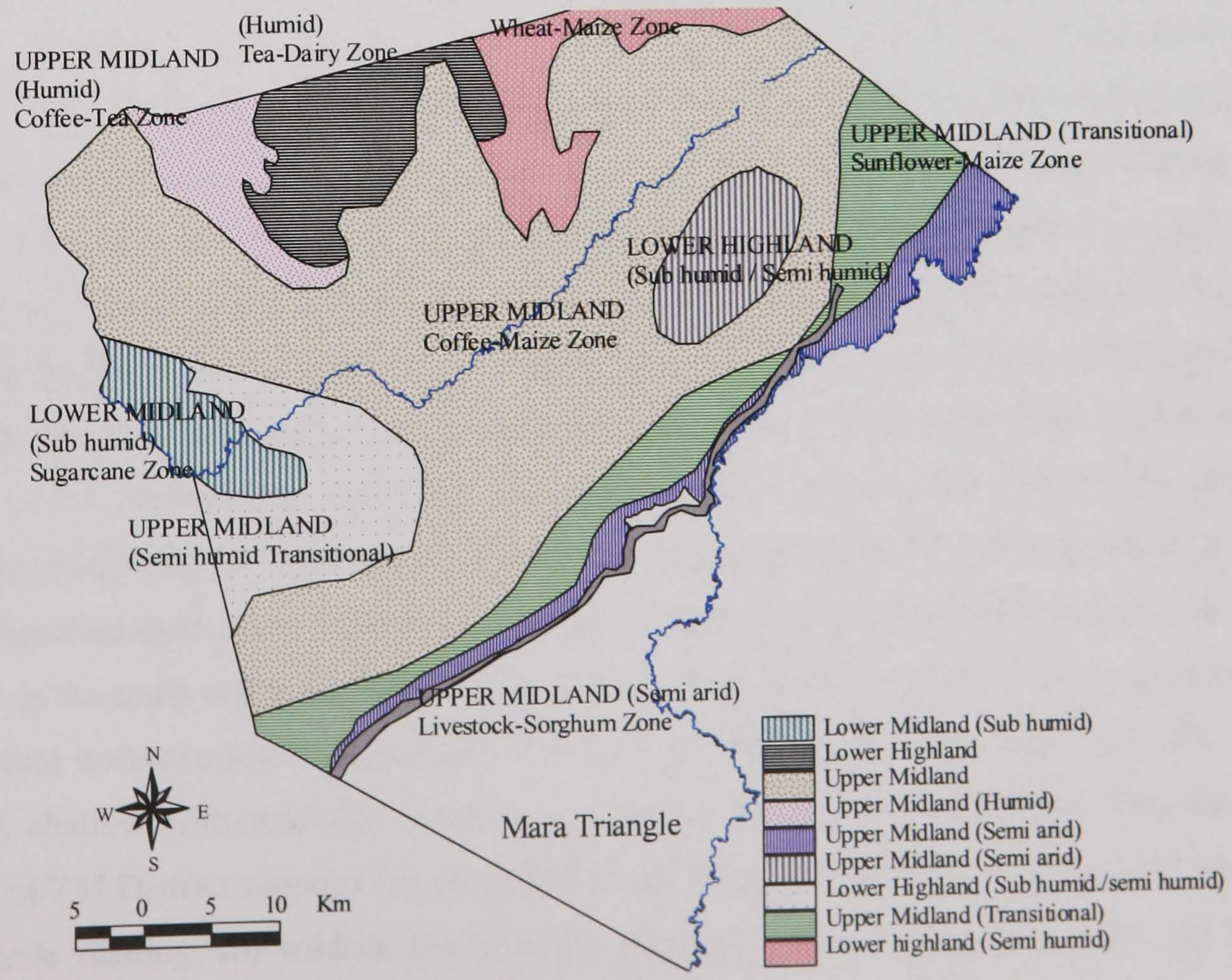


Figure 2.12 The broad categorisation of the agro-ecological zones of TM District (based on Jaetzold & Schmidt 1986).



2.4.3.1 Crop farming

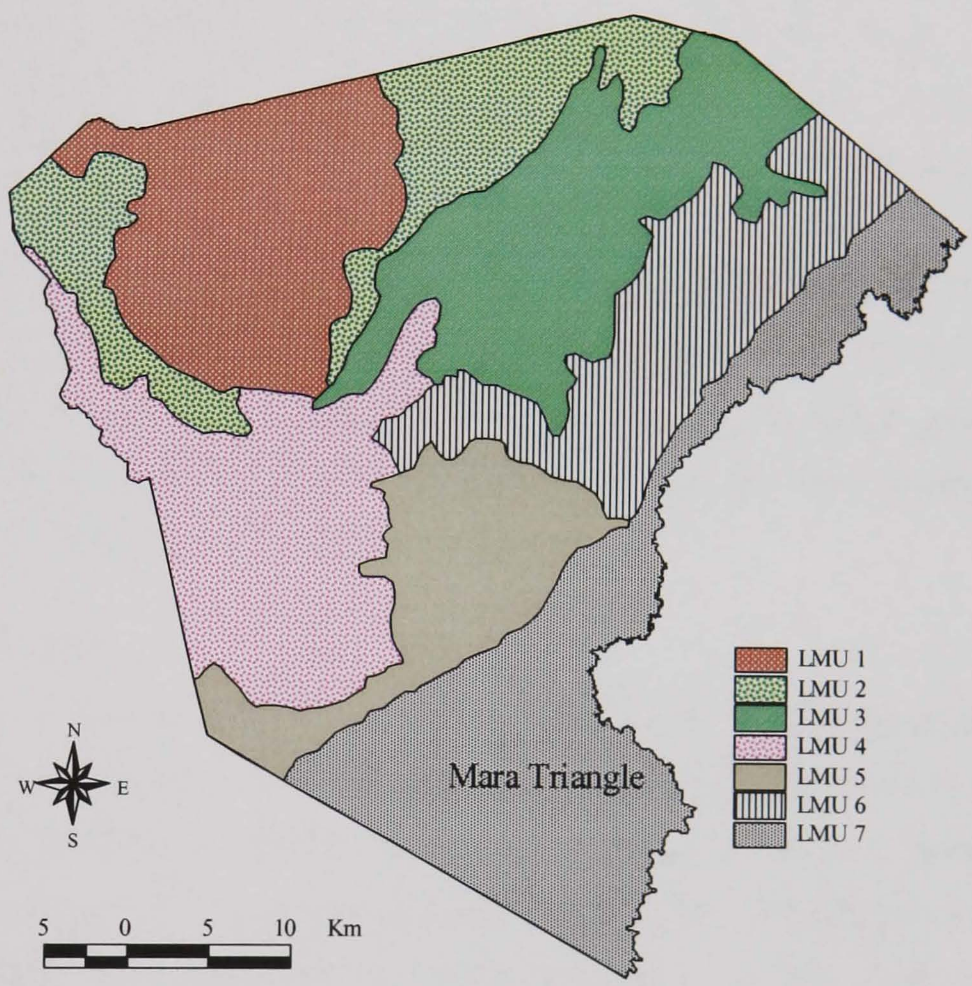
TM grows quite a variety of both cash and food crops, mainly on the highlands. The main crops grown, starting with the most dominant, include: maize; sugarcane; beans; Irish potatoes; cabbage; finger millet; kale; onions; sorghum; sweet potatoes; tea; pyrethrum; tobacco; and, banana. Destruction by wildlife, the high costs of inputs, and the patterns of communal land ownership are the main constraints to farming in the area. The high rainfall patterns (Figure 2.3) and fairly fertile soils (Figure 2.4) have attracted many farmers from outside the District, as the Maasais themselves also try to engage into farming.

According to DDP (1997), the land under agriculture has increased due to favourable prices and an increased influx of agricultural communities. Because maize is the staple food for most of the population in TM District, the hectarage of maize has increased from 49,600 tonnes in 1991 to 91,100 tonnes in 1995. Other crops showed a similar increase and more land is definitely being put into cultivation because of the immediate benefits. Increased benefits from crops have encouraged the experimental introduction in TM District of new crops like tea by the Kenya Agricultural Research Institute (KARI). Such attempts are a pointer to the need to harmonise development with conservation.

Critical analyses of the suitability of TM District for farming has resulted in the delineation of seven land management units (LMUs), based on a combination of climate, soil characteristics, and vegetation types (Figure 2.13). Therefore, LMUs form an ecological and agronomic basis for interpretation of site potential a basis for management (Thurrow 1996). LMU 1 falls in high rainfall (1600-1800 mm), has deep friable and very productive soils, but which have lower nutrients because of leaching. LMU 2 has slightly less rain (1400 mm) and shallow soils, but with higher nutrients, and low crop production because of the hilly terrain and shallow soils. LMU 3 has substantial rainfall (1200 mm) and fairly deep soils, but with moderate nutrients. It is forested and not good for farming because of the hilly terrain, poorly trained valleys and tsetse fly infestation. LMU 4 has severe limitations for cultivation despite its well drained soils, which are shallow with moisture stress and substantial rainfall (1200 mm). LMU 5 receives high rainfall (1400 mm) and has deep clay soils with moderate nutrients and has the high potential for crop production. LMU 6 has low rainfall (900 mm) and deep soils with moderate nutrients and is therefore moderately suitable for farming. A high percentage of fallow farms exist due to wildlife in the south and tsetse flies near the forest. The rangeland condition is good, despite the low natural watercourses. Finally, LMU 7 is the driest (800 mm) with sandy clay soils, poorly drained, shallow with moderate nutrients, and hence unsuitable for farming. The south-east portion of TM District supports the rangeland condition that is limited because of: (a) insecurity from cattle rustling; (b) wildlife that transmit diseases and cause predation; and, (c) lack of water (Thurrow 1996). This information was instrumental in developing a land use plan for TM District (Chapter 11).

Lolgorian Division has the highest farm area per km^2 and grows mostly maize, beans, vegetables and tobacco. Kirindoni Division has the second highest, growing mostly maize, beans and millet. The majority of the households in Kirindoni are engaged in both food (86%) and cash (80%) crops (DDP 1997). However, farming is most common in the north, east and west where Kisii, Kipsigis and Luo tribes are settled.

Figure 2.13 The classification of TM District into Land Management Units (LMUs) based on analyses of rainfall, soils and vegetation (based on Thurrow 1996).



The recommended varieties of maize in TM District are H614 and H625 for the long rainy season, and H511, H512 and 514 for the short rains seasons. The average maize production per division varies depending on soil fertility, rainfall amount and wildlife destruction. Keyian and Kilgoris divisions produce an average of 37–50 bags per ha during the long rains and 15–20 bags per ha during short rains. Lolgorian, Pirrar and Kirindoni divisions produce between 30–37 and 12–15 bags per ha during long and short rains, respectively (MOA 1999).

2.4.3.2 Livestock

Livestock keeping is prevalent on the plateau on TM District. The local Maasai community are pastoralists and attach a high value to livestock keeping. Goats, sheep and local zebu cattle are the dominant livestock. The local German Technical Co-operation (GTZ) introduced some exotic dairy breeds to maximise milk production, especially on private or individual land. Dairy farming is common in areas bordering Kisii and Bomet districts, especially Pirrar, Kilgoris and

Keyian divisions. TM District has been famous as a dry season grazing ground for both livestock and wildlife from other districts, especially Narok. Therefore, increased farming activities in the area threaten the future viability of both livestock and wildlife in the area. The limiting factors to livestock keeping include the presence of trypanosomiasis, group ranches and resource use, which conflict with human activities and wildlife. According to KWS Occurrence Books (OBs) records, livestock predation is very high in TM District and no study has ever been done to that effect.

Kirindoni Division has the highest number of livestock in the district followed by Keyian, Pirrar, Lolgorian and Kilgoris divisions, respectively. Kirindoni and Pirrar have the highest livestock densities and Lolgorian and Kilgoris divisions the least. The land carrying capacity of Kirindoni Division is high with 123 cattle/km^2, while Lolgorian Division only has a carrying capacity of 58 cattle/km^2. Livestock products include milk, hides, skins, beef, poultry, mutton and honey. Sommerlatte (1997) estimated the total livestock population of TM District was 69,199, at a density of 49.5 animals/km^2 and with a biomass of 11,591kg/km^2. The high livestock density contributes to overgrazing and encroachment. Rotational grazing, which has been the backbone of the Maasai range management practice, has been disrupted, pasture has been depleted, and livestock have been displaced.

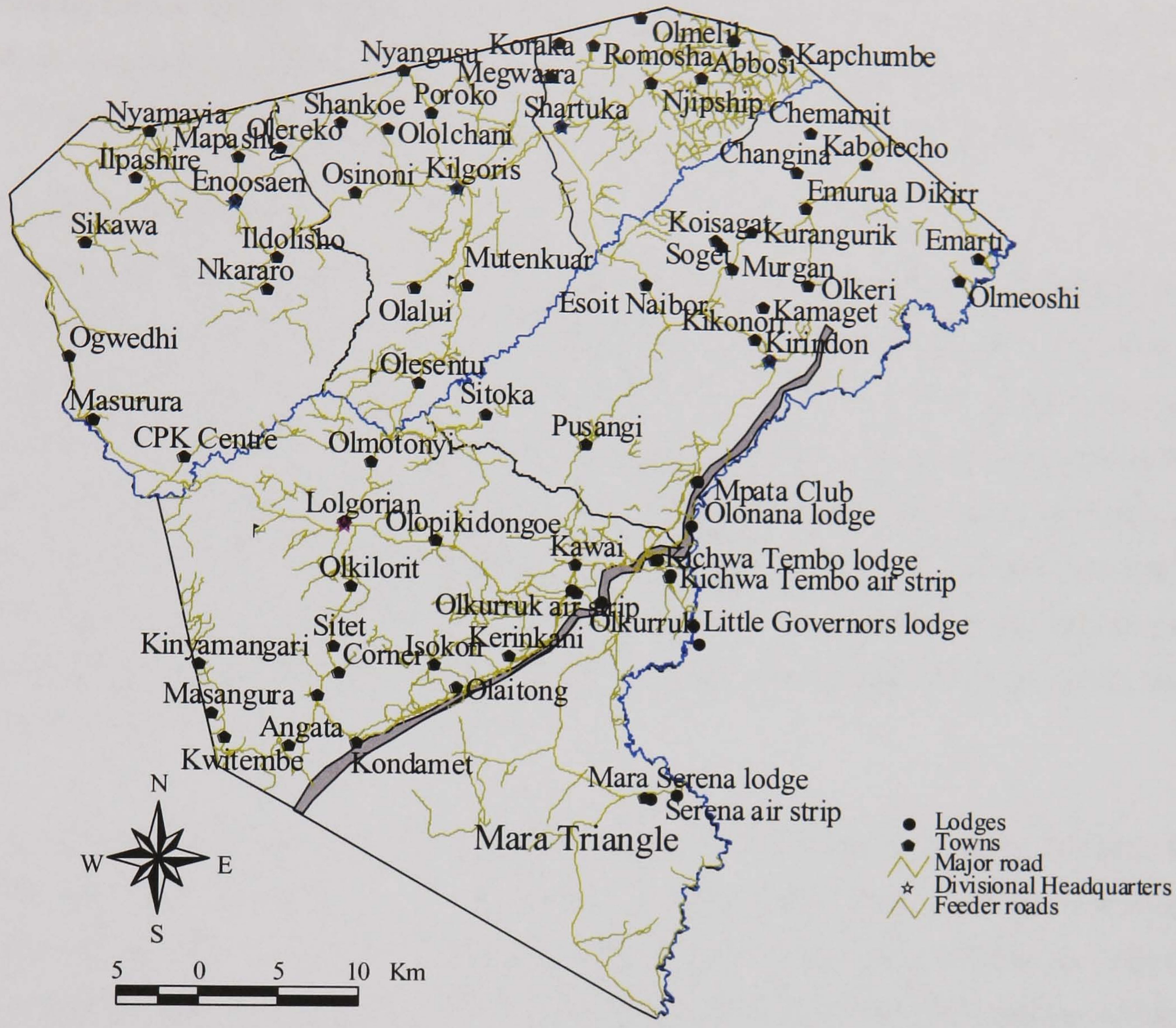
2.4.4 Urban centres

Many unplanned market centres have evolved in TM District and expanding into the elephant range (Figure 2.14). Kilgoris town is the headquarters of TM District and is a major business centre. Lolgorian and Enosaen are the other urban centres in the district. Shartuka, Kirindoni and Njipship are market centres developing into urban centre, while Emarti and Murgan are agricultural markets. The development of urban and market centres attract immigrants for business and encourages deforestation because of increased use of forest products.

2.4.5 Land tenure

Land ownership in TM District falls under two categories: communal land or group ranches; and, individual or private land. Group ranches cover about 82% of the entire district, are mainly found in Lolgorian, Kirindoni, Pirrar and Keyian divisions. The remaining 18% of land is held by private individuals. Most of the privately owned land is found along the Transmara-Kisii and Transmara-Bomet borders. In Kilgoris Division, it is common in Osupuko, Shankoe, Poroko, Ololchani, and Oloiborsoito areas. In Kirindoni Division, ownership is common in Emarti and Murgan areas, and in Megwarra and Ololmasani in Pirrar Division. The average land holding is between 8 and 12 hectares. The group ranch members are now clamouring for sub-division of land into individual holdings. This is because of the increasing human population, the need to raise capital and the fear of marginalisation by stronger groups (Kituyi 1990).

Figure 2.14 The establishment of towns, market centres and infrastructural facilities in TM District (based on DDP 1997).



2.4.6 Infrastructure

TM District has connections of primary, secondary and minor roads (Figure 2.14). Most sections of these roads are impassable during the wet season. Kirindoni Division has the shortest network (42.6 km) and poorest roads in TM District. Lolgorian Division has the longest network of 153 km. The only tarmac road covers a distance of 10 km and connects Kisii District to Kilgoris. TM District has three functional airstrips at Kichwa Tembo, Olkuruk and Mara Serena that bring in tourists. The airstrips at Megwarra, Lolgorian and Murumbi are not functional. The poor state of infrastructure has serious implications for the tourism industry in the area, and for problem animal control by the Kenya Wildlife Service (KWS). The expansion of infructural facilities has contributed to deforestation through charcoal burning for export to the neighbouring districts.

2.4.7 Mining

Small deposits of quarry stones and gold occur in TM District, especially in Osupuko Hills and Olalui in Kilgoris Division. Gold is mined in Lolgorian area by both the small-scale Mlima Mining Group and the large scale Sebimu Exploration and Mining Company Ltd. However, these ores occur in small quantities that are uneconomical for commercial exploitation. Murrum is found all over the TM District in large quantities, though it is of low economic value.

2.5 General methods

Details of specific methods are described in each chapter but herewith follow a brief description of methods used throughout the study. Multidisciplinary techniques of data collection were employed, since little information has been collected previously in TM District on human-elephant conflict (HEC) issues. Both primary data and secondary data sources were used for the study. Data collected included those concerning indigenous knowledge, socio-economic status and attitudes and perceptions, human demography, land use changes, elephant numbers and distribution, and types of conflict and conflict mitigation. The study provides information for comparison with other studies undertaken in different agro-ecological regions of Africa, such as Kasiki (1998).

A participatory approach using Rapid Rural Appraisal (RRA) was followed (Chambers 1992) with the local community to relate indigenous knowledge system (IKS) with elephant conservation. There was need to determine whether elephants are of any value to the community and identify and rank types of conflict and mitigation strategies. The historical background of the elephant in TM, their important areas, and possible explanation(s) of the causes of increasing conflict were also sought. This base line information was also important in redesigning the study approach and for comparison with the questionnaire survey that was carried out alongside it.

Data for the socio-economic survey were derived from questionnaires and interviews mainly in the elephant ranges, attitudes and perception towards elephant conservation, status of conflict and conflict resolution. People of 20 years and above were interviewed, and a total of 251 questionnaires were administered.

Ecological parameters were monitored monthly to determine changes in the ecological system that could act as explanatory variables of factors determining the patterns of crop raiding. These include rainfall records and grass height and weight in established plots. Land uses and cover types data were derived from secondary literature, field mapping and use of remote sensing techniques.

Data on previous elephant numbers and past ranges were obtained from survey records and through a participatory approach. Field surveys were undertaken to determine their present numbers and distribution. Data on past and present elephant numbers and distribution were obtained from KWS/WWF and DRSRS aerial surveys, and from other studies. Two elephant censuses were carried out using indirect method of dung counts and transects before and during crop raiding seasons.

Past HEC reports were obtained from Kenya Wildlife Service (KWS) Occurrence Books (OBs) and Report Books (RBs). All the six stations and out-posts were visited to obtain all reported cases on elephants. Because of the inability of some local community members to report to KWS, conflict cases also had to be monitored and recorded in the field. The notes taken included location, time, number of elephants, sex, crops damaged, area damaged, protection measures, stage of maize, tribe and many other attributes. Information on human deaths included area, sex, time, and state of the person and compensation. Schools both within and outside elephant ranges were visited and the records of school performance, student performance and student interruptions were obtained.

All the spatial data was entered into a GIS-Atlas program for spatial analyses and production of maps. Because of the limitation of the GIS-Atlas program in analysis and exporting to MS Word, the maps were converted to Arcview-GIS program version 3.1. A translator was downloaded from ESRI's web page to convert the Atlas agf files into shape files for Arcview to read. Map common features like rivers, district boundary, divisional boundary, escarpment and MMNR are not shown in the legend in latter maps. However, MMNR is represented as Mara Triangle. Statistical analyses were performed using SPSS statistical package version 9.0, DISTANCE program 3.0 and Excel 97 spreadsheet at the Durrell Institute of Conservation and Ecology (DICE), University of Kent. Data normality was evaluated through tests of skewness and kurtosis (Snedecor & Cochran 1980). Highly skewed variables were subjected to a logarithmic transformation before conducting analysis of variance and regression analyses. The details of the logistic regression analysis shown in the tables include B = regression coefficient, SE = Standard Error, Wald = Wald statistic, p = significant level and R = correlation coefficient.

I now move to the first data chapter, which is a participatory approach to describing the parameters of human-elephant conflict in TM District.

CHAPTER THREE

Using indigenous knowledge to design the assessment of human-elephant conflict

"Whose knowledge counts"? (IDS 1979)

3.1 Introduction

Participatory approaches have become an increasingly important research methodology in natural resource management, and in other disciplines (Potten 1985, Groenfeldt 1989, Maxwel 1989, Case 1990, Pretty 1990, Welbourn 1991, Cornwall 1992, Buchanan-Smith 1992). Rapid Rural Appraisal (RRA) methodologies are of four of types: participatory; exploratory; topical; and, monitoring (McCracken *et al* 1988). RRA gives diversity (Beebe 1987) and valuable information (Dunn & McMillan 1991) on a particular community, and it is based on the assumption that local people do understand their problems, priorities and solutions better than outsiders. It is used to assist in identifying researchable constraints and opportunities (Dorwad *et al* 1996).

The current status of the elephant in TM District and its conservation problems can best be understood in the context of its historical association with people. This chapter gives an historic overview of the elephant's interaction with people in TM District that has determined its present range, important elephant resources, conflicts, and previous conflict mitigation strategies. Participatory RRA was applied to understand the past and present elephant status and interaction with the community and conflicts based on the use of local knowledge. RRA was used in this study as the first step to understanding HEC on communal lands (CLs) around Masai Mara National Reserve (MMNR) and to assist in the identification of researchable constraints and opportunities. The participatory approach was used to identify and formulate scientific approach, for questionnaires and field measurements. This chapter aims to answer the following questions:

- What is the historical status of the elephant in TM District?
- What are the elephant related events that the community considers to be important?
- How has the elephant range by sub-locations changed in TM District
- What are the important elephant areas and their resources in TM District?
- What changes have occurred in different resources and human activities over time?
- What are the types of HEC in order of importance?
- What are the types of HEC mitigation measures in order of importance?
- What factors have contributed to increasing HEC in TM District?

- What are some of the taboos, beliefs and values of the elephant among the Maasais of TM District?

In this chapter, I describe the historical perspective on human-elephant interactions (3.3.1), elephant-related events (3.3.2), patterns of farming activity and crop raiding (3.3.3), status of land use activities and natural resources (3.3.4), analysis and ranking of types of HEC and mitigation strategies (3.3.5) and attacks on humans by elephants (3.3.6). I then describe the factors contributing to increased HEC (3.3.7) and value and taboos and beliefs related to elephants (3.3.8). This chapter concludes with a discussion of these results (3.4).

3.2 Methods

3.2.1 Group discussions

Twenty four members of the Maasai community of Transmara District participated in a two day survey in March 1999 (Figure 3.1). In order to have diverse views and experiences, local community members with different background experiences were selected including those working with Kenya Wildlife Service (KWS), various government departments and the German Technical Cooperation (GTZ). The survey was guided by a prepared sheet of questions (Appendix 1). After the survey, eight selected members participated in field surveys to map the spatial data with a GPS in order to get the actual locations of resources such as salt licks.

Figure 3.1 The participants of RRA survey from Transmara District.

3.2.2 Historical accounts of TM elephants

Older members of the participatory team were asked to give historical accounts of the status, distribution and behaviour of elephants in TM District, assisted by an interpreter where necessary. Questions were raised to further explore and better understand past human-elephant relationships. Sketch maps were drawn and used to achieve further clarity where necessary. Through cross-checking and triangulation, contradictions, anomalies and differences noticed were investigated and corrected. Triangulation involves using a range of methods, and different types of information or investigation, and/or different disciplines, for verification (Grandstaff & Grandstaff 1987, Gueye & Freedenberger 1991). To offset biases, the exercise was relaxed and involved listening (Chambers 1992) and probing approaches were used to stimulate the participants to produce more information (Russell 2000). A leading question was read to the participants from the local community (Appendix 1) and the reactions by the participants elucidated more leading questions. A combination of probing techniques were used including: echo probe; Uh-huh probe (Matarazzo 1964); leading probe that depended on the responses; and, phased assertion (Russell 2000), which resulted in more exciting and interesting information. This was necessary in order to gather information that the community members would not say openly such as elephant poaching. Therefore, leading questions were asked in an indirect and careful way, since they trick people into answering a question in a particular way. Interesting responses were treated with an echo probe to allow the participant to continue talking. Sometimes I had to introduce some statements that I know about the Maasai culture and behaviour to generate more information. That was until one elder commented '*ero eminjo lomon pooki*' (do not give him everything), because the Maasai generally believe in withholding some information, especially to outsiders, for security reasons. As a result, I then resorted to a baiting probe (Agar 1980) to reaffirm what I had already learned and to elicit further what the participants were reluctant to talk about. This was necessary to collect as many views as possible.

RRA survey was used to elicit information for testing scientifically where researchable opportunities and constraints were identified. It is only the local people who understands elephant issues and hence they have to be key partners in conservation efforts. RRA involves interaction with the local people and more information is acquired within a short period. Equally, it is a better way of learning without much expectations from the local community. However, participants got emotional and veered off the main subject wasting a lot of time deliberating on sensitive issues. Language barrier with the elderly people also required translation, which sometimes distorts the message.

3.2.3 Resource mapping of elephant resources

The participants mapped important elephant-related resources within the elephant range. Sketch maps were drawn in which spatial features were added, based on questions raised by the participants. At each stage, I made sure the participants were in agreement in order to have a definite answer. Some participants, guided by specific household members, visited some locations identified in the field and their exact locations were mapped using a Global Positioning System (GPS). More information was collected through observations and interviews about the following: field conditions; land under different farming and non-farming activities; salt licks; elephant range; corridors; and, HEC areas, which formed the baseline for conflict monitoring sites.

Brief informal interviews with residents were conducted since interviews are essential to proper RRA (Grandstaff & Grandstaff 1987). In this case, an open ended mental checklist was used in conjunction with impromptu follow-ups. During these interviews, a major focus was on resource conflict issues such as: types of conflict; protection measures; and, response by KWS. Finally, spatial data were geo-referenced and entered into the geographical information system (GIS) using ATLAS software, which was later converted into GIS Arcview (Chapters 5 & 6).

3.2.4 Past elephant related events and trends in resources

There are three principal time-related data sources, namely: time lines; trend lines; and, seasonal calendars (Chambers 1992). In the case of TM District, these data were necessary to: (a) obtain information on major elephant-related historical events that occurred in the area, which helps to explain the changes in the human-elephant interaction in relation to resource availability and the changing socio-economic and cultural status of the community; and, (b) understand the period of active and severe conflicts during the year, as indicators of the best periods to patrol and assign strict control.

3.2.4.1 Elephant-related key events

A list was determined of elephant-related key events in the history of the community that helped to identify trends, problems and achievements of the community from a specified starting point to the present day. These included: drought; poaching; crop raiding; drying of streams; change of diet; and, so on. It also included how the community has dealt with natural resource management and elephant issues in the past. The procedures were explained and described to the participants, who were then allowed to identify and list the events from year to year, and probing questions were asked to make the whole discussion clear.

3.2.4.2 Peoples' perceptions of trends in resource availability

Understanding peoples' perceptions of trends in resource availability was necessary to understand the elephant-related issues that were considered important and how they are changing. The direction of any trends shows how villagers view their changing environment, and discussing trends in resource use among different groups highlights important resource management issues. The concept was first explained to the participants, who were then asked to state the changes in resources between 1950s and 1990s. A graph of each corresponding activity was drawn and an explanation for the changes was sought. The trends studied included those in: elephant population; wire grass; agriculture; forest size; livestock population; human population; pasture; poaching; water sources; and, education. The participants were given 15 seeds for assigning scores across the years for every resource (Kabutha *et al* 1988). The scores were categorised as 'nothing' (0), 'few or little' (1-3), 'many or high' (4-7), 'very many or very high' (8-11) and 'extremely many or extremely high' (12-15). The ratio of the scores was obtained and plotted against the year period.

3.2.4.3 Seasonal activity patterns

The participants were asked to draw their seasonal activity patterns over an annual cycle. This was used to compare with localised activities each month relative to HEC, and to suggest appropriate mitigation measures. The annual cycles within the community are important in determining labour availability for elephant surveillance, control, elephant movement and other management options. HEC related activities that take place in the area throughout the year were identified and plotted against month on a horizontal common time scale.

3.2.5 Ranking of types of HEC and mitigation strategies

The twenty four participants from the local community were asked to list the various types of HEC and possible mitigation measures. Two cases of each type of HEC and an appropriate mitigation strategy were compared at a time. The most serious conflict and/or the best mitigation strategy had marks awarded, and the marks were totalled after comparing all the conflict cases and mitigation strategies against each other. A case with high scores was rated as being the most serious conflict or the best mitigation, and vice versa. The formula [N(N-1)/2] was used to rank pairs of items, and the rank order was obtained by counting how many times each item won.

3.2.6 Value, beliefs and taboos of elephants to the community

The participants were asked to recollect any past and/or traditional values of the elephant to the community. Initially, they all laughed and in unison said "*metii bii* (none at all), *the elephant is our number one enemy because it is a killer*". Hence, most participants said initially that elephants have no value, apart from those members of group ranches who benefit from tourism revenue. However, after probing further, the participants understood the meaning of "value" and were able to remember their past experiences. The participants also listed the beliefs and taboos associated with the elephants.

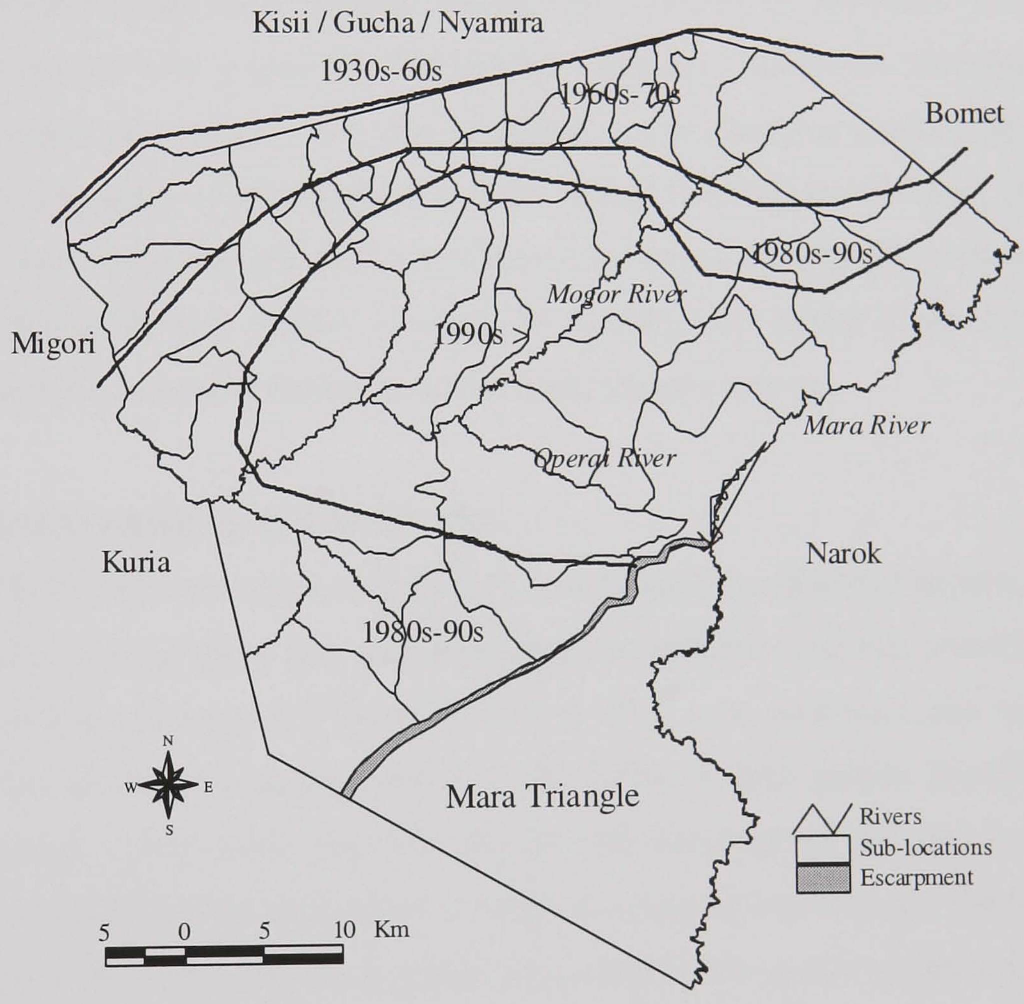
3.3 Results

3.3.1 Historical perspective on human-elephant interaction

3.3.1.1 Historical trends in elephant distribution, according to local informants

From the 1930s to 1960s, elephants in TM District once held sway over a vast region from Kuria District in the south, Migori District in the west, Kisii, Gucha, Nyamira and Bomet districts in the north and Narok District in the east (see Figure 2.1). Elephants used to extend 30 km into Kisii during the 1930s and 1940s (Figure 3.2). By the 1960s-70s, elephants had become restricted in range up to the Kisii-Transmara border. During the 1980s-90s, elephants were forced further into their present range in the central part of TM District. Elephants have now disappeared entirely from all the non-Maasai inhabited districts: Kuria; Kisii; Gucha; Bomet; Nyamira; and, Migori. The immigration and subsequent settlement of the Kuria tribe from Kuria District, of the Kisii tribe from Kisii, Gucha and Nyamira districts, and of Kipsigis tribe from Kericho and Bomet districts into TM District further pushed elephants to the central part of TM District. The current distribution of elephants is restricted largely to the remaining remnants of forests. Indeed, their fragments are also being encroached unwittingly (Chapters 5 & 6).

Figure 3.2 Changes in elephant range in TM District from 1930 to 1999.



The settlement of Kipsigis in the south was meant to 'buffer' the Maasai and the Kuria from cattle rustling. However, instead it has accelerated reduction of elephant resources, blocked elephant migration routes and increased conflict as a result of farming. The Nandi tribe from Nandi District also settled and farmed at Olalui from 1955 to 1960 until the Maasai usurped them. The 'spill over' and subsequent settlement of the Kipsigis in the north also accelerated conversion of elephant habitat into crop plantations, and the rivers and marshes have since then dried up, leaving dry river valleys. Currently, the expansion of human settlement and agriculture is so great that the Kipsigis are encroaching on the remaining Maasai occupied wildlands (Figure 2.8).

The conflict between elephants and people for cultivated crops began with the immigration of non-Maasais into TM District in the 1920s, and with the return of Moitanik and Uasin Gishu Masai clans from western Kenya in the 1940s. These tribes intermarried with predominantly farming Luhyia and Nandi tribes. Whilst the Siria and other Maasai groups campaigned against grass destruction, compensation for crop destruction also brought large-scale wheat and maize farmers into important elephant areas (Chapter 10). Hence, farmers cultivated with no regard for elephants and other wild animals, in order to make compensation claims. As a result, these areas were farmed briefly, but were abandoned when compensation was stopped in 1989 (Chapter 10).

This history underscores the dis-harmony between elephants and the people in TM District, which has resulted in depletion of elephant habitat, and therefore of elephants. The magnitude of decline, which has been far greater for TM District elephants than for Narok District elephants, is primarily because of a greater reduction of habitat, more poaching and heavier immigration. These findings prompted an investigation into the spatial distribution of ethnic groups, and the resulting land tenure and land use conflicts (Chapter 5), which are intimately related to elephant distribution (Chapter 6) and conflict (Chapter 7). Equally, the extent of the present elephant range also helped circumscribe the nature of the questionnaire survey.

3.3.1.2 Elephant poaching in TM District

Elephants in TM District have been subjected to uncontrolled commercial hunting for ivory that in turn reduced their population size and changed their behaviour. Maasai poaching had started in 1950s, especially involving the Ndorobo of Siria clan, who sold the tusks to non-Maasais. TM District was declared a hunting block in the 1960s to help reduce poaching. However, poaching increased in the 1970s and 80s, due to high international demand for ivory. Black rhinos were decimated on CLs and presently only one rhino is found in the TM District side of MMNR. By late 1980's, the elephant population had been reduced to a remnant, inhabiting only the thick forest areas of Laila, Esoit, Kirindoni and Nyakweri (Chapter 2). The Maasais who actively participated in poaching still maintain their nickname *Ole magendoi* (derived from a Swahili word meaning `illegal business`).

Whatever the impact of poaching on the elephant population, the spread of settled agriculture and increased mortality through spearing and arrowing eliminated them from the north-west-southern periphery of TM District. While the Maasai had a close cultural association with elephant, other tribes exterminated elephants as vermin and as a source of food. Elephant numbers started increasing again by mid 1990s, due to improved security and re-establishment of elephants back into their ranges from MMNR. Yet, even tuskless elephants were killed to remove the vestigial tusks. The once common big bodied, tusker elephants are no longer seen.

Elephant poaching is another form of HEC (Chapter 7) and a change in elephant behaviour has been noted because of increasing human pressure on elephants.

3.3.1.3 Behavioural and physical differences of TM District elephants

TM District supports two elephant populations, the migratory Mara elephant and the resident TM District elephant population, which according to participants show some distinct differences (Table 3.1). However, some characteristics could not be verified because of the elusive nature of elephants. Participants suggest that the resident elephant population has undergone a change in behaviour, which was attributed to increased human activity on their former ranges and the resulting conflict. Resident elephants used to move both day and night, but now they move only at night and hide in the forest during the day. Elephants no longer rumble, thus making them difficult to locate. They hide in the forest immediately they see or sense the presence of a person, or they will run away to seek refuge in the forest, or wait to attack. Resident elephants are intolerant of dogs, which they chase, in turn destroying many houses. Resident elephants used to move in large herds, but now they move in smaller groups, which increases the likelihood of conflict. Calves seldom accompanied elephants in the past, whereas now every group has several. The frequency of elephant mortality has reduced and fewer tuskless elephants are observed, probably because of their non re-establishment back into CLs because of the inability for self-defence. Elephants also used to run away from fire or smoke but are now more tolerant of such disturbance. As a result of changed behaviour, many children under 15 years of age have never seen an elephant on CLs, even though fresh elephant dung is spotted every morning.

Table 3.1 Physical and behavioural differences between the migratory Mara and resident TM District elephants.

Migratory Mara elephants	Resident TM District elephants
• Move during the day and night	• Move at night only
• Rumble	• Rarely they do rumble
• Intolerant of cattle	• Intolerant of dogs and sheep
• Large herds with calves	• Small herds with calves
• Long, thin tusks	• Short, thick tusks
• Small body size	• Big body size
• Grey-light, brown colour	• Dark brown

3.3.1.4 Elephant distribution by sub-locations

The participants classified the sub-locations in terms of importance to elephants based on how they perceive the current distribution of elephants (Table 3.2). Elephant range was classified under four headings: 'permanent' refers to areas where elephants are present throughout the year; 'seasonal' is where they occur seasonally; 'erratic' refers to areas where elephants occurred periodically, that is not every year; and, 'situation unknown' refers to areas where elephants stray infrequently. Elephant presence in specific areas is shaded while the years and name indicate the time and place of the event (Table 3.2). For instance, elephants appeared in Oloborsoito, Lepolosi and Megwarra sub-locations, in 1999 after many years of absence (Chapter 6). Mogor River is important for elephants and runs across the TM District, being shared by all the five divisions. Likewise, Laila forest extends across some divisional boundaries, including those of Kilgoris and Keyian divisions, while Nyakweri forest occurs in Kirindoni and Lolgorian divisions. This information provided the baseline information necessary to identify and establish ecological monitoring and conflict sites (Chapters 7 & 8).

3.3.1.5 Important elephant areas in TM District

The participants identified 59 important elephant areas and resources in TM District (Figure 3.3, Table 3.3). Human encroachment into important elephant areas limit access of elephants to salt licks (*embolioi*), swamps and forest and woodland products. Old elephants are known to die mainly in swampy and marshy areas and in salt lick areas such as Ng'irare swamp and Kibailo swamps, as well as Serena Hippo pool and Governors Camp swamp. Twenty three of these are considered to have been encroached, which this study defines as the resources that are no longer utilised by elephants or where fewer visits are noted. In contrast, 36 of these resources remain intact, which this study refers to resources that are still in use by elephants. Elephants also give birth to their calves in many areas, refuting assertions that Laila forest is the "maternity ward" for elephants.

3.3.2 Patterns of farming activity and crop raiding

Participants noticed that crop harvesting took place during a time that overlapped with most incidents of crop raiding (Table 3.4). Rainfall occurs in two seasons over five months, while elephants are present throughout the year. Crop planting takes place twice per year over four months, while crop ripening and harvesting also occur over three to five months. Crop raiding takes place over the periods of the year when crops are ripening or being harvested (Tables 3.4 & 3.5). Because of the relationship between rainfall and HEC, rainfall data were collected for verification, as were details of crop phenology including the stage of crop maturation at the time of raiding (Chapter 8). Crop raiding usually commences after a few elephants go out on a fact-finding mission to determine the levels of maize maturity, and they return later in large numbers.

Table 3.2 Classification of elephant ranges in TM District by division and sub-location.

Division	Sub-location	Permanent	Seasonal	Erratic	Situation unknown
Lolgorian	Lolgorian	Mogor River			
	Mashangwa			1973, 1975, 1998	
	Enkoiperiai			Salt lick 1997	
	Olkiloriti			1993, 1998	
	Ang'ata Barrikoi			Salt lick 1997	
	Kerinkani			1993, 1998	
	Isokon			1986, 1997	
	Oloolmong'i	Nyakweri			
Kilgoris	Osinoni	Laila forest			
	Oloborsoito				1999
	Olesentu	Mogor River			
	Lepolosi				1999
	Olomismis	Mogor River			
	Olalui	Laila forest			
	Illmeshuki	Laila forest			
Pirrar	Oronkai		Mogor River		
	Shartuka		Mogor River		
	Megwarra				1999
Keyian	Masurura		Mogor River		
	Nkararo	Laila forest			
	Moita	Mogor River			
Kirindoni	Sitoka	Nyakweri			
	Pusangi	Nyakweri			
	Oloololo	Escarpment			
	Emarti		Olosakwana		
	Kimintet		Nyakweri		
	Esoit		Mogor River		
	Olkeri				1998, 1999
	Ntulele		Oloonkolin		

Shaded names and years refers to specific areas and year(s) of visit by elephants

Figure 3.3 Some of the resources preferred by elephants (a) salt lick at Ng'irare on the MMNR-Serengeti National Park boundary, (b) *Warbugia ugandensis* fruits and (c) *Acacia* spp.

(a)

(b)

(c)

Most salt licks on communal land have been encroached and are out of use by elephants. The fruits of Warbugia ugandensis (c) are highly preferred by elephants and the fermenting seeds make elephant drunk and more aggressive, resulting in more conflict. The Acacia woodlands are becoming opened up because of increased felling.

Table 3.3 Important elephant areas and resources in each division of TM District, and classified according to whether encroached or intact.

Sub-location	Area	Resources	Encroached	Intact
Lolgorian Division				
Lolgorian	Lolgorian forest	Mud/swamp	*	
Lolgorian	Naiswea forest	Doninge fruits	*	
Lolgorian	Nkapone Hill	Cool temperature		*
Lolgorian	Olmotonyi bridge	Salt lick		*
Lolgorian	Lopilokuny	Salt lick		*
Lolgorian	Saneti	Swamp/mud		*
Lolgorian	Olchorok	Swamp/mud	*	
Lolgorian	Olare orok	Salt lick	*	
Lolgorian	Labor	Salt lick/mud	*	
Ang'ata Barrikoi	Keshuro	Salt lick	*	
Ang'ata Barrikoi	Kitetoi	Salt lick	*	
Ang'ata Barrikoi	Ngi'rare	Salt lick/swamp		*
Oloolmong'i	Olpanyati	Salt lick		*
Oloolmong'i	Nyakweri	Forest/salt		*
Kilgoris Division				
Osinoni	Olenaurr	Forest		*
Olesentu	Osanankururi	Salt lick/swamp		*
Olesentu	Olenarwa	Swamp	*	
Olesentu	Illera	Salt lick		*
Olesentu	Nailare	Salt lick	*	
Olomismis	Olomismis	Forest		*
Olalui	Laila	Forest		*
Olalui	Mutengwarr	Salty bank	*	
Olalui	Illemeshuki	Salt lick		*
Olalui	Nashiliangare	Swamp	*	
Olalui	Engare ongitwak	Salty bank	*	
Pirrar Division				
Oronkai	Tororeki	Forest	*	
Oronkai	Ntumot	Salt lick		*
Oronkai	Naboena	Salt lick/forest		*
Oronkai	Nyakwenyi	Salt lick/swamp		*
Oronkai	Entankila	Salt lick/forest		*
Shartuka	Enkisokonin	Salt lick		*
Shartuka	Olepoposhi	Forest/swamp		*
Shartuka	Emoisetet	Forest/swamp		*
Shartuka	Nyahururu	Swamp	*	
Shartuka	Nalangitom	Swamp		*

Keyian Division				
Nkararo	Endondol	Swamp/mud/*Acacia*	*	
Nkararo	Olomito	Swamp/*Acacia*	*	
Nkararo	Laila	Forest		*
Moita	Olenguruon river	*Acacia*		*
Moita	Embolioi oltome	Salt lick	*	
Moita	Kenkore	Forest		*
Moita	Endebesi	Swamp		*
Kirindoni Division				
Esoit	Osewani lole nasiti	Swamp	*	
Esoit	Kibailo	Swamp		*
Esoit	Illtwati	Salt lick		*
Esoit	Tumbelion	Salt lick		*
Esoit	Iteriaek forest	Salt lick/forest		*
Ntulele	Kirbwet	Forest	*	
Emarti	Oloonkolin	Forest	*	
Emarti	Sambueker	Salt lick	*	
Murgan	Obashiarani	Salt lick	*	
Kimintet	Kilutori	Salt lick		*
Pusangi	Nairenyi	Salt lick/forest		*
Pusangi	Olailole	Salt lick		*
Pusangi	Enginye	Forest	*	
Pusangi	Tangile	Salt lick/forest		*
Pusangi	Maing'usi	Salt lick/forest		*
Pusangi	Serena Hill	Salt lick		*
Pusangi	Naibor	Forest		*

* refers to either encroached or intact

Table 3.4 Calendar showing seasonal patterns in environmental parameters and crop raiding in TM District.

Activity/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall			■	■	■					■	■	
Presence of elephants	■	■	■	■	■	■	■	■	■	■	■	■
Crop planting	■	■						■	■			
Crop ripening	■					■	■	■				■
Crop harvesting		■						■	■			
Crop raiding	■	■				■	■	■	■			■

Table 3.5 Seasonal variations in planting and harvesting of maize in TM District.

Division	Long rains		Short rains	
	Planting	Harvesting	Planting	Harvesting
Keyian	Feb/Mar	Aug/Sept	Aug/Sept	Feb/Mar
Lolgorian	Jan/Feb/Mar	July/Aug	July/Aug	Jan/Feb
Pirrar	Jan/Feb/Mar	May/Jun/Jul	July/Aug	Jan/Feb
Kirindoni	Dec/Jan	May/June/July	-	-
Kilgoris	Feb/Mar	July/Aug/Sept	Aug/Sept	Feb/Mar

3.3.3 Elephant-related key events

Historical analysis of key events that could have affected elephant conservation were outlined by participants (Table 3.6). TM District experiences drought every 10 years or so, which influences elephant movement patterns and behaviour. Hence, raiding of maize stores and houses where maize meal (*ugali*) is prepared is a behaviour that has only been observed recently, mostly during drought. Drought also resulted in drying of rivers, death of wildlife and migration of livestock. Heavy rains also endangered the lives of elephants, livestock and people. Locust invasions also finished the grass for livestock, resulting in their migration to other areas. Locust invasion also covered the sun, and solar eclipses made elephants come out of the forest early, while livestock returned to the *bomas* early for fear of theft. Elephants dispersed widely during droughts because of water and food shortages and some elephants migrated from the MMNR into TM District during wildebeest migration (Chapter 6). Elephants moved out of the forest quite early and retreated back late during cloudy weather.

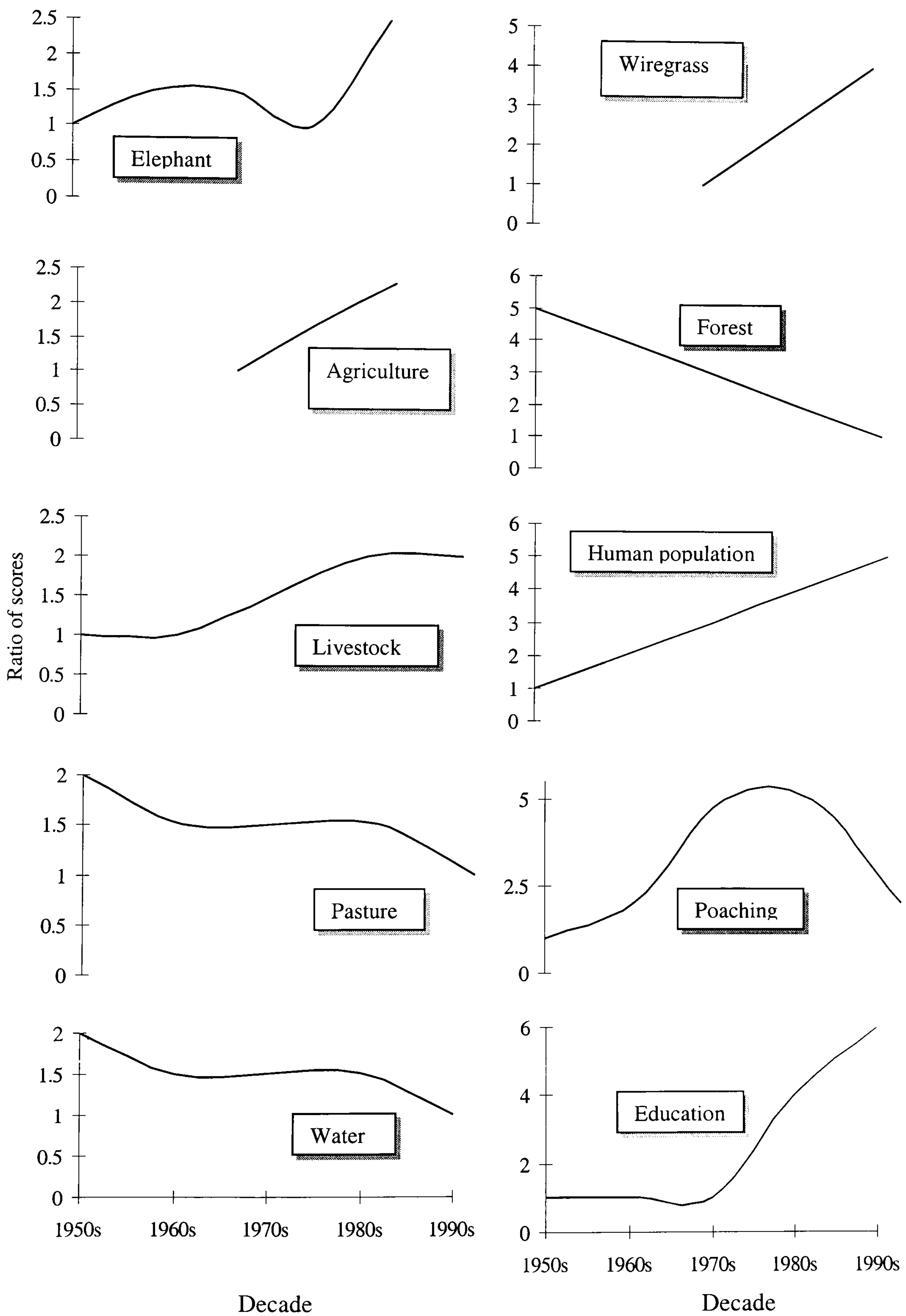
3.3.4 Status of land use activities and natural resources

Participants were asked to compare changes in 10 important resources and human activities over time (Figure 3.4). The elephant population was believed to have increased, then declined and then increased. However, sharp increases were believed to have occurred in wiregrass, agriculture, human and livestock populations. In contrast, forest, pasture and water resources were thought to have shown a drastic decline. Poaching was also believed to have increased and then declined, while education levels remained constant upto the 1970s and then started to increase. This prompted me to collect data on wiregrass encroachment, extent of cultivation, forest loss, and human population increase (Chapter 5), as well as on the elephant population (Chapter 6) and educational standards (Chapter 7).

Table 3.6 Historical analyses of the key events that could impact on elephants in TM District as described by local informants.

Year	Event	Impact	Coping mechanism
1920's	Fight between Loita and Siria Maasai clans	Many people died	Siria moved to Luo Nyanza
1937	First school build at Nkararo	Parents forced to take their children to school Affected cattle herding	People ran away from the area
1946	Locust invasion	Pastures overgrazed and tree branches broke due to heavy weight	Laibon made fire and burnt grass to chase the locusts
1948	Solar eclipse	Temporary darkness	Livestock returned early
	Contagious bovine pleuro-pneumonia (CBPP) outbreak (*Olkipie*)	Cattle died in large numbers Famine and poverty	Boiled elephant and zebra bones and mixed with *Oropuko* and *emaroi* for drenching animals.
1949	Solar eclipse	Temporary darkness	Livestock kept indoors
1950	Drought	All rivers dried except Mogor River	All elephants and livestock moved to Mogor River
	Rinderpest outbreak	Many cattle and wild animals died	
1952	Drought	All rivers dried except Mogor River	Migrated to Mogor River for pasture and water
1954	*Ugali* eaten for the first time by Siria clan	People liked it	
1960	Heavy rainfall	Elephants, other wildlife and livestock were carried away by flood water Famine	Livestock kept around *bomas* most of the day Felled trees on rivers to cross
	Locust invasion	Shaded the sun and ate all grass	People moved livestock to other areas
	TM District declared a hunting block	Many elephants killed	
1962	Invasion of wire grass	Cattle lost teeth	People migrated to other areas
1963	Kenyas independence	Celebrations	Fire lit on hilly areas
	Heavy rainfall (*Olari 100 ngariak*)	People indoors	Fire lit on iron sheet. Change of roof structure
	Famine (*Olari le nadotolit*)	Many animals died	Food dropped by helicopters
1964	Wildlife protection order	People beaten for any wildlife related offence	People avoided grazing in the game reserve
1973	Solar eclipse	Elephants come out of the forest early Fear of cattle theft	Livestock returned early from the field Childrens eyelids punctured from below with a needle to avoid loosing eyesight
1974	Fight between Uasin Gishu and Siria	Many people died	
1976	Drought	Cattle and wildlife died in large numbers	Livestock migrated to other areas
	Rampau age group walked to Ngong to sell cattle and killed elephants and sold tusks	This age group is now the nucleus of Maasai wealth	
1981	Solar eclipse	Temporary darkness	People kept indoors
1984	Drought	Livestock, people and wildlife died	Livestock migrated to Kuria land
1993	Drought	Elephants broke into houses and grain stores for food Livestock and wildebeest died in big numbers Cattle from Narok moved into TM	People cooked early Livestock migrated to Kuria land

Figure 3.4 Local participants views of changes in different resources and human activities over time from 1950s to 1990s.



3.3.5 Analysis and ranking of types of HEC and mitigation strategies

3.3.5.1 Pair wise matrix ranking for types of HEC

Twenty four participants from the local community identified 11 elephant-related conflicts (Table 3.7a) that produced 55 pairs. Two items were compared at a time using a pair wise ranking matrix (Table 3.7b). Attack on humans by elephants was considered the most serious type of conflict followed by crop damage. Limiting people's free movement and their night activities also featured as important. In contrast, attacks on livestock ranked last. The numbers of people killed or injured by elephants were also enumerated and their exact locations marked later (Chapter 7).

Table 3.7a. Types of HEC listed by participants in TM District.

Type of HEC	Types of HEC
1. Kill people	7. Destroy water points
2. Injure people	8. Destroy trees
3. Kill livestock	9. Limit free movement
4. Destroy fence	10. Limit night activities
5. Raid crops	11. Carry tsetse flies and ticks
6. Destroy maize store	

Table 3.7b Pair-wise matrix ranking of types of HEC by participants. Types of conflicts are shown in Table 3.7a and are coded 1-11.

Type of conflict	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total score**	**Rank order***
Kill people		1	1	1	1	1	1	1	1	1	1	10	1
Injure people			2	2	2	2	2	2	2	2	2	9	2
Kill livestock				4	5	3	7	8	9	10	11	1	10
Destroy fences					5	6	7	8	9	10	11	1	10
Raid crops						5	5	5	5	5	5	8	3
Destroy maize stores							6	8	9	6	11	3	4
Destroy water points								8	9	10	11	2	7
Destroy trees									8	8	11	6	9
Limit free movement										9	11	5	5
Limit night activities											11	3	6
Carry tsetse flies and ticks												7	7

Columns 1-11 are coded types of conflict; *Rank order using 1-11 scale (1 = Extremely important, 11 = unimportant).

3.3.5.2 Pair-wise matrix ranking for HEC mitigation strategies

Twenty four participants from the local community identified eight conflict mitigation strategies (Table 3.8a) that produced 28 pairs, which were ranked using a pair-wise matrix (Table 3.8b). Receiving benefits, providing compensation, creating awareness and increased efficiency of problem elephant control by KWS were ranked as the most important strategies. In contrast, keeping elephants away from people through fencing ranked last. Possible mitigation strategies were explored further in questionnaire survey (Chapter 4) and during field survey of raided farms (Chapter 10).

Table 3.8a Types of HEC mitigation strategies by listed by participants in TM District.

HEC mitigation	HEC mitigation
1. Fence forest areas	5. Establish an elephant sanctuary
2. Chase elephants to Mara and fence MMNR	6. Conduct elephant census
3. Receive benefit from wildlife	7. Create awareness
4. Provide compensation	8. Increase KWS ranger posts and patrols

Table 3.8b. Pair-wise matrix ranking of HEC mitigation strategies by participants. Types of HEC mitigation strategies are shown in Table 3.8b and are coded 1-8.

Type of mitigation strategy	1	2	3	4	5	6	7	8	Total score	Rank order*
Fence forest areas		1	3	4	5	6	7	8	1	7
Chase elephants to Mara and fence MMNR			3	4	5	6	7	8	0	8
Receive benefits from wildlife				4	3	3	3	3	6	1
Provide compensation					4	6	4	4	6	1
Establish an elephant sanctuary						6	7	8	2	6
Conduct elephant census							7	8	4	4
Create awareness								7	5	3
Increase KWS stations and patrols									4	4

Columns 1-8 are coded types of HEC mitigation strategies; *Rank order using 1-8 scale (1 = Extremely important, 8 = unimportant).

The participants finally ranked the relation between the three Maasai clans and level of education, population, elephant density and farming (Table 3.9). The Siria clan ranked last in all aspects but first in supporting a high elephant density. The Uasin Gishu clan ranked last in supporting high elephant densities because of farming, while the Moitanik clan was regarded as having the highest education level and highest human population density. This analysis was used as the basis for explaining the level of education and resource depletion (Chapters 4, 5 & 6).

Table 3.9 Ranking of the three Maasai clans with important resources.

	Maasai clan		
	Siria	**Uasin Gishu**	**Moitanik**
Education level	3	2	1
Human population	3	2	1
Elephant density	1	3	2
Farming	3	1	2

Rank order: 1 = First; 2 = Second; and, 3 = Third

3.3.6 Attacks on humans by elephants

The participants listed all people killed or injured by elephants (Chapter 7) and it was noted that more men than women are killed for a variety of different reasons:

(a) Men walk for long distances looking for and/or after cattle;

(b) Women have to be home early to milk while men stay out late;

(c) Men engage in social activities that usually involve drinking alcohol, whereas women attend to domestic responsibilities;

(d) Women are only allowed to leave the *boma* when the elephants reach the forest; and,

(e) Maasai women are regarded as cowards and they keep away from elephants.

3.3.7 Factors contributing to increased HEC

Participants outlined the factors that were regarded as contributing to increasing HEC in TM District and some of these factors are further measured and analysed in Chapters 5 to 10.

- Human population: larger human populations have increased the chance of encounters with elephants, and have encroached into areas traditionally used by elephants, restricting elephant access to their important areas (Chapters 5 & 9).

- Immigration of other tribes: some tribes are reported to shoot elephants with arrows, making them aggressive towards humans. They have also introduced farming and are teaching the Maasai farming techniques, as well as promoting forest destruction (Chapter 5).

- Peak season of tourism activity: the number of people in the Mara increases during the high tourism activity season increasing the chances of people encountering elephants.

- Introduction of market days in market centres next to the MMNR: the opening up of market days at Kawai and Mararianda (in Narok District) has increased the flow of human traffic along the elephant corridors, increasing the chances of conflict.

- Drunkardness: some elephant attacks on human are attributed to intoxication and men returning home late at night (Chapter 7).

- *Moranism* and breakdown in community organisation: *moranism* is an age set between youth and adult, and contributes to increased HEC because the remaining family members are either elderly or young and children, who cannot contain elephants. Since the *morans*' diet is mainly meat, milk and blood, they have less interest in crop production. Similarly, changes in community organisation and institutions have resulted in a less cohesive, fragmented society where traditional communal practices, which united villagers, have been abandoned.

- Breakdown in the information flow system and traditional methods of evading elephants: the Maasai could very easily by-pass elephants unnoticed by determining the wind direction using grass or saliva, and staying down wind. The Maasai also never used to bathe with factory soap, but instead used some plant species such as '*Olmusigiyioi*' (*Rhus natalensis*) and '*Olmarashrash*' (*Trichocladus ellipticus*) which did not produce any unusual smells that could be detected by elephants. Now, the Maasais have forgotten the traditional methods of by-passing elephants.

- Crop farming: the introduction of crop farming has attracted elephants in some places. Elephants prefer maize and banana, while variation in planting dates in the district attracts elephants all year round. Haphazard planting of crops makes problem elephant control difficult because crop ripening occurs at different times (Chapters 5, 7, 8 & 9).

- Encroachment on elephant range: elephants cause problems when trying to access their former ranges that have been encroached. For example, the Ketura and Olaitong' forests and salt licks have been encroached completely, yet elephants still attempt to access these areas. They also frequent specific encroached areas to access to certain plant species, including: *Acacia* spp; *Hibiscus fuscus; 'Olmeshwa';* and, *Olinia usambarensis*. As a result, some areas are associated and named after elephants (*Oltome* is a Maasai word for elephant), such as *embolioi oltome* (elephant salt lick), *engare oltome* (elephant river), *olchurorai oltome* (elephant acacia) and *lariak oltome* (elephant bird).

- Blockage of elephant corridors: the Kichwa Tembo and Oloololo corridors are important routes for daily movement of elephants up and down the escarpment. These corridors are also used by people and livestock that has restricted elephant movement during the day and caused many human deaths (Chapters 5, 6 & 7).

- Elephant population: the recovery of the elephant population after security was restored has increased the chances of contact between humans and elephants (Chapter 6).

- Change in habitat quality: the elephant population in TM District increases when the MT becomes very dry, as elephants are attracted by the cool forest and its rich resources (Chapter 9).

- Elephants are attracted to livestock *bomas*: kikuyu grass (*Pennisetum clandestenum*), pumpkin (*Curcabita maxima*), and the calabash plant subject *bomas* to destruction, and livestock to attack, by elephants.

- Poaching and human aggression towards elephants: the aftermath of elephant poaching has made elephants very cautious of humans, and they may attack people. Equally, simply beating sticks or clapping could scare elephants away (Chapters 6 & 8).

- Rainfall: resident elephants usually move out of forest during the wet season. In contrast, the Mara elephant population moves onto communal lands during the dry season, when maize has been harvested (Chapters 6, 7, & 8).

- Artificial water dams: the dams built for livestock attracts elephants, especially during the dry season, thus causing conflict at Masurura, Olomismis and Kawai (Chapter 5).

3.3.8 Value, taboos and beliefs associated with elephants in TM District

The Maasai believe that a dead elephant lying on its left side is a curse. Similarly, a Maasai who comes across a fresh elephant after-birth is endowed with riches. An after-birth that has already been seen is surrounded by grass with two openings to signify inlets for the riches, which are mainly cattle. Elephant trails are believed to be without obstacles and were used during Maasai blessing ceremonies. Killing an elephant does not have much of a cultural value, apart from the praise sung by women who opt for such courageous men as husbands, in contrast to other areas.

Tourism-based economic value of elephants was recognised as deriving from among various activities such as revenue, employment, selling food and handicrafts. In addition, the participants identified the following as reasons for the traditional importance of elephants to the local communities:

- Elephants discover and expose salt licks and water for livestock use;
- Elephants destroy thick forest increasing visibility;
- Elephant bones treats trypanosomiasis;

- Elephant fat treats skin disease and other ailments and is mixed with herbs to speed baby growth;
- Pregnant mothers take a mixture of elephant dung with milk for healthy babies;
- Elephant after-birth speeds delivery in pregnant mothers and is a source of riches;
- Elephant dung is burned to smoke bees during honey harvesting and to treat measles;
- Traditional rings are carved from the scales of an elephant foot;
- Elephant tails are used to make bangles;
- Elephant tusks are used to make bangles for beauty and tobacco containers;
- Tusks are a source of money;
- Elephants provide security against cattle rustling as thieves are forced to take longer routes;
- Status accrues when one kills an elephant; and,
- Elephants trails are used for ceremonies because they are believed to have no obstacle(s).

3.4 Discussion

The RRA study has shown that Transmara is a complex ecosystem undergoing rapid changes that provides clues as to why HEC occur. Changes have occurred in the socio-economic status of the local human population. Indigenous knowledge has proved an important tool in understanding the historical background of HEC. Previous studies used questionnaires rather than RRA (Kasiki 1998). Integrating scientific and local knowledge is important in any study (Gobin *et al* 2000). Elephants once occupied most parts of TM District, but their distribution and activity have now become seasonal, nocturnal and fragmented. Lack of monetary benefits from wildlife is changing the attitudes of local people towards elephant conservation, although the local community is still willing to conserve elephants as long as they receive benefits. Benefits related to mitigation strategies have superseded others aspirations, showing an appreciation of elephants by local people and a willingness to co-exit. Equally, the Transmara community might have realised that farming is not viable in elephant areas. However, land tenure is a very sensitive issue, and a lack of trust and suspicion has hindered an attempt by GTZ to establish an elephant sanctuary.

The study has also shown that the traditional values of the elephant are no longer of prime importance. Therefore, the only benefit that could be derived from elephants is through revenue generation. An increasing human population and their changing land use patterns are thought to be the cause of increased HEC, while loss of human life and crop destruction are highly salient consequences because of the subsequent suffering of family members. Nevertheless, participants view driving elephants into the MMNR and fencing as the last option for conflict resolution.

3.4.1 The role of participatory approach as the first step in a HEC study

RRA surveys as described by IDS (1979) and Brokensha *et al* (1980) began to emerge in the late 1970s and it is considered as one of the best way to learn about rural life and conditions (Chambers 1992). RRA evolved because of (a) dissatisfaction with biased brief visits by urban professionals who are only spatial, peripheral, sex-biased, dry-seasoned and diplomatic, (b) disillusion with questionnaire surveys and their results, which have subsequently reduced response rates, and, (c) the cost-effectiveness in terms of finance and time. Since RRA conversations and fieldwork are stimulating and more interesting (Bayer 1988, Inglis 1991), the approach was changed to a more participatory, learning technique that could be appreciated by the community. As John Devavaram noted "*one does not get bored, it is interesting and what is shared is often unexpected and fascinating at times*". Hence, the local community is itself more knowledgeable on many topics that touch their lives than the researcher (IDS 1979, Brokensha *et al* 1980). This was the best approach since Maasais have been over-studied (Kituyi 1990) and have subsequently developed a negative attitude towards questionnaire surveys (Sitati 1997).

In the past, most professionals have been reluctant to publish work on RRA surveys for fear of professional criticism (Chambers 1992), since it does not conform to conventional ways of of statistical analysis. However, comparisons between conventional questionnaire surveys and RRAs have produced similar results (Franzel & Ford 1987, Rocheleau *et al* 1989). Yet, sharp discrepancies were also noted in some questionnaire (Inglis 1991) and RRA surveys (Pottier 1992), allowing misleading conclusions to be drawn. This was probably because of poorly formulated questionnaires, hurried interviews and insensitivity to the context. Unlike the standard questionnaire surveys, where the investigator takes much while little or nothing is given back, RRA is less exploitative (Chambers 1992). Similarly, methods that can generate figures, matrices and tables help in getting started and in making other methods more acceptable (Chambers 1992, Mearns *et al* 1992). It is for these reasons that this RRA approach was adopted and its outcomes followed up through more formal scientific investigations (Chapters 5 to 10). This study confirms that much of the interesting and important information about elephants could not have been acquired by any other method. In fact, the local community felt abandoned by the government and was impressed that the study would highlight their plight sympathetically. This was reflected in the total support I received from the local community.

RRA information is cost effective, valid and reliable when compared with more conventional methods (Chambers 1992). However, despite this, RRA surveys have been misused (Chambers 1992). Most data are collected rapidly without verification. In contrast, this study measured the RRA findings for further verification through methods of triangulation. With the understanding that well planned RRA surveys can elicit important local knowledge, it is increasingly becoming an important technique in academic studies (Pretty 1990, Welbourn 1991, Cornwal 1992, Buchanan-Smith 1992, Ashenafi 2001).

Communities have the capacity to map, model, quantify and estimate, rank, score and diagram (Chambers 1992). Participatory mapping and modelling is the most striking and local communities have more extensive and detailed mental maps than urban people. Participatory social mapping has also yielded similar results, even when using different triangulation methods (Chambers 1992). Discrepancies are normal in the spirit of embracing error, as opportunities to learn and to get closer to the truth. One community elder said, "*It is only the Maasai that can live with the wildlife because we don't eat nor kill them*", sentiments also supported by Parkipuny (1996).

3.4.2 Ecology of the elephant

According to the RRA survey, the twenty four participants from the community noted that the elephant range in TM District has declined over the years, mainly due to human encroachment and farming (Figure 3.2, Table 3.2). Currently, the elephant range is on the Maasai inhabited land, which in turn is threatened with encroachment by the non-Maasais. Important elephant resources have been lost (Table 3.3), contributing to increasing conflict as elephants attempt to access these lost resources. Reduced elephant range and increasing human population increases the chances of conflict. Resident elephants have developed different behaviour patterns because of increasing HEC (Table 3.1).

The present elephant ranges in TM District include: the Laila; Mogor; Esoit; and, Nyakweri forests. In Lolgorian Division, the important resources are River Mogor salt licks, Ng'irare salt licks and Nyakweri forest. Nyakweri forest remains intact because of its cultural value (Table 3.3). Kirindoni Division, which has a larger portion of Nyakweri forest, is under pressure from immigrants and many resources have been encroached. Population pressure in Pirrar and Kilgoris divisions threatens most elephant resources apart from the intact Laila forest, which is the core of the resident elephant population. Although the mapped information is arbitrary, it is a pointer to conservation managers. Similarly, TM District has other rich elephant resources like salt licks, swamps and drainage.

The droughts that used to be experienced in TM District every 10 years or so have now become more intermittent due to forest loss. The Mogor River, which now dries up during very dry seasons, never used to and people, livestock and elephants could converge without conflict. Elephants began breaking into houses to eat *ugali* during droughts in the 1990s, it is believed due to food shortage. Heavy floods were also common, leading the Maasai to change their roof structures from flat-topped *manyattas* to a non-Maasai cone shape to avoid leakage, and leading to the drowning of many livestock and young elephants.

The elephant population in TM District has increased, and more calves are born, both signs of recovery and re-establishment after heavy poaching. Equally, wiregrass is thought to be expanding and replacing the nutritious grass for livestock and wildlife (Thurrow 1996). Therefore, cultivated crops have become the target of wildlife. Other increases were noted in human population, agriculture, livestock population and the levels of education. In contrast, poaching, forest size, and water and pasture resources have declined. The presence of many dry river valleys, especially in the once rich drainage area in the north and south of TM District where the forest is completely cut, confirms the declining water resources. A decline in elephant range has been reported in other studies (Parker & Graham 1989a, Berger 1993a).

3.4.3 Ranking of conflict types

Ranking and scoring are part of the repertoire of social scientists (Pelto & Pelto 1978). A close correlation has been reported between different informants in various studies (Silverman 1966, Bayer 1987 and 1988, Grandin 1988, Chambers 1992). Not all ranking exercises can yield reliable and valid data, but a close correlation occurs between informants where information is common knowledge, where criteria are commonly held and well understood, and where ranking is a matter of intense interest (Chambers 1992). The situation of Transmara very well fits these three conditions, and a few triangulation corrections validated most data. Also, paired comparisons are suited to non-literate informants, as lists of pairs can be read to them, one at a time, and their responses recorded.

Loss of human life is the most serious form of HEC (Campbell *et al* 2000). Attack on humans by elephants was ranked by the local community as the most crucial form of conflict because of the value they place on life (Table 3.7b). Crop damage was ranked second because of the importance of food, while livestock killing by elephants, was ranked last. This was a conflict that most expected to feature as important, but indicates the declining cultural attachment to livestock. The Maasai believe a person killed by an elephant is a curse and is a way of getting rid of unwanted people. Drunkards often became victims of elephant attack because of being out during late hours when the elephants are moving into settled areas. Pupils also cannot attend school regularly resulting in their poor educational performance (Chapter 7).

3.4.4 Reasons for increasing HEC

Elephants in TM District have recently developed aggressive behaviour and other survival tactics due to poaching and encroachment on its habitat (Table 3.1), as reported in other studies (Kangwana 1995, Kasiki 1998). As a result, more dead elephants were encountered with wounds than in the past. Immigrants attempted to spear elephants from the farms before the Government became strict on wildlife protection. Tuskless elephants are no longer seen in TM District, although they probably remained in the Mara for security reasons during the poaching era, while the tusked elephants have re-established back into TM District. Elephants remain in the forest during the day and come out at night (Table 3.4). However, during the eclipse, elephants were seen to come out of the forest early, while livestock also returned home early. Resident elephants are toletant to cattle, but are intolerant to dogs and sheep. The difference in colour between the two elephant populations is due to bathing in different soil types. That is how Amboseli elephants were also differentiated from the Kimana elephants (pers. observation).

Participants believe the reasons behind HEC include: increasing human population and immigration; spatial settlement and drunkenness; agricultural expansion and encroachment; declining habitat quality and rainfall patterns; and increased elephant population and poaching. Crop raiding occurs seasonally when maize is ripening or mature, but other forms of HEC occur throughout the year. Crop harvesting takes a short time, and usually takes place prematurely to avert further loss. Elephants are aggressive because crops and certain plants are sweet, and they are thought to get drunk on the fermenting *Warbugia ugandensis* fruits. Because of poaching, elephants associate humans with danger (Chapter 7). Breakdown in clumped settlements due to reduced cattle rustling and reduced livestock encourage dispersed settlement, contributing to increased conflict. This is because people have to walk a long distance from one *boma* to another risking encountering elephants. Serious conflict occurs again when elephants spread out during the rainy season. Elephants move up the escarpment to feed on *Acacia* spp., *Warbugia ugandansis* and '*Cordia africana*', using some natural corridors (Chapter 6).

3.4.5 Conflict mitigation strategies

Because of increasing conflicts, the elephant ditch or moat at Masurura was meant to prevent elephants from crossing into Luo Nyanza Province and it was also a colonial boundary to prevent non-Maasais from entering into Maasailand. Problem animal control (PAC) by KWS was regarded as ineffective, since elephants are simply moved from one place to another, which merely passes on the problem. The Kipsigis are successful in farming because Maasai farms buffer them. The Kipsigis once used to build makeshift houses on top of tall large trees and to blow a horn to scare away elephants. However, the trees have since been cut, as elephants no longer reach their farms. The elephant is considered to be the most dangerous animal because an attack cannot be avoided by climbing a tree, as for other wildlife.

Participants felt that the government holds elephants in higher regard than humans, because of the protection and quick response shown whenever an elephant is killed, compared to the lack of or slow action when a person is attacked. A good example was when an elephant calf was airlifted to Nairobi after the mother, who had just delivered on the road, was shot. Such a response has never happened whenever a person is attacked. Equally, the community does not understand that the action was by the Sheldrick orphanage that rescues orphaned baby elephants rather than the government. Equally, the donor agencies could also rescue people who are injured by elephants and provide medical support. The community is not willing to continue living with elephants unless they benefit from tourism, which they suggest is the best strategy for conflict resolution (Table 3.8b). For example, Laila and Esoit forested areas are key elephant areas, but the community in these areas does not benefit from these species. In contrast, most of those who do benefit no longer live in areas that support elephants because of the escarpment and farming. Despite that, the community is still willing to live with elephants as long as: they receive some benefits; the number of KWS rangers is increased; there is prompt processing of compensation; and, a sanctuary is established. These recommendations also featured prominently in a KWS (1994) report. Nevertheless, frequent changes in the ministry, which controls KWS hampers compensation. Previously, the Ministry of Tourism and Natural Resources was in charge, but now it is under the Office of the President. According to KWS (1994), the community felt that compensation issues should be handled by KWS. The Maasai did not like being associated with a dead person and compensation money was not valued until recently during economic hardship. Chasing elephants into the MMNR and putting a fence around ranked last, because the community still believes that wildlife conservation generates more revenue than any other form of land use without much input. However, farmers strongly suggested that elephants should be fenced off in the MMNR.

3.4.6 Value of the elephant

The elephant has a number of traditional values, such as elephant blood curing skin disease and diabetes, meat curing allergies and dung curing measles and yellow fever. Elephant after-birth is given to women in labour to hasten delivery, or it is buried in cattle a kraal to make a person wealthy as in Tsavo (Kasiki 1998). The special attachment to the after-birth shows the value of the elephant and the wish that they produce calves to generate wealth. Again, the *Rampau* age group is the richest, because of sales of tusks. Apart from discovering water and salt licks for livestock, elephants keep off cattle rustlers and artefacts like bangles and tobacco containers are made from elephant parts. However, most of these values are no longer being exploited.

The value of elephants might be seen differently depending on the level of education. The Siria clan remains less educated and has not changed its lifestyle much. Hence, the areas occupied by this clan support more elephants. The Siria clan migrated from Nkararo when the first school was established to avoid education. Until very recent times, it was only the children not liked by their parents that were forced to attend school. Most of the educated groups from the Uasin Gishu and Moitanik clans have acquired land titles because of their political influence in land adjudication process. The two clans have inter-married with other tribes and have become almost fully agro-pastoralist.

3.4.7 Implications

Conservationists and wildlife managers who are scientists and policy-makers should be impressed by the criteria, judgement and abilities of local people. As was demonstrated in this participatory approach to assessing the historical context of HEC, much was learned that would otherwise have been missed (Shah 1992) that is vital for understanding the complex relationship between people and elephants. A commonly used questionnaire survey would definitely have missed many details. Conventional approaches in science suffer when faced with many important questions (Mearns 1991, Appleyard 1992), such as predicting or prescribing important and complex open systems. Large study areas with uncertain environmental issues demand a 'second old science' approach (Funtowics & Ravet 1990) involving second judgement for thorough coverage. It is in this context that this study took this approach. It is clear that TM District has two elephant populations and that CLs is an important dispersal area for elephants because of its rich and diverse flora and salt licks, which are preferred by elephants. However, unless the local people receive benefits from elephant conservation, HEC will escalate, as more land will be converted into incompatible land use strategies and elephants will lose all the important resources on CLs.

The results in this chapter anticipated and/or uncovered the following, which are investigated and discussed further in subsequent chapters:

- Identifying important elephant resources like salt licks (Chapters 5 & 6);
- Delineating present elephant range (Chapter 6);
- Defining existence of elephant migratory corridors (Chapter 6);
- Noting daily movement of elephants between MT and CLs (Chapter 6);
- Suggesting increased elephant movement onto CLs during the dry season wildebeest migration (Chapter 6);
- Showing that two elephant populations exist in TM District (Chapters 6 & 9);
- Suggesting types of conflict and where they occurred most (Chapter 7);
- Noting interruptions with education process (Chapter 7); and,
- Outlining factors contributing to HEC (Chapters 5, 6, 7, 8, 9, & 10).

The data could not be checked against other sources since very little research has been done in TM District. However, these findings were important in refining the questionnaires, identifying monitoring sites and re-designing scientific study methods in an attempt to confirm the responses from the local community scientifically. As change in socio-economic patterns was observed as the major cause of HEC, which equally has an implication on peoples attitudes and perceptions towards elephant conservation, in the next chapter I will discuss the socio-economic changes in relation to elephant conservation.

CHAPTER FOUR

Attitudes and perceptions of the Transmara community towards elephant conservation

4.1 Introduction

The assessment of peoples' attitudes and perceptions towards conservation has become an important aspect in many studies of wildlife conservation (Newmark *et al* 1993, Kasiki 1998, Ashenafi 2001). In the case of elephant conservation, success depends on the attitudes of people towards the species (Omondi 1994). Equally, understanding factors influencing attitudes is important to enable wildlife managers to implement approaches that attract support of the stakeholders and the general public. The Maasai have been better documented and more sympathetically described than most African people (Kituyi 1990). The Maasai community of Transmara (TM) District has undergone considerable recent transition that needs to be understood in relation to elephant conservation. The communal lands (CLs) around Masai Mara National Reserve (MMNR) are important habitat for the resident and migratory elephant population. However, the gradual death of pastoralism, a land use strategy compatible with wildlife conservation (Western 1989), and the introduction of crop farming has caused increasing human-elephant conflict (HEC), as in other elephant ranges (Kasiki 1998, Kailas 2000, Low 2000). Previous studies have shown that the local community may develop a negative attitude towards wildlife if their crops and livestock are depredated, and if no benefit is derived from wildlife resources (Omondi 1994).

TM District has undergone rapid changes in the social and economic terms (DDP 1997), which can influence the relationship between people and natural resources. This chapter aims to understand the attitudes of the TM District communities towards their activities, and their social, economic and technological context in relation to the elephant. This chapter aims to answer the following questions:

- What possible relationship exists between the various changes being experienced in TM District and the elephant?
- How can the forces shaping the environment of Maasai adaptive behaviour contribute to an understanding of the dynamics involved in conflict and attitude changes?
- How does the specific way in which material transformation occurs shape the way it affects the human-elephant relationship?
- What factors determine different opinions between respondents?

In this chapter, I describe human activities and family details (4.3.1), farming activities (4.3.2), livestock keeping (4.3.3) and peoples' attitudes and perceptions towards the elephant (4.3.4). I then examine factors determining these attitudes and perceptions (4.3.5). I then describe the problems with other wild animals (4.3.6) and with land issues (4.3.7) respectively. This chapter concludes with a discussion of these results (4.4).

4.2 Methods

Informal interviews were held with selected government officials, staff of Transmara County Council (TMCC), German Technical Cooperation (GTZ) and with the local community. Also interviewed were staff of Kenya Wildlife Services (KWS) (Appendix 2), chiefs and councillors, respectively. The purpose of the study was communicated to the officials through administrative channels, from whom permission was acquired and appointments made with the officials accordingly.

A multistage cluster sampling technique (de Vaus 1996), using structured interviews based on a questionnaire, was followed to collect information from the community (Appendix 3). Initially, the aim was to sample the entire TM District, but this was narrowed down to focus on the areas experiencing elephant problems. The district was divided into 54 smaller areas based on the administrative boundaries of sub-locations. To reduce sampling error further, 25 sub-locations in which elephants are present either permanently, seasonally or erratic were selected, based on the findings of the RRA survey (Chapter 3). Sketch maps within sub-locations showing locations of homesteads produced by GTZ formed the base for random choice of households. Random samples of a minimum of 10 households per sub-location were drawn, to give a total of 251 respondent out of which 169 were Maasais and 82 were non-Maasais. This sample size was adequate since the population is relatively homogeneous and gave similar responses (Moser & Kalton 1972), and a preliminary analysis had shown that an increase in the sample size would not have increased the precision (de Vaus 1996). However, the culture of the Maasai does not allow females to freely address issues concerning the Maasai livelihood (Sitati 1997), therefore, gender differences were not well represented. Therefore, from each household, one person was identified and interviewed. Any member of the household who was above 18 years was interviewed to give a balanced representation of views from all age groups and both sexes.

The purpose of the socio-economic information from a cross section of households was to gain an understanding of the wide range of variation between families in areas with different elephant impacts. The questionnaire was developed based on my past experience with the Maasai community. Sensitive questions were handled with care to elicit unequivocal responses. Pilot testing was done on a sample of 30 respondents and some questions were rewritten before final administration (de Vaus 1996). Each household was visited, the purpose was explained and interviews conducted on site. Both open and closed-ended questions were asked, and the respondents were encouraged to elaborate on points of interest and relevance. Also critical observations and use of indicators were employed to gather information in each homestead. A research assistant selected on the basis of his level of education was trained on the relevance of the questions and assisted in translation. A pre-test was conducted with the assistant to ensure that the questionnaire was fully understood.

During statistical analysis, relative frequencies were calculated based upon the total number of responses rather than upon the total number of people surveyed. However, in some questionnaires, relative frequencies were based upon the total number of people surveyed. Non-parametric statistics, comprising chi-squared and one-way ANOVA, were used to examine the relationships between variables. Chi-square test was used to compared the differences in response between the Maasai and non-Maasai. This was necessary because of the differences in their culture and traditions, which might have an implication for conservation. A multivariate analysis using forward logistic regression was performed to examine which socio-cultural-economic activities influence the attitude of the local people towards elephant conservation (Draper & Smith (1981). In the analysis, three logistic regression models were developed using three dependent variables against eight similar independent variables to identify the factors that determined the responses to the dependent variables. The dependent variables comprised: 'future of the elephant'; 'live with elephant'; and, 'benefits of elephant', which were all coded as '1' for yes and '0' for no. The independent variables examined comprised: age; sex; education level; occupation; family size; tribe; livestock numbers; and, land tenure. This was necessary to understand the factors that determined the response to 'future of elephants', 'live with elephants' and 'benefits and or value of elephants' based on different socio-economic and cultural differences, which are important tools for elephant conservation and management. Value and benefits are monetary and were understood by informants to be defined that way.

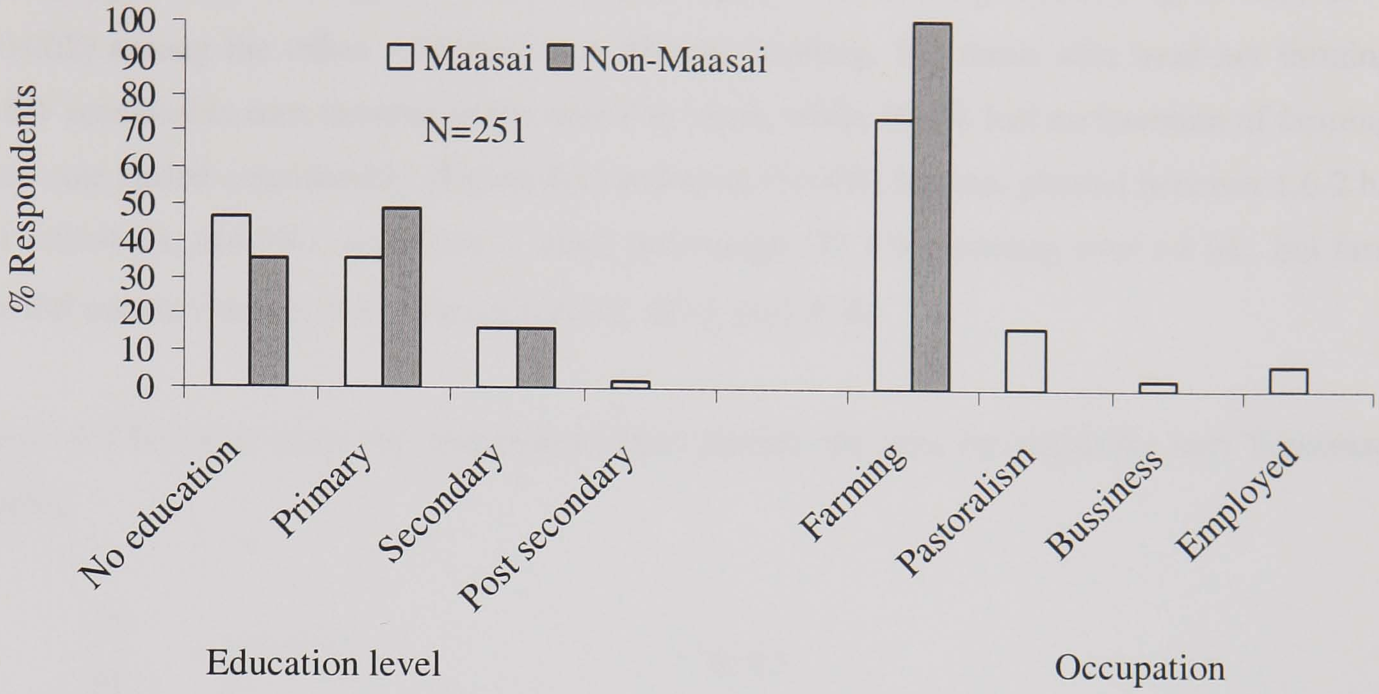
4.3 Results

4.3.1 Human activities and family details

Most respondents had no formal education (45%), or only primary levels of education (37.1%) (Figure 4.1). Educational levels did not differ (χ^2=3.384, df=3, p=0.336) between the Maasai and non-Maasai. Respondents engaged in different economic activities (Figure 4.1), with most (76.9%) engaged in farming, while a few (14.3%) kept livestock, and a very few (2.4%) were in business or other forms of employment (6.4%). However, more non-Maasai (100%) were engaged in farming (χ^2=10.529, df=2, p=0.015) than Maasai (73.4%).

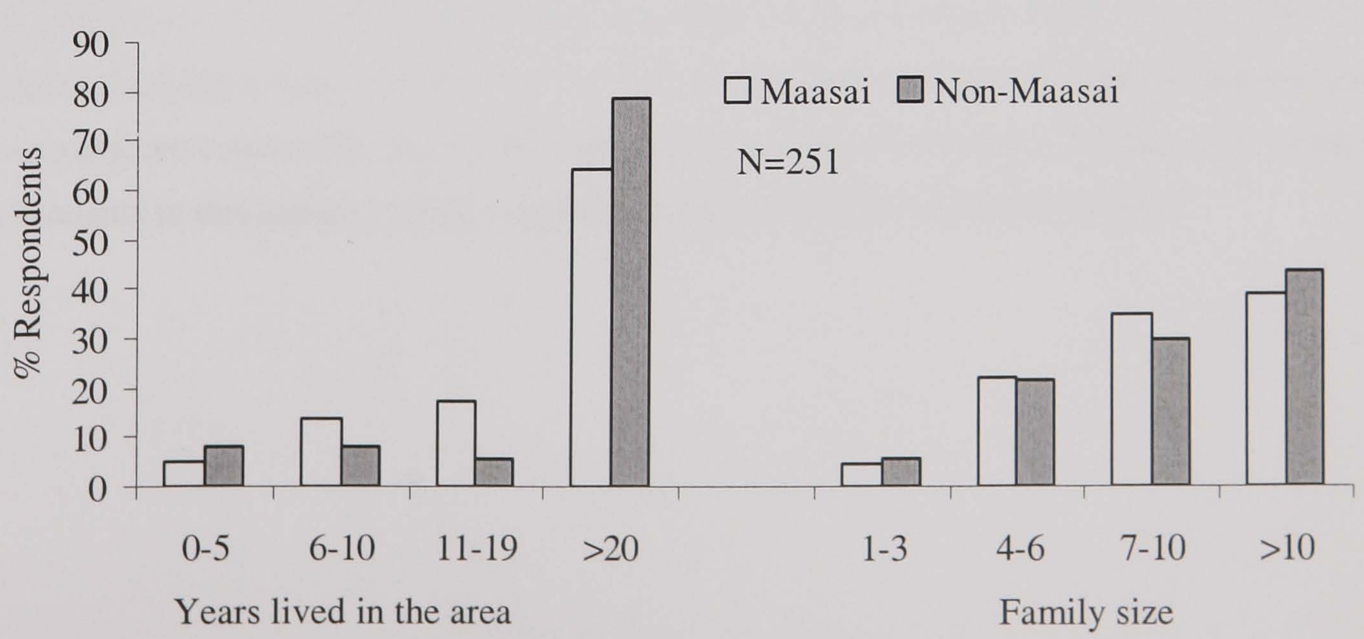
Most respondents (66.1%) had lived in the area for over 20 years (Figure 4.2) whilst fewer respondents had lived in the area for 11-19 years (15.5%), for 6-10 years (12.7%), or for 5 years (5.6%). However, length of residence did not differ (χ^2=5.082, df=3, p=0.166) between tribes. Family size ranged between 1 and 17 members. Most respondents had big families of 7-10 (33.9%) or more than 10 (39.4%) members, but the family size did not differ (χ^2=0.415, df=3, p=0.937) between tribes.

Figure 4.1 Education levels and occupations among respondents of different tribes in TM District.



Most respondents were born in the area (92.4%) but more Maasais (93.9%) were born in the area (χ^2=4.637, df=1, p=0.031) than non-Maasais (83.8%). Those who were born outside cited various reasons for immigration (Figure 4.3). Farming (33.3%) and registration of members under group ranches (27.8%) were the major cause of localised movement. Other people migrated to acquire more land for livestock keeping (16.7%), while marriage (16.7%) and colonialism (5.6%) were other factors. However, the reasons for migration differed between tribes ((χ^2=14.250, df=4, p=0.007) with non-Maasai moving in purposely to farm.

Figure 4.2 Length of residence and family size among respondents of different tribes in TM District.

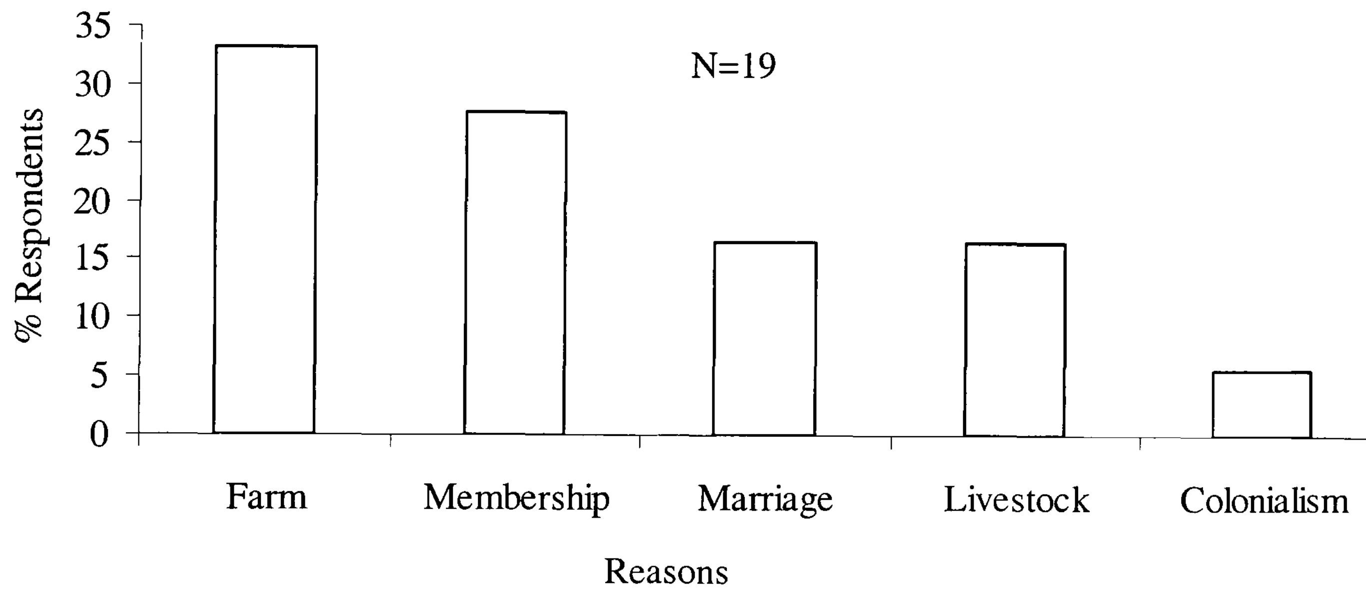


4.3.2 Land use activities

4.3.2.1 Crop farming

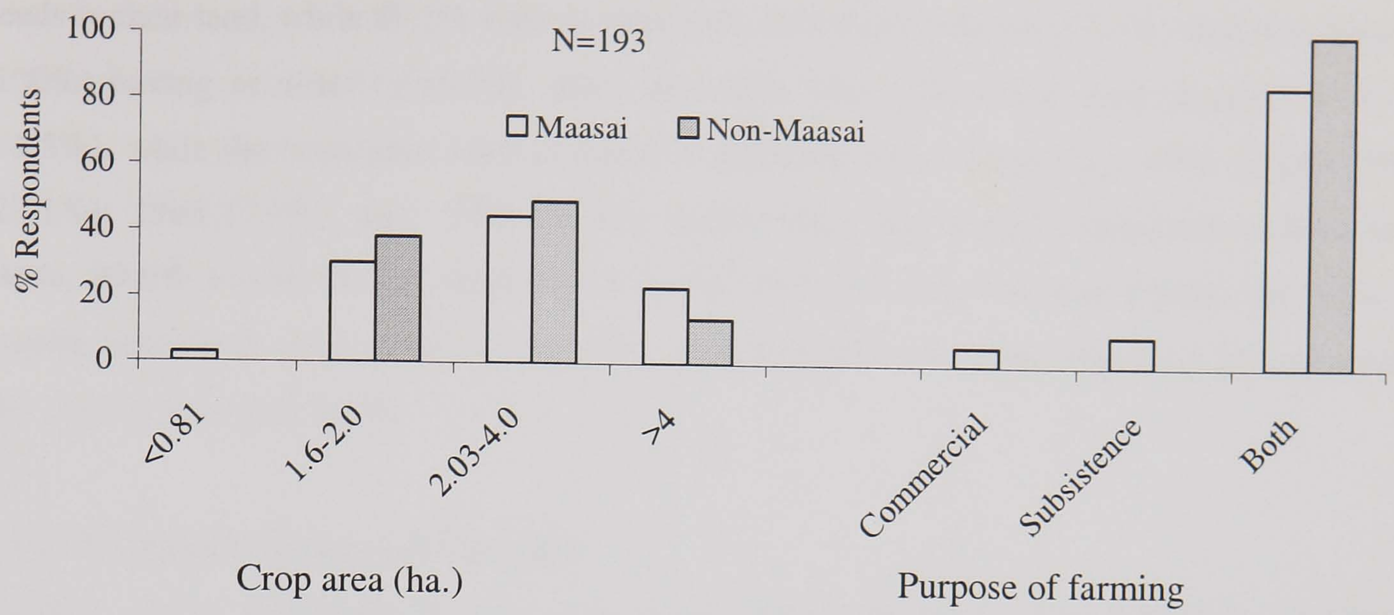
Most people were farming (76.9%), but participation in farming differed (χ^2=9.225, df=1, p=0.002) among the tribes with most non-Maasai farmimg. For those who were not farming, 81.8% intended to start farming in the next five years, while 18.2% had no intention of farming. Farm size varied considerably (Figure 4.4) and most (31.4%) farmers planted between 1.6-2 ha. and 2.03-4 ha. (44.9%), with only a small percentage (21.3%) growing over >4 ha., but farm size did not vary among the tribes (χ^2=3.092, df=3, p=0.378).

Figure 4.3 Reasons given by respondents born outside the area for migrating into Transmara District.



The purpose of growing crops was for both commercial and subsistence use (87.4%). Very few farms were either solely subsistence (7.7%) or solely commercial (4.8%). However, the purpose of growing crops differed between tribes (χ^2=6.472, df=2, p=0.039) with some Maasai growing for commercial, subsistence and for both while non-Maasai growing only for both commercial and subsistence. The wildlife destruction has hindered many people from farming (79.5%). In addition, keeping of grass for livestock (11.4%) and a lack of interest (9.1%) are reasons typical of a pastoralist community way of life and regard for livestock keeping. Equally, there were few respondents in this sample, which is perhaps a sign of a shift to agro-pastoralism.

Figure 4.4 Farm sizes, and reasons why most people farm in TM District.



The logistic regression model for factors that might have played a role in determining participation in crop farming was significant and produced a goodness of fit of 85.9% of observed to expected values (Table 4.1). Only the variables of division and livestock numbers were included in the model. Farmers with less than 20 livestock were more likely to farm than those with high livestock numbers. Respondents in Kirindoni and Lolgorian divisions, which border the MMNR and the community wildlife association, were more likely to farm than in other divisions. Equally, most of Keyian Division, which is located far from the MMNR, and has high rainfall, fertile soils and supports a resident elephant population, is under farming. However, the results should be interpreted carefully for Pirrar Division because of the small sample size.

Table 4.1 Factors influencing responses on the likelihood of farming in TM District, based on logistic regression.

Variable	B	SE	Wald	df	Sig	R
Constant	-0.272	0.499	0.296	1	0.5867	
Division			36.903	4	0.000***	0.354
Kirindoni	1.823	0.472	14.923	1	0.0001***	0.240
Lolgorian	3.121	0.629	24.583	1	0.000***	0.318
Pirrar	1.171	0.919	1.640	1	0.2003	0.000
Keyian	4.378	1.085	16.290	1	0.0001***	0.253
Livestock numbers			13.908	4	0.0076**	0.163
None	0.811	1.291	0.395	1	0.5296	0.000
<20	1.668	0.702	5.644	1	0.0175*	0.128
21-50	-0.243	0.564	0.186	1	0.6662	0.000
51-100	-0.794	0.566	1.968	1	0.1607	0.000

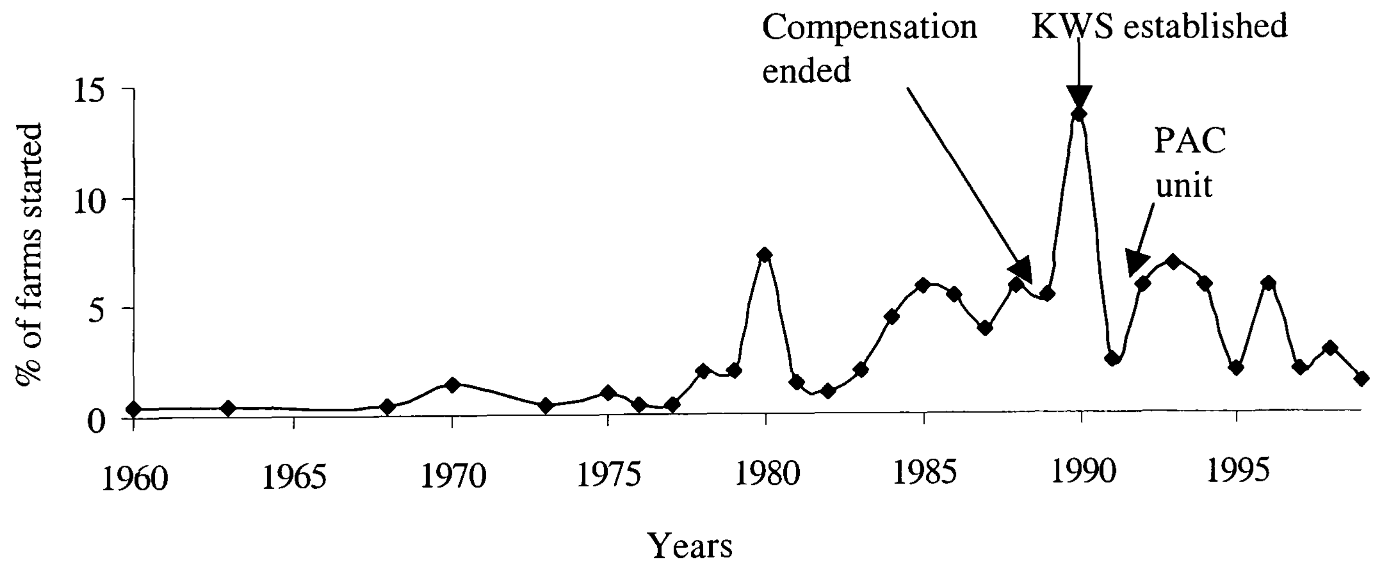
4.3.2.2 Land ownership

Land use in TM District has been largely communal. Only 10.8% of the respondents had title deeds to their land, while 89.2% were without title, with fewer Maasai (87.4%) than non-Maasai (100%) having no titles (χ^2=5.231, df=1, p=0.022). Most title deeds were acquired in 1997 (61.5%), while the remainder were acquired at different times, comprising: 1975 (3.8%); 1993 (23.1%); 1994 (7.7%); and, 1998 (3.8%), respectively. For those respondents without title deeds, 99.6% would like to obtain them, while 0.4% are not interested. Hence, the need to acquire title deeds differed (χ^2=5.104, df=1, p=0.024) between tribes where all Maasai would like to have land title deeds.

4.3.2.3 Commencement of farming

Farming started in TM District as early as the 1960s. However, there was little growth in farming until the late 1970s when big farms were started (Figure 4.5). Many farms were established in the 1980s because compensation was introduced for crop raiding. Further farms were started in 1990 after establishment of KWS, possibly the introduction of a good reporting system might improve the possibility of compensation. With increased conflict since the early 1990s and the end of compensation in 1989, most people have avoided farming. Establishment of Problem Animal Control (PAC) unit in 1992 resulted in fluctuations in farming depending on the policy guidelines. However, very few farms have been established since 1997.

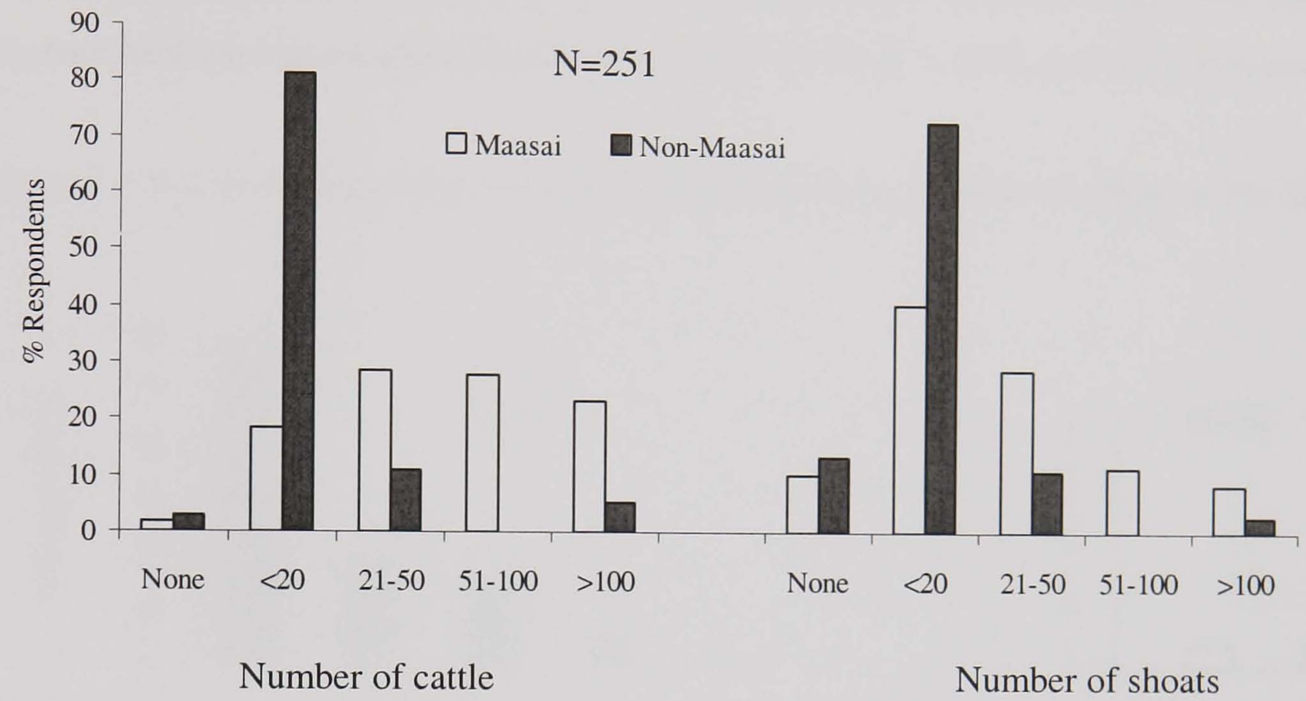
Figure 4.5 Pattern showing when respondents began farming in TM District.



4.3.2.4 Livestock keeping

Numbers of people keeping less than 20 cattle (27.5%), 21-50 cattle (25.9%), 51-100 cattle (23.9%) and more than 100 cattle (20.7%) were fairly evenly divided. However, people kept less than 20 shoats, thus sheep and goats (45.4%), while fewer people kept 21-50 shoats (26.3%), 51-100 shoats (10%) and >100 shoats (7.6%). Some Maasais did not have livestock and most cattle kept were less than 20 (Figure 4.6). The keeping of cattle by Maasais (85.3%) and by non-Maasai (14.7%) differed (χ^2=64.548, df=4, p=0.000), as did the keeping of shoats by Maasai (85.3%) and non-Maasai (14.7%) also differed (χ^2=17.199, df=4, p=0.002). Those with fewer livestock were non-Maasais, who are not allowed by the Maasai to keep livestock. Indeed, any attempt to do so has always ended up with them being stolen, because of the traditional Maasai belief that all livestock belongs to them.

Figure 4.6 Relative proportions of livestock numbers by tribe in TM District.



4.3.4 Elephant ecology and HEC

4.3.4.1 Status of elephant population in TM District

Most respondents felt the elephant population was increasing (82.1%), while 9.6% felt the population was declining, and 8.4% had no idea about the trend. Various reasons were given for the increase and the decline (Figure 4.7). An end to poaching (58.7%), increased availability of food (19.4%) and improved reproduction (15.5%) and were the main reasons for assuming an increase in the elephant population. The other reasons given included elephants not being speared by the local community (4.9%) and immigration of elephants onto CLs (1.5%). However, some respondents felt the population has declined in some areas because of increased human population (45.8%) and habitat loss (45.8%). However, a few felt that the decline was due to farming (4.2%) and being chased by the community (4.2%) but the status of elephant population differed (χ^2=21.474, df=2, p=0.000) between tribes with most non-Maasai having no idea.

4.3.4.2 Status of HEC

Elephants raided farms of 89.2% of respondents, comprising more raids (χ^2=16.273, df=1, p=0.000) of Maasai (92.5%) than non-Maasai (70.3%) farms. Most respondents (89.3%) felt that conflict has increased, while 10.3% felt that it has declined and 0.4% had no idea about the status of conflict. The status of conflict did not differ (χ^2=2.111, df=2, p=0.348) between tribes. Various possible reasons were given for the increase and decline of conflict (Figure 4.8).

Increases in the human population (38.9%), in the elephant population (34.1%), and in habitat encroachment (24%) were the main reasons given for an increase in conflict. However, a few respondents felt elephants have become bolder than before (1.4%), while intact forest (1.4%) seems to attract elephants from areas where the forest has been lost. However, those who thought there was a decline in conflict attributed this to increased human populations (34.8%), elephants having stopped visiting some areas (34.8%) and loss of habitat (30.4%). The reasons for increased HEC did not differ (χ^2=2.551, df=4, p=0.635) between tribes. The size of the elephant herd seen on communal lands did not differ (χ^2=3.422, df=3, p=0.331) between tribes.

Figure 4.7 Possible explanations for increasing and declining elephant numbers in TM District.

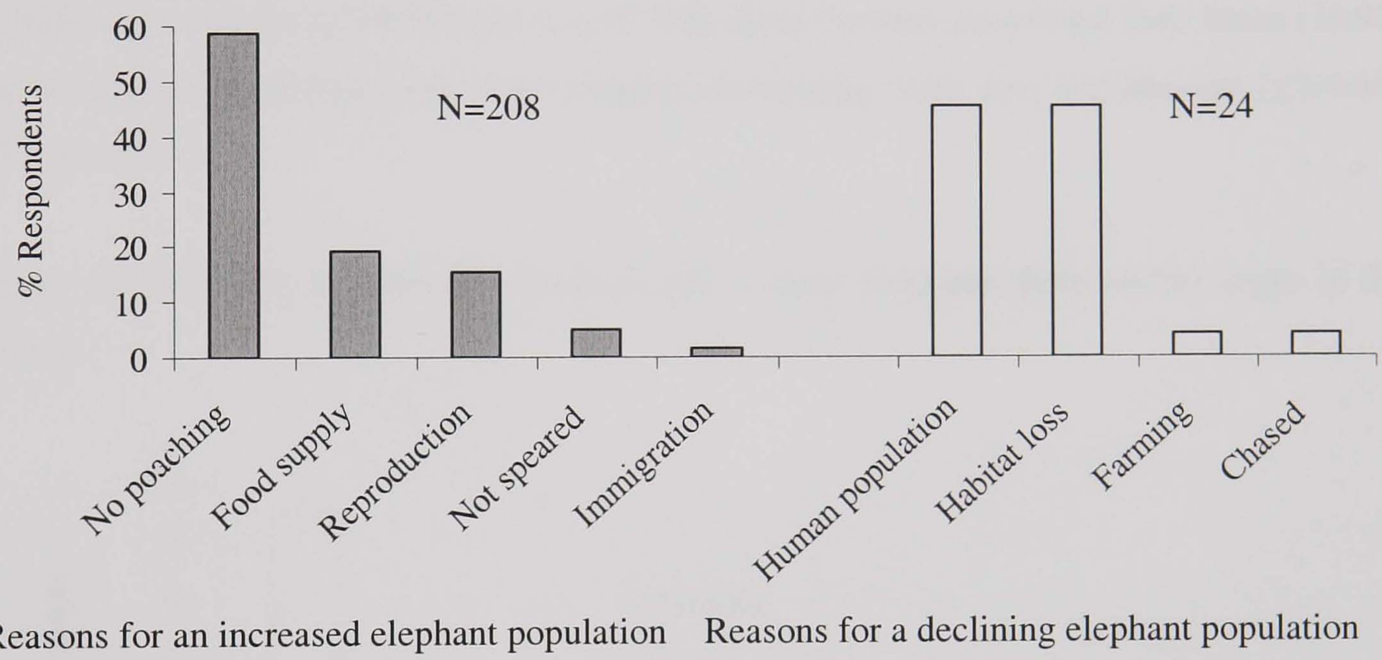
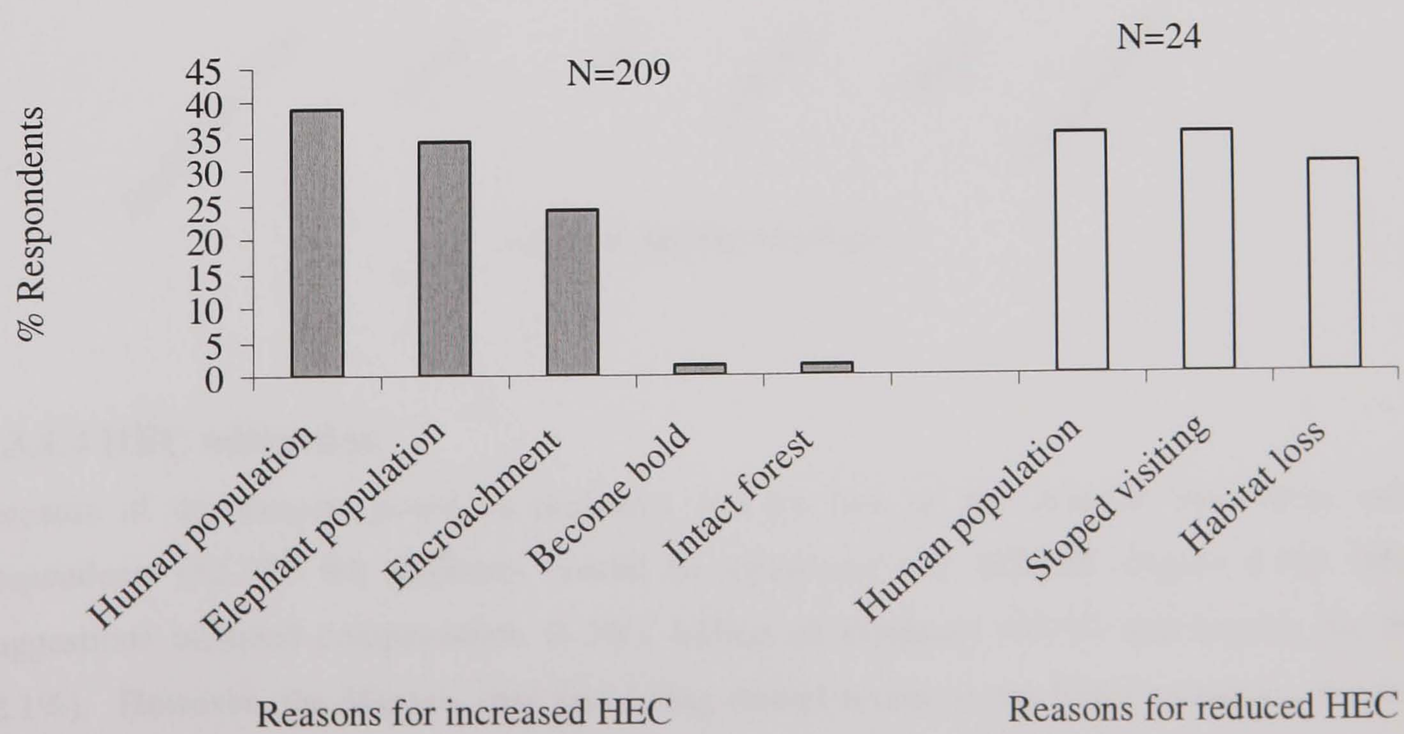


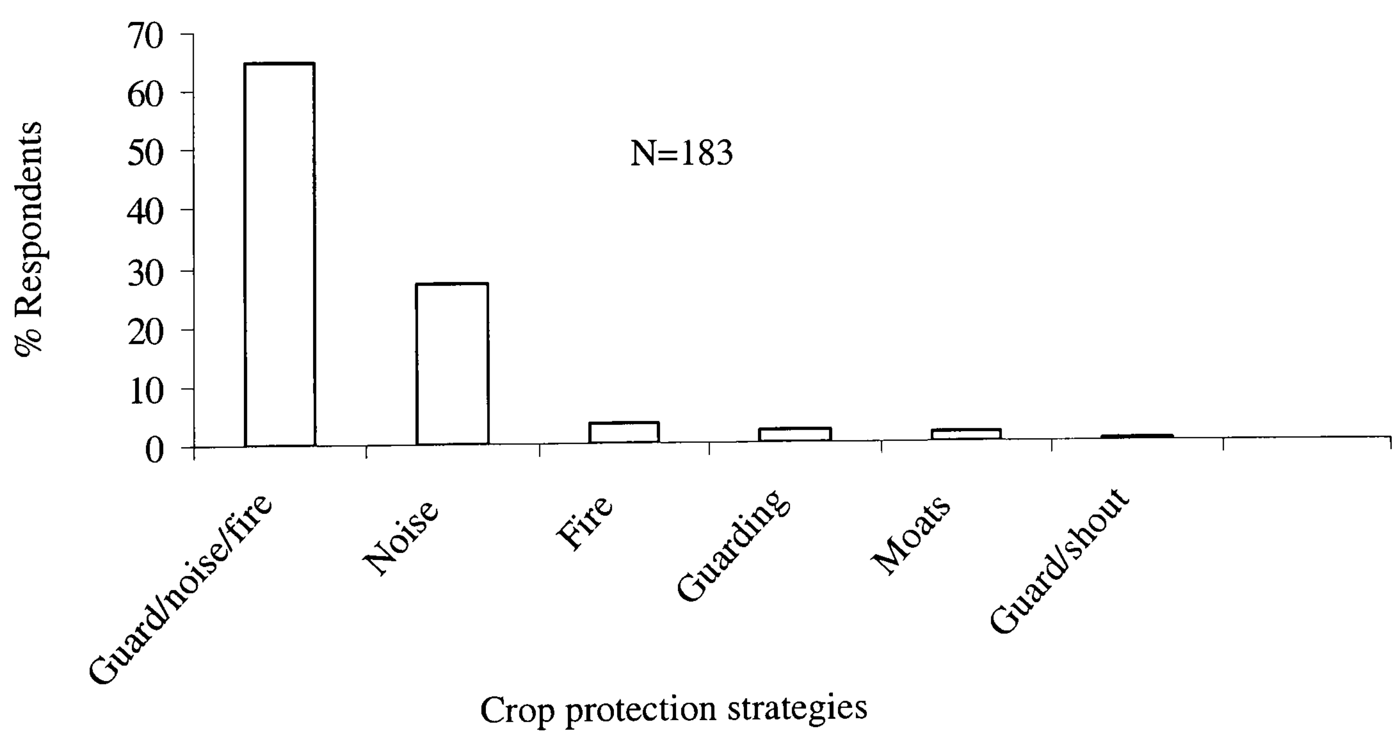
Figure 4.8 Possible explanations for the increase and decline of HEC in TM District.



4.3.4.3 Crop protection strategies

The community generally felt that a combination of guarding, fire and noise were the most commonly used methods (65%). The only single strategy of any use was noise (27.3%) from tins and drums (Figure 4.9). However, using any single strategy of guarding (2.2%), fire (3.3%) and moats (1.6%) were not useful in deterring elephants. Nevertheless, a combination of guarding and shouting (0.5%) is risky and most people prefer to keep quiet. Fencing is not useful against elephants but most farms are fenced (92.4%), mainly to keep off other wildlife species and to alert the guard when broken by elephants. However, fenced farms did not differ (χ^2=0.723, df=1, p=0.395) between tribes. Crop protection measures differed (χ^2=18.189, df=5, p=0.003) between tribes with most non-Maasai lighting fire and making noise. However, reporting to KWS did not differ among tribes (χ^2= 0.098, df=1, p=0.754) nor did the response by KWS to each tribe (χ^2=0.707, df=1, p=0.702). Some farmers abandoned their farms (28.9%) due to elephant problems, with more Maasais abandoning them than non-Maasais (χ^2=4.662, df=1, p=0.031).

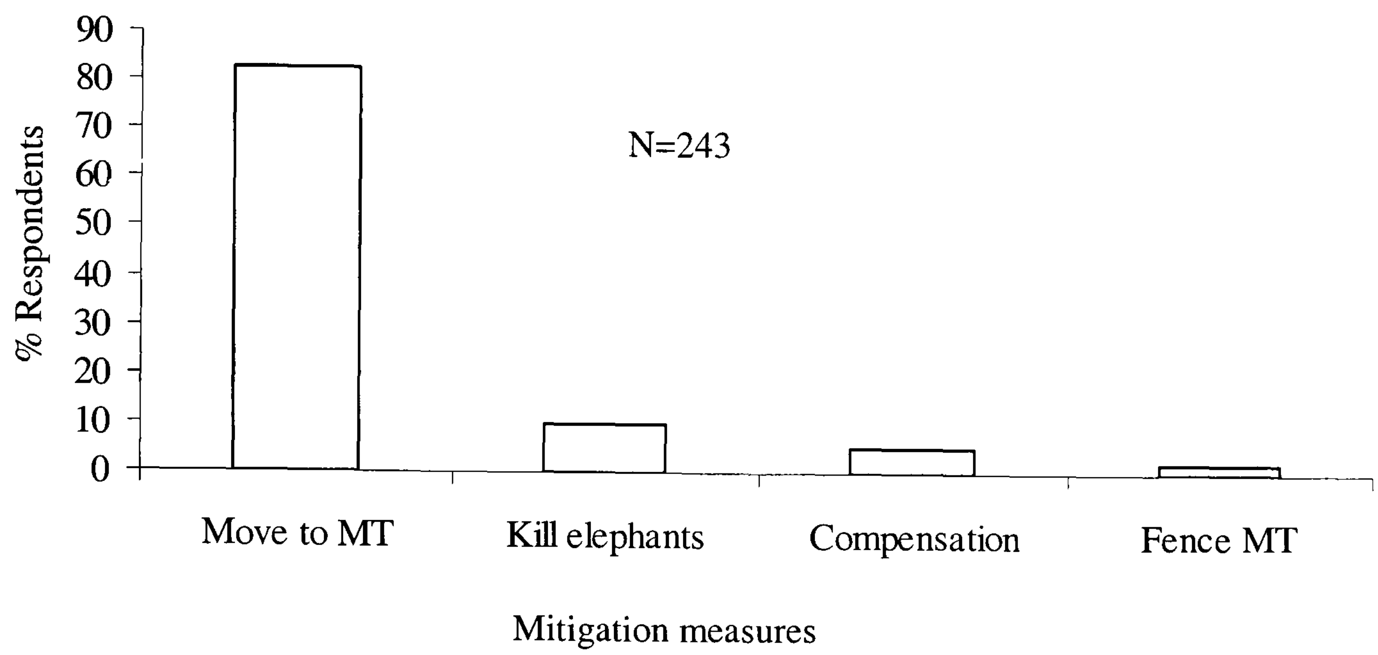
Figure 4.9 Strategies employed by local people to deter elephants from raiding crops in TM District.



4.3.4.4 HEC mitigation

Because of the dangers posed by elephants and the lack of any benefits from them, most respondents (82.7%) felt elephants should be repatriated into MMNR (Figure 4.10). Other suggestions included compensation (5.3%), killing all elephants (9.9%) and fencing the MT (2.1%). However, the Maasais may fear being denied access to the Mara resources. Possible mitigation measures suggested by respondents did not differ (χ^2=1.767, df=3, p=0.779) between tribes. However, benefits accrued to the respondents did not differ (χ^2=0.997, df=1, p=0.318) between tribes and most respondents claimed they do not receive benefits from wildlife conservation.

Figure 4.10 Possible conflict mitigation measures suggested by respondents in TM District.



4.3.5 Attitudes and perceptions towards the elephant

4.3.5.1 Value of the elephant

Most respondents (90%) in TM District did not consider the elephant as beneficial, with no difference (χ^2=4.947, df=1, p=0.084) between Maasai and non-Maasai. Only 10% agreed that elephants are beneficial, mainly through tourism earnings (65.2%), provision of security against cattle theft (26.1%) and the digging of wells (8.7%). When asked more generally if wildlife is beneficial, 80.5% said it was not beneficial, and 19.5% said it was beneficial. This represented a small increase compared with those who thought the elephant is of value. However, the response did not differ among the tribes (χ^2=0.997, df=1, p=0.318).

The logistic regression model for factors that might have played a role in determining whether elephants were beneficial to the community was significant and produced a goodness of fit of 90.8% of observed to expected values. Benefit and division were the only factors that were included in the model (Table 4.2). Surprisingly, those who are meant to receive benefit were more likely to say that elephants are of no monetary value. Respondents from Kirindoni and Lolgorian divisions were more likely to say that elephants were of value because these divisions border MMNR and it is a policy that these areas receive benefits from revenue collected. In contrast, respondents from Pirrar and Keyian divisions were more likely to say the elephant is not beneficial, because these divisions are located far from MMNR and suffer the most elephant problems, yet they do not receive any benefits.

Table 4.2 Factors influencing responses on the value of elephants in TM District, based on logistic regression.

Variable	B	S.E	Wald	df	Sig.	R
Constant	-8.556	56.47	0.023	1	0.8796	
Benefits	-2.647	0.615	18.50	1	0.001***	-0.348
Division			6.069	4	0.194	0.000
Kirindoni	8.739	56.47	0.024	1	0.877	0.000
Lolgorian	7.272	56.47	0.017	1	0.897	0.000
Pirrar	-0.00000000003	111.16	0.000	1	1.000	0.000
Keyian	-0.00000000003	70.87	0.000	1	1.000	0.000

Level of significance shown with ***=p<0.001

4.3.5.2 Future of the elephant

Most respondents felt that the future of elephants in TM District is bleak (95%), and only 5% said it is good, and the response did not differ among the tribes (χ^2=0.143, df=1, p=0.705). Those who wish to live with elephants did not differ (χ^2=0.2263, df=1, p=0.608) between tribes. The logistic regression model for factors that might have influenced the response was significant and produced a goodness of fit of 95.8% of observed to expected values. Sex and division were the two variables that were included in the model (Table 4.3). Males were more likely than females to say the future of elephants is good. Respondents from Lolgorian Division, that has most of the remaining elephant range, were most likely to say the future of the elephant is bleak.

Table 4.3 Factors influencing responses on the 'future' of elephants in TM District, based on logistic regression.

Variable	B	S.E	Wald	df	Sig.	R
Constant	-1.741	0.582	8.942	1	0.0028**	
Sex	2.670	1.052	6.434	1	0.0112**	0.237
Division			7.674	4	0.1043	0.000
Kirindoni	-1.319	0.838	2.482	1	0.1151	-0.078
Lologorian	-3.179	1.285	6.117	1	0.0134**	-0.229
Pirrar	-0.295	1.189	0.062	1	0.8040	0.000
Keyian	-8.462	26.309	0.103	1	0.7477	0.000

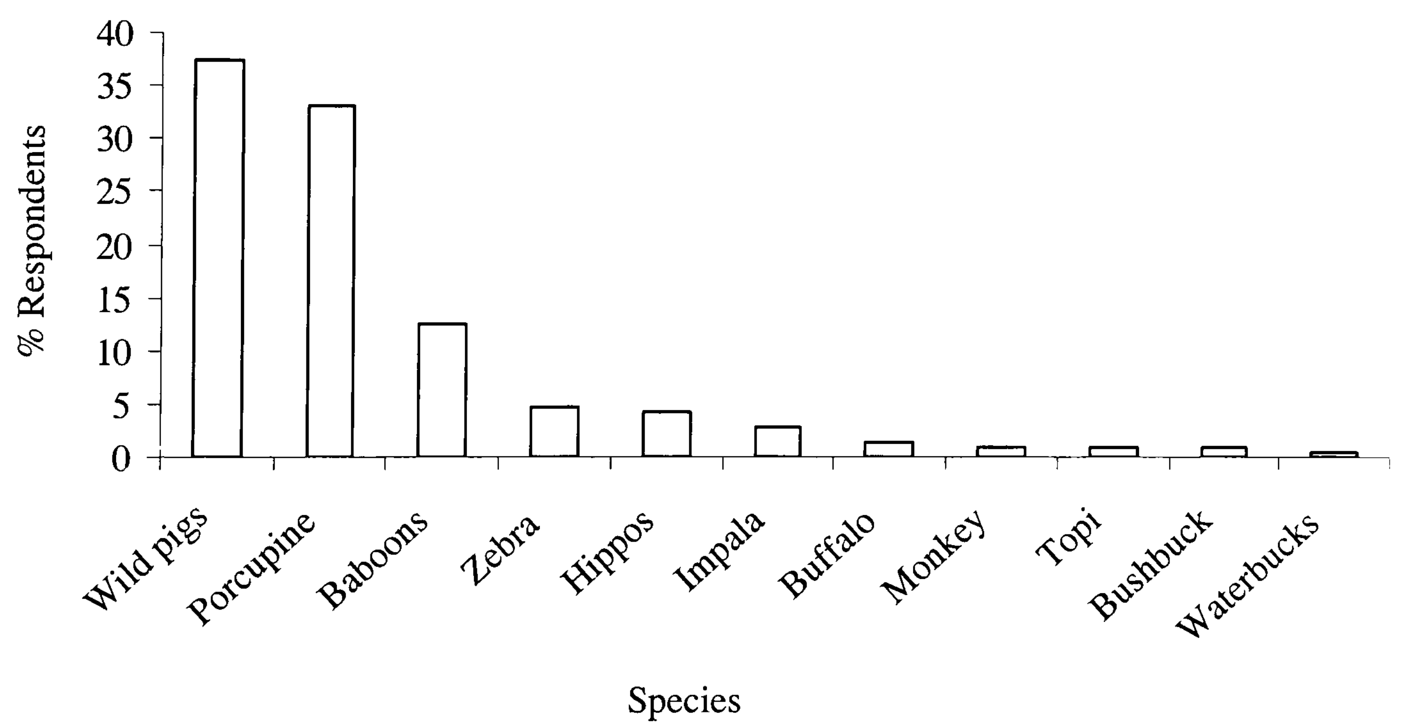
Level of significance shown with **=p<0.01

Most respondents do not want to continue sharing their land with elephants (95%) while only 5% wish to live with elephants. The response did not differ among the tribes (χ^2=0.263, df=1, p=0.608). However, the factors that might have influenced the response were tested and none of the factors could be included in the model, which had 94.95% goodness of fit meaning high variation in responses.

4.3.6 Other problem wild animals

Wild animal species other than the elephant were variously ranked as causing most problems (Figure 4.11). A total of 11 wildlife species were listed as problematic. Wild pigs (37.5%), porcupine (33.2%) and baboons (12.5%) are viewed as causing most problems. Other species like zebra (4.8%), hippos (4.3%), impala (2.9%), buffalo (1.4%), monkey (1.0%), topi (1.0%), bushbuck (1.0%) and waterbuck (0.5%) were regarded as posing few problems. This might be because of differences in the spatial distribution of different wildlife species. For instance, areas near Mara River are prone to hippo problems unlike areas near Mogor River, which has no hippos. Equally, baboons and monkeys are highly localised and attack during the day, unlike wild pigs and porcupine that attack crops at night and are highly dispersed. However, other problem wildlife species differed (χ^2=19.523, df=10, p=0.034) between tribes.

Figure 4.11 Ranking of other destructive wildlife species in TM District.



4.4 Discussion

Many communities in wildlife areas do not receive benefits and yet they bear the costs of living with wildlife (Kiss 1990). As a result, the communities develop a negative attitude towards conservation (Omondi 1994, Hill 1998). However, despite the costs of living with wildlife, some communities have retained a positive attitude towards conservation (Newmark *et al* 1993, DeBoer & Banguete 1998). A rapid decline of wildlife has been noted in areas where benefits are not accrued to the local community (Norton-Griffiths 1998). This is because the community tries to engage in other land use types that are not only detrimental to wildlife population, but also cause increased conflicts. TM District is a typical example of such an area. Chapter 4 has shown that by denying people benefits from resources, the local people are bound to develop a negative attitude towards the resource and engage in activities that are detrimental to conservation. This supports the findings of the RRA survey. Therefore, the future of the elephant in TM District is uncertain, and many members of the community are no longer wishing to "live with" elephants.

4.4.1 Socio-economic changes among the Maasai of TM District

TM District has experienced socio-economic and cultural changes just like anywhere else. However, the Maasais are victims of accusations comprising: (a) clinging to ancient and outmoded pastoral practices that make no contribution to national economic development; and, (b) resisting integration into the Kenyan nation (Kituyi 1990). Indeed, the resistance of Maasai to integration has been beneficial to conservation (Parkipuny 1996). However, a key question that continues to challenge the minds of conservationists is whether or not the Maasai community should retain their culture for the sake of conservation, even if it does not benefit the majority of them.

Clumped settlements constituted by kin co-operating on labour and security tasks is disappearing as solitary farming settlements proliferate. The types of houses are also changing, while family size is reducing. For instance, in areas of northern TM District, relatively permanent structures are replacing temporary huts, and a new form of prestige and permanency is emerging that is normally associated with sedentary societies.

The severe drought and rinderpest epidemic of the late 1880's and early 1890's led to the loss of over 80% livestock and over 60% of people died. Many Maasai's adapted as Dorobo hunter-gatherers, while others sought shelter among agricultural neighbours, and others sold their children in exchange for food (Kituyi 1990). Hence, Maasai developed farming skills and the eating of cereals. Farming started to expand with the coming of the Moitanik, and the Uasin Gishu Maasai clans from western Kenya intermarried with the farming tribes. Currently, the Maasai can no longer satisfy their grain needs through the sale of livestock and livestock products, because drought and disease have reduced livestock, while a high human population remains. Equally, inflated prices and unfavourable terms of trade between pastoralists and agricultural products have limited access to agricultural products, further encouraging Maasais to engage in cultivation.

4.4.2 Attitude and perception towards elephants

The future of the elephant in TM District is thought bleak (Table 4.3) and most people are not willing to "live with" the elephant because of lack of elephant related benefits to the community (Table 4.2). Therefore, with more people wishing to farm in the next few years, and further habitat loss and increasing human population, complicated the future elephant conservation efforts. In order to promote peaceful co-existence, respondents feel that elephants should either be moved to the MMNR (Figure 4.10) or their attitudes and incompatible activities should be reversed through realisation of benefits from elephants and other wildlife. The respondents who were against fencing MMNR fear loosing access to salt licks and pasture.

4.4.3 Land use benefits

When local people do not benefit from conservation, they lack the commitment to conservation objectives (Mwamfupe 1998). As a result of conflict, local communities develop negative attitudes towards elephants (Ndung'u 1998, Kasiki 1998, O'Connell-Rodwell *et al* 2000). However, some communities were aware of the benefits of elephants and PAC was preferred as the best conflict control strategy (Ndung'u 1998). As a result of lack of benefits, Kenya has lost over 44% of its wildlife in the last 18 years (GOK 1995a, 1995b). Norton-Griffiths (1998) blames this loss on major policy failure. This trend is serious because about 70% of wildlife live permanently or seasonally outside PAs (GOK 1995c). Hence, PAs have been only partially effective in wildlife conservation, losing less wildlife than areas outside PAs (GOK 1995a, GOK 1995b). However, some communities still retain a positive attitude towards elephants (Kangwana 1995, Newmark *et al* 1993).

The respondents who are purported to receive benefits from wildlife tend to believe that elephants are not beneficial. A common feeling within the community was that "we just hear that wildlife is beneficial, but we don't see any benefits". Probable reasons are either: that the revenue does not trickle down to the common people; or that the earnings are not sufficient for the reserve management to share with the community; or that revenue goes to the wrong people. TM District has a less developed tourism industry than Narok, especially on CLs where people can benefit directly from tourism activities. Only three lodges are sited on CLs in TM District, while the Narok side has over 50 lodges and campsites. Hence, the accrued revenue is insufficient to be seen as a benefit from wildlife. Poor infrastructural development and insecurity have hampered tourism development, while mismanagement of one of the three lodges resulted in its closure. Hence, the tourism potential of TM District, which includes bird watching in the forest, climbing the escarpment and educational activities on forests apart from game viewing, is not fully tapped.

Wildlife loss in non-tourism areas is higher than in tourism areas because the derived benefits support conservation activities and people are willing to conserve because of these benefits. Direct benefits are more important than indirect benefits through social investments (WCMC 1992, Goodwin 1996). The TMCC enforce their property rights to the MT by granting access only to tourists and by excluding landowners. Natural resources like salt licks have been alienated from the local community. At the same time, wildlife raises the costs of livestock and agricultural production, the extent of property destruction and loss of human life, and grazing competition reduces net benefits of livestock (Norton-Griffiths 1996). Because of conflict, landowners are forced to take all kinds of defensive activities, some of which are detrimental to wildlife and the majority of landowners would like to see all wildlife eradicated and PAs opened for development (KWS 1995c).

The KWS policy towards community conservation (KWS 1995a & 1996) aims to ensure that landowners are partners in conservation with KWS rather than opponents by providing incentives (KWS 1995a & 1996, Knock 1995). However, there are doubts and uncertainty on the new KWS approach because of many compliance costs and unnecessary regulations that discourage landowners. Thus the policy of allowing limited consumptive wildlife utilisation, of licensing wildlife associations, of opening up of more tourist circuits, of establishing Wildlife Development Funds (WDF), and of assisting land owners to start their own private tourist operations like campsites, has not succeeded.

TM District has areas of both high and low agricultural potential. Hence, the opportunity costs of conservation will vary. Areas of high agricultural potential enjoy high net returns from the land, but opportunity costs for conservation are high. However, all the high potential areas are heavily settled and are under farming without wildlife. The low potential areas have low net returns, low opportunity costs and low costs of maintaining land for conservation, which can easily be met by wildlife-generated benefits. Otherwise, promoting conservation interests without compensation condemns the Maasai to a poverty trap (Homewood & Rodgers 1991). Therefore, there is need to review policy options for landowners to manage their own tourism ventures to receive greater benefits, and to allow consumptive use of wildlife and distribute benefits to communities or supports a lease-back policy to pay economic rents to land owners for not developing their land (Adger & Brown 1994, Thurrow 1996, Norton-Griffiths 1998).

4.4.4 Implications for management

The future of elephants in TM District will depend largely on how the local community will utilise their land and immigration of the non-Maasais into the district. The negative attitude developed by the local community towards elephants is as a result of lack of wildlife-related monetary benefits. There is need to correct this attitude by initiating entrepreneurial activities that can generate income to the local community to offset the costs incurred and at the same time discourage land use strategies that are incompatible with elephant conservation. The time to act is now since elephants in TM District have a bleak future while CLs are important for migratory and resident elephant populations.

Given different views on elephant problems, which were mainly related to the transformation of the Maasai from pastoralism to agro-pastoralism, the next chapter will focus on the extent of land use and land cover changes that have occurred in TM District, which in turn will be related to elephant distribution and conflict.

CHAPTER FIVE

Land use patterns in Transmara District

5.1 Introduction

Human induced changes in land use are as ancient as human kind (Turner *et al* 1993). The unprecedented rates of land use change particularly since the middle of the last century have been reported elsewhere (Turner *et al* 1990). This has been attributed to society's demand for physical resources, expansion of technological, managerial, and institutional capacity to produce, move, and consume resources (Thomas 1956, Wolman & Fournier 1987). Ojima *et al* (1991) argues that changes in land cover can only be understood with better knowledge of the land use changes that drive them and their links to human causes. However, relating human driving forces of land use to changes in land cover is difficult because of the complexity of the interactions between human and environmental factors, and the different ways these interactions unfold in different areas.

The rising human population in Transmara (TM) District has created a large demand to expand food crop cultivation into elephant frontier zones, resulting in serious resource-use conflicts between pastoralism, agriculture and elephants. Hence, the elephant is viewed as the most destructive wildlife species (Deodatus & Lipiya 1991, Omondi 1994, Hillman-Smith *et al* 1995, Sitati 1997). Dublin (1986) reported the potential for habitat damage by elephants and increased conflict with humans in the Masai Mara National Reserve (MMNR) region. According to KWS (1994), changes in land tenure and land use increases sensitivity and intensity of conflict and TM District is one of the elephant areas experiencing these changes.

Much documentation on land use patterns in other areas has been produced. However, the dynamics of major land use and important uses are never investigated (Turner *et al* 1993). This study considered the dynamics of land use change as an important component in trying to understand the evolution of human-elephant conflict (HEC) whose findings are also important to upgrading the already proposed land use plan of TM District (Chapter 11). Considerable changes in land use have occurred in the TM District over the past 25 years especially on communal lands (CLs). In the 1970s, the human population was low, and there was nomadic pastoralism and communal land tenure (Pratt & Gwynne 1977). Today, the human population in TM District is rapidly increasing (4.1%) per annum, and permanent human settlements, agriculture and livestock productions have expanded considerably (Lamprey 1985, Omondi 1994, Kiyiapi *et al* 1996, Ottichilo 2000). As a result, areas hitherto occupied by elephant and/or used seasonally for semi-nomadic pastoralism are rapidly shrinking and contributing to increased HEC.

The future and sustainability of elephant management systems in TM District protected area or open ranges will largely depend on the way rural communities allocate and use their land. Kailas (2000) and Smith & Kasiki (2000) considered the component of land use in their studies. This chapter analyses the changes in land use types, patterns and trends in TM District, which will finally be related to HEC. This chapter aims to answer the following questions:

- What is the trend and density pattern of the human population in TM District?
- How are different ethnic groups distributed in TM District and how has this distribution resulted in land-related conflicts and tensions?
- What land tenure patterns exist in TM District and how are they related to elephant range?
- What are the types of land use and cover types that exist in TM District?
- How has land under farming and forest changed over time?
- What are the implications of these changes to elephant conservation in TM District?

In this chapter, I describe changes in human population and density (5.3.1), land tenure, ethnic distribution and land conflicts (5.3.2), changes in land cover (5.3.3) and changes in land use types (5.3.4). I then describe the correlates of deforestation (5.3.5) and other land uses (5.3.6). This chapter concludes with a discussion of these results (5.4).

5.2 Methods

5.2.1 Human population density patterns and related activities

Human population data for 1948, 1969, 1979, 1989 and 1999 were obtained from the Central Bureau of Statistics (CBS), Ministry of Planning and National Development. The 1999 census data were imported in Atlas GIS program and transformed into density range fill maps. These data were compared with the density map produced for 1989 by Transmara Development Program (TDP) (1994), to compare spatial changes in human population density. Other important human activities were also mapped using a GPS, and were entered into a GIS. Analysis was done using ANOVA and chi-square tests.

5.2.2 Land tenure pattern, ethnic distribution and land use conflict

Land tenure data were obtained from the Ministry of Lands and Adjudication office, which showed the land sub-division process in TM District. This information was digitised and entered into a GIS to map the spatial distribution of different land tenure patterns, and to extrapolate areas of each. Data on ethnic and/or clan distributions were obtained from local administrators through interviews, and their boundaries were also digitised and mapped to compare with their distribution in 1992. The areas of land under different tenure systems were extrapolated and their percentages were obtained. Tests for comparisons were performed using a chi-square test. Information on land-related tribal or inter-clan fighting was obtained from the District

Commissioner and through interviews of the local people. Specific areas of fighting were mapped and entered into a GIS. The ethnic groups involved in conflict were ranked using a pair wise matrix and the proportion of each ethnic group involved in fighting was calculated.

5.2.3 Land use and land cover patterns

Secondary data on the historical and physiographic features of the study area, on human and elephant numbers over time, land use patterns, and on distribution of vegetation types, were obtained from various sources including maps, government and private documents. These materials were found from civil sources including the District Commissioner's reports, Transmara County Council (TMCC), Masai Mara National Reserve (MMNR), German Technical Cooperation (GTZ), Central Bureau of Statistics (CBS), Ministry of Agriculture (MOA), Soil Survey of Kenya, Sebimu Mining and Exploration Co. Ltd, and Department of Resource Survey and Remote Sensing (DRSRS).

5.2.3.1 Land cover types

Aerial photo slides of TM District were obtained from DRSRS for 1986, 1991, 1993, and 1997. The photo slides were taken at approximately 90 m height and cover an area of 45-50 ha depending on the terrain, at a scale of 1:12000 (Norton-Griffiths 1978). The number of photo slides varied depending on the survey area covered and the strip width. The year 1986 had 61 slides, 1991 had 183, 1993 had 182, and 1997 had 178 slides, respectively. The photos were interpreted visually and proportions of different land use and cover types were estimated using a dot grid analysis.

The dot grid method of photo interpretation is a system whereby a given number of dots representing different types of land use are systematically arranged on a white sheet of paper. Regularly arranged dots are normally used because interpretation is faster, and it is easier to identify and count the dots. The standard number of dots on a grid is 100, which was preferred because one crop was seen to cover the whole slide photo, particularly in the north and south of the TM District. In such cases, the 100-dot grid works better than in areas where scattered small-scale farming is practised and different types of crops are grown.

The interpretation begins from the bottom of the left-hand side of the dot grid and systematically moves upto the last dot on the top of the right-hand side, thereby allowing the recorder to check that no dots are omitted. In cases where a dot fell on the boundary of two crops, the crop on which most of the dot fell was recorded. Nevertheless, if a dot fell equally on two crops, then both crops were recorded to keep a total of 100. The limitation of the dot grid method is that it might indicate absence of a particular feature when in fact, it was there but could not be recognised because it did not fall on the dot. Hence, that is why odd trends can be noticed in changes that are apparently very gradual.

Photo interpretation was supplemented by ground observation, which varied depending on the following: the type of interpretation; the accuracy required; the quality of slide photos; and, the knowledge of local conditions. In cases where high accuracy was required, it was necessary to conduct ground checks before, during and after the interpretation. Land use practices vary according to culture, politics, climate, soil type, and crop type. Successful photo interpretation entailed knowledge of all these factors, since TM District has varied ethnic groups, climate and soils. Field observations gave adequate weight to these variations because distinct variations occurred between adjoining farms or parts of the same farm in some areas. Consultations were held with farmers to familiarise myself with the local conditions.

Before a survey was started, aerial photo slides were studied to note areas of special interest, such as: points of observation; roads; road cuts; pits; and, other physical and topographic features. Photo slides of special interest areas were studied in more detail. Specific trees and buildings, such as schools, made orientation on the ground easier once the time of the day that the photos were taken, shadows, and direction of the aircraft, were known. Accuracy in interpretation was attained by the double interpretation method where three people interpreted the same photograph screened on the wall using a projector. In case of any doubt, a discussion was held to reach a solution either through reasoned discussion and/or recommendations for further field checks. Finally, the percentages of different land use classes were calculated and an ANOVA test performed.

5.2.3.2 Land use patterns

Data on sizes of forests and farming areas were obtained from previous work by Kiyiapi *et al* (1996). The 1996 land-use survey map was upgraded during field surveys, and aerial photographic data were incorporated to produce the current land use map. Emphasis was placed on land use types that conflict with elephant conservation, following the procedure described by Sitati (1997). The map was ground truthed to confirm and correct the different land cover types. A GPS was used to map new land use patterns that were not shown on the 1996 map, including new areas under farming, areas of wire grass infestation, and *Acacia* woodlands. The information was digitised and entered into a GIS program using Atlas software to generate maps. Data was analysed using ANOVA and linear regression.

The typology of deforestation patterns based on Husson *et al* (1995) were used to draw patterns of deforestation, based on proposals of geometric, corridor, fishbone, diffuse, patchy and island loss. The patterns were determined based on local knowledge of the area, and on land use and cover maps. Four spatial variables were generated using GIS software package Arcview 3.1 analysis tools, following the procedure of Mertens and Lambin (1997). These included: (a) distance to the nearest road; (b) distance to the nearest town; (c) distance to the forest edge; and, (d) spatial fragmentation of the forest cover in each location. Kilgoris is the only big town in

TM District that was considered in the analysis. For spatial forest fragmentation, calculation was based on the Matheron index, M, (Matheron 1970). A 1 km^2 of *Pixels* were generated by Arcview and used during analysis because small pixels are more accurate at representing spatial data with finer resolution and is suitable for forests which are not seriously deforested. This was overlaid on the forest layer to calculate pixels with or without the forest. A series of univariate spatial models were built with a measure of deforestation frequency as the dependent variable against distance to road, town, forest edge and fragmentation. The dependent variable was measured as the frequency of occurrence of the pixel attribute 'deforestation' per interval of values of the independent variables. The derived frequencies were subjected to least-square regression against the successive independent variables, as follows:

$$M = \frac{\text{number of runs between forest and other cover types pixels}}{\sqrt{(\text{number of forest } pixels)} \times \sqrt{(\text{total number of } pixels)}} \qquad (5.1)$$

Mahalanobis statistics were used to analyse means of deforestation in relation to the independent variables in each *pixel* using GIS, as it is similar to the multivariate mean.

Areas predicted as being at risk of deforestation on the basis of several independent variables have the highest probability of being cleared in the future. They are defined as 'deforestation risk zones'. This model assumes that cultural and political factors have a minor influence on the selection of the sites to be cleared (Mertens & Lambin 1997). Similarly, cultural and political factors are difficult to model, since land tenure systems and the presence of sacred forests influence forest clearing decisions. These factors are important in TM District because of the complexity of the land tenure and Nyakweri forest is considered a sacred forest. Therefore, the deforestation risk zones were determined by comparing specific areas which had experienced much damage between 1994 and 2000.

5.3 Results

5.3.1 Changes in human population density

The human population density in TM District has increased tremendously over the years (Figure 5.1). Immigration of other tribes has contributed significantly to population increase (Table 5.1). The net migration of people into the two districts bordering Narok, of which TM District that was then part, was compared between 1979 and 1989. Immigration was determined by subtracting those born in the district from those enumerated in that district. The negative percentage change in population in Kisii and Kericho districts signifies emigration to other districts. In contrast, the positive change in Narok/TM District districts signifies immigration from other districts. Hence, the population of TM District comprises many Kipsigis from Kericho, with Kisiis being the third largest ethnic group. The spatial density pattern also varied with sub-location (Figure 5.2).

Figure 5.1 Changes in human population density in TM District from 1948 to 1999.

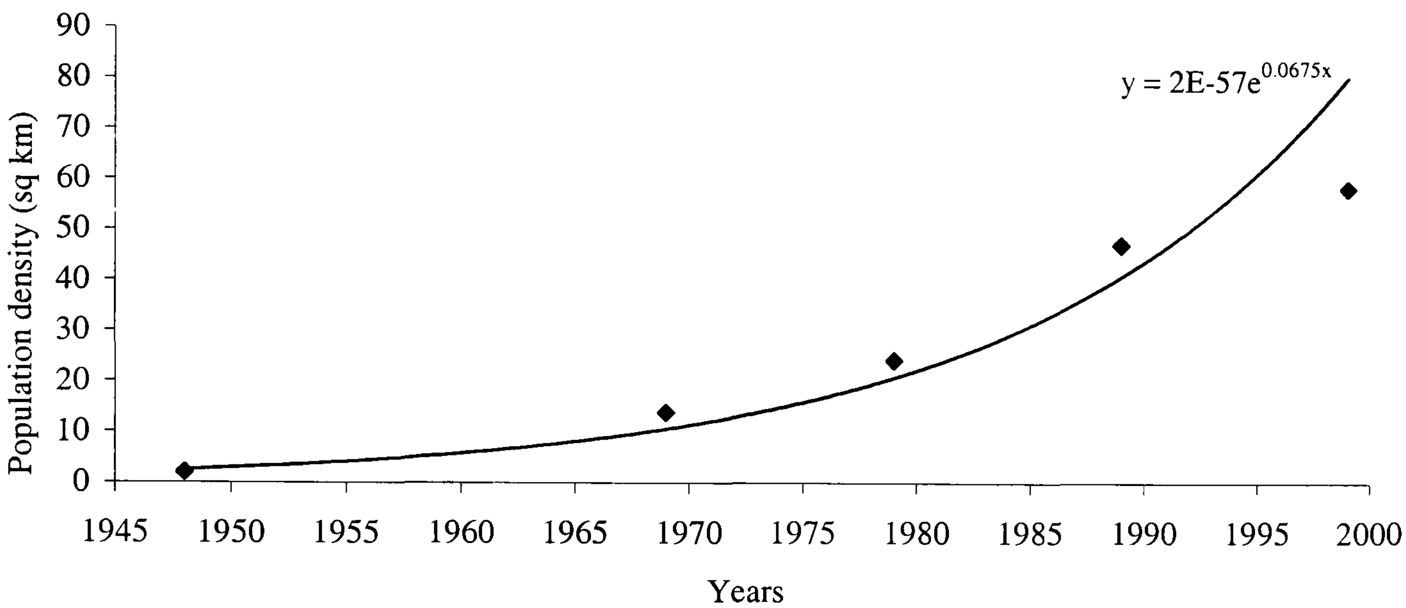


Table 5.1 The immigration of people into Narok District from adjacent districts.

	Year			
Districts	**1979**	**1989**	**Change (1979 – 89)**	**% Change**
Narok	27,030	83,374	56,344	208
Kisii	-56,235	-136,897	-80,662	-143
Kericho	-5,666	-5,840	-174	-3

5.3.2 Land tenure, ethnic distribution and land use conflict

5.3.2.1 Land tenure pattern

Excluding the MT, the areas of land under different tenure systems (Figures 5.3 & 5.4) comprised: 49% (1,085.7 km^2) that is still undergoing sub-division; 14% (303.8 km^2) that has been sub-divided but title deeds have not been issued; 16% (369.8 km^2) that has been sub-divided with title deeds issued; and, 21% (453 km^2) that has not yet been sub-divided. Initially, there were 42 group ranches in TM District (Table 5.2). Keyian Group Ranch is the only non-adjudicated land because it has been leased to Sony Sugar Co by Ltd for a sugarcane plantation. Moyoi B, Oloirien and Olalui group ranches, have not been adjudicated because of either boundary disputes, or disputes between mixed Maasai clans or two group ranch committees. Other group ranches include Moita, Nkararu, Osinoni, Shartuka, Olomismis, Masurura, Olonkolin, Kimintet (A-D) and Ntulele, in which adjudication is either in process or complete. Only fifteen group ranches are currently within the elephant range (Table 5.2).

Figure 5.2 Human density patterns by sub-locations in TM District based on the 1999 census.

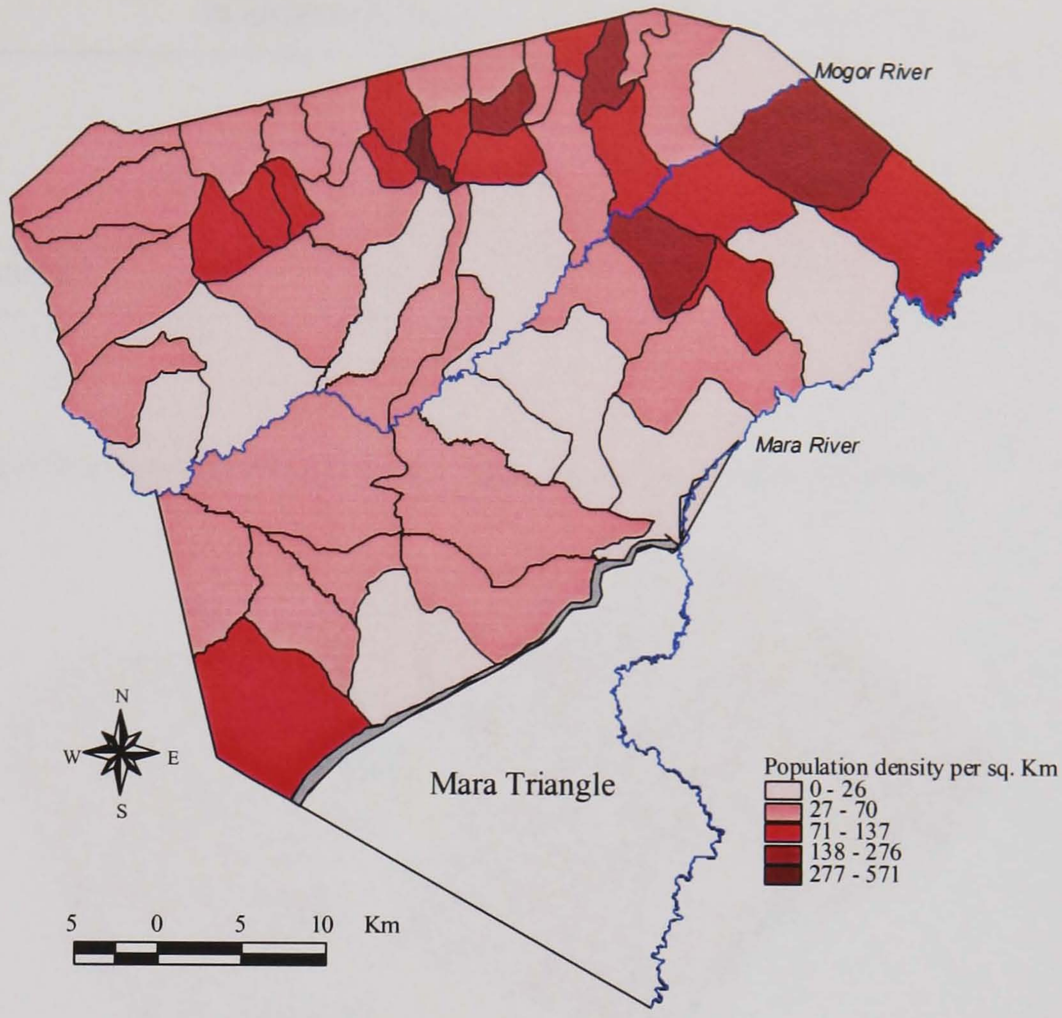


Figure 5.3 Proportions of land held under different forms of tenure in TM District in 2000.

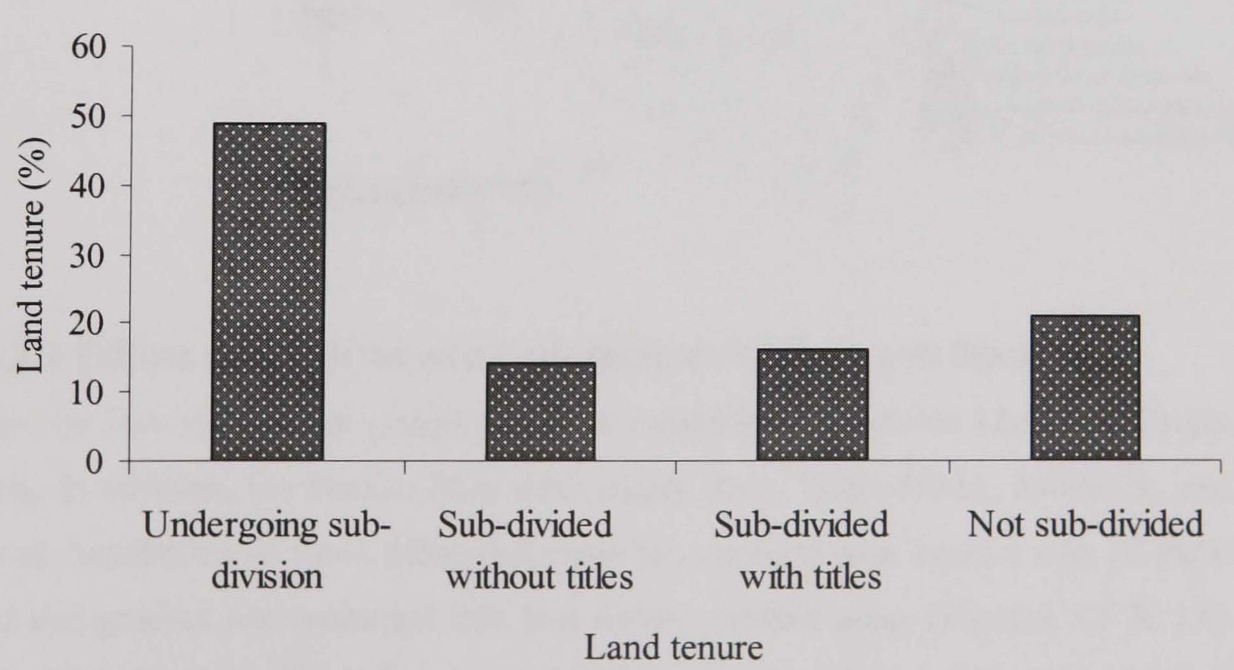
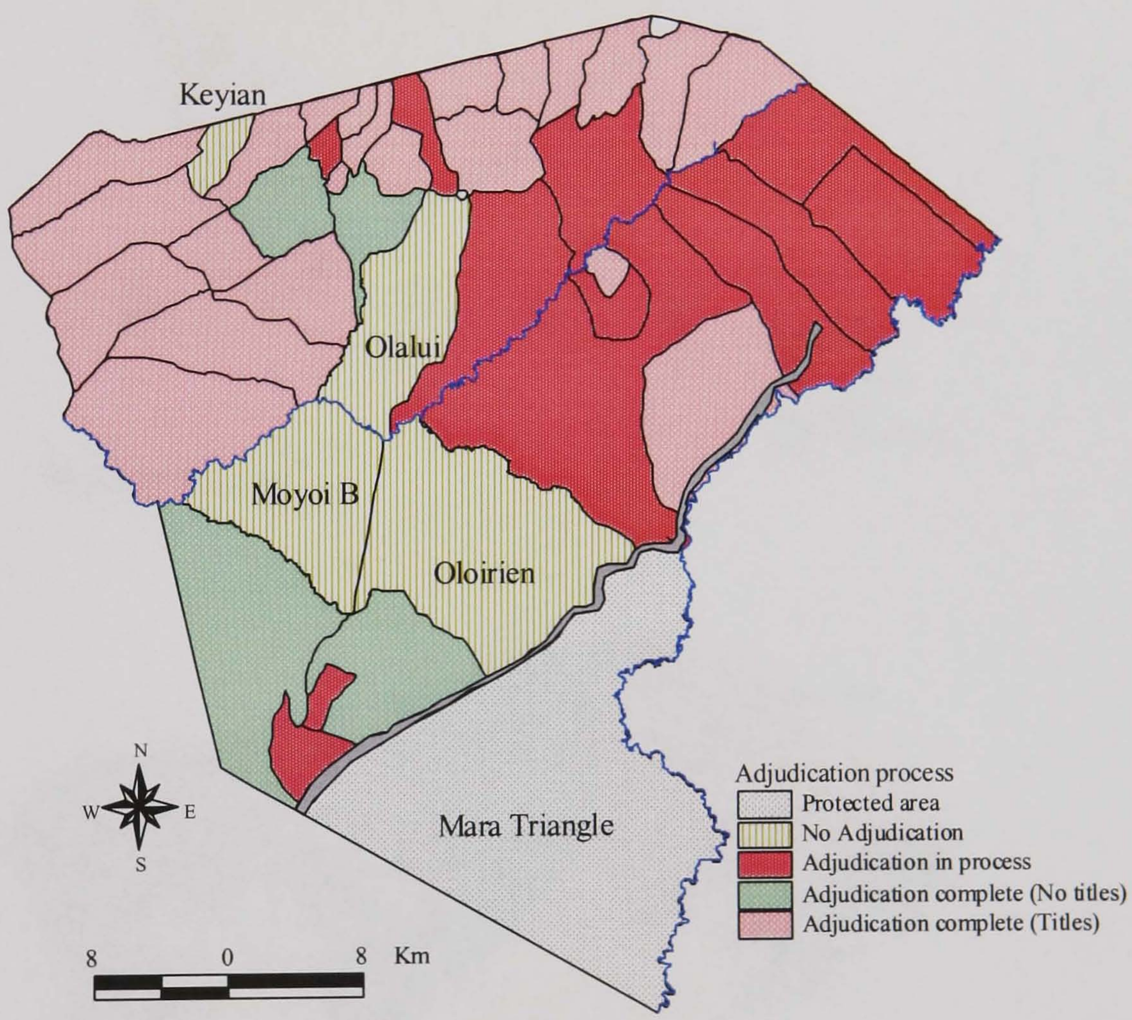


Table 5.2 Relationship between group ranches and elephant range in TM District in 2000.

Adjudication status	No. of group ranches in elephant range	No. of group ranches outside elephant range	Total ranches
None	3	1	4
In process	8	9	17
Complete	4	17	21
Total group ranches	15	27	42

Figure 5.4 Spatial distributions of land tenure patterns in TM District in 2000.

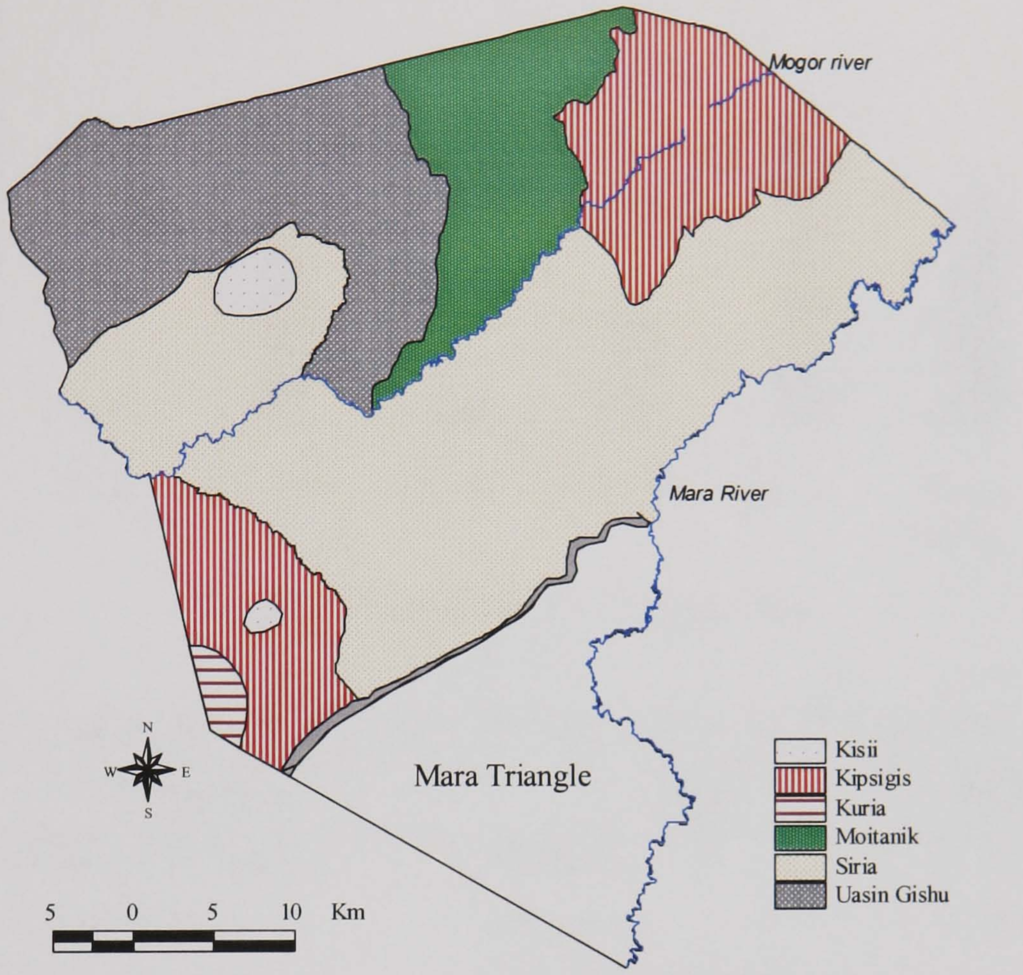


5.3.2.2 Ethnic distribution and land related conflicts and tensions

There are four major tribal groups that have settled in TM District: Maasai; Kipsigis; Kisii; and, Kuria. In addition, the Maasai have three major clans: Uasin Gishu; Moitanik; and, Siria. The spatial distribution of these tribes and clans has changed over time, a sign of the scramble for land and gradual encroachment into less densely settled areas (Figures 5.5 & 5.6). The areas occupied by both the Siria Maasai and the Kisii tribe have declined because of tribal fighting. In contrast, areas occupied by the other tribes and clans have increased (Figure 5.6). All six groups have been involved in conflicts (Table 5.3). There was a general increase in cases of fighting and tension related to land issues in 1999, when eight cases were reported, but this had dropped to two in 2000. The Siria Maasai clan has fought all the other tribes and Maasai clans because they initially occupied most parts of TM District.

Figure 5.5 Distribution of different ethnic groups and land-related conflicts in TM District in (a) 1992 and (b) 2000. Notice the location of conflict areas relative to tribal or ethnic boundaries.

(a)



(b)

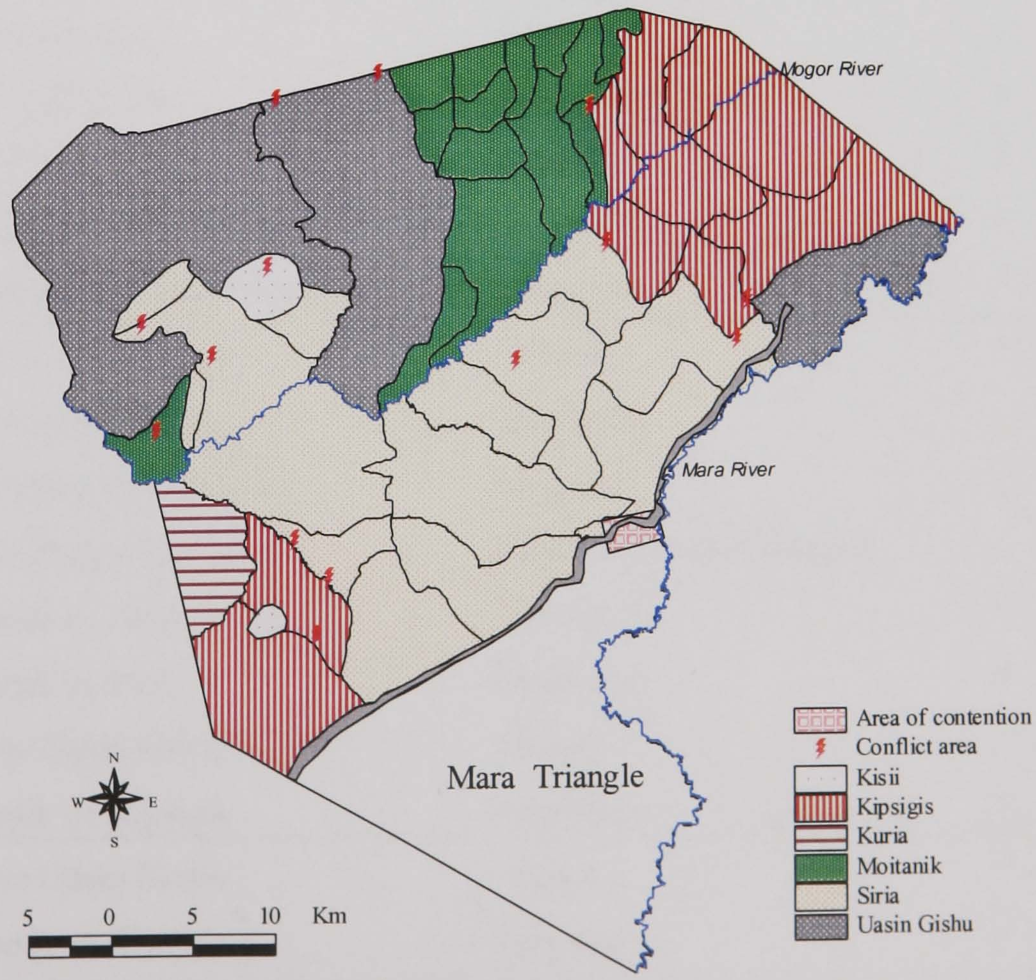


Figure 5.6 Areas occupied by Maasai clans and non-Maasai tribes in TM District in 1992 and 2000.

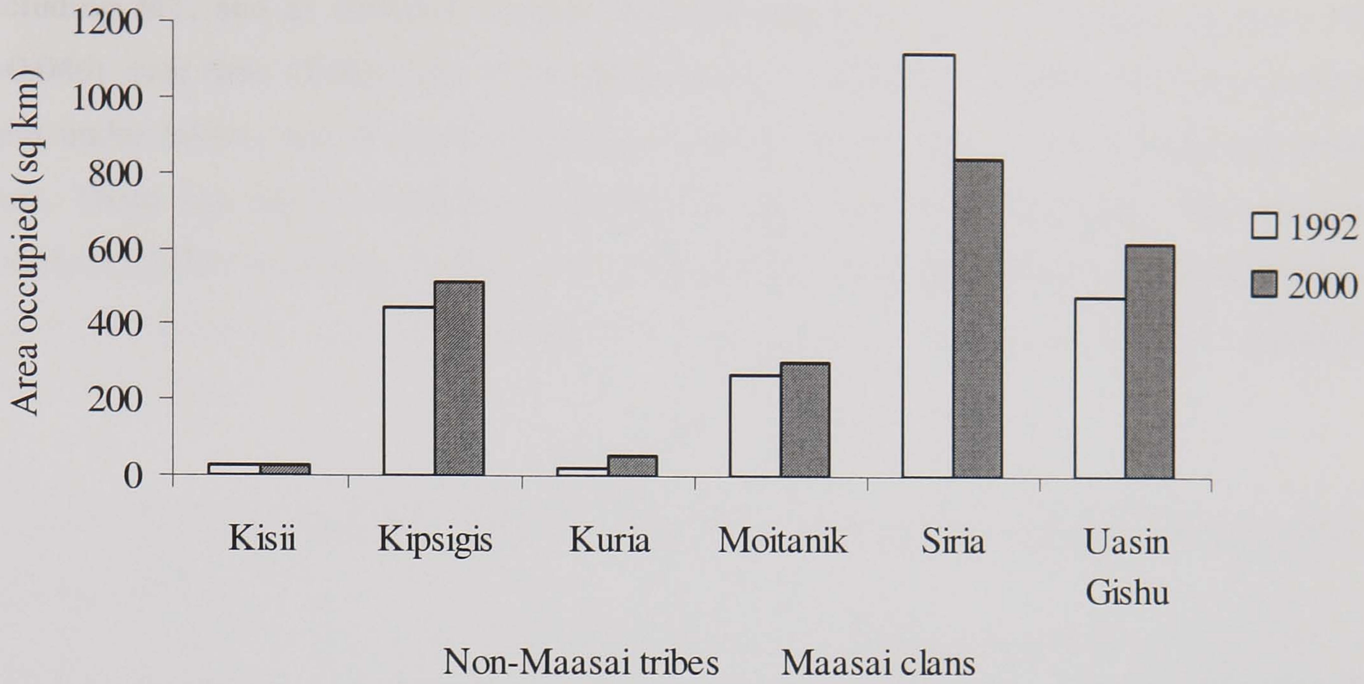


Table 5.3 Ethnic or tribal and clan fighting in TM District between 1953 and 2000.

Year	Tribes/clans	Area	Fight	Tension
1953	Uasin Gishu vs Moitanik	Kilgoris	*	
1974	Siria vs Uasin Gishu	Nkararo	*	
1986	Siria vs Kipsigis	Sitet/Oldonyo orok	*	
1988	Siria vs Kuria	Lolgorian/Mashangwa	*	
1989	Siria vs Kipsigis	Kirindoni	*	
1990	Siria vs Moitanik	Masurura	*	
1992	Siria vs Uasin Gishu	Oldanyati	*	
1995	Siria vs Uasin Gishu	Olongolin	*	
1998	Moitanik/Uasin Gishu vs Kisii	Nyanguso	*	
1999	Siria vs Uasin Gishu	Nkararo	*	
1999	Siria vs Uasin Gishu	Olongolin		*
1999	Siria (Ndorobo) vs Siria	Pusangi		*
1999	Siria (Ndorobo) vs Siria	Kichwa Tembo/Olkurruk		*
1999	Moitanik vs Kisii	Nyanguso	*	♣
1999	Moitanik vs Kisii	Nyanguso	*	♣
1999	Siria vs Uasin Gishu	Nkararo		*
1999	Moitanik vs Kipsigis	Njipship	*	♣
2000	Siria vs Uasin Gishu	Nkararo	*	
2000	Moitanik vs Kipsigis	Njipship	*	

* land related conflict ♣cattle related conflict

5.3.3 Changes in land cover in TM District

Sixteen classes of land use and cover type were classified in the core area of elephants, excluding MT, and as ANOVA showed their percentage cover had changed ($F_{66,132}$ = 1.518, p=0.046) over time (Table 5.4). A comparison of six important classes showed a decline in areas under fallow, and of riverine forest and forest, but an increase in bushland and farming areas. There was also an increase in woodlot, hedge, structures and tracks. The increase in structures (0.5%) and hedge (0.4%) is slow. The Maasai community preferred living together in groups for security reasons. The woodlots have increased by 1.4%, with elephants contributing to tree destruction.

Table 5.4 Percentage lands use and cover types in the core area of the elephant range between 1986 and 1997.

	Year			
Land use / cover	**1986**	**1991**	**1993**	**1997**
Grazing	69.0	76.4	57.2	60.0
Fallow	2.0	0.08	0.1	0.1
Ploughed	0.03	0.52	0.91	1.2
Bare ground	0.03	0.25	0.23	0.22
Bushland	8.0	3.6	13.1	14.7
Bushed grazing	0.6	-	-	-
Woodlot	-	0.05	0.04	1.4
Forest	16.0	10.3	13.5	9.6
Riverine forest	1.0	1.6	1.4	0.4
Hedge	0.2	0.2	0.46	0.61
Structure	-	0.09	0.15	0.14
Road / path / track	0.8	0.5	0.7	0.9
Water bodies	-	-	0.01	0.03
Swamp	-	0.2	0.28	0.6
River	0.3	0.1	0.33	0.11
Crop farming	2.7	6.1	11.6	11.0

5.3.4 Changes in land use types in TM District

Six land use types were derived and delineated (Figure 5.7) comprising: forest; farming; *Acacia* woodland; wooded grassland; wire grass; and, MMNR (regardless of habitat types). A comparison of the area of key land use types of forests and of farms from 1975 to 2000, showed a large decrease in the area of the forest, and a large increase in the area of farms (Table 5.5). The extent of *Acacia* woodland, wooded grassland and wire grass could not be determined since they were not mapped in the 1994 land use map. Farming has resulted in the conversion of forest, especially during the mid 1980s to 1990s. The highest annual forest conversion (8.7%) occurred between 1994 and 1996 but a lower rate forest conversion (1.4%) was noted between 1996 and 2000. The highest annual conversion of land into farming (28.5%) was from 1983-1994, followed by 1994-1996 (11.6%). Land under forest has declined significantly ($F_{1,4}$ = 89.034, p=0.003) over time. Similarly, land under farming in TM District has increased significantly ($F_{1,4}$ = 37.71, p=0.009) over time (Figure 5.8). A strong and significant relationship also occurred between the changes in farm and forest sizes (r^2=0.85, $F_{1,4}$ = 17.17, p=0.025). However, post-hoc could not be analysed to compare differences between years because of fewer cases. Excluding the MT, 38% of TM District is currently under farming while the forest occupies only 10%. The government has provided storage facilities to encourage farming (Figure 5.9).

Figure 5.7 Land use and cover types in TM District in 2000.

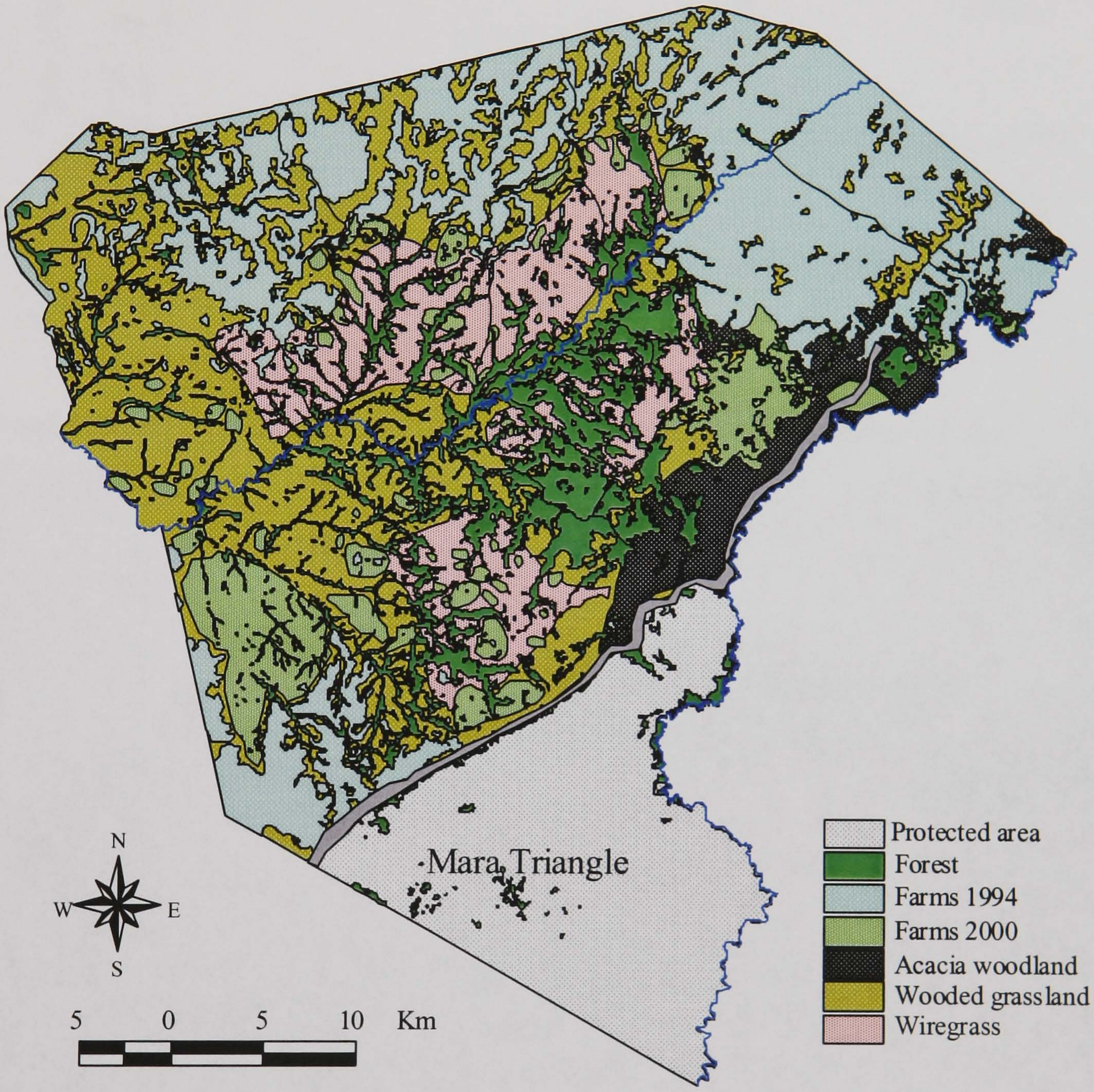


Table 5.5 Area of land under crop farming and forest in TM District between 1975 and 2000.

Year	Forest size (km^2)	Farm size (km^2)	Source
1975	848.7	117.3	Kiyiapi *et al* 1996, Sitati 2000 (FS)
1983	579.4	161.7	Soil Survey of Kenya 1983
1994	406.1	714.0	Kiyiapi *et al* 1996
1996	300.0[a]	963.2[b]	Kiyiapi *et al* 1996, Sitati 2000 (FS)
2000	282.9	1104.5	Sitati 2000 (FS)

[a] Kiyiapi *et al* 1996, [b] Sitati 2000, FS is Field survey

Figure 5.8 Regression models, showing changes in areas of land under forest and farming in TM District from 1975 to 2000.

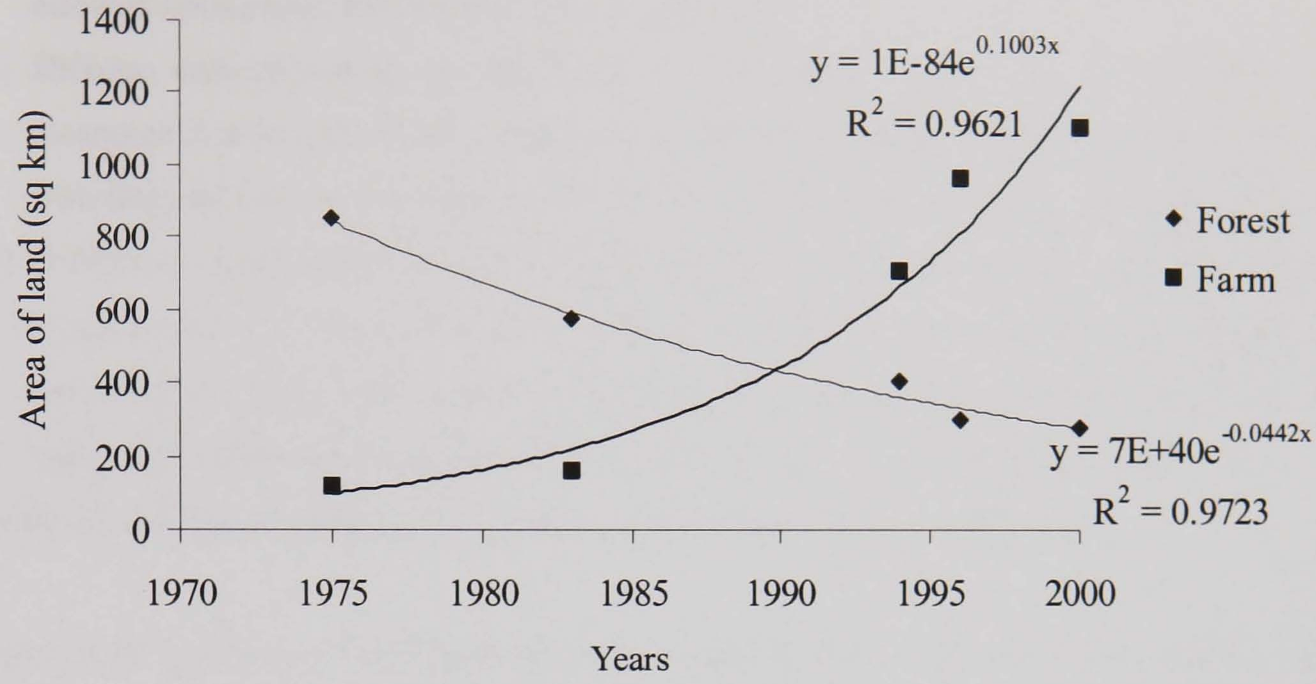


Figure 5.9 Maize storage facilities to encourage farming at Kirindoni market centre

(This expensive facility is not fully used because the immigrant farmers abandoned farming due to elephant problems while the Siria Maasai clan are still rooted to pastoralism. The Kipsigis population density is quite high and do not have surplus maize for sale).

5.3.5 Correlates of deforestation

5.3.5.1 Forest patterns

Four patterns of forest/non-forest loss were identified in the study area; geometric, corridor, diffuse and patchy (Figure 5.10).

(a) Geometric: corresponds to large scale clearing by the highly populated Kisii tribe at Nkararo, extending towards Laila forest and areas adjacent to Kilgoris town.

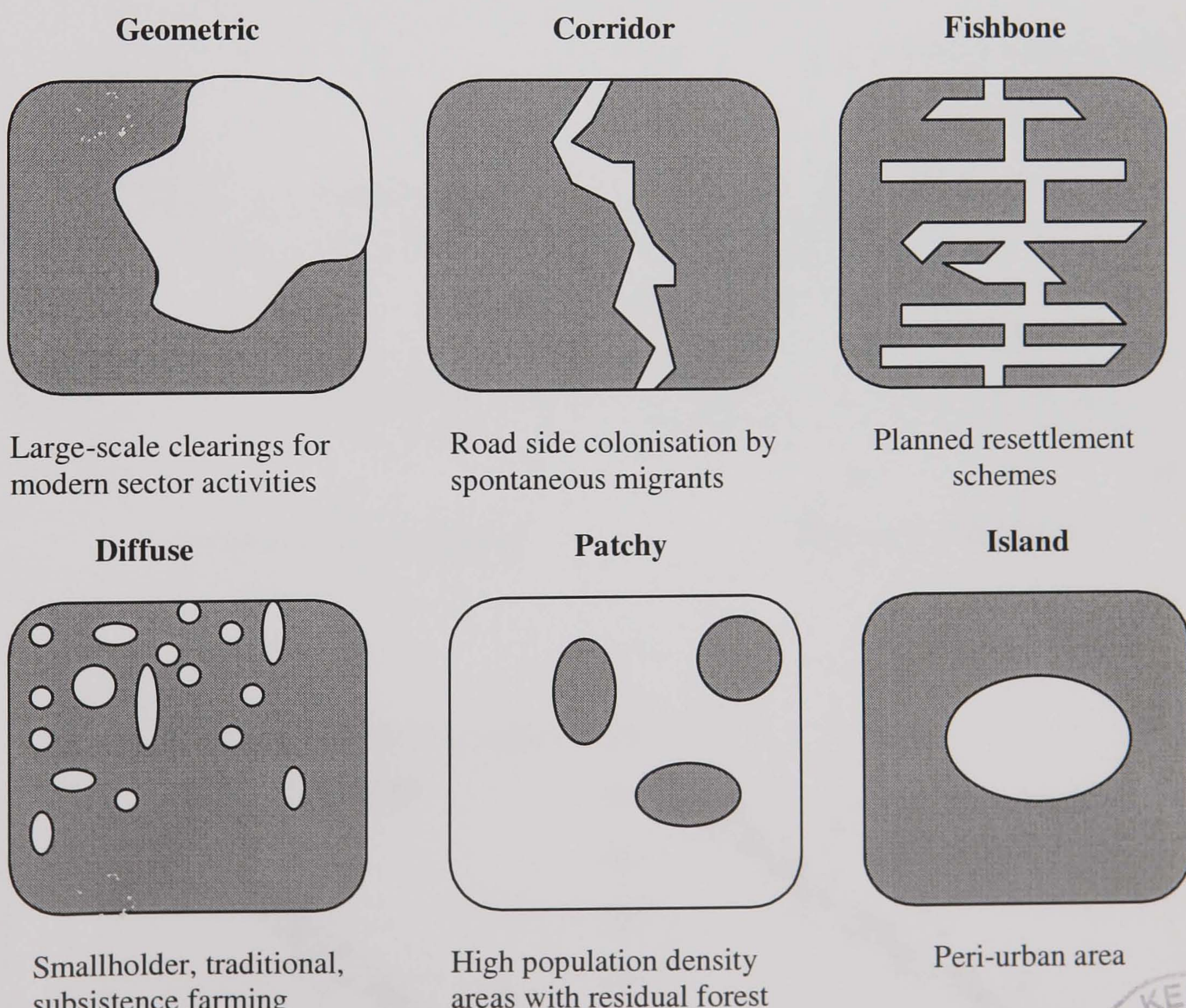
(b) Corridor: corresponds to the recent gradual move by the Kipsigis to clear land for charcoal and to farm along the main road from Kirindoni to Shartuka. These cultivated areas are expanding rapidly because of the already sub-divided land and because the Maasai have allowed immigrants to clear the forest for farming.

(c) Diffuse: corresponds to the upcoming of small farms by the Maasai community. Forest clearance is also carried out just for clear visibility in elephant areas mainly at the livestock watering and human crossing points. The Maasai community mainly cultivates these areas.

(d) Patchy: corresponds to the forest fragments that are surrounded by heavy farming such as Ketura, Olaitong', Olonkolin and Kimintet forest fragments. Attempts by elephants to reach these forests have often resulted in conflict. Because of heavy human settlement and the small size of the forests, elephants no longer use Ketura and Olaitong' forests.

Fishbone and island patterns of clearance have not been seen in TM District.

Figure 5.10 Typology of the forest/non-forest spatial patterns and their interpretation in terms of deforestation process (adapted from Husson *et al* 1995).

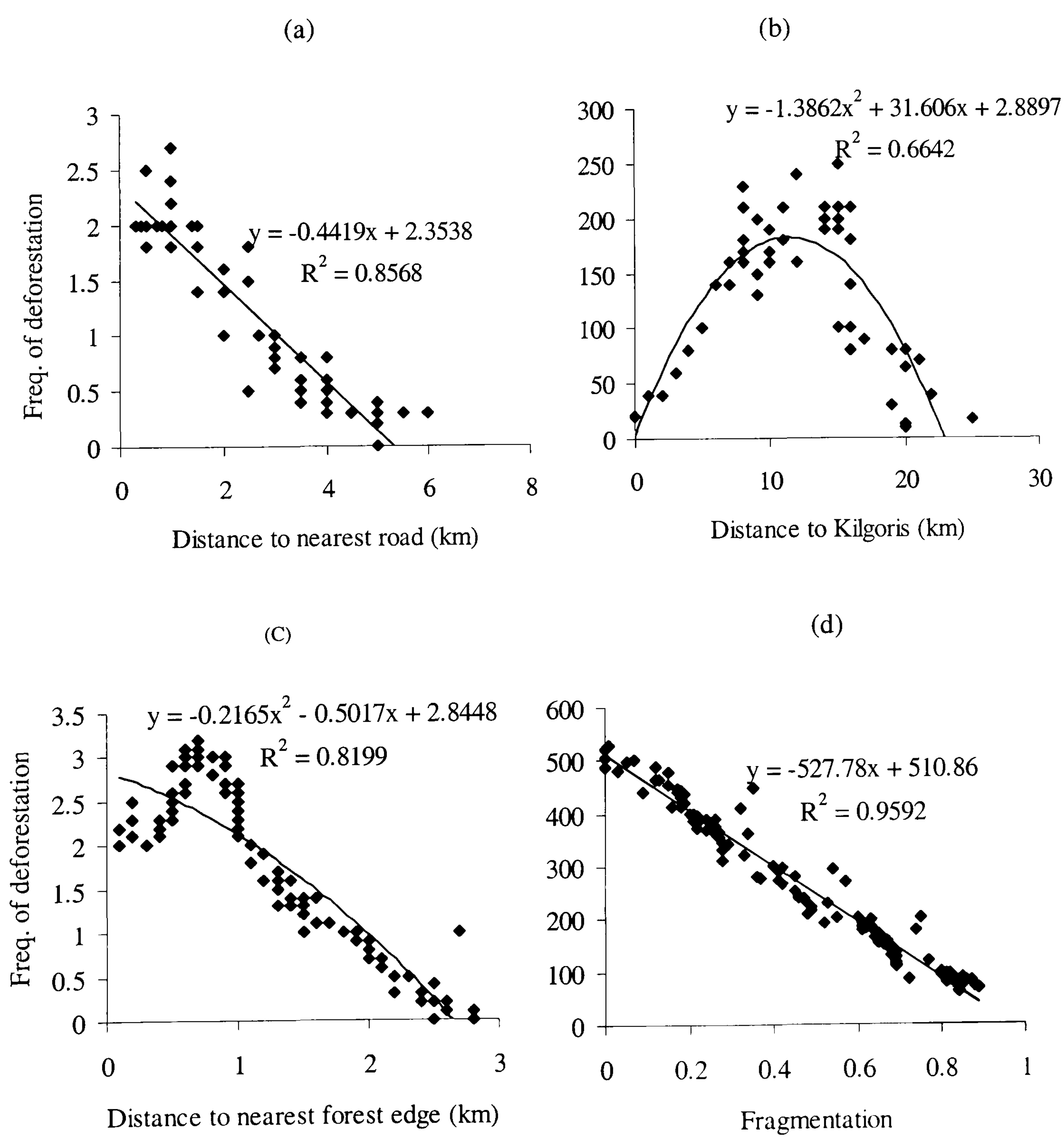


5.3.5.2 Spatial factors determining deforestation rate

Change in area under deforestation decreased with increasing distance from the road (Figure 5.11a). The regression for model for factors that might have influenced deforestation was significant ($F_{1,51}$ = 305.054, p=0.001) and explained 85% of variance. Hence, some 85% of total deforestation occurred within 3 km of a road. No deforestation occurred beyond 6 km from a road. Therefore, forest areas without a road network have not been exploited.

Change in area under deforestation in relation to the proximity to Kilgoris town (Figure 5.11b) increased upto 5-7 km distant and decreased after 15 km distance from the town. Hence, deforestation was not correlated directly with distance from the town. The regression model for factors that might have determined deforestation was significant ($F_{1,49}$ = 1.459, p=0.233), and explained only 9% of variance.

Figure 5.11 Relationships between the frequency of deforestation (Y) and the different independent variables of the model (X) (a) proximity to roads (linear); (b) proximity to town (polynomial); (c) proximity to forest edge (polynomial); and, (d) forest fragmentation (linear).



The frequency of deforestation decreased with increasing distance from the nearest forest edge (Figure 5.11c). Most (85%) deforestation occurred within 1.5-2 km of the forest edge. The regression model for factors that might have determined deforestation was significant ($F_{1,79}$ = 324.247, p=0.01) and explained 80% of variance.

There was a negative relationship between forest fragmentation and deforestation. Fragmentation occurred in areas with low frequency of deforestation (Figure 5.11d). The regression model for factors that might have determined forest fragmentation was significant ($F_{1,110}$ = 2586.67, p=0.01) and explained 96% of variance.

5.3.5.3 Spatial projections of 'deforestation risk zones'

The areas with the highest likelihood of deforestation could not be projected. However, all the areas associated with a high rate of deforestation during the period 1994-2000 were determined. These areas included Olongolin, Kirbwet, Ntulele and Kirindoni forest blocks. Nevertheless, the deforestation risk zones identified are most likely to be cleared in the near future because of open access and hence require priority attention.

5.3.6 Other forms of land uses in TM District

Wildlife conservation and gold mining are the other major land uses in TM District. The Mara Triangle (MT) is part of the MMNR and is the only PA in TM District (Figure 5.9). The MT covers about 20% of the area of TM District, and about 32% of the main MMNR. There are six tourist lodges and two campsites in TM District, while Narok supports over 58 tourist lodges and several campsites. Equally, TM District does not have any community wildlife associations, while Narok has three such associations. The survey and exploration of gold covers about 54 km^2 within Moyoi group ranch in Lolgorian Division, which is also within the seasonal elephant range.

5.4 Discussion

Effective development of a land use plan can only be derived after understanding the historical context of land use change. HEC normally occurs as a result of the changes in human population, which in turn results in changes in land use patterns that may be incompatible with elephants. Land use change often result to conflict with wildlife (Schulz & Skonhoff 1996). Studies have recommended a land use plan to mitigate conflict (Ngure 1995, Kasiki 1998, Hoare 1999). Hence, the findings of this chapter were important in designing a land use management plan for TM District. It has also provided relevant variables for a GIS analysis of spatial patterns determining crop raiding (Chapter 9). Therefore, this is the only HEC study to have considered detailed land use data and cover information. This is the first study also to show the implications of land tenure, ethnic distribution and habitat loss on elephant behaviour and conservation.

Previous surveys showed a general increase in land under cultivation around PAs (Mwangi 1995, Awere-Gyekye 1996). Himiyama (1999) argues that agricultural statistics from the government are less reliable and difficult to trace back many years. Motoki (1992) used government statistics to estimate changes in the area of cultivated land, whose accuracy was difficult to check. These statistics also do not provide details of land use changes because of the coarseness of classification (Himiyama 1999). Predictions made from such statistics can be misleading and do not provide meaningful recommendations for proper land use planning. However, these studies did not show the extent of cropland and used figures from Ministry of Agriculture that are not reliable. Therefore, this study aimed to map changes in land use and cover patterns over time, and to produce the most recent and accurate land use map for TM District.

5.4.1 Human population changes in TM District

According to the national population census of 1999, the density of human settlement in TM District has increased over the years (Figure 5.1), due to both a high population growth rate of 4% (Muticon 1994) and to immigration (Table 5.1). Excluding the MT, the human population density has increased from 58.2 people/km^2 in 1989 to 72.09 in 1997 (DDP 1997). The highest population densities occurred in areas settled by non-Maasai, including Emarti, Ang'ata Barrkoi, Abossi, Murgan and Oldonyo Orok, all settled by the Kipsigis tribe (Figures 5.3 & 5.5). The current pattern of settlement in TM District reflects: (a) differences in agricultural potential; (b) the propensity to accommodate other tribes; and, (c) shielding from insecure cattle rustling areas. Mistrust between Kuria and Maasai tribes has restricted settlement and large scale farming along the border (Kiyiapi *et al* 1996). Elephants have disappeared from this area completely as a result of poaching.

Elephants have also been excluded from their former areas (Chapter 6) and their current range is in areas with low human population density (Figure 5.2). This implies that increasing human density has contributed to reduction of elephant ranges in TM District as elsewhere (Parker & Graham 1989a, Thouless *et al* 1992, Kasiki 1998). Encroachment on elephant range increases conflict and also threatens the future of elephant conservation. Elephants were wiped out by white settlers and during the ivory trade along the eastern coast of South Africa, as well as in Zululand and Transvaal (Said *et al* 1995). In TM District, the human need for land is so high that elephants cannot survive the competition. With increasing human populations, the chances of human-elephant contact are high given the increased demand for resources.

5.4.2 Land tenure and land related conflicts in TM District

Land in TM District was initially held as trustland, used both for wildlife and livestock grazing. Group ranches evolved through the Land Group Representative Act, which turned it into private land. Land disputes are common during sub-division of group ranches. The changing land tenure system has resulted in more cases of land-related conflicts (Figure 5.5 & Table 5.3) because of boundary disputes and allocation, corruption, land disputes and poor management of the group ranches. Fighting is also due to immigration (Table 5.1) of other tribes who view TM District as "people without land moving in land without people" (Moran 1981).

Changes in land tenure results in changes in patterns of land use (Ottichilo 2000), which in turn have serious long-term implications for the future survival of elephants now pushed into low potential areas (Chapter 2 & Chapter 6). Other studies have shown that change in land use patterns result in conflicts and displacement of elephants (Parker & Graham 1989, Waithaka 1999). The Maasai of Kajiado are experiencing new forms of land use conflict between and amongst the farmers, herders and wildlife (Campbell *et al* 2000), because of the limited water supply. In contrast, TM District has sufficient water because of heavy rain it receives for much of the year, while pastures are sufficient. Therefore, the yearly immigration of herders from Narok District during the dry season into TM District has never resulted in conflict.

The recent land crisis in Zimbabwe led to increase in poaching of elephants in Save Valley Conservancy (BBC News, Thursday, 7 September 2000). Land issues in TM District have become very volatile. Tribal and clan fighting, and tension, have increased both between the Maasai and other tribes and between Maasai clans (Table 5.3 & Figure 5.5). The Kisii tribe, who border with the three Maasai clans, showed most conflict historically, and are regarded as violent and uncompromising to their neighbours and even ready to commit murder at the slightest provocation (Sunday Standard 2000). Previous pronouncements by Maasai leaders for non-Maasais to move out of Maasailand often resulted in conflict (Daily Nation 2000a). Therefore, land conflicts will only subside if land sub-division is an ongoing process and land sub-division is the only solution to resolving land tenure disputes (Campbell *et al* 2000). Most of the already sub-divided areas have been sold and or converted into farming. In Kenya, customary tenure rights exist with western property law as the dominant overlay and the pastoral land rights are a "peripheral system". Indeed, this corresponds to the pastoralists' lack of political power to protect their land tenure system. A series of Land Acts, implemented on top of surviving customary tenure, has created great confusion to the land allocating authority, which is the main source of conflict in TM District.

Land sub-division is sensitive in Kenya and with deep policy conflict (Norton-Griffiths 1998). While the Kenyan land policies encourages land sub-division, KWS discourages it and instead encourages landowners to form associations to jointly manage wildlife (KWS 1995a, KWS 1996). Hence, conflict is observed between the economic interests of landowners and the social and scientific interests of the Government and conservationists (Norton-Griffiths 1998). In TM District, there has been mistrust between the Maasai community and KWS (Borsy 1996), a factor that can frustrate any conservation effort. Because of communal land tenure system and insecurity, the Maasai lived in clusters, a more compatible pattern with the elephant than the present dispersed pattern arising from individual land holdings, which have brought people closer to the elephant.

5.4.3 The implications of land adjudication for elephant conservation

Land registration leads to access to formal credit, higher land values, higher investment in land and higher output or income (Wai 1957, Sacay 1973, Dorner & Saliba 1981, Collier 1983, Aku 1986, Feder & Akihiko 1999). Workshops have been held in TM District over natural resource management and the on going land sub-division, with fears expressed that individuals will own the forest whose exploitation may not be sustainable. Most land already adjudicated has lost its elephants and the local community has rejected to set aside the forest fearing that the government will take over. Hence, they feel that land should be sub-divided first before negotiating on forest use. However, there are prerequisites for land registration to be economically viable, and social aspects that need to be considered when designing a land registration system. Since the Maasai are traditionally not farmers, the productivity of their land will be lower than that on land under a farming community because tenurial insecurity is an important source of low productivity in agriculture (Mosher 1966, Salas *et al* 1970). Through land sales and rentals, the other operators have better skills or means to invest in contemporary improvements. Since registration reduces tenurial insecurity (Feder & Akihiko 1999), more land sales and rentals are anticipated, which poses a further threat to the natural elephant habitat.

An increase in investment has been noted in registered land (Salas *et al* 1970, Villamizar 1984), as has an increase in permanent or semi permanent crops (IDB 1986). However, the level of economic rigor of these studies was not adequate to support a firm conclusion as the magnitude of the economic impact generated by land registration systems since other factors affecting economic performance were not fully controlled in the analyses (Feder & Akihiko 1999). Their arguments are supported by a casual relationship that was observed between land registration and yields (Migot-Adholla *et al* 1991, Lopez 1996, Carter & Olunta 1996, Alston *et al* 1996). In Africa, output is controlled by physical infrastructure, effective credit system and marketing institutions (Migot-Adholla *et al* 1991) and land registration is unlikely to be economically worthwhile for much of sub-Sahara Africa, except in certain cases where indigenous tenure systems are weak or where the incidence of land disputes is high (Besley 1995, Moore 1996). In conclusion, the future direction of land use in TM District after registration remains uncertain because of its high agricultural potential, high immigration rates and high conflicts. Equally, the future of the elephants will depend upon the Maasai community who will be allocated the forestland.

5.4.4 Land use types

The necessity of historical study of land use changes has been discussed with a common belief that a true understanding of land use change cannot be achieved without studies encompassing historical depth (Turner *et al* 1990, Brouwer *et al* 1991). Most studies have not considered historical land use changes when assessing HEC because: (a) interest in land use change is only recent; (b) there is a lack of understanding of the importance of historical perspective; and, (c) there is difficulty in obtaining relevant historical information (Himiyama 1999). There are eight major land uses in TM District, which this study considered as important to elephant conservation and management. These are: wildlife conservation and tourism; crop farming; human settlement; pastoralism; agro-pastoralism; gold mining; market centres; and forestry. Such broad classifications have been used to describe land use elsewhere (Countryside Commission 1989, 1991, Newbury District Council 1993).

5.4.4.1 Crop farming

TM District has a high potential for crop and livestock farming due to its high rainfall (Figures 2.3 & 2.8). TM District falls in Agro-ecological zone III, which has a semi-humid climate with medium agricultural potential (Awere-Gyekye 1996, Kiyiapi *et al* 1996). Cultivation in TM District occurs in areas with high human density (Figures 5.1 & 5.2). Kasiki (1998) also found a positive relationship between human population density and percentage of land under cultivation. The Maasai who have been pastoralists, are now engaging in farming as outlined by Spear and Walleirs' (1993) prediction that "the future will appear to belong to those agricultural Maasai once known as *lloikop*".

Studies have shown that cultivation increases with decreasing areas of forests (Myers 1991, Richards 1990). Tiwari (2000) reported an increase in cultivation and a decline in forest, but most expansion occurred in barren areas and other wastelands. Farming in TM District increased at the expense of the forest (Figures 5.8). In 1980s, new farms were started to claim compensation and were abandoned when the government scrapped compensation. The encroachment of farms into forest areas, which are elephant habitat, results in HEC. Cultivation has encroached on the important elephant resources like salt lick and swamps, which results in conflict in an attempt by elephants to access these resources. Livestock carrying capacity has equally increased resulting in overgrazing and spread of wiregrass. According to Thurrow (1993), wire grass once covered only a small area. However, it now covers an approximate area of 325 km^2 (Figure 5.7). The grass is less nutritious than native species and contributes to reduced elephant ranges and to reduced livestock food availability. Wiregrass is associated with livestock increase and it is difficult to eradicate (Thurrow 1996, Borsy 1996). Digging out is the most effective method of control, which again encourages farming on fragile land (Thurrow 1993), and a source of HEC. The grass is now especially establishing along the Mara River.

5.4.4.2 Forest

The total volume of TM District forest was estimated at 1.4 *Mio* M^2/ha and its total value estimated at Ksh. 3.22 billion (Kiyiapi *et al* 1996). Social transformation is responsible for forest destruction while the current climatic change could be a consequence of forest change (Borsy 1996). Studies have shown that deforestation affects climate (Shukla *et al* 1990, Crutzen & Andreae 1990, Houghton & Skole 1990, Houghton *et al* 1992). From a conservation point of view, larger habitat patches are beneficial. Therefore, continued forest fragmentation will deny elephants access to the few important resources like salt licks and swamps (Chapter 3).

The forest is undergoing rapid degradation and conversion into cropland, especially in the northern part of TM District settled by the Kipsigis (Figure 5.5 & 5.7). Both the forest and bushed grassland are being converted into crop farming. Forest destruction stabilised later when the Kipsigis could not extend their activities beyond their clear boundary with the Maasais. However, destruction has now spilled into areas settled by the Maasai.

Deforestation is correlated with human density (Allen & Barnes 1985, Rudel 1989, Reis & Margulis 1990, Palo & Mery 1990). In contrast, other studies have shown that deforestation is not related to human density (Tucker & Richards 1983, Richards 1984). In the Amazon, government policies and fiscal incentives were more significant determinants of deforestation than demography (Hecht 1983, Hecht & Cockburn 1989). Therefore, demographic factors alone may not be a good basis for projecting future land use and land cover change (Hecht 1983, Anderson 1986, Hecht & Cockburn 1989, Kummer 1992). Logging and other non-agricultural activities cause significant land use change (Richards 1984) and their omission might not give a true picture of land use change. Because of law enforcement, charcoal burning in TM District is further away from town and in densely populated areas.

High forest fragmentation has occurred in areas with a low frequency of deforestation, because the TM District forest is naturally fragmented into forest blocks and any deforestation at the edge causes further fragmentation (Figure 5.11 (d). Similarly, almost the entire forest is inhabited by the Maasai community who are engaged in small farm cultivation because of wildlife menace, which appears like low deforestation. But with increasing cultivation, the trend is likely to change to a positive linear relationship. A large and uniform forest showed a positive linear relationship between deforestation and fragmentation (Mertens & Lambin 1997) because forest openings attract forest clearing. A similar outcome was observed with other relationships but with slight differences with respect to distance (Figure 5.11). The current deforestation risk areas in TM District are important dry season elephant ranges. The high HEC in these areas is because of the shrinking forest, which the elephants still frequent. However, elephants no longer visit Ketura and Olaitong forest fragments because of high human population density and the reduced forest size.

There is no clear policy about forest ownership in TM District. According to the Department of Forests (DF), there is no government forest in TM District (DDP 1997) but under the Legal Notice No. 236 of 1964, TM District forest is still a gazetted central government forest (Kiyiapi 1996). There are five land use legislations that try to regulate forest cutting, licences and punishment in Kenya comprising: the Chiefs Authority Act; Water Act; Forest Act; Agriculture Act; and, the Mining Act. These Acts are supposed to protect the forest by law, but have several limitations. Firstly, the old legislation places emphasis on exploitative rather than resource management. Secondly, there is a lack of co-ordination between the various Acts. Thirdly, there is a lack of provision for conflict resolution for competing land uses (Kiyiapi 1996). The Agricultural Act gives the option for protecting forest under public interest but is hindered by law enforcement. The Water Catchment Act was enacted to protect the water catchment areas. However, the Forest Act has no powers to protect the catchment areas outside gazetted areas. Therefore, the conflicting government policies pose a big threat to conservation efforts.

5.4.4.3 Changes in woodlands and bushed grasslands

Caughley (1976) argued that vegetation change is cyclical in nature and woodlands and grasslands have historically alternated with each other over space and time. The Kirindoni area of TM District has experienced a gradual change of vegetation from grassland to *Acacia* woodland, which is highly preferred by elephants. Despite the natural process of vegetation changes through succession, rapid expansion of agriculture has endangered most plant species (Natural Environment and Human Settlement Secretariat 1984). The district has 300 genera of plants, and over 5000 species (Msafiri 1981), but most species have disappeared due to deforestation (Borsy 1996).

5.4.5 Other land use types in TM District

5.4.5.1 Wildlife conservation and tourism

This difference between those who receive benefit and those who do not, has also been reported in other studies (Kasiki 1998). The government and KWS policy of channelling benefits takes a long time to work (Kasiki 1998, Norton-Griffiths 1998). Many people bear the costs of living with wildlife, but without obtaining any significant benefit (Kiss 1990), such that they view wildlife as a liability (Kasiki 1998, Ndung'u 1998). Kimintet, Olorien and Kerinkani Group ranches that border MT receive revenue from tourism related activities. Yet most of their land is under agriculture, unlike other areas that do not receive revenue but that harbour many elephants. This is because of conflicting government policies. In TM District, just like other wildlife-inhabited areas, the community bears the cost of living with the elephant without getting any benefits. There are four lodges on CLs and two within the MMNR from which the community benefits through leasehold and employment. However, tourism potential has not been fully exploited because of insecurity and poor infrastructure.

5.4.5.2 Pastoralism and agro-pastoralism

Pastoralism is considered as a compatible land use strategy with wildlife (Western 1989), while crop farming is the cause of increased HEC (Sukumar 1990, Kasiki 1998, Hoare 1998). The Maasai community, just like any other pastoral community, has experienced transformation in lifestyle from nomadic to sedentarization and presently, agro-pastoralism. Pastoralism, which entailed keeping large herds of livestock, is no longer viable with increased human population and reduced grazing land. The Moitanik and Uasin Gishu clans accepted farming much earlier because of intermarriage with the farming communities.

The results in this chapter have shown the extent of agricultural expansion into Maasai and elephant ranges. If this rapid expansion is allowed to continue, then the following are likely to happen:

- An increase in human-elephant conflict;
- The loss of dry season wildlife grazing and breeding areas;
- An increase in elephant densities in the MT and/or MMNR;
- The loss of forest and important elephant resources;
- The disappearance of the resident elephant population; and,
- An increase in the loss of riverine forest of the Mara River and *Acacia* woodland, which is supplemented by dispersal areas.

Equally, the persistent long dry spells being experienced currently limits water and pasture availability to livestock, wildlife and the community. The heavily used herbal trees are declining while the future generation of the Maasai community will not have an opportunity to interact with wildlife like their ancestors or fore bearers. Therefore, loss of the natural forest will be detrimental to human, livestock and the wildlife.

5.4.6 Implications for management

The declining area under forest as a result of changing land use and tenure patterns, which are compounded by immigration and conducive conditions for farming is a big threat to the resident and migratory elephant populations in the Mara ecosystem apart from the general loss of biodiversity. The important elephant resources, which are utilised during the dry season, will be lost while an increase in HEC is anticipated. Land adjudication poses another danger, as the already adjudicated areas are no longer part of the elephant range. Among other factors, lack of wildlife-related benefits is crucial to the future survival of elephants on CLs and community participation in natural resource management should be encouraged.

After having explored the issue of land use transformation in some depth, I will now examine the status of elephants in the Mara ecosystem, which in turn will be related to land use change and conflict.

CHAPTER SIX

Elephant densities and distribution in the Mara ecosystem

6.1 Introduction

Changes in elephant numbers and distribution have implications for new forms of human-elephant conflict (HEC). HEC can be managed effectively if there is a clear understanding of the status, distribution and movement patterns of the elephant population. Earlier studies of HEC did not study the ecology of the elephant in detail (Kiiru 1995, Kangwana 1995, Ndung'u 1998), yet have cited the need to incorporate the ecology of elephants in decisions on how to mitigate HEC. An understanding of the spatial and temporal patterns of HEC can be related to elephant distribution and movement patterns. As pastoralism is being gradually replaced with an agro-pastoralist lifestyle in many areas, and as farming is reducing the elephant range, resource competition and conflict results (KWS 1995c). Such conflict threatens the survival of wildlife, especially elephants, outside protected areas (PAs) (Omo-Fadaka 1989). Crop damage, livestock predation, and loss of land to conservation and lack of control over wildlife resources cause negative attitude towards wildlife (Asibey & Child 1990). The elephant range and numbers have declined at regional, national and continental levels (Graham & Parker 1989a, Said *et al* 1995).

Transmara (TM) District is an important wildlife and livestock dispersal area, especially during the dry season and harbours a refuge of the savannah elephant (*Loxodonta africana africana*) population. Elephant numbers in the MT have been extrapolated from the past surveys across the entire Mara ecosystem by total aerial counts (Muruiki *et al* 1999), and sample aerial counts from DRSRS GIS Data base (Grunblatt *et al* 1995). Muriuki *et al* (1999) proposed the inclusion of TM District in the aerial surveys. However, in TM District there is no comprehensive review of the status and distribution of elephants. A 1997 survey based on dung counts along transects is the most recent and only available information (Wamukoya *et al* 1997). This chapter analyses changes in elephant numbers and distribution which will be related to conflict. This chapter aims to answer the following questions:

- Determine past and present elephant density and distribution patterns both in TM District and across the Mara ecosystem;
- Establish the past and the present elephant range and its implications for elephant conservation;
- Compare elephant dung densities between crop raiding and non-crop raiding seasons;
- Compare elephant dung densities between different forest blocks and other vegetation types;
- Show the important elephant corridors and the pattern of usage by elephants;
- Identify the factors that might determine corridor usage by elephants in TM District; and,
- Relate elephant range and densities to human density and other parameters.

In this chapter, I describe past trends of elephant populations in the Mara ecosystem (6.3.1), wet and dry season total aerial counts (6.3.2), present elephant density (6.3.3) and changing elephant range (6.3.4). I then describe corridor usage by elephants (6.3.5) and relationship between elephant range and human factors (6.3.6). This chapter concludes with a discussion of these results (6.4).

6.2 Methods

6.2.1 Elephant numbers in the Mara ecosystem

6.2.1.1 Sample aerial counts of elephants

The main source of information on elephant densities and distribution across the Mara ecosystem was from secondary data in the DRSRS-GIS database on wildlife numbers and distribution (Granblatt *et al* 1995). This database is based on aerial surveys conducted in 1977, 1983, 1985, 1986, 1987, 1989, 1991, 1992, 1993, 1994, and 1996 using the survey methodology of Norton-Griffiths (1978), and estimating populations according to Jolly (1969). However, users are cautioned that population estimates may be bound by probably high standard errors, based on: (a) small areas surveyed; (b) the forested nature of many study areas; (c) the often large herds of elephants observed; and, (d) an assumption that elephants are randomly distributed. Seasonal migrations or local disturbances can also produce large differences in survey results. Any lack of occurrence of elephants indicates that they were not observed within the sample strip width during the survey, but does not necessarily indicate that they were not present in the area. However, the information was useful in giving an impression of the general pattern of trends in elephant numbers and distribution over the years. For this study, elephant numbers were extrapolated from four study locations namely: TM District; MT; MMNR; and, Narok, in order to compare any changes in group size and trends in numbers with conflict. A statistical analysis was performed using ANOVA.

6.2.1.2 Wet and dry season total aerial counts of elephants

Elephant numbers and distribution during wet and dry season counts were obtained from WWF/FOC and KWS reports for the years 1984-2000 (Muriuki *et al* 1999). Observed numbers in each 5 km^2 grid were extrapolated and compared using ANOVA.

6.2.1.3 Elephant dung count survey in TM District

It was not possible to determine any trends in the elephant population in TM District, since only one previous ground survey based on dung counts has been conducted in TM District alone (Wamukoya *et al* 1997). However, two surveys were conducted to relate elephant density and distribution with the frequency and distribution of crop raiding following the procedures of Barnes *et al* (1994). One was in May 2000 when there was no crop raiding, and the second was in August 2000 during crop raiding. The transects established by KWS in 1997 (Wamukoya *et* *al* 1997) were used for both surveys to improve the resolution of testing the difference between two density estimates in future.

According to (Plumptre 2000), dung counts should be focused in regions with high populations of elephants, and few transects should be sited in low-density areas. A set of 27 transects measuring 1 km each, and of 5 transects measuring 3 km each, were walked. These transects covered a total distance of 42 km within the five main forest blocks and across the corridor (Figure 6.1). Based on Buckland *et al's* (1994) recommendation of a minimum of at least 10 transects, and the need for 20-25 transects in Gabon to approach normality (Plumptre 2000), it was assumed that this sample size of 32 transects was sufficiently large and the distribution close to normal. Transects took four days to walk, starting with transects in the same area to avoid repeat counting of elephants. Dungs were classified as A (fresh dung), B (intact bolus), C (disintegrating bolus), or D (completely disintegrated bolus) accordning to Barnes *et al* (1997). A count of elephant dung density was treated in two ways. Firstly, all transects were used to give a general dung density estimate for the entire TM District. Secondly, transects in the same forest blocks were combined to determine the density per forest block. Transects were combined as follows: Transects 1, 2, 13, and 14 in Nyakweri forest; transects 3, 4, and 5 in Laila forest; transects 6 and 7 in Esoit forest; transects 8 and 9 in Kirindoni forest; transect 10 in the corridor; and, transects 11 and 12 in Mogor riverine forest.

The program DISTANCE was used to estimate dung density (Buckland *et al* 1994). This program allows the users to fit distribution curves to the data before analyses. Using the wrong distribution curve results in serious over-estimates and/or under-estimates of elephant density (Barnes *et al* 1997). Therefore, the program DISTANCE uses the polynomial distribution options, which fit the data equally well, giving more reliable results. TM District habitat has varying visibility, as some forests have thick or no undergrowth, glades and different grass heights. Hence, the strip width used in this case varied, thereby excluding the variable of decreasing variability with increasing distance from the transect. Deviations from transect lines due to obstacles was few, covering only a short distance (<50 m) at most, and hence did not affect the distribution of dung. The strip width was determined by plotting the perpendicular distance to determine the outlier values, which were not used in the analyses. The same strip width was used for each transect during the two surveys in order to permit effective comparison. Because of inability to measure the rate of dung decay, this study considered dung density only as a relative index with which to assess elephant abundance. Since the data had been normalised, ANOVA test was performed to assess whether dung density differed between the two months and between forest blocks and other vegetation types.

6.2.2 Elephant distribution

6.2.2.1 Past and present elephant ranges in TM District

Various methods were used to determine elephant range and distribution patterns in the study area, starting with historical data obtained during Rapid Rural Appraisal (RRA) surveys (Chapter 3), and questionnaire surveys (Chapter 4). This was followed with examination of KWS OBs records and field measurement of raided farms (Chapter 7). The present elephant range was related to human density and land tenure (Chapter 5), soil fertility and drainage patterns (Chapter 2).

6.2.2.2 Elephant movement between MT and CLs

The local community living adjacent to the Oloololo escarpment identified all the wildlife movement corridors along the escarpment and these locations were all mapped and coded from 1 to 10 during RRA survey (Chapter 3). Three locations were identified that are used frequently and were easy for monitoring elephant movement comprising: Oloololo with corridors 5 and 6; Kichwa Tembo with corridors 2, 3, and 4; and, Mpata with corridor 1 (Figure 6.10). Records of elephants using these corridors were monitored daily for 12 months, comprising information on: numbers; type of herd (mixed herd or bulls); time; and, direction of movement (up, down or along). The direction of movement was recorded as 'along' when an elephant herd stayed for more than one hour at the base of the escarpment, and this category was necessary as a basis to compare the frequency and intensity of corridor use at different times and seasons. To confirm the findings of RRA (Chapter 3) that elephant movement into TM District increases with numbers of migratory wildebeest, a monthly count was conducted of the wildebeest numbers in the MT. Wildebeest within a distance of 200 m on both sides of the road were counted for a distance of 10 km, and the density was then derived as the number per km^2 and densities were compared using ANOVA, correlations and chi-square tests. A linear regression was performed to determine the factors influencing elephant movement across the three corridors (Draper & Smith 1981). The independent variables were wildebeest density, fruiting (coded as "0" for yes and 1 for no), rainfall, grass height, grass percentage cover and grass biomass while the dependent variable was the number of elephant groups crossing the escarpment.

6.3 Results

6.3.1 Group size and trends across the Mara ecosystem

The extrapolated data from DRSRS showed no differences in elephant group sizes for TM District ($F_{3,56} = 2.12$, P=0.11) or MMNR ($F_{3,56} = 2.17$, P=0.10). However, significant variations in group sizes existed in the MT ($F_{3,56} = 5.17$, P=0.003) and in Narok ($F_{3,36} = 2.85$, P= 0.046). Combined data over time showed differences ($F_{3,205} = 3.258$, p=0.023) in group size in the four study locations (Figure 6.1). Elephants occurred more frequently in small groups of 5 or less in MT and TM, while few groups of more than 20 individuals were seen. In Narok, group sizes of

6-10 and 5 or less were equally common. In contrast, elephant group sizes were largest in MMNR (Figure 6.1).

Elephant numbers observed during aerial surveys across the Mara ecosystem showed a decline during the periods 1977-1980 and 1981-1984. This was followed by a steady increase in elephant numbers in the MMNR itself. In contrast, a decline in elephant numbers outside MMNR occurred during the periods 1989-1992 to 1993-97 (Figure 6.2). This decline coincides with the period when numbers of human deaths and crop raiding increased (Chapter 7).

Figure 6.1 Mean ± SE group size of elephants observed in the four study locations of MT, TM District, MMNR and Narok from 1977 to 1997.

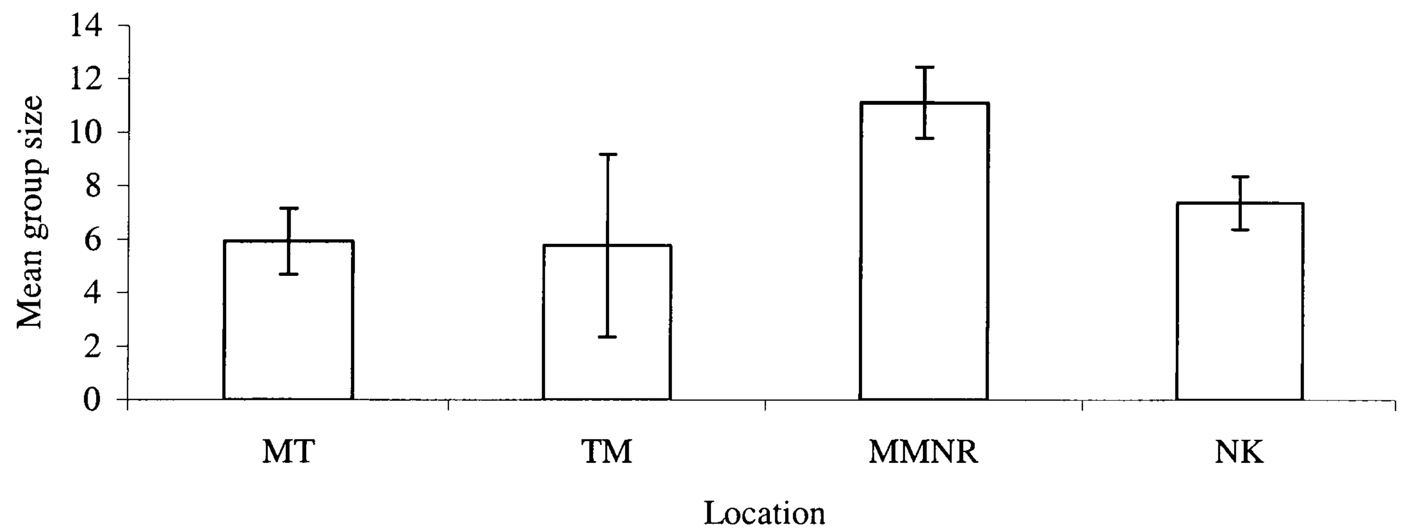
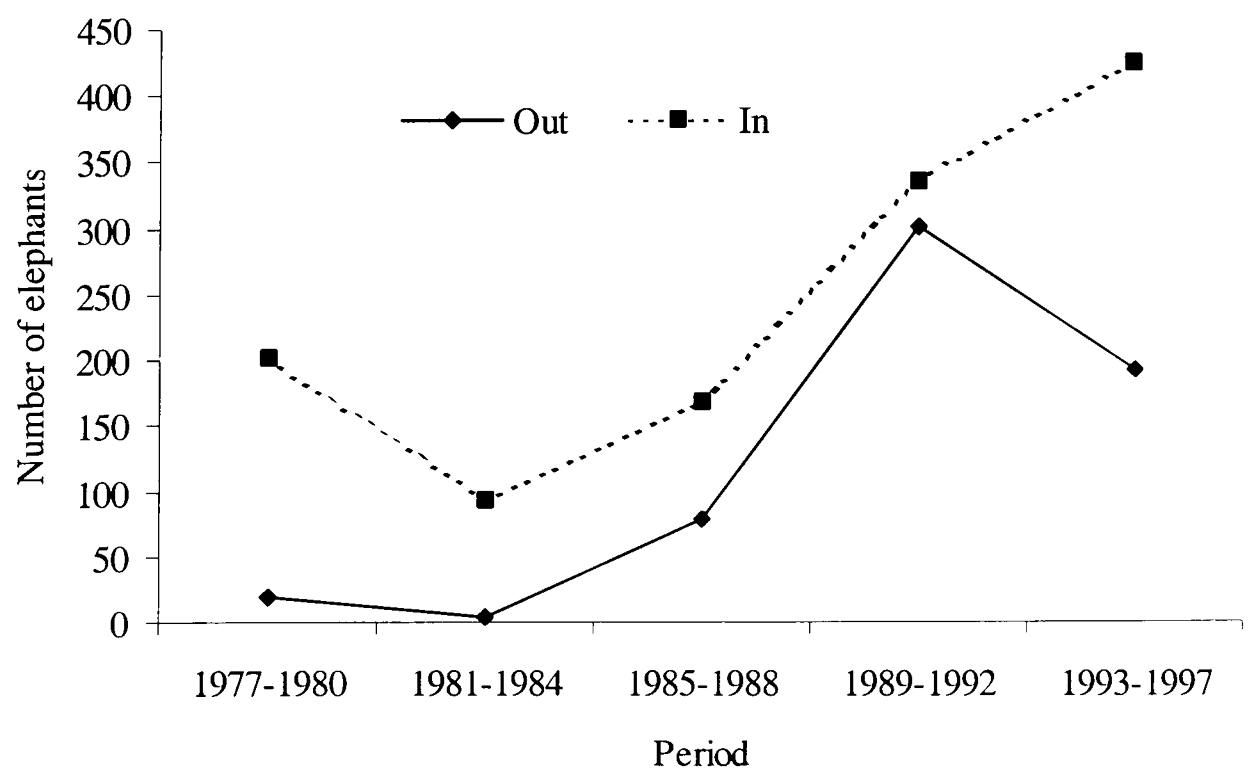


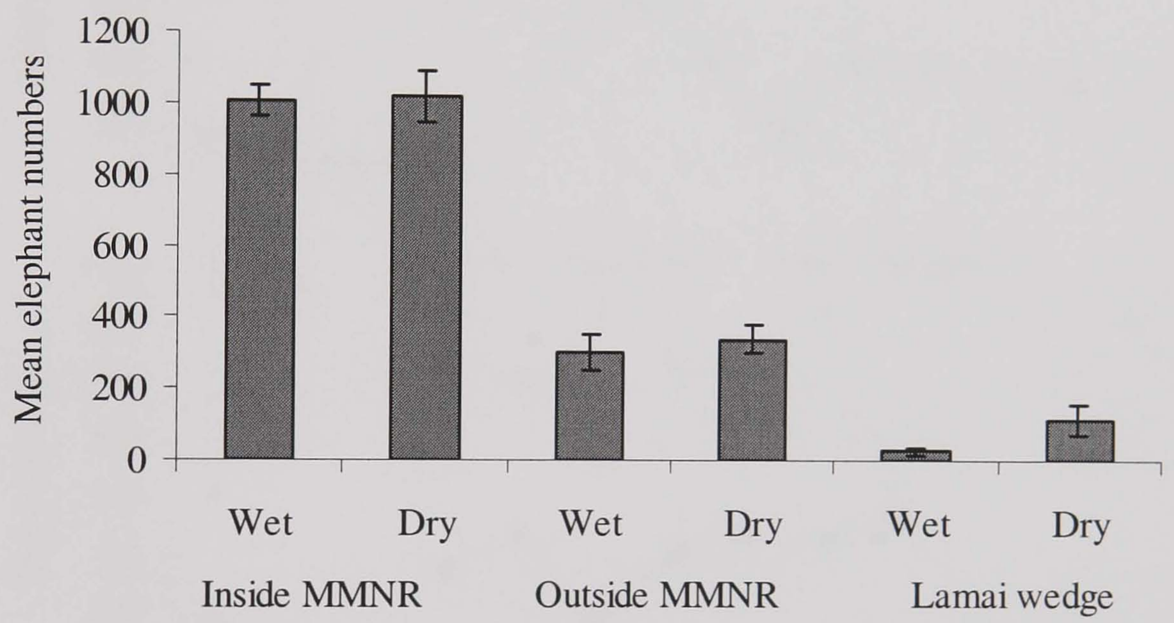
Figure 6.2 Trends in elephant numbers within the Mara ecosystem observed inside and outside MMNR from 1977 to 1997.



6.3.2 Wet and dry season total aerial counts

There was no difference ($F_{1,2}$ = 18.51, p=0.95) in elephant numbers between the wet and dry seasons in the Mara ecosystem. However, numbers of elephants differed ($F_{1,2}$ = 18.51, p=0.001) between wet and dry seasons in and outside MMNR (Figure 6.3). There was no difference ($F_{1,2}$ = 34.21, p=0.55) in elephant numbers between the wet and dry seasons outside MMNR while a difference ($F_{1,2}$ = 27.52, p=0.001) existed in Lamai. Only a small proportion of the Mara elephants move into TM District during the dry season, while the Lamai Wedge contains more elephants during the dry season. The results indicate that this is not a very pronounced pattern of localised movements during the two seasons and that crop raiding in TM District during the dry season (Chapter 8) could be by the resident elephant population.

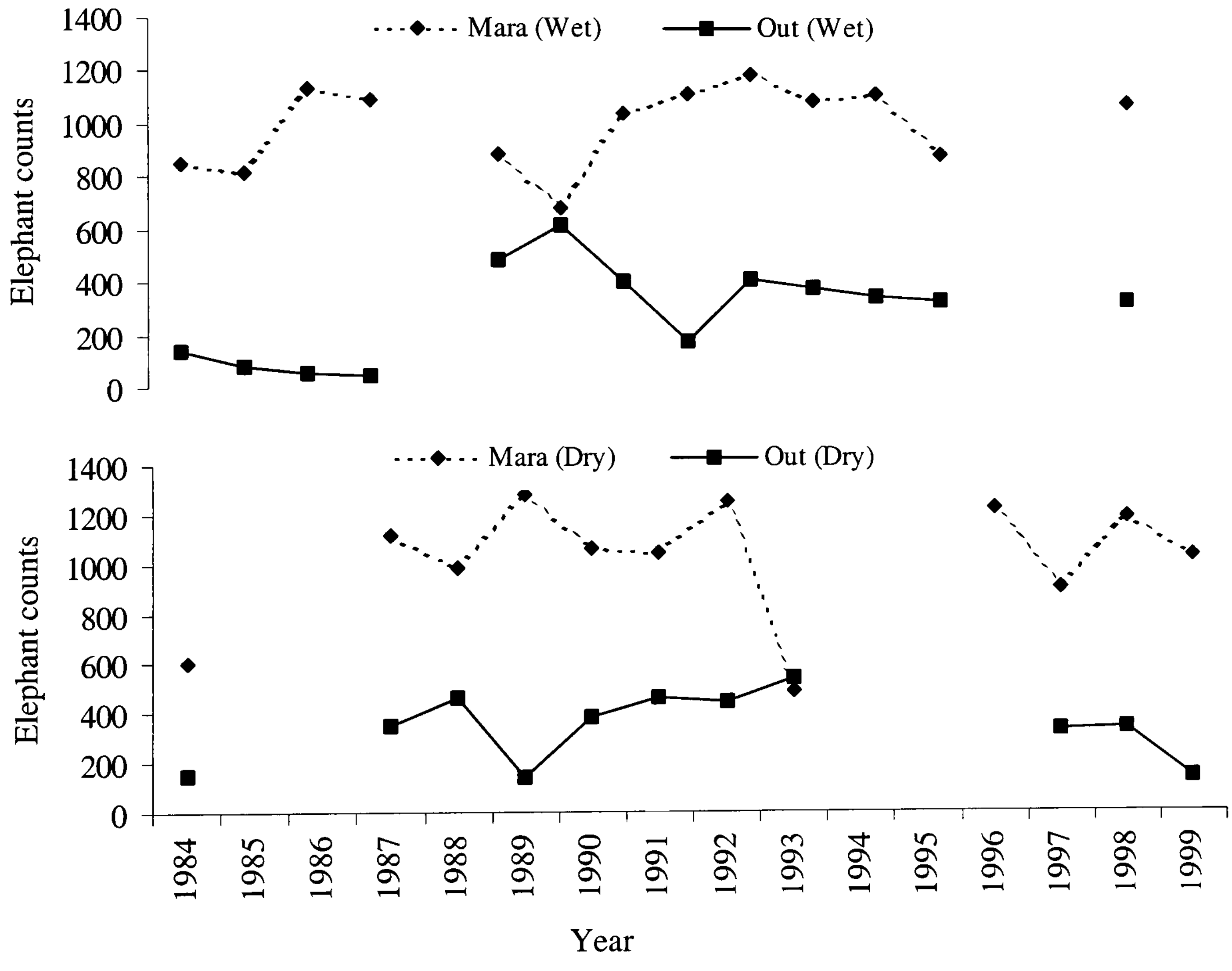
Figure 6.3 Mean ± SE number of wet and dry season total counts of elephants in the Mara ecosystem between 1984 and 1999.



Dry season counts were not undertaken in four years 1985, 1986, 1994 and 1995, while wet season counts skipped two years, 1997 and 1998 (Figure 6.4). Elephant numbers were higher during both wet and dry seasons inside MMNR than outside. A decline in elephant numbers outside MMNR corresponded with an increase in elephant numbers inside MMNR and vice versa, a sign of movement of elephants between MMNR and CLs. There was a large slump in elephant numbers in the MMNR during the 1993 drought. However, there was no corresponding decline in numbers outside, suggesting that elephants could have moved into Mara River riverine forest and onto forested CLs of TM District especially during the drought periods of 1998 and 1999.

The elephant population in the Mara ecosystem has increased from the 1960s to the 1980s, but has stabilised since 1989 (Figure 6.5). This trend is similar to the findings from the RRA survey (Chapter 3) confirming the role of local knowledge in understanding local resources. A linear regression model showed a strong and direct relationship (r=0.83) between elephant numbers and years (y=25.278x–48968) and explained 66% of variance. Years account for 68% of the variation which differed significantly ($F_{1,15}$ = 32.506, p=0.001) meaning that years alone cannot predict elephant population trend despite the strong relationship. The fluctuation in numbers could be as result of other factors like poaching and migration. Nevertheless, the increasing trend in elephant numbers is an indicator of the increasing HEC.

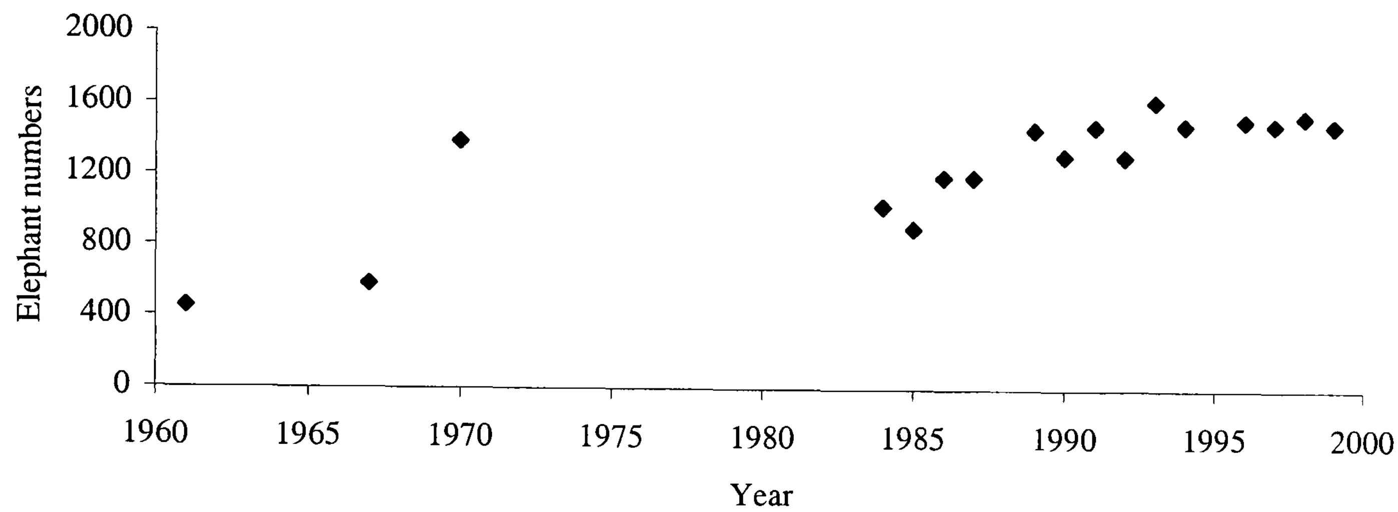
Figure 6.4 Changes in the elephant population in the Mara ecosystem, based on seasons and location between 1984 and 1999. The gap signifies no census was done.



6.3.3 Elephant dung densities on CLs of TM District

Transects 1a-c, 3a-c, 5a-c, 7a-c, 8a-c, 9a-c, 10a-c, 11a-c and 12a-c were of 1 km each. Transects 2, 4, 6, 13 and 14 were of 3 km each and could not be split into smaller transects, both because of the logistics involved and because few or no dung was found, such that splitting would have resulted in high variance. In May, four elephant herds were seen on transects, 2, 3, 7 and 11. But 1-4 day old dung was observed on transects, 3, 6, 8, 10, 11 and 12. In August, two elephant herds were observed on transects 9 and 11.

Figure 6.5 A scatter plot showing the trend of elephant population in the Mara ecosystem from 1960 to 2000 (Source: Njumbi 1995, Muriuki *et al* 1999).



Furthermore, 1-4 day old dung was observed on nine transects 2, 3, 4, 6, 7, 8, 9, 10, and 11. The increase in fresh dung along transects was due to increased immigration of elephants into TM District from Narok. These results suggest that elephants regularly use areas with transects 2, 3, 7, and 11 located within Nyakweri forest, Laila, Esoit and Mogor Riverine forests. In contrast, locations around transects 1, 8, 9, 13 and 14 were not commonly used, possibly because of increasing human encroachment, low water availability and or low vegetation cover. Hence, dung density decreased with distance from the forest towards settlements on transects 3, 5, 7, 11 and 12.

The mean dung density for each transect (combining a, b, and c where these occurred for each location), were plotted to show the spatial variation in dung density across the study area (Figure 6.6). The dung density in the six study locations did not differ ($F_{5,26} = 1.025$, p=0.424) in May but differed ($F_{5,26} = 2.719$, p=0.042) in August (Figure 6.7).

Dung counts for the two seasons were combined and the mean density of elephant dung determined for the six different forest blocks (Nyakweri, Laila, Esoit, Kirindoni and Mogor) and woodlands in the corridor (Figure 6.8). Laila, Mogor River and Kirindon forests are important ranges for the resident elephant population. Farming near these forest blocks therefore will increase the chances of conflict and indeed confirms the spatial distribution of crop raiding (Chapter 9) in respect to these areas. The high standard error (SE) for Nyakweri forest block was as a result of lack or low dung counts on transects 13 and 14.

Dung densities varied considerably on different transects. The mean dung density in all transects was 2.752/km^2 ± 665.2 for the month of May and 2,413/km^2 ± 450.1 for the month of August. There was no difference ($F_{1,26} = 0.777$, p=0.68) in dung density between the two months.

Figure 6.6 Combined mean dung densities in different locations during May and August 2000 in TM District.

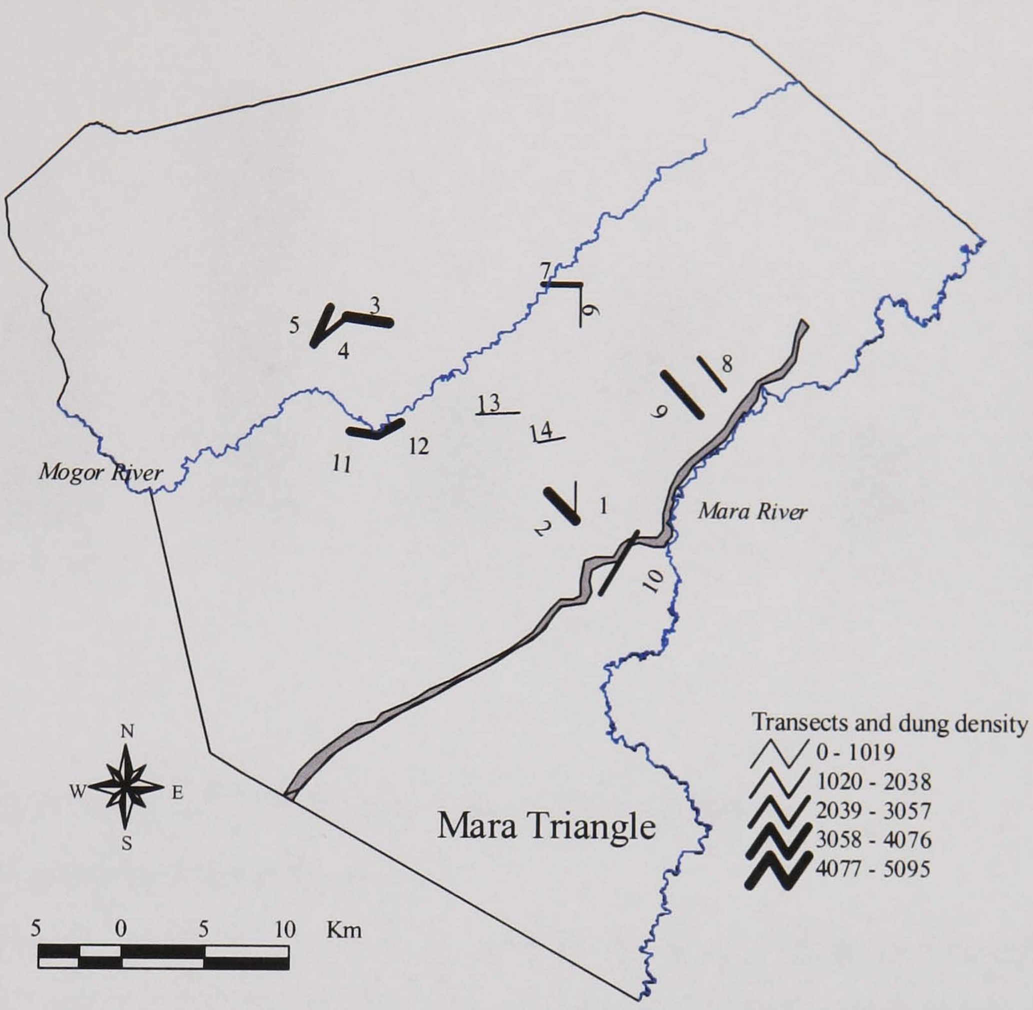


Figure 6.7 Mean ± SE dung density in May and August 2000.

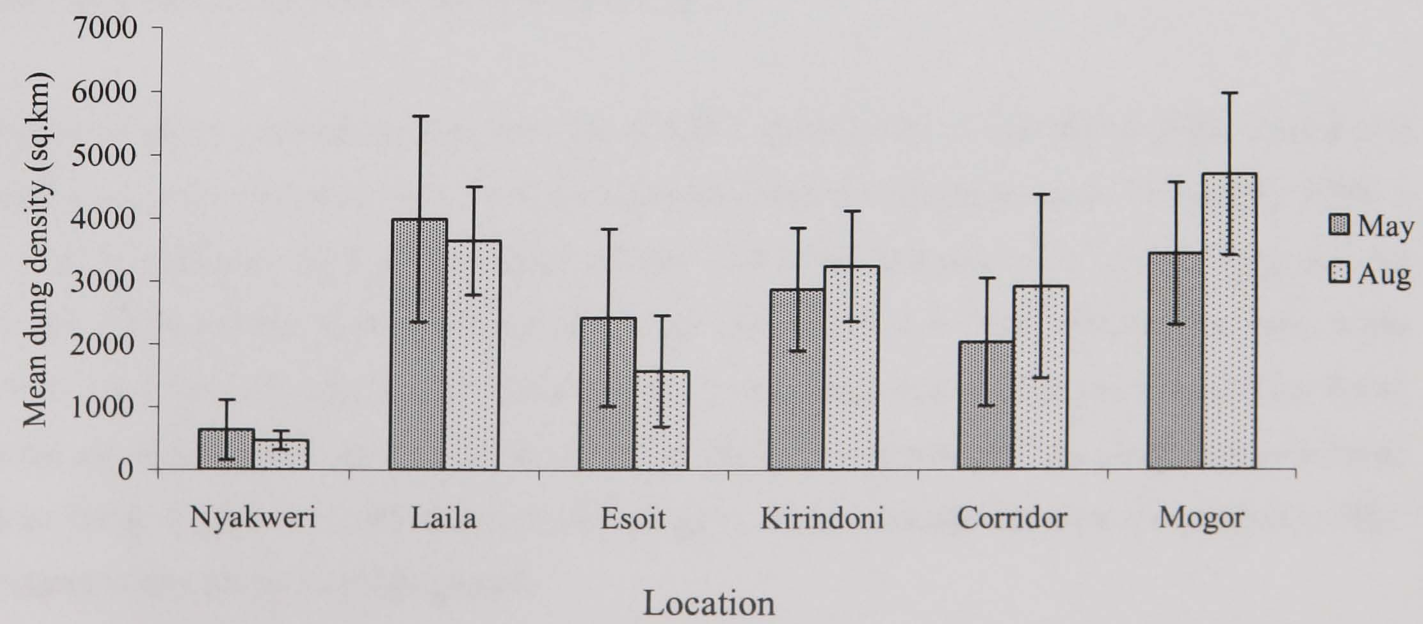
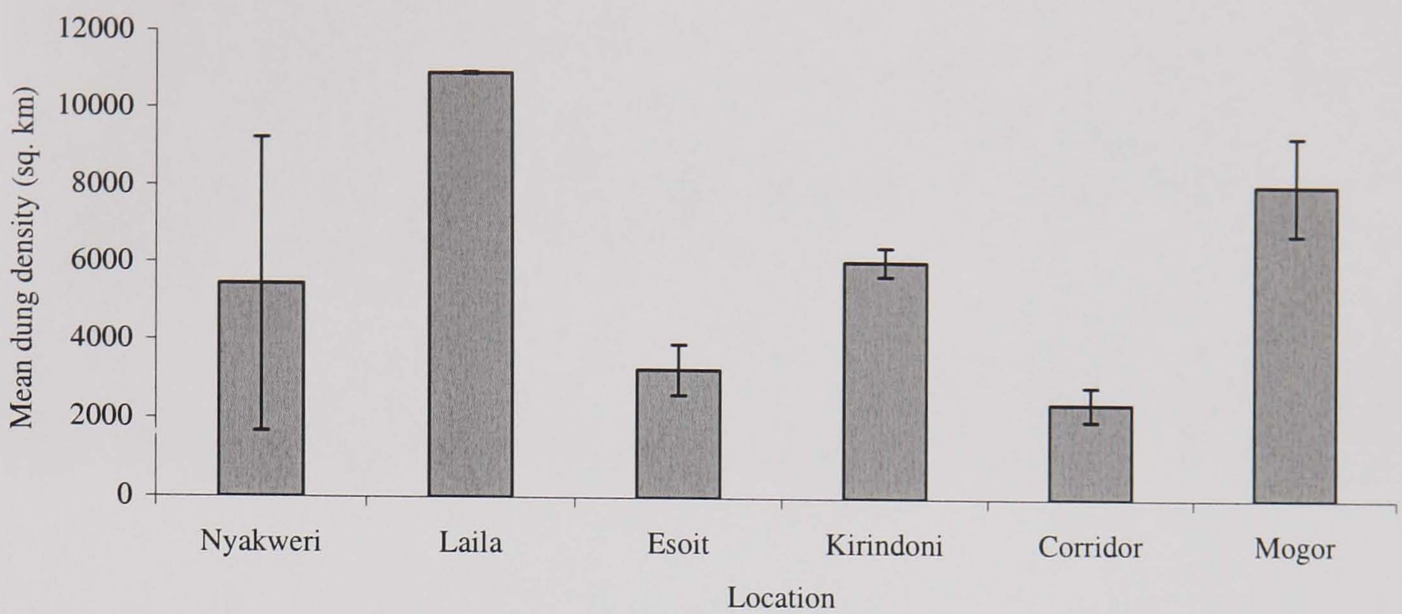


Figure 6.8 Combined mean ± SE of dung density in different forest blocks and woodlands in 2000.



6.3.4 Reduction in range of TM District elephant population

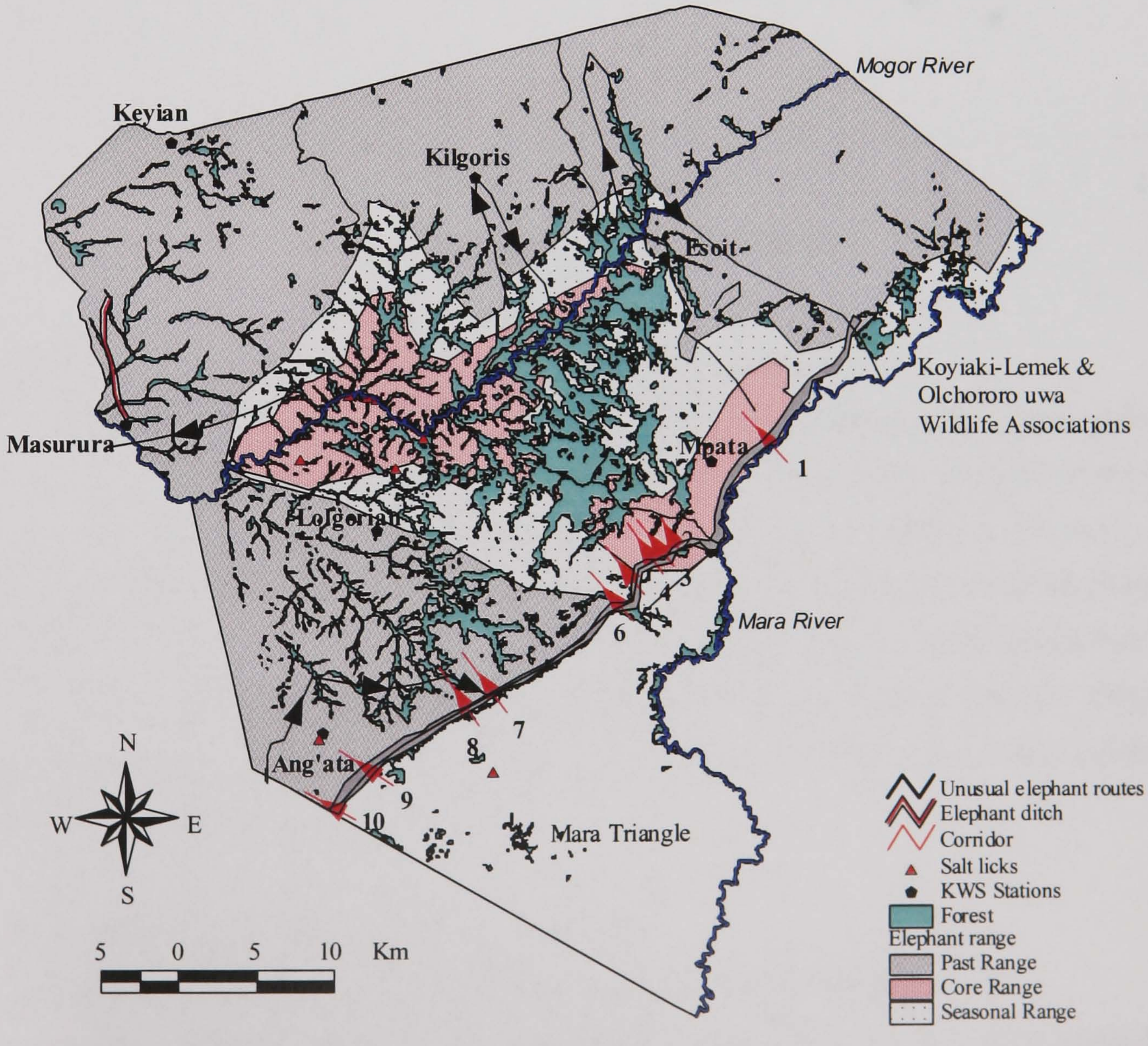
6.3.4.1 Past and present elephant range

Elephants once ranged across most parts of TM District and beyond (Chapter 3), and covered an area of more than 2,340 km^2. The present elephant range is of scattered, fragmented populations confined to central parts of the district where important resources like salt licks have been lost (Figures 6.9 & 6.10). Their overall range now covers 1,158 km^2, which represents a 51% reduction in range. Their core range only covers an area of 342 km^2, some 30% of the overall range. The elephants have been pushed into areas with: lower rainfall (Figure 2.3); low soil fertility (Figure 2.4); lower river density (Figure 2.5); low human density (Figure 2.8); and, where only forest fragments remain (Figure 6.10).

Unusual elephant movement patterns were noted (Figure 6.10). In December 1998, a herd of 5 elephants went to Kihanja town in Kuria District from the Masurura area. In January 1999, a herd of 3 elephants from Mara followed the Kirindoni-Shartuka road up to Megwarra. In October 1999, another herd of 3 elephants went to Kilgoris town and followed the same route back to the forest. Finally, in November 1999, 3 elephants went to Murgan centre from Esoit. All the movements took place at night but where elephants stayed until morning only at Kihanja before being chased at night back towards Tanzania. These unusual movements resulted in HEC incidents where crops were destroyed.

Figure 6.9 A popular elephant salt lick at Mogor bridge next to the Mogor riverine forest.

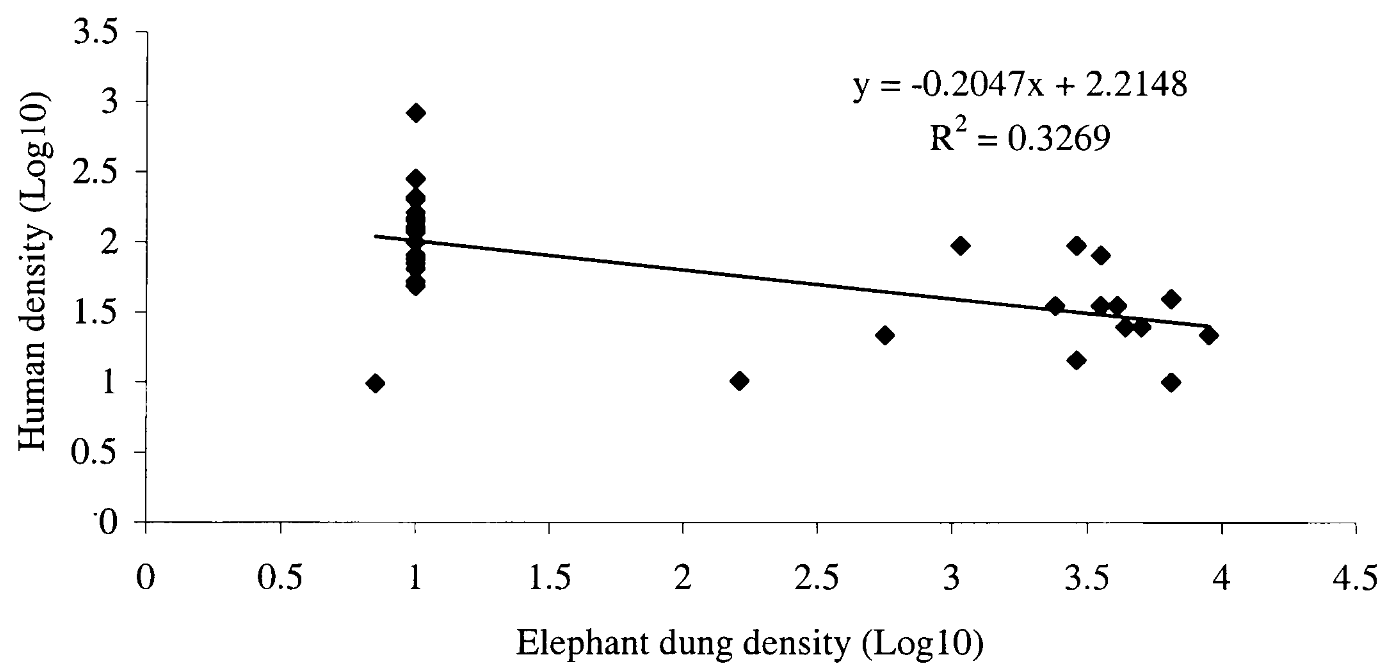
Figure 6.10 Past and present elephant range in TM District, both seasonal and core range, the unusual elephant movement routes and the corridors, linking MT to CLs.



6.3.4.2 Relationship between elephant range and human density

The proportion of elephant range within the 29 sub-locations of TM District in which elephants were present (N=12) or absent (N=17) did not differ (χ^2=1.69, p=0.194). There was correlation between elephant range and human density (r_S=0.376, p=0.022). The regression model for the relationship between elephant dung density and human density was significant (r_S=-0.572, $F_{1,30}$ = 14.57, p=0.001) and explained 33% the variance (Figure 6.11).

Figure 6.11 A linear regression illustrating the inverse relationship between human and elephant dung densities in TM District.



6.3.4.3 Relationship between elephant range and land tenure

The current status of the adjudication process varies across the elephant range (Figure 5.5) and land tenure was related elephant range (χ^2=6.183, df=2, p=0.045). Most adjudicated land with titles lie outside the elephant range (Chapter 5). Keyian Group Ranch is the only non-adjudicated land outside elephant range. In contrast, three key ranches for resident elephants in the elephant range, Moyoi B, Oloirien and Olalui group ranches, have not been adjudicated. The other group ranches within the elephant range include Moita, Nkararu, Osinoni, Shartuka, Olomismis, Masurura, Olonkolin, Kimintet (A-D) and Ntulele, in which adjudication is either in process or complete (Chapter 5, Table 5.2).

6.3.5 Corridor usage by migratory elephants

6.3.5.1 Seasonal variation in elephant numbers using the corridors

Local people identified 10 wildlife corridors along the escarpment that were used regularly by elephants (Figure 6.10 & 6.12). Low-lying and less steep three locations that were used frequently and easy to monitor comprised: Oloololo; Kichwa Tembo; and, Mpata. A total of

13,059 elephants were recorded moving up, down or along the escarpment over the 12 month period, between July 1999 and June 2000 (Figure 6.13).

Figure 6.12 Elephants leaving Mara riverine forest heading towards CLs.

The composition of elephant groups using the corridors differed between months ($F_{11,981}$ = 14.365, p=0.000). Mixed herds dominated between August and December while more bulls used corridors from January to July (Figure 6.14). Increased elephant movement coincided with end of crop raiding season (Chapter 8) meaning that crop raiding is mainly by the resident elephant population.

Figure 6.13 Mean ± SE number of elephants observed moving across the escarpment between the MT and the CLs from July 1999 to June 2000.

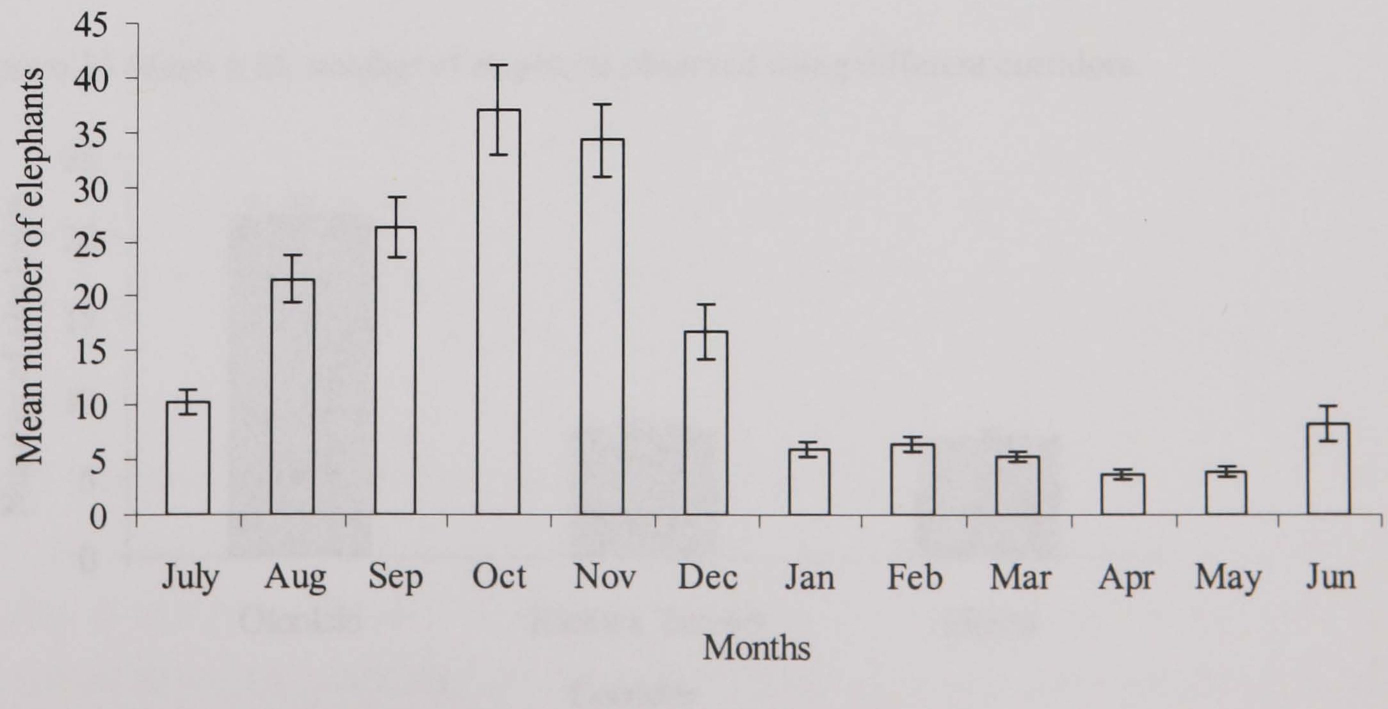
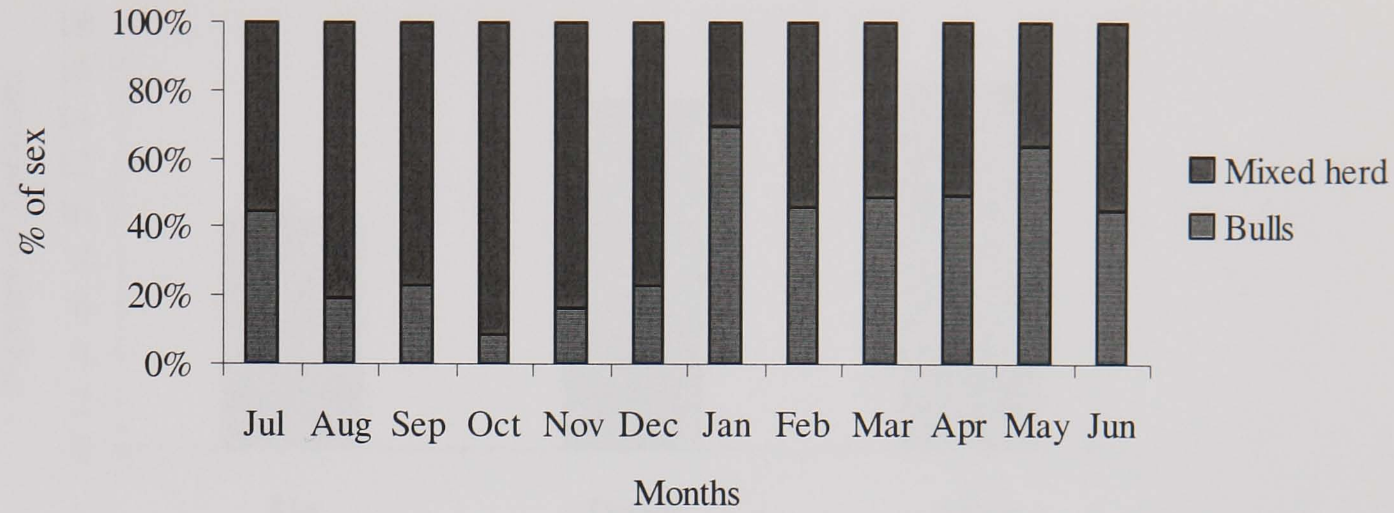


Figure 6.14 Seasonal proportions of elephant groups observed in relation to sex using the corridors.



6.3.5.2 Differences in corridor usage by group size and sex and corridor location

The size of mixed herds (19.4 ± 0.90) was larger ($F_{1,991}$ = 200.011, p=0.001) than bulls (3.6 ± 0.23) using the corridors. More elephants used the Oloololo corridor ($F_{2,990}$ = 66.478, p=0.001) than Kichwa Tembo and Mpata (Figure 6.15). More bulls used the Kichwa Tempo corridor, while more mixed herds used the Oloololo and Mpata corridors (χ^2=64.775, df=2, p=0.001).

More elephants were seen going down or along the escarpment ($F_{2,990}$ = 8.468, p=0.001) than up the escarpment (Figure 6.16). A Tukey test showed differences between up and down (p=0.001), and between and up and along (p=0.01), while there was no difference between down and along (p=0.936). Hence, during daylight hours, more elephants appear to move along the escarpment than up it but they finally crossed onto communal land at night. More mixed herd (χ^2=12.32, df=2, p=0.002) than bulls were seen moving down. However, there was no difference between up and along (p=0.749) and down and along (p=0.219) movement between mixed herd and bulls.

Figure 6.15 Mean ± SE number of elephants observed using different corridors.

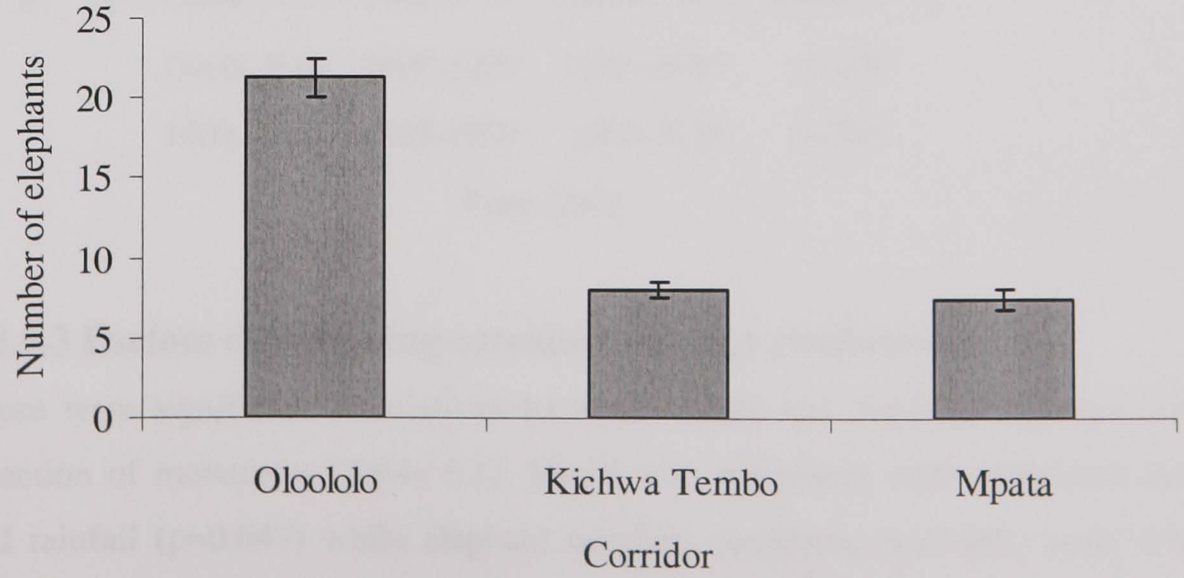
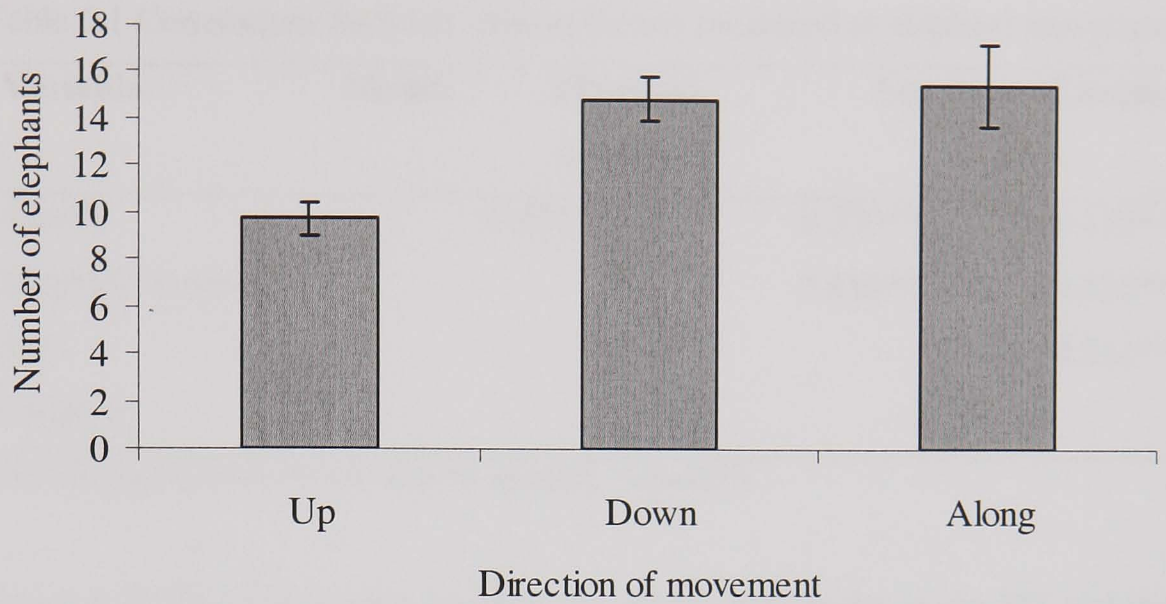
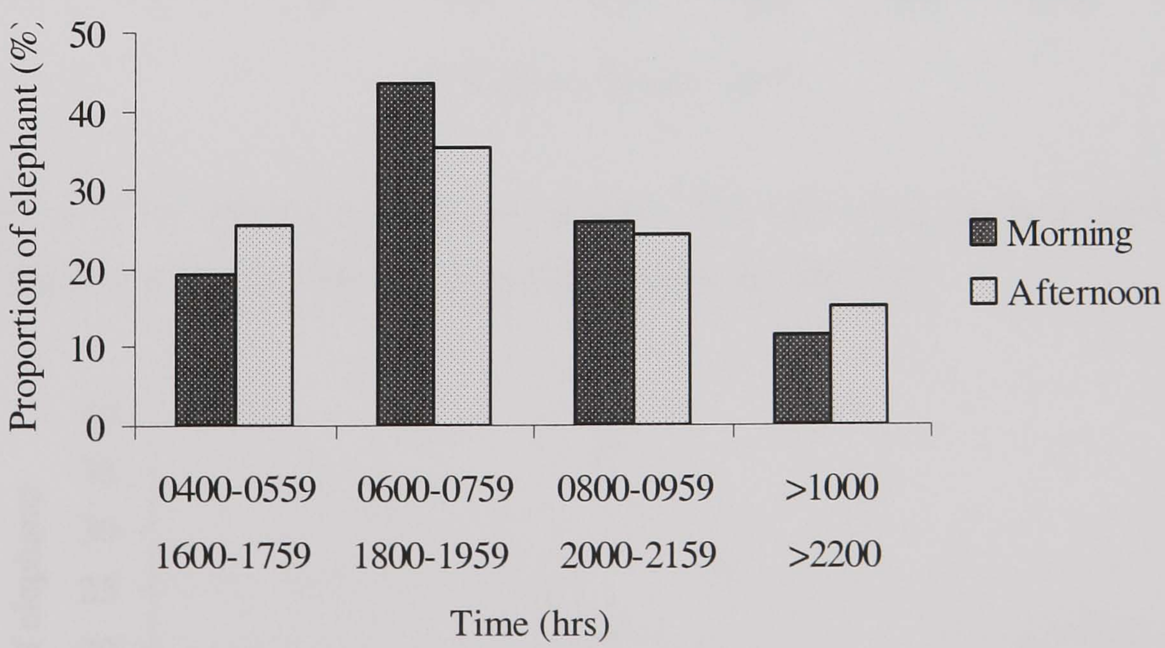


Figure 6.16 Mean ± SE number of elephants observed at the three corridors moving in different directions.



The MT elephants utilised four habitat types at different times: open grassland between 0600-1100 hrs; riverine vegetation of the Mara River and open grassland between 1100-1500 hrs; open grassland between 1600-2000 hrs; *Acacia* woodland, the forest and bushed grassland up the escarpment between 1900-0600 hrs; open grassland between 0600-1100 hrs and back to the riverine forest of the Mara River. Elephants used the corridors between 0600-0759 hrs and 1800-1959 hrs than other times (Figure 6.17).

Figure 6.17 Variation in the usage of corridors by time.



6.3.5.3 Factors determining corridor usage by elephants

There were significant correlations between month and elephant numbers, sex, location and direction of movement (Table 6.1). Month also correlated with wildebeest density ($p=0.016$) and rainfall ($p=0.047$) while elephant numbers correlated ($p=0.001$) with wildebeest density

(Figure 6.18) and rainfall (p=0.032, Figure 6.19) and finally wildebeest density and rainfall (p=0.04).

Table 6.1 Correlations between various factors measured at elephant movement corridors.

Variable	Month	Elephant numbers	Sex	Location	Direction
Month		0.405**	0.320**	-0.115**	-0.060*
Elephant numbers			0.410**	-0.326**	0.118**
Sex				-0.211**	-0.147**
Location					0.59*

Level of significance shown with **=p<0.01, *=p< 0.05

Figure 6.18 The relationship between the wildebeest density in the MT and the mean number of elephants moving across the escarpment between July 1999 and June 2000.

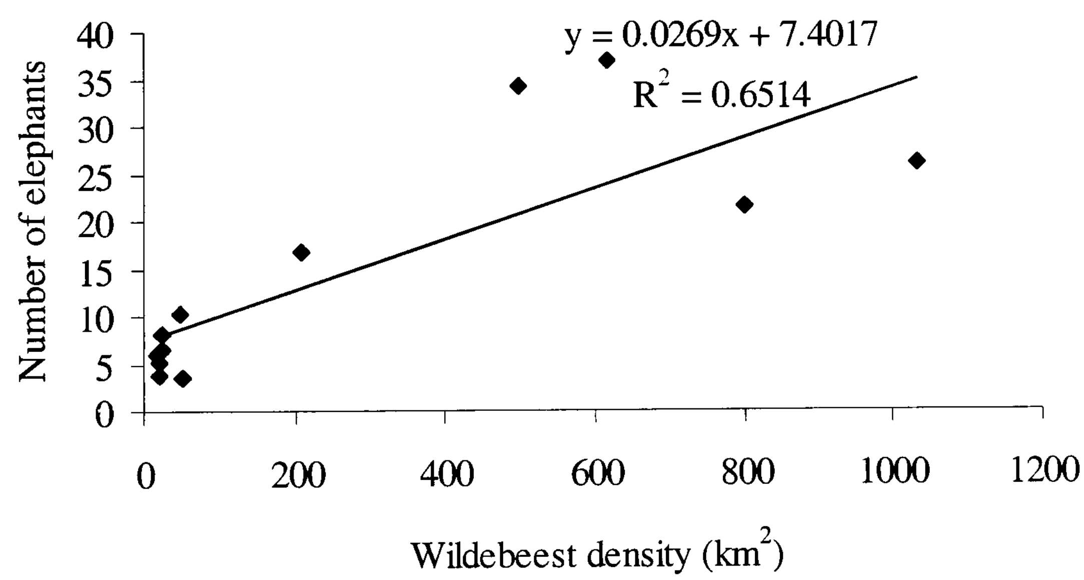
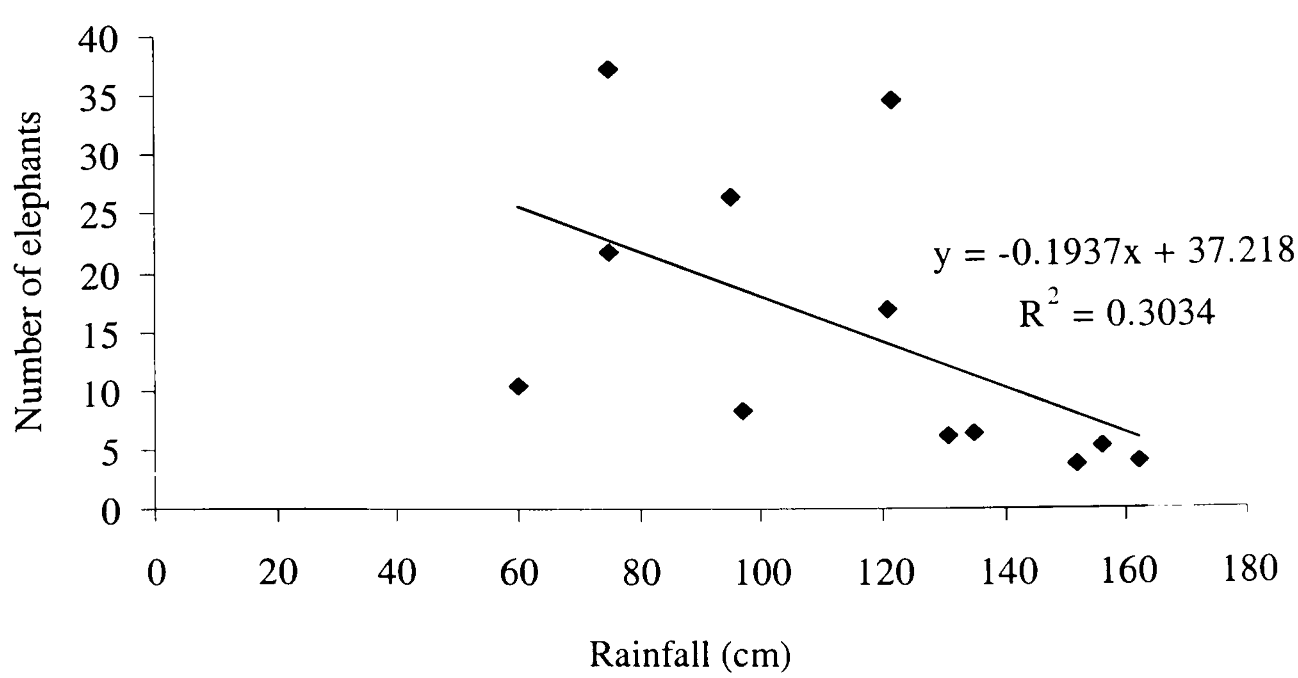


Figure 6.19 The relationship between rainfall in TM District and the mean number of elephants moving across the escarpment between July 1999 and June 2000.



The regression model for factors that might have determined elephant movement into CLs was significant ($F_{1,10}$ = 18.689, p=0.002) and explained 65% of the variance (Table 6.2). Significant relationships were observed between elephant movement and wildebeest density.

Table 6.2 Factors determining elephant movement across the escarpment, based on linear regression.

Variable	B	t	Sig.
Constant		2.670	0.023*
Wildebeest	0.807	4.323	0.002**
Fruiting	-0.271	-1.442	0.183
Rainfall	-0.177	-0.792	0.448
Grass height	-0.033	-0.135	0.896
Grass cover	-0.100	-0.475	0.646
Biomass	-0.008	-0.032	0.975

Level of significance shown with *=p<0.05, **=p<0.01

6.4 Discussion

Understanding elephant numbers and their distribution is a critical step towards understanding and managing the spatial patterns of conflict in any elephant range (Lindique & Lindique 1991, Barnes *et al* 1993). However, the loss of elephant range through habitat loss is the most threatening factor to the survival of the African elephant (Parker & Graham 1989a, Hoare 1999). Hence, the shrinking elephant range with the increasing elephant numbers pose a big challenge to wildlife managers. To be able to understand and manage HEC, an understanding of elephant numbers in relation to the range is imperative. Most previous studies on HEC focused on the types of conflict without considering other explanatory variables like elephant densities and distribution (Kangwana 1995, Kiiru 1995, Naughton-Treves 1998). The range of elephants has not been studied previously in TM District. TM District forms an important habitat for the Mara ecosystem elephant population, both migratory and resident. Elephant range has dwindled and is highly fragmented as a result of human encroachment compressing elephants into a small area. This poses great risk of habitat degradation, particularly the riverine forests along 'refuges' of the Mara and Mogor rivers. In turn, important elephant resources have been lost, resulting in unusual movement patterns (Figure 6.10). Creating or preserving bands of suitable habitat linking core populations is seen as the best solution to the problem of habitat fragmentation. Therefore, the daily movement of elephants from MT into CLs suggests its importance for elephant conservation and management (Figure 6.12 & 6.13). Hence, corridors should be free from encroachment. This study has established that wildebeest migration (Table 6.2) into MMNR influence elephant movement through the existing corridors, which confirmed the knowledge by the local community as reliable (Chapter 3). However, private land and high human density areas are no longer part of the elephant range.

6.4.1 Spatial and temporal patterns of elephant numbers and distribution

Aerial surveys are used in large and poorly accessible areas but may be of limited value depending upon visibility, topography, distribution of animals and survey design (Norton-Griffiths 1978). The elephant population in the Mara ecosystem has remained stable since 1984 (Ottichilo 2000). Elephant population is expected to increase by 5% a year in good environmental conditions (Dublin *et al* 1997). However, since fewer large males remained after poaching (Lewis 1984, Poole 1989), this could have affected the breeding status of the Mara elephants. Equally, land use change and poaching regulates changes in population rather than natural control (Dublin *et al* 1990). Due to the forest nature of TM District, aerial surveys are difficult and the recent survey estimates about 200 and 300 elephants (Wamukoya *et al* 1997). Elephant numbers in the Mara ecosystem remained the same between the dry and wet seasons (Figure 6.3) but variations in actual numbers during surveys (Figure 6.4) could be attributed to localised migrations onto forested CLs and keeping to the riverine forest of Mara River. Dublin (1994) attributed change in elephant numbers to drought and migration to TM District, Serengeti and Loita, and Muriuki *et al* (2000) attributes it to re-establishment of Lamai Wedge between MMNR and Serengeti NP. This could be due to a reduction in poaching in Serengeti, and/or encroachment on corridor 10 to CLs forests, which is completely blocked.

DRSRS aerial sample data has been frequently used in understanding elephant population trend though it is inconsistent due to variation in strip width (De Leeuw *et al* 1998). However, population estimates using both aerial sample counts and total counts methods are not different but with less reliable results (Ottichilo 2000). During poaching, elephants moved into safer PAs and re-established back into CLs resulting to increased HEC (Kasiki 1998, Sam 1998). The trend of elephant numbers in the Mara ecosystem between 1960 and 2000 shows an increase (Figure 6.5) The increase in population is attributed the listing of African elephant on Appendix I in 1989, protection of elephants and natural recruitment (Kasiki 1998). In 1970s, there was a population crash because of increase in the price of ivory that led to poaching (Poole 1990), while from late 1980s, Mara was free from poaching (Dublin *et al* 1990). Later, the build up of elephant population in PAs caused ecological problems (Dublin 1986) and started dispersing back onto CLs.

Elephant census in a forest environment can be tricky, expensive and time consuming. The droppings count method has been used for estimating elephant densities (Wing & Buss 1970, Jachmann & Bell 1984, Barnes *et al* 1997). It provides relatively good results for its costs but it has several potential sources of error related to deriving the index of abundance and turning this index into an estimate of elephant numbers (Barnes *et al* 1991, Tchamba & Mahamat 1992, Barnes *et al* 1993). Because of inconsistent data on elephants in TM District, this study adopted several methods to gain meaningful information for management (Plumptre 2000). Relying solely on transect counts is inadvisable because of the low resolution of changes that can be detected. Elephants prefer very dense undergrowth especially secondary forest and avoid forest with open undergrowth (Barnes *et al* 1991). Laila and Mogor riverine forests had the highest dung density (Wamukoya *et al* 1997) though KWS method tends to over estimate elephant population (Vanleeuwe 2000). These estimates could not be compared with the estimates of this study because of different statistical approaches used to estimate dung densities. However, Laila and Mogor riverine forests still had the highest dung density (Figure 6.8) probably due to the preferred thick undergrowth, unlike Nyakweri forest with no undergrowth and fewer rivers.

Elephant density could not be determined in this study because dung decay rate and defecation rate were not determined. Use of a standard defecation rate (Wing & Buss 1970, Plumptre & Harris 1995) may result to wrong estimates (Hiby & Lovell 1991, Barnes *et al* 1994, Plumptre & Harris 1995, White 1995, Barnes *et al* 1997). Equally, dung decay rate differs with altitude (Vanleeuwe 2000) and this may affect the estimation of population density. Also, fewer transects were used, which could result in high SE and over or under estimate. Because of these limitations hence dung density was used as an index of elephant density. Dung density did not differ between May, a non-crop raiding season and August, a crop raiding season implying that the resident population are potential crop raiders.

Elephants can spread widely during the dry season (Bhima 1998) or during the wet season and but aggregates near artificial water points during the dry season (Glover & Sheldrick 1964, Laws 1969, Leuthold & Sale 1973, Cobb 1976, Leuthold 1977, McKnight 1996, Kasiki 1998) and respond to sporadic rainfall (Low 2000). Elephants have the ability to sense a local rainstorm over considerable distance (Leuthold 1977) but this ability has never been explained. In TM District, wildebeest density influenced the movement of elephants from MT to CLs (Figure 6.18, Table 6.2) possibly because wildebeest finished all the grass (Dublin *et al* 1997, Ottichilo 2000).

6.4.2 Changes in elephant range in TM District

According to Norton-Griffiths (1998), most wildlife loss in Kenya occurred on unadjudicated land, areas outside PAs and non-tourism districts. Equally, wildlife loss was higher in National Reserves and Narok/TM District leading because of little benefit to the community. Due to encroachment, unusual elephant movement pattern has been noted (Thouless 1998). In TM District, elephants occur in two classified areas: (a) protected area (MT) (b) non-protected area which include the group ranches (CLs) and private land that act as a dispersal area for MT and Narok elephants and the resident population. The Mogor riverine forest on CLs and its forested tributaries are the core elephant range where they hide during the day. Most elephant range has been lost on private owned land (Figure 6.10, Chapter 5) and with the ongoing adjudication process, more crucial elephant range will be lost due to increased human settlement. Presently, elephants no longer use adjudicated land in TM District (Chapter 5). In an attempt to remember the old routes, four unusual elephant movements were observed, which could be an indication of disruption of the traditional migratory path and important resource areas (Figure 6.10) and a confirmation of the Maasai proverb that "*The elephant never forgets where it passed*".

6.4.3 Elephant movement onto CLs using corridors

Migration refers to the movement of a species beyond the limits of its home range on an annual or seasonal basis. Elephants avoid steep slopes and areas with intense human pressure (Vanleeuwe & Lambrechts 1999) and can go up places where man, has the most difficult in climbing (Melland 1938). Migration corridors have been known to exist in most elephant ranges, which again influences elephant movement (Gulinck *et al* 1991, Soule & Gilpin 1991, Sam *et al* 1997, Low 2000). In Zimbabwe, elephants feed on wild browse on CLs because fire and elephants have reduced the availability of preferred tree species within PA (Osborn 1998). In Luangwa Valley, elephants moved from the valley to the higher slopes of the Muchingas to get *Musuku*, (wild fruit), which ripened during Christmas season or to a pool of medicated water known as *chipatala* (hospital) of sick and wounded elephants (Melland 1938). Elephants in TM District move up the escarpment to feed on *Acacia*, which is not in the northern part of the MT (Chapter 5) and to access the forest products and salt licks. Elephant herds aggregate to form larger groups at the base of the escarpment before proceeding onto CLs when dark for security reasons and on returning they break into smaller family groups. Elephants then proceed towards Mara River taking shorter time through the plain probably because of high wildebeest population and increased number of tour vehicles.

Elephant corridors along the escarpment in TM District influenced elephant movement between MT and CLs (Figure 6.10). The MT population moves up the escarpment every evening and return to the MT in the morning covering a distance of between 10 - 20 km into CLs. Fairly steep corridors (6, 7, 8, 9 and 10) are no longer used because of increased human activities on the escarpment and were mostly used for downward movement to MT. Elephants can no longer access Ketura and Olaitong' forest products and salt licks while livestock cannot access Ng'irare salt licks in the MT. Oloololo corridor, (4 and 5) which lies in the reserve, is gently slopping and frequently used by elephants because it is not, encroached by humans. The gently sloping Kichwa Tembo corridor, (2 and 3) is encroached with settlements, tourist structures and a market centre reducing its usage by elephants (Figure 6.15). This corridor follows Moyian River and ends at Sabuenker salt licks and also has a confluence of three roads increasing attacks on humans by elephants (Chapter 7). According to Gulinck *et al* (1991), corridors are often associated with opportunistic land use patterns such as road infrastructure. Because of increased human activities in this corridor, its function as a conduit for wildlife might cease in the near future. Elephants have changed their behaviour pattern probably for security reasons, and use the corridor during late hours (2100 hrs) and return into MT quite early (0400 – 0600 hrs) (Figure 6.17). Mpata corridor (1) was used mainly during the dry season when elephants moved from the adjacent Koiyaki-Lemek and Olchororo uwa Wildlife Associations areas in Narok District onto TM District CLs. However, it was not possible to observe elephant movement through this corridor because of its usage during very late hours of the night.

More mixed herds than bulls used the corridors, the difference that could be attributed to the temporal aggregation in which the herd was recorded as a mixed herd. More bulls crossed onto CLs between January and July, while mixed herds increased in other subsequent months (Figure 6.14). The mixed herds did not utilise CLs frequently in the absence of a high wildebeest density. The highest number of individuals in the mixed herd observed was 121 recorded in September. The number of elephants using the corridors in the evening and in the morning differed in some instances probably because some elephants remained on CLs or left the CLs while still dark and hence were not recorded. Also, some elephants moved onto CLs very late hours of the night and returned very early in the morning without being noticed. Unlike the male groups, mixed herds groups went up the escarpment very late in the evening when dark, and returned early while still dark, a factor related to security. However, the trend changed from August where all elephants crossed early and returned into the MT after dark. Fire also influenced elephant movement as was noted when elephants avoided Oloololo corridor when it was burnt and used Kichwa Tembo corridor recording the biggest herd ever. This shows how crucial and determined the movement is for elephants.

According to Laws *et al* (1975) and Leader-Williams *et al* (1990b), elephants form large herds in situations where they feel threatened. As a result of this, they may cause severe damage when crop raiding or while foraging in large groups. The aggregation behaviour of mixed herd of elephants at the base of the escarpment and their movement while dark possibly serves as a security measure on CLs. Similarly, while the mixed herds avoided the encroached corridor of Kichwa Tembo, the bulls used it regularly. Bulls have been reported to venture into risky movement (Sukumar 1991, Thouless & Dyer 1992, Hoare 1998) to access high nutritive food for reproductive purpose. However, elephants are now loosing their fear of humans (Kangwana 1995, Tchamba 1995, Naughton-Treves 1998).

6.4.4 Relationships between elephant range and other parameters

Many factors have been attributed to pushing elephants out of their range. These include deforestation, expansion of wheat fields and settlement (Muriuki *et al* 1999, Vanleeuwe 2000), poaching (Milner-Gulland & Beddington 1993) and colonial economic development programmes of road, rail and piped water (Sikes 1971). Overlaying maps of the present elephant ranges (Figure 6.10) with maps of soil suitability (Figure 2.4), rainfall pattern (Figure 2.3), drainage pattern (Figure 2.5) and human density (Figure 2.8) forms a perfect jig-saw-fit implying elephant displacement from highly productive areas to unsuitable, low production areas, low rainfall, low drainage and low human density. The progressive constriction and fragmentation of elephants towards the adverse conditions are a threat to the future survival of both the resident and the migratory elephant populations of the Mara ecosystem.

Elephants usually coexist at variable levels or abundance until a threshold of land cover transformation is reached in natural habitat matrix and disappear thereafter. Parker and Graham (1989a) predicted elephant extinction at a human density of 82.5/km^2 in Kenya's rich soils and at 18.9/km^2 in poor soils of Zimbabwe. Loss of elephant range has been documented (Brooks & Buss 1962, Stewart & Stewart 1963, Largen & Yalden 1987). Elephants can re-establish back once an area is devoid of people. A case in point is in Tanzania's Rukwa area where elephants moved in after the government evicted people from the area (Parker & Graham 1989a). While elephants in TM District occurred in areas with low human density, Nkararo sub-location has very high human density (82/km^2) due to immigrants, yet it has the highest density of the resident population in Laila forest. Increase in farming threatens the Laila forest, an *'elephant maternity ward'*. However, a greater part of the forest is in Illemeshuki sub-location, which has the lowest human population density (0.2/km^2). In contrast, some areas with low human density like Sitoka (10.2/km^2) and Pusangi (9.75/km^2), which have Nyakweri forest have low elephant numbers probably due to lack of a permanent water source, lack of forest undergrowth and insecurity. However, the weak model cannot adequately predict elephant extirpation in TM District (Figure 6.11) but elephants start disappearing from an area at a human density of 50/km^2. For instance, Ang'ata Barrikoi and Shartuka with a human density of 64/km^2 and 59/km^2, respectively, are no longer part of the elephant range. Elephants in TM District are currently occupying areas with human density ranging between 0.2 and 40/km^2. Based on this, and even with a higher confidence limit, the elephants of TM District are not very secure.

6.4.5 Implications for management

From the above results and discussions, the corridors seem to be crucial to elephant conservation and management. Therefore, maintenance of elephant corridors, establishment of wildlife associations and wildlife user rights on CLs in TM District is the way forward. This is the sure way to avoid damage to the already declined riverine forests of Mara and Mogor rivers by accessing CLs. Elephants destroy riverine vegetation during the dry season because they would concentrate around permanent water and range over a wider area during the wet season, which allows vegetation to recover. There is need for a regional management of the entire Mara ecosystem.

The land use patterns influence the spatial and temporal distribution and numbers of elephants in human inhabited areas, which often results into HEC. In the next chapter, I will now examine the types and patterns of HEC as a result of changes in land use patterns and elephant numbers and distribution.

CHAPTER SEVEN

Types and trends of human-elephant conflict

7.1 Introduction

Human-elephant conflict (HEC) has always existed whenever humans and elephants have shared their habitats. However, changes in the sizes of human and elephant populations, and in land use patterns have increased competition between humans and elephants for space and resources. Conflict with humans is now a major conservation issue threatening the future of elephants, especially outside protected areas (PAs). Equally, conflict with elephants can affect human livelihoods and threaten life. Different types of conflict have evolved as different spatial and temporal patterns of human behaviour emerge, while people and elephants have evolved strategies to cope with increasing tensions. Earlier studies of HEC were descriptive and lacked quantitative data (Melland 1938, Allaway 1979) or were simply brief problem statements (Nicholson 1968, Vessey-Fitzerald 1968, Matzke 1975). However, more critical analysis emerged in the 1980s (Bell 1984), which provided a good baseline for more focused studies (Sukumar 1990, Kasiki 1998, Hoare 1998, Low 2000, Kailas 2000, Smith and Kasiki 2000). These studies have shown interesting variations and similarities in the types and patterns of conflict in different elephant ranges, epitomising the suggestion that:

"An elephant does so many things that are remarkable that we can believe almost anything of them"
(Radclyffe Duggmore in Melland 1938).

Most previous studies of HEC focused mainly on crop raiding, with descriptive analysis of human deaths and injury inflicted by elephants. Equally, previous studies have not considered the negative impact of human activities upon elephants, such as poaching, habitat encroachment, and the spatial and temporal patterns of attack on humans and human caused elephant mortality.

Masai Mara National Reserve (MMNR) is a leading international tourist destination and supports a remnant elephant population in Kenya. Transmara (TM) District is important for both resident and migratory elephants, especially during the dry season. It is one of the key areas of Kenya experiencing high HEC (KWS 1994). The findings of this study are compared with a study in Tsavo (Kasiki 1998), in which semi-arid savannah woodland habitat with irrigation farming, electric fencing, individual land tenure system, and the management of the PAs by Kenya Wildlife Services (KWS) were the main features. In contrast, this study covered both savannah and a forest habitat of TM District, where there is no irrigation farming due to high rainfall, no electric fencing, a land tenure system in transition from communal to individual, and where Transmara County Council (TMCC) manages Mara Triangle (MT) section of MMNR while the wildlife outside is managed by KWS. This chapter aims to answer the following questions:

- What are the main types of HEC in TM District?
- What other wildlife species cause problems in comparison with elephants?
- What are the spatial and temporal patterns of human attack by elephants relative to tribe, time of attack and distance from MMNR?
- What factors determine attack on humans by elephants?
- What are the trends of elephant mortality in Kenya and the Mara ecosystem?
- Which elephant groups are involved in crop raiding and the time of most attacks?
- How and what factors determine KWS response to reported cases?
- What is the impact of elephants on education in TM District?

In this chapter, I describe attacks on humans by wildlife (7.3.1) and elephants (7.3.2), trends in elephant mortality (7.3.3), human wildlife conflict (7.3.4) and the response made to reports by KWS (7.3.5). I then examine crop damage by elephants (7.3.6) and the interruption of educational activities (7.3.7). This chapter concludes with a discussion of these results (7.4).

7.2 Methods

7.2.1 Human deaths and injuries

Past data on human deaths and injuries caused by elephants and other species of wildlife were obtained from the RRA survey (Chapter 3), KWS Occurrence Books (OBs) records from 1986 to 2000, and the District Compensation Committee documents from 1961 to 2000. The information acquired included: the area of the incident; sex; tribe of the victim; time; state, whether drunk or sober; year; and, if compensation was paid. With the help of the local chiefs, the families of victims of past incidents were visited and interviewed, and the specific locations of elephant attacks were mapped for GIS application. This detailed approach was necessary to acquire accurate information on past incidents and to confirm the validity of RRA and interview surveys. All subsequent human deaths and injuries that occurred during the study were also recorded to a similar level of detail.

7.2.2 Elephant mortality

Any dead or injured elephants found during the course of fieldwork were recorded, and their exact locations mapped. In order to compare trends in elephant mortality under different circumstances, data on past elephant deaths and/or injuries from 1990 to 2000, and their locations, were also obtained from KWS OBs records. This enabled a comparison between elephant mortality data for the Mara ecosystem with the national figures obtained from the KWS Elephant Programme database.

7.2.3 Crop damage

Secondary data on crop damage were collected from OBs in six KWS stations and out-posts, to compare trends in conflict in TM District between 1986 and 2000. The information obtained included: division; location; months and year; type of crop; the tribe of the victim; action taken by the farmer and KWS rangers; and, time taken by KWS to respond to the conflict. Primary data were also collected through field surveys and monitoring, to determine the current status of crop raiding. RRA surveys (Chapter 3), followed by intensive field surveys, were used as a basis to determine where 10 field assistants should be selected to strategically cover important crop raiding locations. These 10 assistants were trained in procedures, to assist in recording crop damage. Data sheets and a GPS were provided to all field assistants for mapping purposes (Chapter 9). The specific guidelines under which they worked included collecting the following data: date and time of incident; farm size; elephant herd size and sex (bulls or mixed herd); type and age of crop; proportion of crop damaged; and the reactions of KWS personnel and local people towards crop raiding, as discussed in Chapter 10.

7.2.4 Response to reports by KWS

The response by KWS rangers to reports of HEC recorded in OBs was categorised as '0' for no response and '1' for a response. Where there was an entry of 'no records', this was interpreted as 'no response' since any movement of the rangers out of the station must be recorded in OBs, to include their destination and the underlying reason for going on patrol. Since responses varied, a multiple logistic regression analysis was performed to determine which factors influenced the response to reports by KWS. The factors examined included: (a) division and were classified as (1) Lolgorian, (2) Kirindoni, (3) Pirrar, (4) Keyian, and (5) Kilgoris; (b) KWS station which included (1) Keyian, (2) Lolgorian, (3) Kilgoris, (4) Mpata, and, (5) Masurura; (c) month and year; (d) nature of conflict which was classified as (1) crop damage, (2) human deaths or injuries, (3) livestock attack, (4) property loss, and, (5) insecurity; and, (e) wildlife species involved. The wildlife species involved were categorised as (1) elephant, (2) other wild herbivores, (3) predators, and (4) primates.

7.2.5 Interruption of educational activities

7.2.5.1 Schools performance

Once it had been established that pupils in elephant range were getting to school late and/or were absent, I sought to compare the performance of schools in the national examination, both in and out of the elephant ranges using ANOVA and multiple linear regression. The mean scores for performance were collected from the District Education Office (DEO), together with other information like school size, number of teachers, and division, and whether schools lay within and outside elephant range.

7.2.5.2 Pupil interruption

With the use of GIS/Atlas programme, it was possible to determine that 31 primary schools out of 132 schools in the TM District are currently found in, or close to, the present elephant ranges. Ten primary schools that were often mentioned as the most affected by elephants were selected for monitoring lateness and absenteeism among pupils. The schools comprised: Olmotonyi; Sitoka; Mutengwar; Olopikidong'oe; Nkararo; Ildolisho; Esoit; Emurtoto; Olesentu; and. Oloonkolin. Data sheets were provided to head teachers, to gather information on pupil numbers, and to record daily numbers of escorted, late or absent pupils, plus their reporting times. Pupils found going to school late were occasionally interviewed to triangulate with the school records. Proportion of pupils arriving late was derived in terms of percentages.

7.2.5.3 Pupil performance

The mean scores of 277 pupils who sat for the national examination in 1999, both from within and outside the elephant range, were obtained from the head teachers in 18 randomly selected primary schools. The scores are normally based on seven subjects that are usually examined by the Kenya National Examination Council (KNEC) with the highest score being 700. A total of 134 pupils were Maasais, of whom elephants affected 32, and 102 were not affected. Similarly, 143 pupils were non-Maasais, of whom elephants affected 30 and 113 were not affected. Other details collected included: the number of days absent; the distance covered to school; tribe; and, whether or not elephants interfered with the pupil. Although it was difficult to verify some information, an assumption was made that the official record of the school should be correct, given it is a government document. Analyses to determine factors that might affect pupil performance were performed using Pearson correlation, ANOVA and multiple linear regressions.

7.3 Results

7.3.1 Analysis of attacks by wildlife on humans from OB books

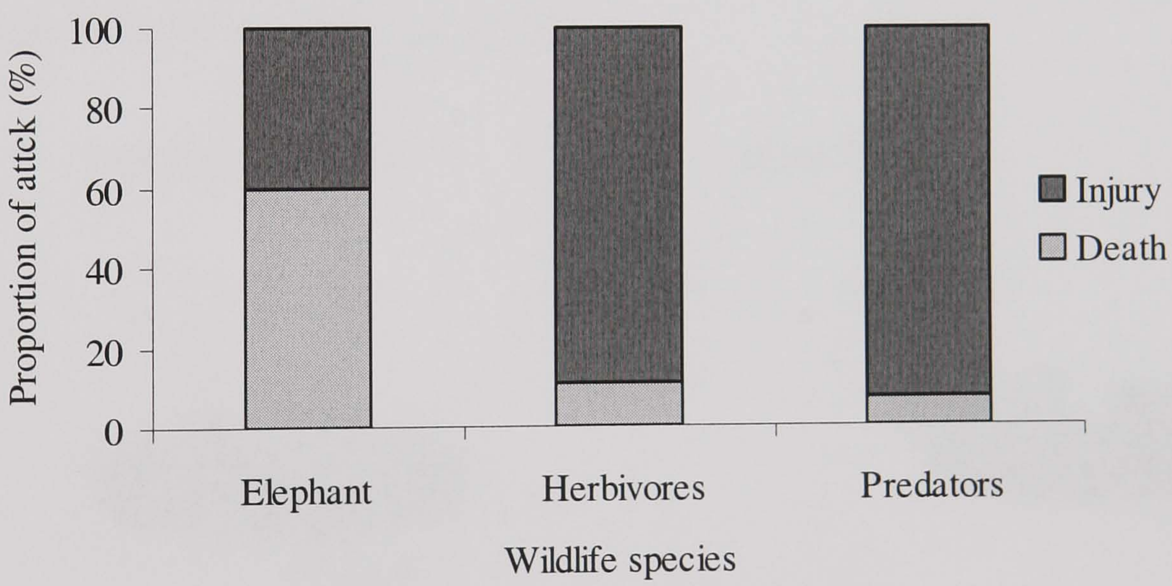
According to KWS records from 1986 to 2000, 46 other cases of attacks on humans were caused by 10 other wildlife species other than the elephant (*Loxodonta africana* Blumenbach 1797). This comprised: lion (*Panthera leo* Linn 1758); leopard (*Panthera pardus* Linn 1758); hippopotamus (*Hippopotomus amphibius* Linn 1758); crocodile (*Crocodylus nilotica*); buffalo (*Syncerus caffer* Sparrman 1779); warthog (*Phacochoerus aethiopicus*); bushbuck (*Tragelaphus scriptus* Pallas 1766); baboon (*Papio cynocephalus* Lesson 1827); hyena (*Crocuta crocuta* Erxleben 1777) and snakes. The attacks by elephants resulted in 29 deaths and 14 injuries, while the attacks by other species resulted in four deaths and 43 injuries.

A comparison was made between the various wildlife species categorised as elephants, herbivores and predators (Table 7.1). There has also been an increase in numbers of injuries caused by predators. Greater proportion of elephant attacks caused more death, while greater proportion of herbivore and predator attacks inflicted more injuries than deaths while the opposite was true for the elephants (Figure 7.1). Given the seriousness of attacks by elephants when compared with other species, the reminder of this chapter concentrates upon attacks by elephants.

Table 7.1 Numbers of people attacked by wildlife in TM District between 1986 and 2000.

	Elephant		**Herbivores**		**Predators**		**Total**
Period	**Deaths**	**Injuries**	**Deaths**	**Injuries**	**Deaths**	**Injuries**	
1986-1990	1	2	1	2	0	2	8
1991-1995	9	5	0	9	0	5	28
1996-2000	11	7	1	5	2	20	46
Total	21	14	2	16	2	27	82

Figure 7.1 Proportion of attacks on humans by different wildlife species classified as elephant, herbivores or predators in TM District from 1986 to 2000.



7.3.2 Analysis of attacks on humans by elephants in TM District from 1961 to 2000

7.3.2.1 Elephant attacks on humans by tribe

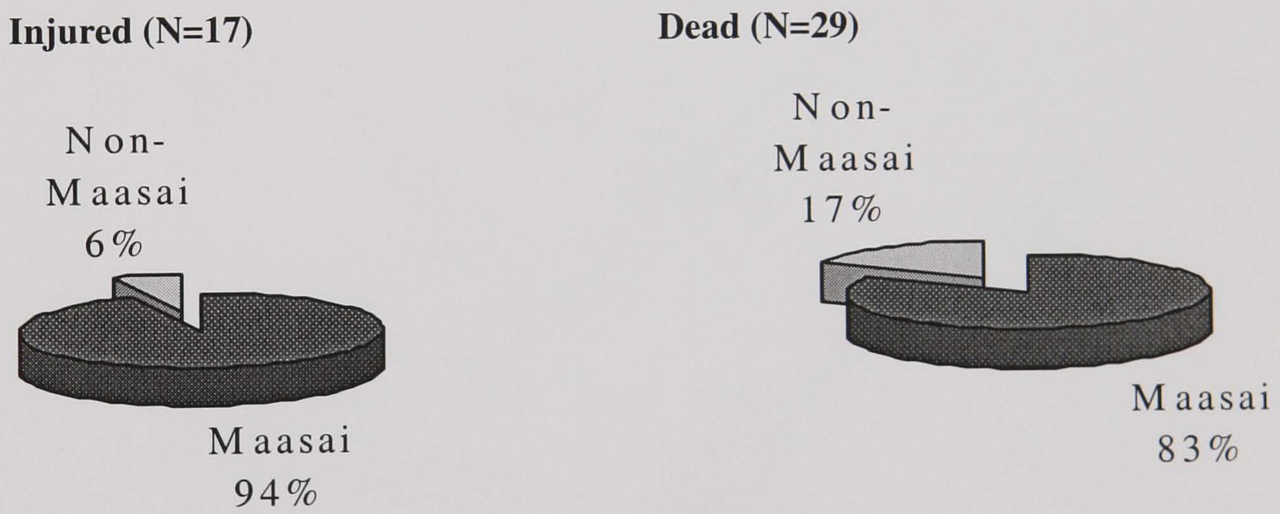
A total of 56 cases of elephant attack on humans were recorded. However, some information could not be retrieved from the 56 cases giving differences in the total number of cases for different analysis. Therefore, only 46 recorded cases from District Compensation Committee accounts were reliable and hence used for analysis. The proportion of human deaths to injuries has not varied (χ^2=2.283, df=1, 0.131) over time. The Maasai suffered more deaths and injuries (χ^2=23.11, df=1, p=0.001) than non-Maasai (Table 7.2 & Figure 7.2). More males were attacked than females (χ^2=25.83, df=1, p=0.001), and the six females (13%) attacked were all Maasais.

Table 7.2 Human deaths and injuries caused by elephants in TM District according to tribal grouping from 1961 to 2000.

	Type of conflict					
	Dead		Injured		Total	
Tribe	**No.**	**%**	**No.**	**%**	**No.**	**%**
Maasai	24	83	16	94	40	87
Non-Maasai	5	17	1	6	6	13
Total	29	63	17	37	46	100

There was no association between elephant attacks on humans and when elephants feed on the ripened fruits of *Warbugia ugandensis* (r_s=0.327, p=0.077). Out of 53 such cases, 17 people were reported as "drunk", and 36 were "sober". Only nine out of 34 cases were compensated and 25 were not which did differ statistically (χ^2=3.573, df=34, p=0.05), while 19 cases did not have reliable data, and so were excluded from the analysis.

Figure 7.2 Percentage of elephant caused human deaths and injuries among Maasai and non-Maasais in TM District from 1961 to 2000.



7.3.2.2 Patterns of human deaths and injuries from 1961 to 2000

The trend in elephant attacks on humans (death or injuries) as shown with the best fit polynomial curve for the total numbers of incidents generally showed a decline from the 1960s to the 1980s, and this was followed by a steady increase (Figure 7.3).

7.3.2.3 Spatial distribution of elephant attacks on humans from 1961 to 2000

The spatial distribution of human deaths and injuries showed areas of high conflict (Figure 7.4). Kirindoni Division suffered the most attacks with 21 (40%), followed by Kilgoris 11 (21%), Lolgorian 8 (15%), Keyian 7 (13%) and Pirrar 6 (11%), respectively, with a clear difference between divisions (χ^2=14.075, df=4, p=0.007). However, a spatial analysis of factors that might determine attack on humans by elephants was not possible, because the changes that have taken place in most independent variables like human population density, elephant density, and land use change, among others do not span the period for which data are available for elephants.

Figure 7.3 Trend in elephant caused human deaths and injuries by decade in TM District between 1961 and 2000.

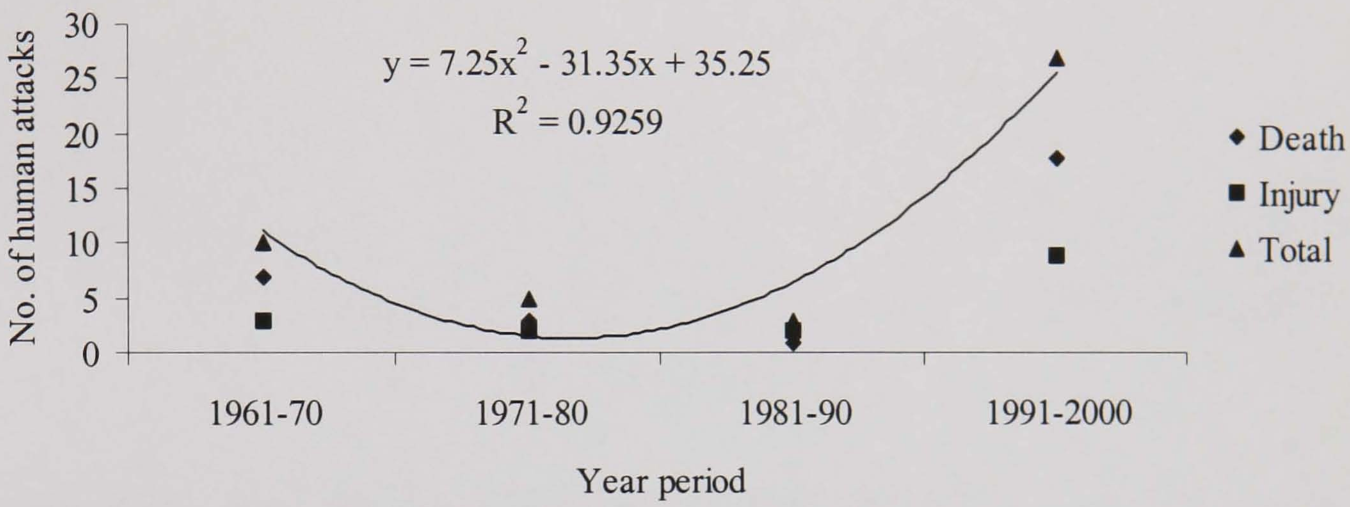
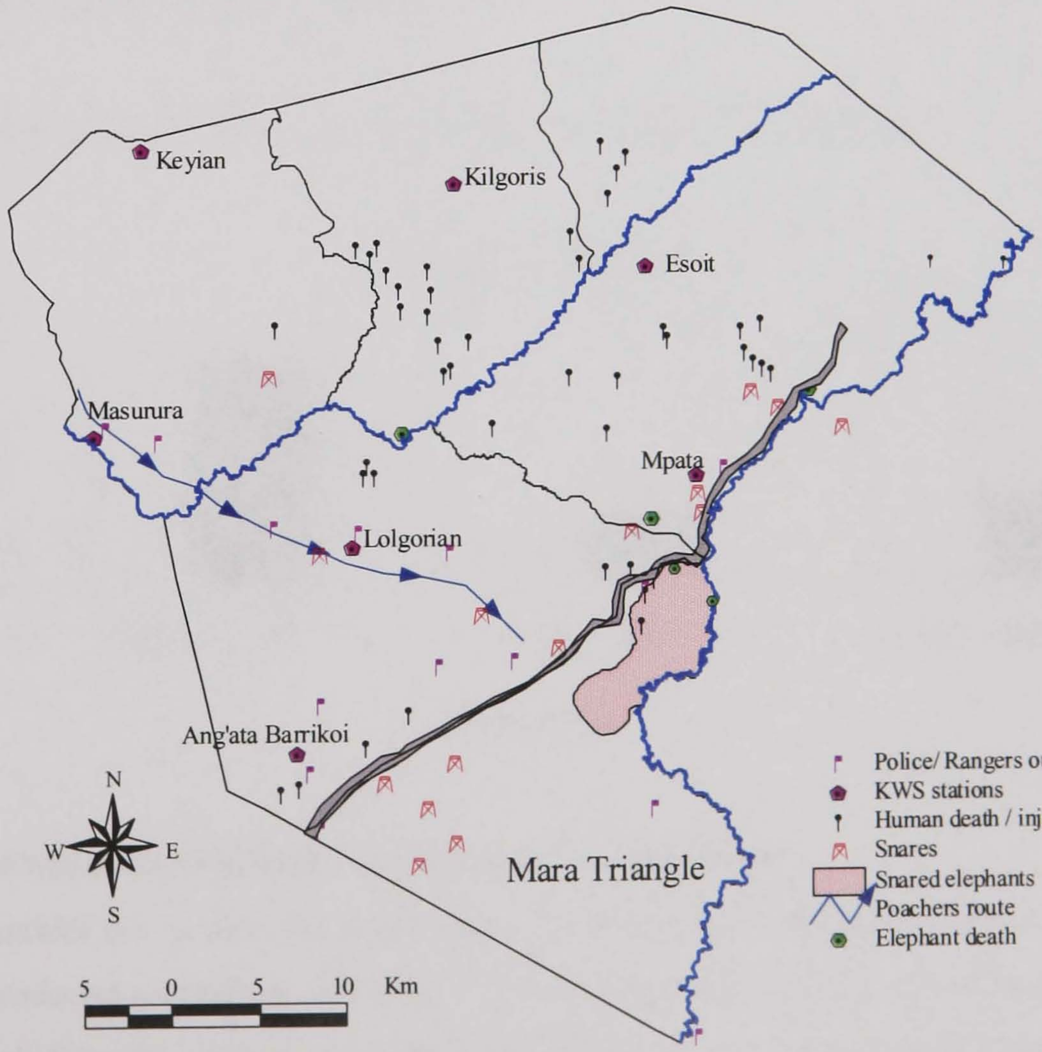
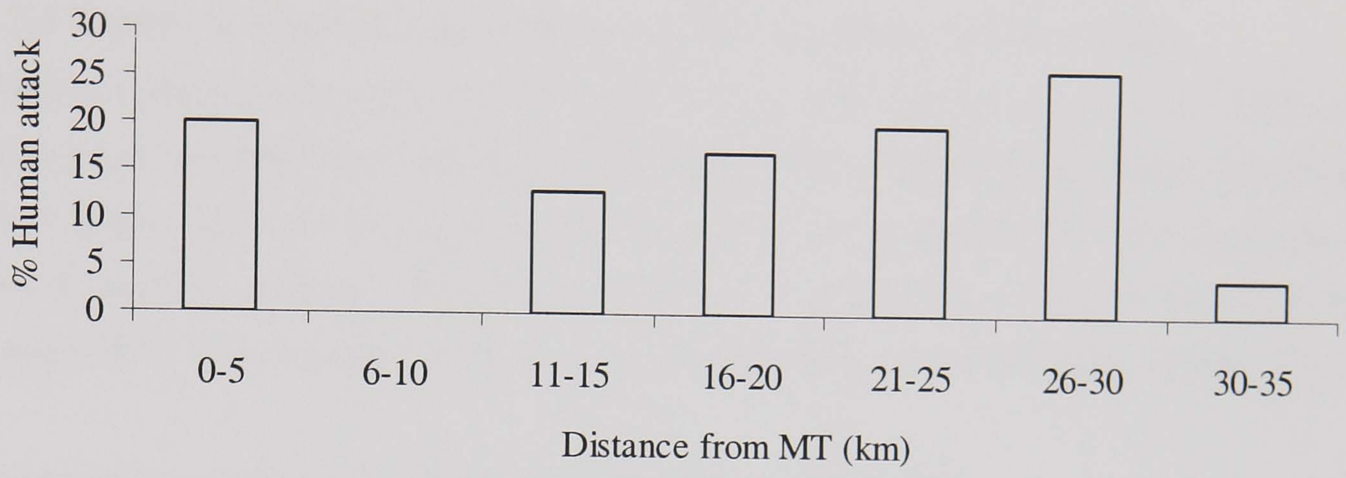


Figure 7.4 Spatial distribution of human and elephant deaths and injuries in TM District from 1961 to 2000.



Many people were attacked within 5 km of Mara Triangle, but none was attacked from 6-10 km away, probably because this area is not settled. There was a gradual increase in attacks from 11 km to 30 km away, and then a decline (Figure 7.5). The peak at distances of 26-30 km was because of the resident elephant population living around River Mogor and Laila forest, where many deaths were recorded.

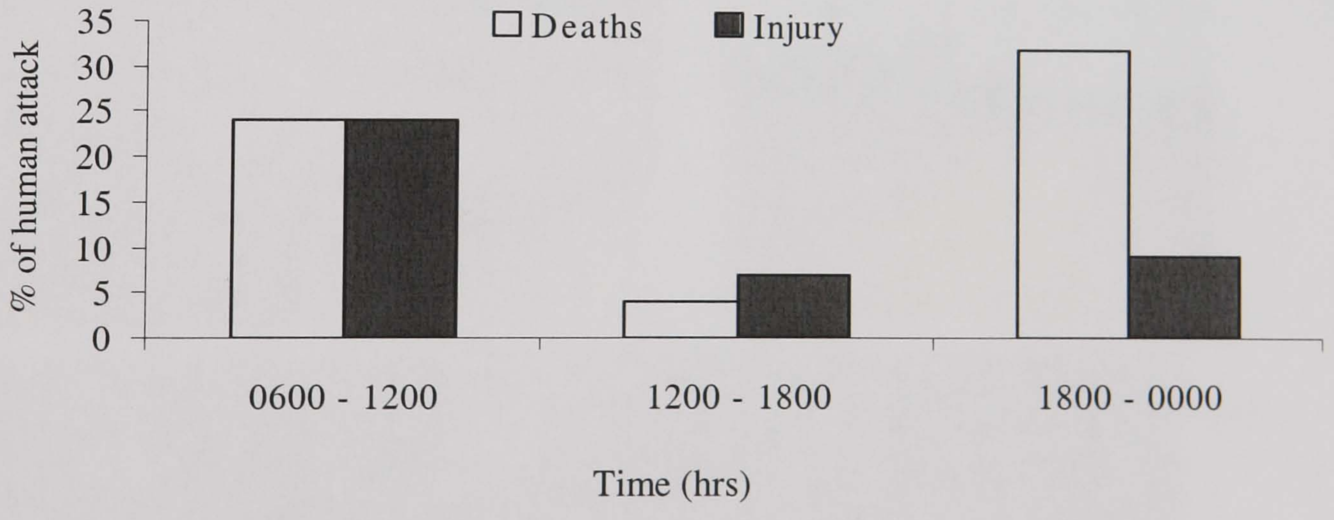
Figure 7.5 Relationship between attack on humans by elephants and distance from the MT from 1961 to 2000.



7.3.2.4 Relative time of attack on humans by elephants

Most attacks on humans occurred early in the morning (0600-0900 hrs) and late in the evening (1900-2900 hrs), while fewer (χ^2=14.075, df=2, p=0.001) cases occurred during the middle of the day and during the afternoon (Figure 7.6).

Figure 7.6 Specific times of an attack on humans by elephants in TM District.



7.3.2.5 Determinants of attacks on humans by elephants

The logistic model for factors that might have determined the likelihood of an elephant attack on humans produced a goodness of fit of 73.3% of observed to expected values. Of the factors examined, including the state of a person, time of attack, sex, tribe and ripening of *Warbugia ugandensis,* the analysis showed that the state of the person, whether drunk or sober, was the only factor that determine likelihood of attack (Table 7.3).

Table 7.3 Factors determining elephant attack on humans, based on logistic regression.

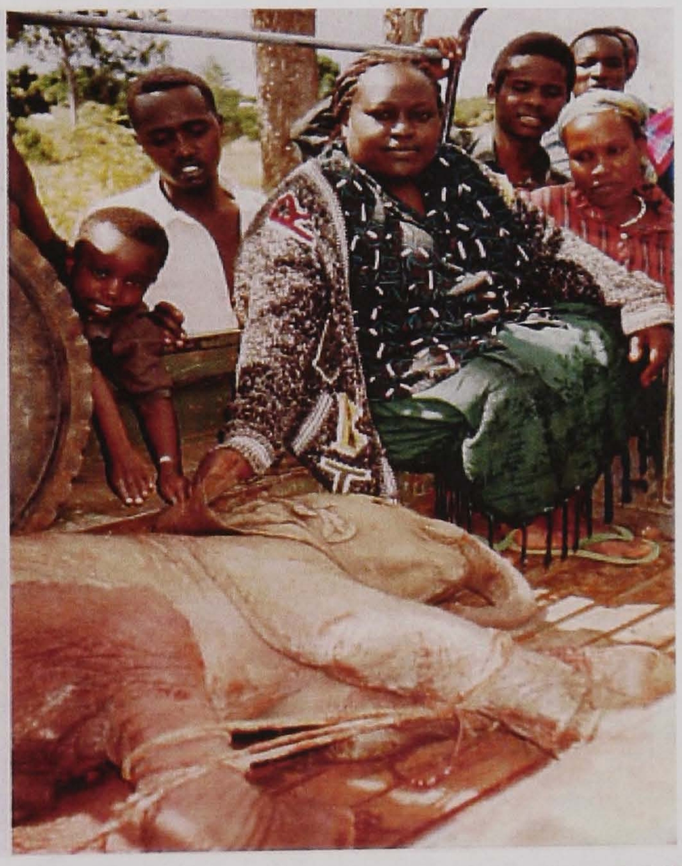
Variable	B	SE	Wald	P
Constant	-5.014	2.159	5.389	0.0203*
State	2.816	1.154	5.959	0.0146**

Level of significance shown with *=p<0.05, **=p<0.01

7.3.3 Trends in elephant mortality from OB books from 1990 to 2000

Forteen elephant deaths were recorded in the Mara ecosystem between 1990 and 2000. Out of these, eight elephant deaths occurred in TM District, each arising under different circumstances. Most deaths occurred within the MT and the adjacent areas (Figure 7.4). Two elephants were shot during PAC, a female elephant after calving on the road (Figure 7.7(a) & (b)), and a bull in a maize farm. One elephant died from an injury inflicted by a snare on the leg (Figure 7.7(c)).

Figure 7.7 Some of the causes of elephant mortality in TM District.



(a) A one-day old elephant calf which was born next to the main Lologiarian-Kilgoris road (see arrow point in picture (b)) and rescued by KWS rangers after the mother was shot by an armed policemen after charging at several vehicles.

(c) A dead female elephant in the MT with a wounded leg as a result of snares and some bleed to death.

(b)

(c)

Across the whole Mara ecosystem from 1990 to 2000, there was a slight increase in elephant mortality until 1994 and a slight decline thereafter. This trend in elephant mortality in the Mara ecosystem correlated closely with the trend across Kenya (r_S=0.884, p=0.001, Figure 7.8). Likewise, the trend of elephant poaching in the Mara ecosystem conforms to the national trend (r_S=0.786, p=0.004, Figure 7.9). Some of the dead elephants without tusks did not die as a result of poaching, but died naturally and the local community removed tusks.

Figure 7.8 Trend of elephant mortality in the Mara ecosystem and other parts of Kenya, between 1990 and 2000, both shown with best fit polynomial curves. (Kenya: y=1.9x + 29.782; Mara: y=0.209x + 2.4727).

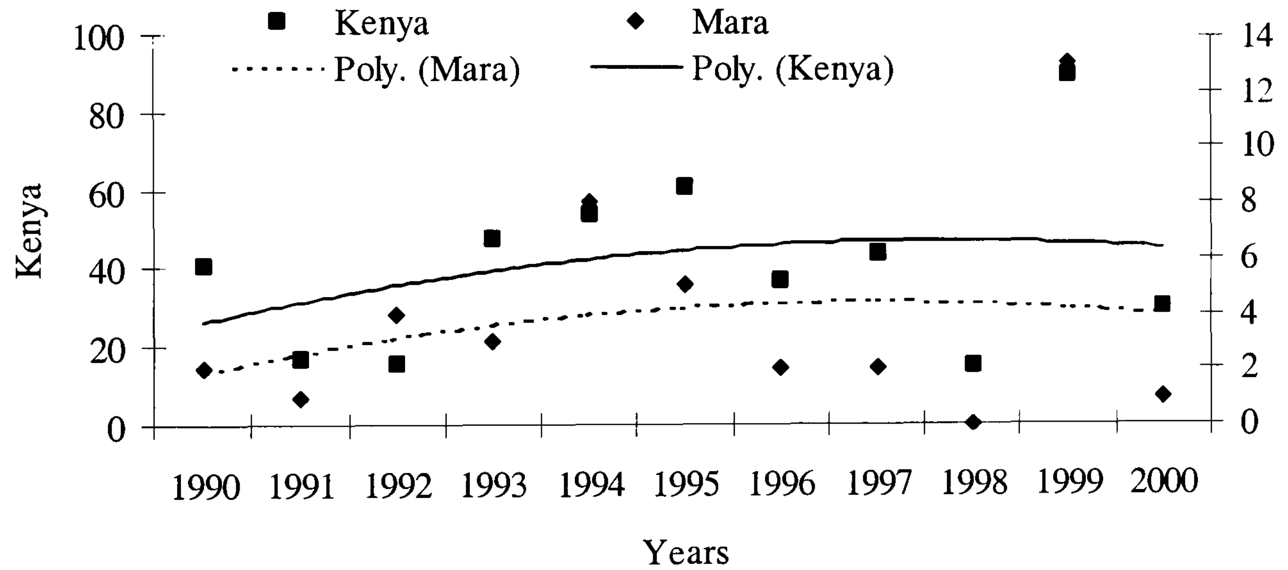
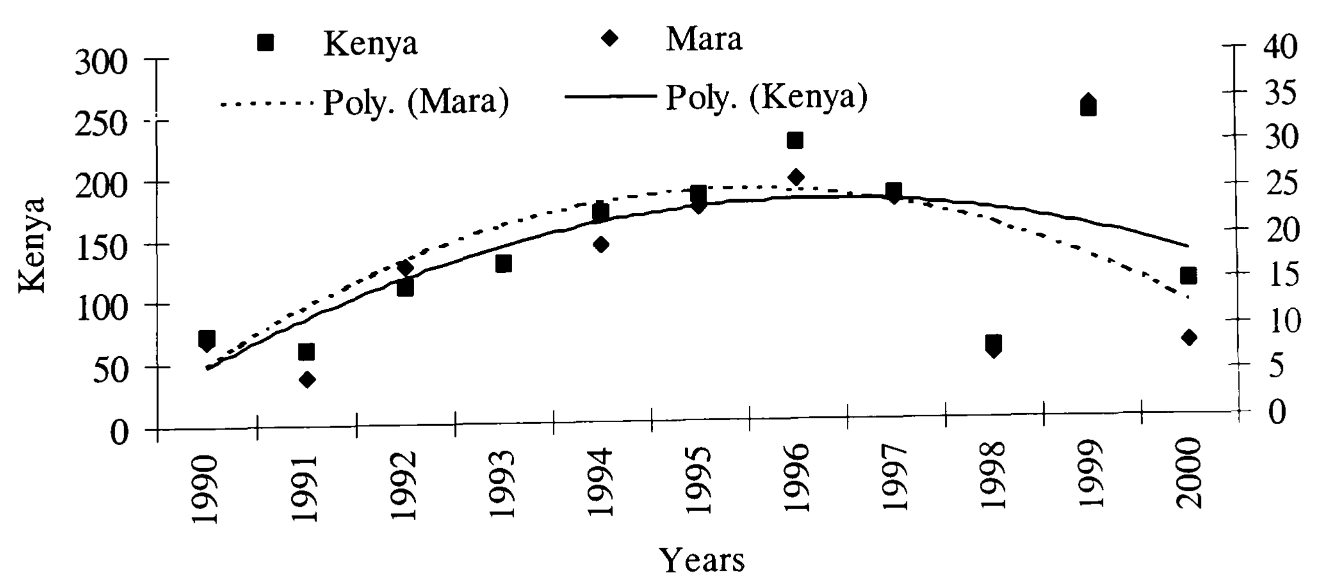


Figure 7.9 Trend of elephant poaching in Kenya and the Mara ecosystem, between 1990 and 2000 both shown with best fit polynomial curves. (Kenya: y=8.673x + 88.873; Mara: y=0.5818x + 15.418).

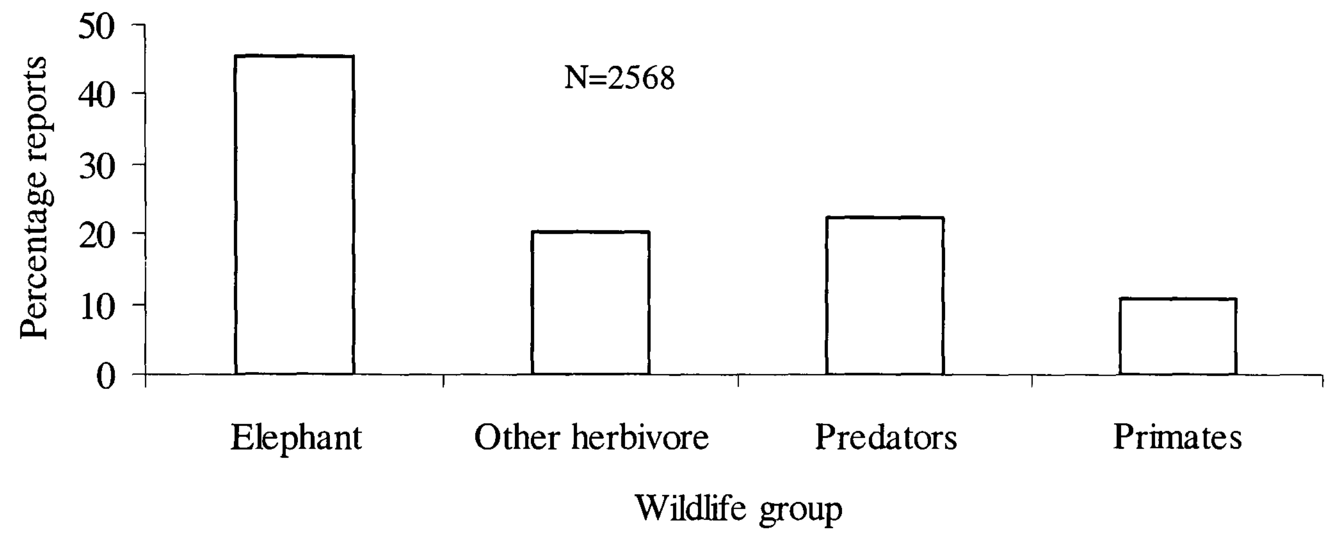


7.3.4 Analysis of other forms of human-wildlife conflict from 1986 to 2000

7.3.4.1 Reported cases of conflict caused by all wildlife species

Reported cases of other types of wildlife-related problems in TM District included: crop damage; livestock attack; competition for water; insecurity; and, destruction of property, among others. There were more reports of human-wildlife conflict for elephants than for other herbivores, predators or primates, respectively (Figure 7.10). Therefore, the remainder of this section comprises results from elephants.

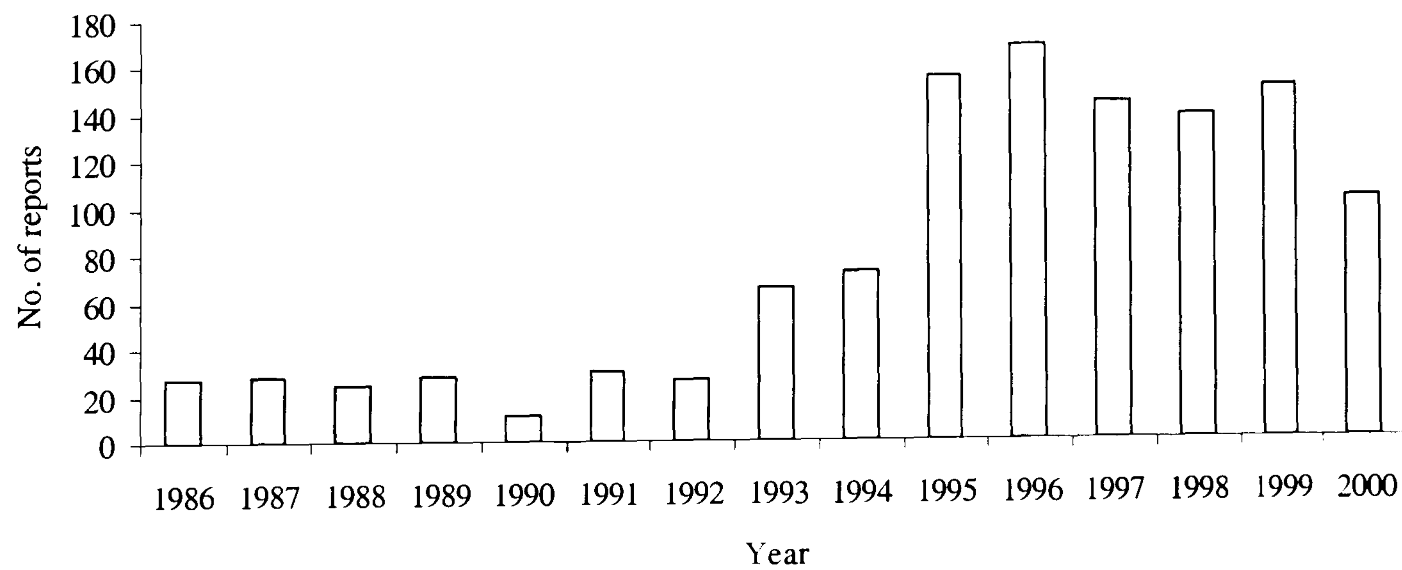
Figure 7.10 The involvement of different species among the total reports of problem animals received by KWS in TM District from 1986 to 2000.



7.3.4.2 Temporal patterns of all HEC based on years

The number of HEC reported cases to six KWS stations recorded in OBs and RBs varied ($F_{14,2534}$ = 5.24, p=0.000) every year (Figure 7.11). There was a steady decline in the number of reports from 1987 to 1990, then a sharp increase to a peak in 1991, a trend corresponds with the decline in elephant numbers seen on CLs (Chapter 6). This was followed by a decline to 1993 and a steady increase from 1995 to 1999. Reports for the year 2000 only covered eight months and might also have reached the 1999 level.

Figure 7.11 Number of elephant related problems reported to KWS in TM District from 1986 to 2000.



7.3.5 Response to reports by KWS from 1986 to 2000

7.3.5.1 Rate of response by KWS to reported cases of HEC

Most (76%) of the reported cases were not responded to by KWS (Table 7.4, Figure 7.12). Response rate varied between division (χ^2=307.68, df=4, p=0.000), KWS station (χ^2=402, df=5, p=0.000), and animal species (χ^2=48.313, df=3, p=0.000). Lolgorian Division had the highest response rate followed by Kilgoris Division, which again had the highest cases that were not attended followed by Keyian Division (Table 7.4). Kilgoris and Lolgorian KWS stations had the highest response while Kilgoris KWS station again did not respond to most cases probably because of the high number of reports followed by Mpata and Masurura respectively. Most reports of elephants were not attended followed by other herbivores. The response time varied and cases attended to were mainly on the same day.

Table 7.4 Percentage response to reported cases by KWS by division, KWS stations and animal species.

	Divisions				
	Lologorian	**Kirindoni**	**Pirrar**	**Keyian**	**Kilgoris**
Responded	56.6	15.4	14.1	14.7	17.9
No response	43.4	84.6	85.9	85.3	82.1

	KWS posts					
	Keyian	**Lolgorian**	**Kilgoris**	**Mpata**	**Esoit**	**Masurura**
Responded	15.2	58.3	20.2	9.3		3.5
No response	84.8	41.7	79.8	90.7	100	96.5

	Animal species			
	Elephant	**Other herbivores**	**Predators**	**Primates**
Responded	28.5	18.7	15.4	26.4
No response	71.5	81.3	86.6	73.6

7.3.5.2 Response time by KWS to reported cases

Mean response time varied between divisions ($F_{4,2548}$ = 104, p=0.000) with more time taken in Lolgorian than in all other divisions (Figure 7.13). Kirindoni and Keyian divisions have two KWS posts each while Lolgorian and Kilgoris have one each, but there are none in Pirrar Division. However, the time taken to respond did not depend on the type of conflict ($F_{4,2548}$ = 1.463, p=0.211).

Figure 7.12 Relationship between reported cases of all species and time taken to respond by KWS.

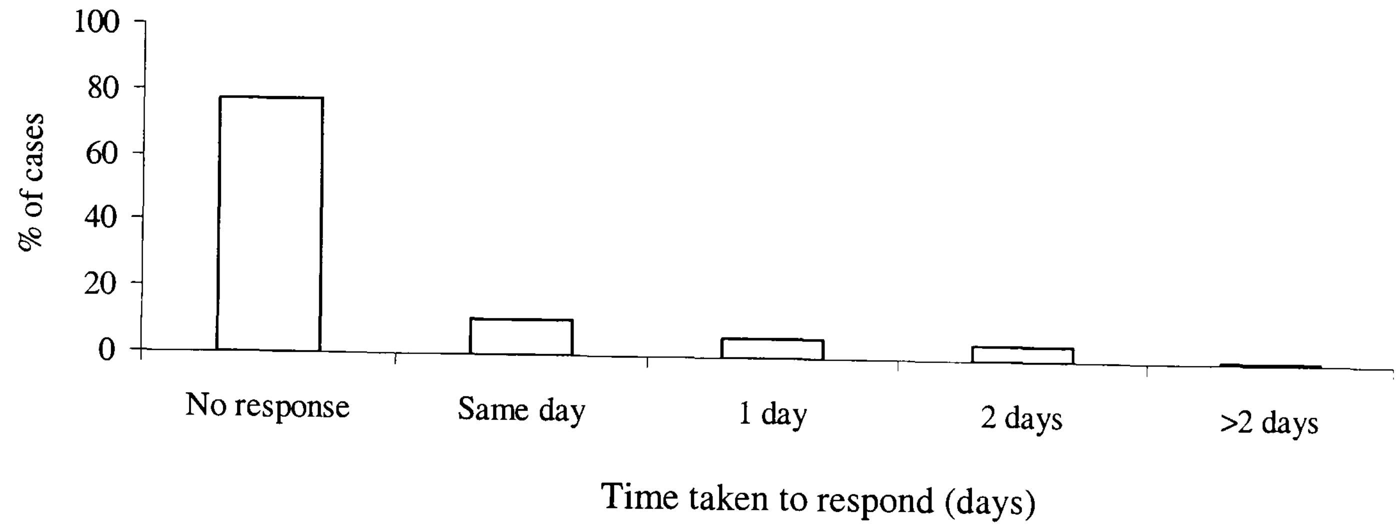
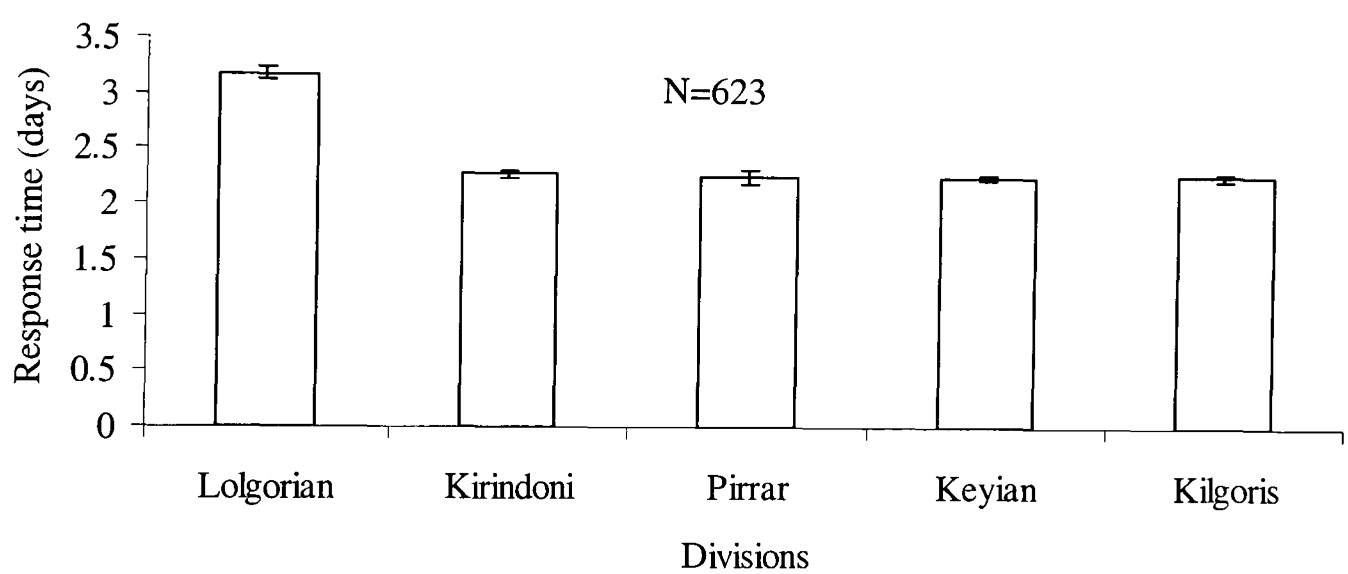


Figure 7.13 Mean ± SE time taken by KWS to respond to reported cases by division.



The time taken to respond to reported cases of human wildlife conflict varied between KWS stations ($F_{5,2547}$ = 106.327, p=0.000), with Lolgorian station taking longer and Masurura the least time to respond (Figure 7.14). However, Lolgorian station covers the biggest area, and is a difficult area with only three rangers and a high wildlife population. Esoit station did not have clear records on response. Esoit and Keyian KWS out posts are located on private land.

The time taken to respond to a particular wildlife species also varied ($F_{3,2549}$ = 6.832, p=0.000) with longer time taken for primates and elephants than for other wildlife groups (Figure 7.15). Because elephant and primate reports are the most common problems, rangers cannot do much other than to solve a problem in one place and ignore a problem in another place, given the large size of TM District.

Figure 7.14 Mean ± SE time taken by each KWS station to attend to reported cases.

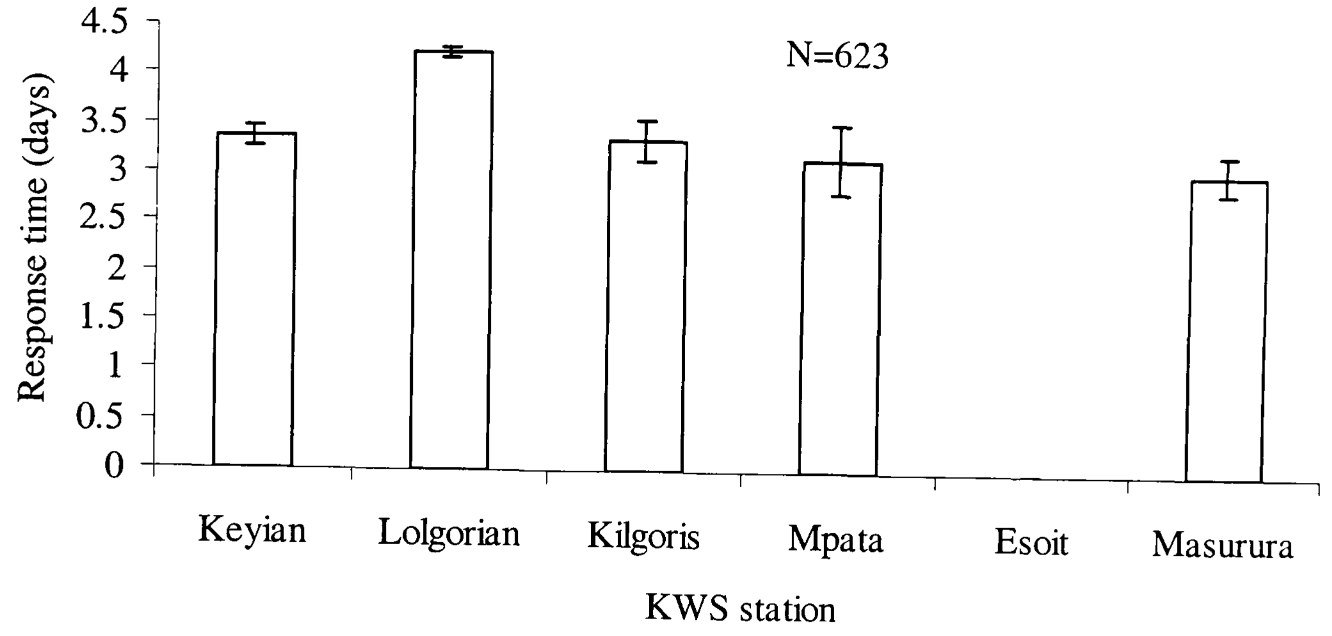
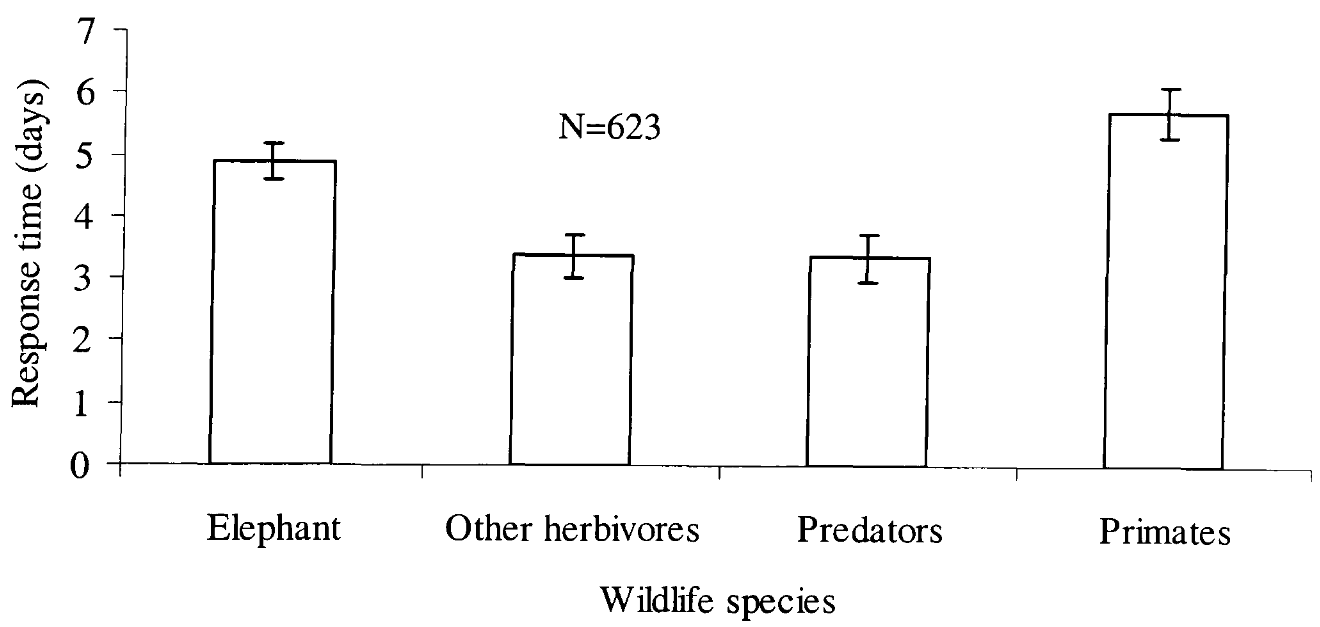


Figure 7.15 Mean ± SE time taken by KWS to respond to particular wildlife species.



7.3.5.3 Action taken by KWS towards problem animals

Most conflict cases were not attended to with a slightly higher percentage of action against the elephant and vice versa for non-attention (Figure 7.16). Only 13.5% of the elephant cases were attended to, and 10% for other wildlife species while 32.2% and 44.3% of the elephant and other wildlife species were not attended to respectively.

7.3.5.4 Determinants of response by KWS to reported cases

The logistic regression model for factors that might have determined the response of KWS to reported cases produced a goodness of fit of 79.39% of observed to expected values. KWS station and year were the two variables that determined the response of KWS to reported cases (Table 7.5).

Figure 7.16 Proportion of action taken against reported cases of elephant and other wildlife species.

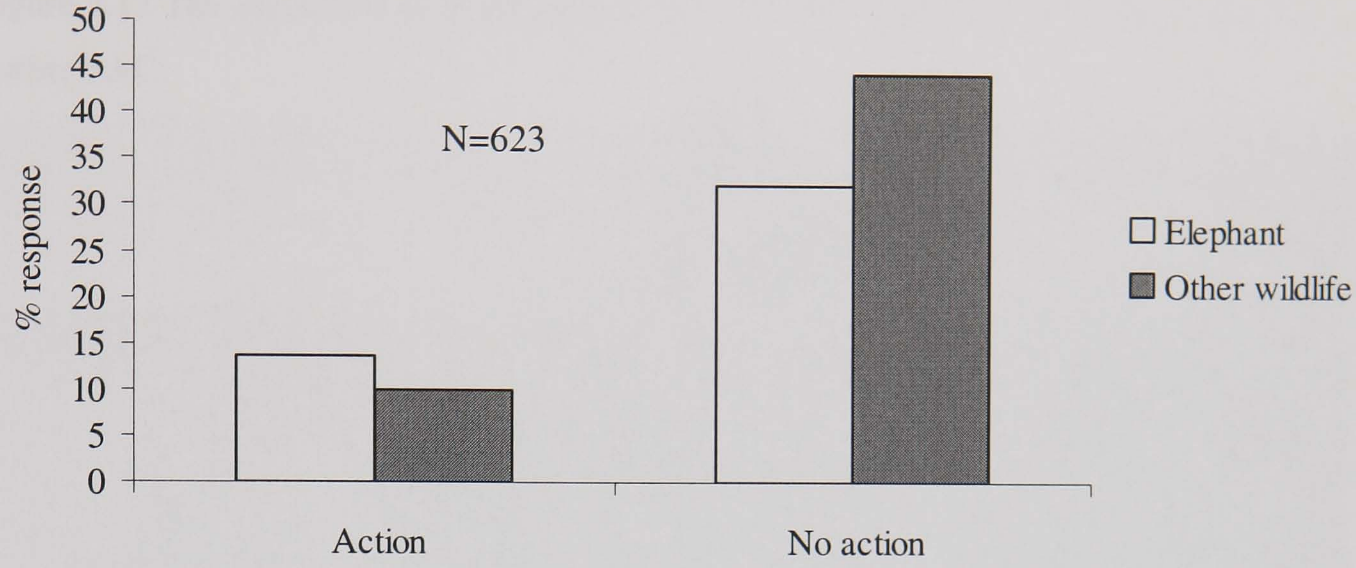


Table 7.5 Factors influencing the response by KWS to reported cases, based on logistic regression.

Variable	B	S.E	Wald	df	Sig.	R
Constant	-313.302	35.58	-77.53	1	0.000***	
KWS station			284.18	5	0.000***	0.314
Lolgorian	1.635	0.463	12.50	1	0.0004***	0.061
Mpata	3.657	0.353	107.26	1	0.000***	0.195
Pirrar	2.228	0.347	41.13	1	0.000***	0.118
Keyian	0.913	0.396	5.32	1	0.021*	0.034
Kilgoris	-4.940	6.295	0.62	1	0.432	0.000
Year	0.155	0.018	75.92	1	0.000***	0.163

Level of significance shown with *=p<0.05, ***=p<0.001

7.3.6 Field survey of crop damage by elephants in 1999 and 2000

7.3.6.1 Numbers of cases and type of crops

A total of 329 farms were damaged by elephants between January 1999 and August 2000 with 105 cases in 1999 and 224 cases in 2000. Crop raiding occurred mainly during the months of May to August, and then during the short growing season of December and January (Chapter 8). The spatial distribution of crop raiding shows an uneven pattern (Chapter 9). During the study period, 18 different crops were damaged and they included maize *Zea mays* (Figure 7.17), sweet potatoes *Ipomea patatas*, millet *Eleusine coracana*, sorghum *Sorghum vulgare*, cassava *Manihot esculenta,* banana *Musa domestica,* sugarcane *Saccherum officinarum,* tomato *Lycoposicon esculentum*, kales *Brasica oleracea* var acephala, pumpkin *Curcabita maxima*, tobacco *Nicotina tobacum* and, beans *Phaseolus vulgaris,* cabbage *Brassica oleracea* var capitata, onions *Allium cepa*, and fruit plants such as avacado, mangoes and pawpaw. Furthermore, Napier grass grown for livestock was destroyed.

Figure 7.17 The carcass of an elephant bull shot by KWS rangers in a maize farm at Kirindoni during PAC.

7.3.6.2 Elephant sex and average group size involved in crop raiding

The mean size of herds involved in crop raiding was 14 ± 1 elephants and differed ($F_{1,327}$ = 56.691, p=0.000) between months (Figure 7.18). More mixed herds (χ^2 = 43.043, p=0.001) were involved in crop raiding than bull herds, and the mean herd size of mixed herds involved in crop raiding was larger ($F_{1,327}$ = 73.691, p=0.000) than of bull herds (Figure 7.19).

Figure 7.18 Mean ± SE group size involved in crop raiding between 1999 and 2000.

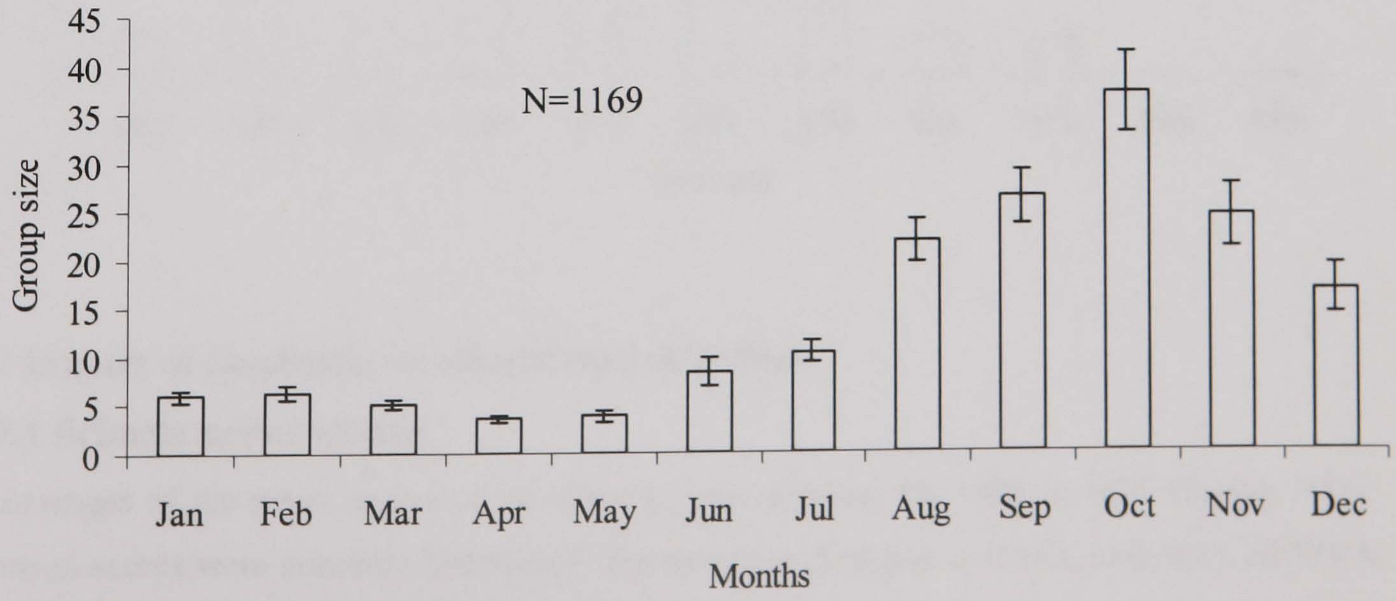
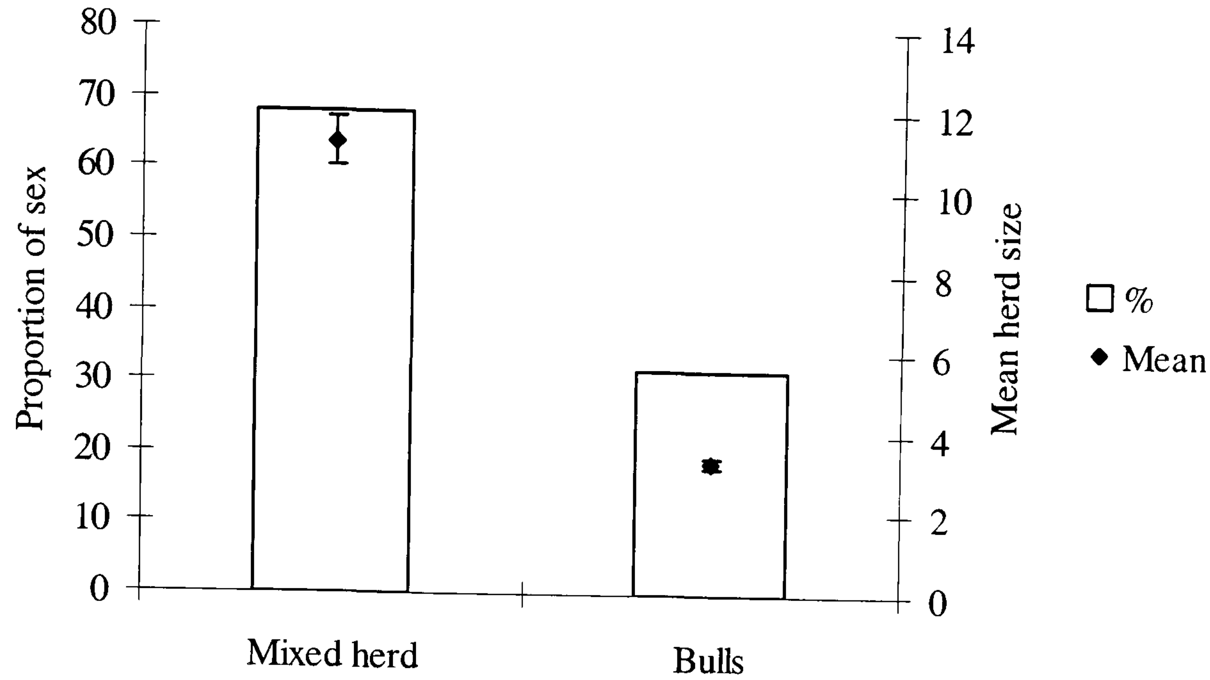


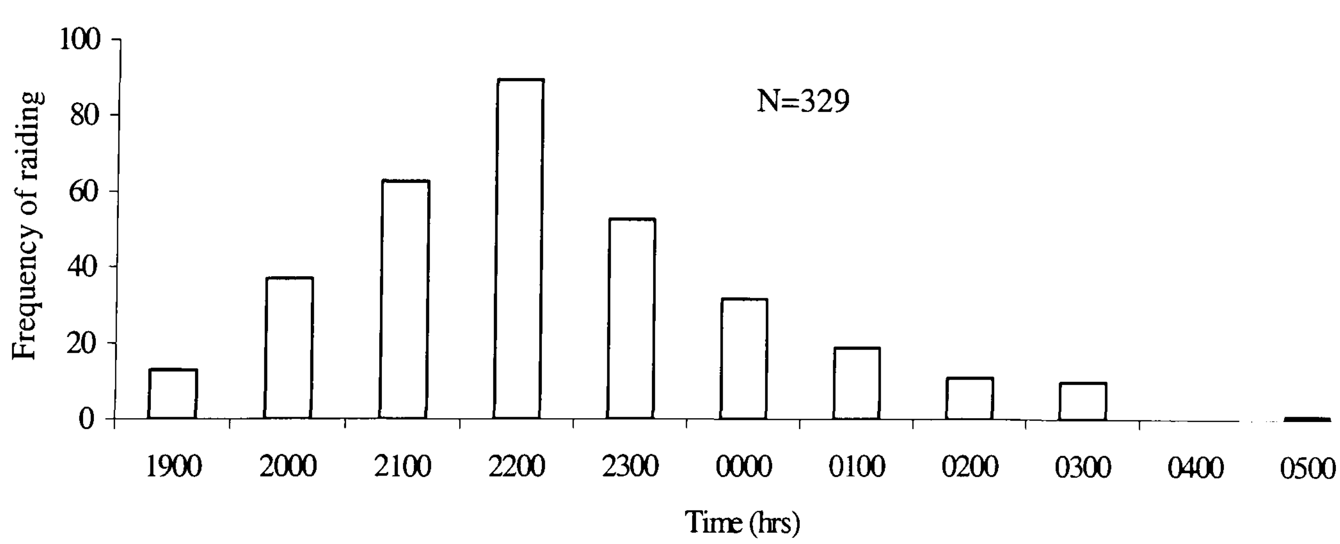
Figure 7.19 Mean ± SE herd size of elephant groups and proportion of sex involved in crop raiding in TM District.



7.3.6.3 Relationship between time and frequency of crop raiding

Crop raiding started as early as 1900 hrs, depending on the distance of the farms from the forest elephant zone and the weather, with most incidents of conflict occurring between 2100 hrs and 2200 hrs (Figure 7.20). Farms near the forest were raided during the early and late hours of the night as elephants left and returned to the sanctuary of forests, respectively.

Figure 7.20 Number of crop raids recorded at specific time in TM District.



7.3.7 Impact of elephants on educational activities

7.3.7.1 Schools performance

The averages of the mean scores of 96 schools were obtained for 1995 to 1999 (Figure 7.21). The mean scores were normally distributed (Kolmogorov-Smirnov z=0.765, p=0.601). ANOVA showed there were differences between: scores and division ($F_{4,91}$=6.70; p=0.001); scores and teacher-pupil ratio ($F_{3,92}$ = 6.13; p=0.001); and, scores for schools located within and outside the elephant range ($F_{1,94}$ = 19.54; p=0.001). However, scores for boarding schools did not differ from day schools ($F_{1,94}$ = 0.263, p=0.609). Thus, schools in Kirindoni and Pirrar divisions had the highest mean scores, while those in Keyian Division had the lowest scores. Schools with a teacher-pupil ratio of 41:50 had the highest scores while those with a ratio of 1:30 had the lowest score (Figure 7.21). Schools with more than 30 candidates had the highest scores while schools with fewer candidates had the lowest score (Figure 7.22). The non-Maasai had a higher score than Maasai. This last result is surprising, given that the mean score was lowest in schools with the lowest teacher-pupil ratio. However, many of these schools occurred within elephant range and experienced very low enrolment.

Figure 7.21 Mean ± SE scores of schools in relation to division, teacher-pupil ratio, elephant range and boarding in TM District from 1995 to 1999.

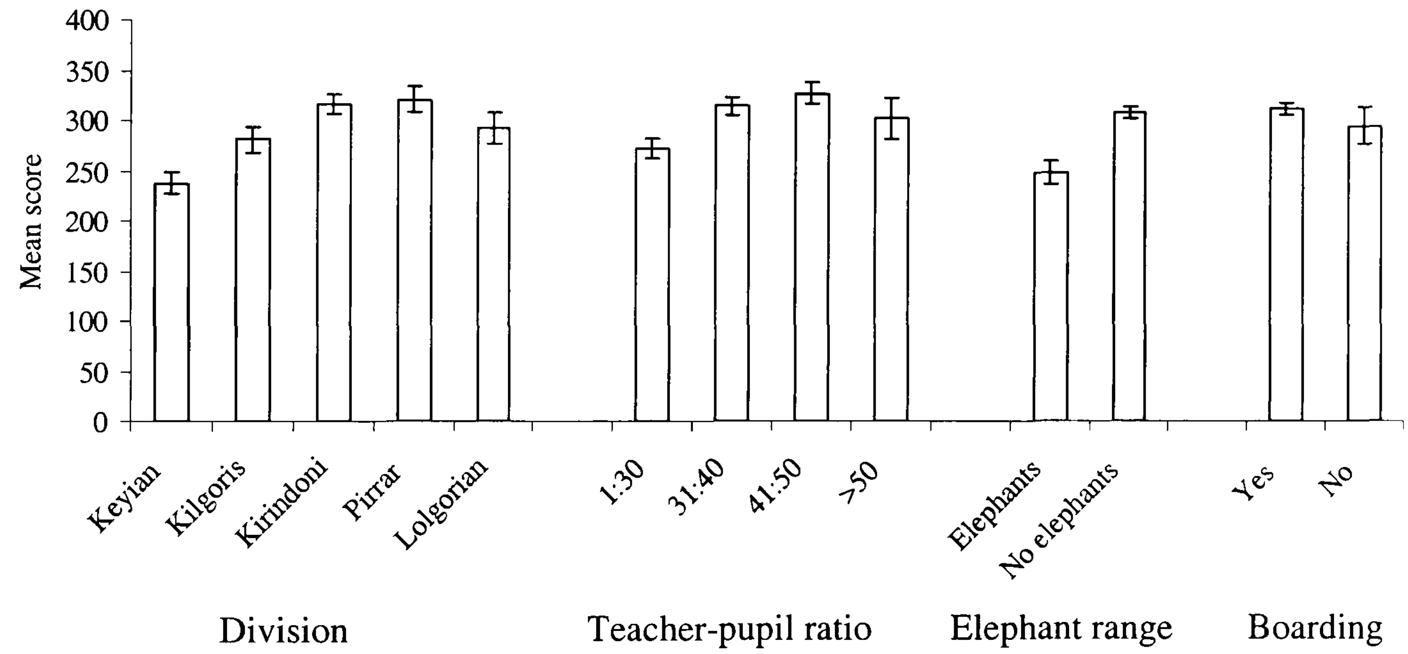
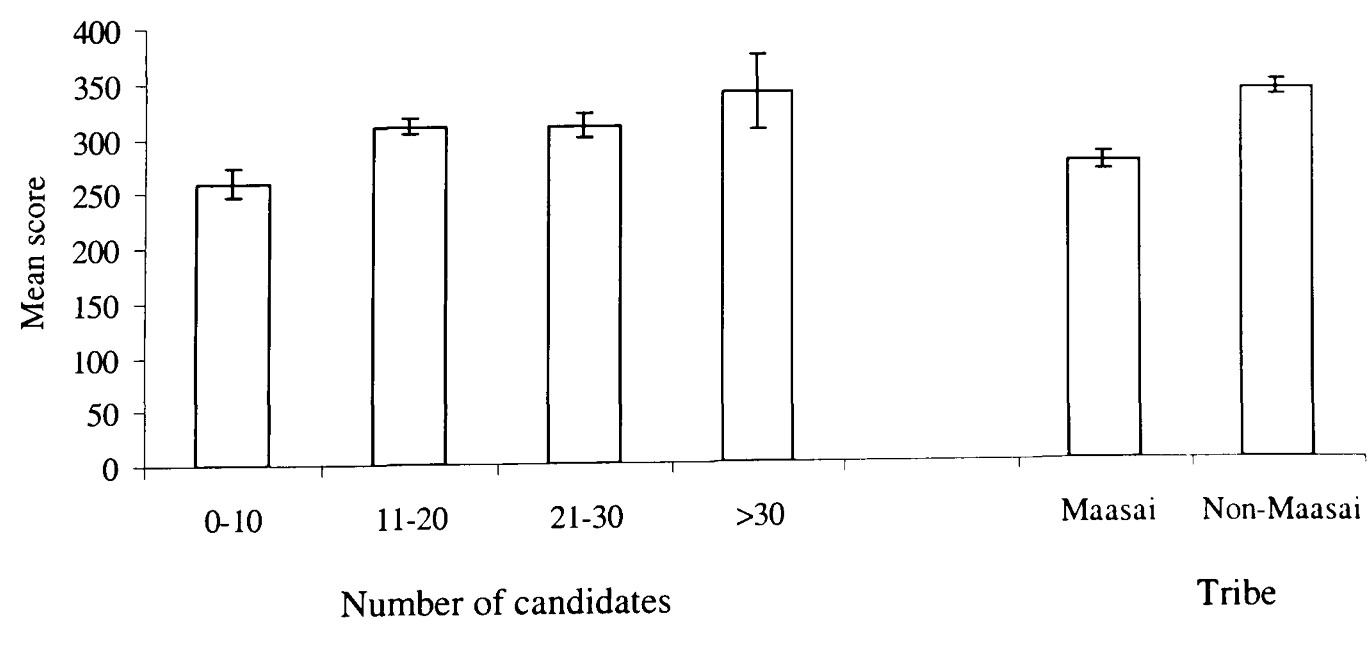


Figure 7.22 Mean ± SE scores of schools in relation to number of candidates and tribe.



The regression model for factors that might have determined schools performance was significant ($F_{6,86}$ = 12.193, p=0.000) and explained 42% of the variance (Table 7.6). Significant relationships were observed between schools mean score and division, elephant, tribe and number of candidates while boarding and teacher-pupil ratio seem not to influence mean score.

Tables 7.6 Factors determining schools mean score in TM District, based on linear regression.

Variable	B	SE	t	Sig.	Beta
Constant	251.52	17.88	14.07	0.000***	
Division	13.29	4.03	3.30	0.001***	0.27
In elephant range	-33.10	12.79	-2.59	0.011**	-0.23
Tribe	-20.10	4.84	-4.31	0.000***	-0.36
Boarding	18.87	26.23	0.72	0.474	0.06
No. of candidates	15.12	6.87	2.20	0.031*	0.20
Teacher-pupil ratio	9.65	5.65	1.71	0.091	0.15

Level of significance shown with *=p<0.05, **=p<0.01, ***=p<0.001

7.3.7.2 Pupils interruption

There are 132 primary schools in TM District, of which 96 (73%) sat for the national examination during 1999. Out of these 96 schools, 77 (80%) are outside the elephant range while 19 (20%) are within the elephant range. Out of the 19 schools, two (10%) are dominated by non-Maasais, 14 (74%) by Maasais, and three (16%) comprised a mix of Maasai and non-Maasai. As elephant killed one pupil at Olesentu Primary School while he was going to school in 1994, most pupils in elephant ranges waited until elephant had receded back into the forest before going to school. Hence, a total of 322 cases were reported in 10 schools within elephant range in which 261 pupils arrived late (Figure 7.23) and 61 (19%) pupils were always absent. With a stipulated arrival time at school of 0700 hrs, of those pupils who arrived late, most lost an average of two or three hours of class, apart from not participating in school cleanliness. Overall, 20.1% of the late cases were escorted to school by parents.

7.3.6.3 Pupils performance

The scores for 277 pupils in 1999 were normally distributed (Kolmogorov-Smirnov z=0.857, p=0.454). ANOVA showed that there was a difference between mean scores and distance from home to school ($F_{3,273}$ = 10.346; p=0.001); scores and tribe ($F_{1,275}$ = 12.101; p=0.001); scores and length of absenteeism ($F_{3,261}$ = 7.76; p=0.001); and, scores and whether or not inside elephant range ($F_{1,275}$ = 7.70; p=0.006; Figure 7.24).

Figure 7.23 The effects of elephants upon arrival time in school in TM District.

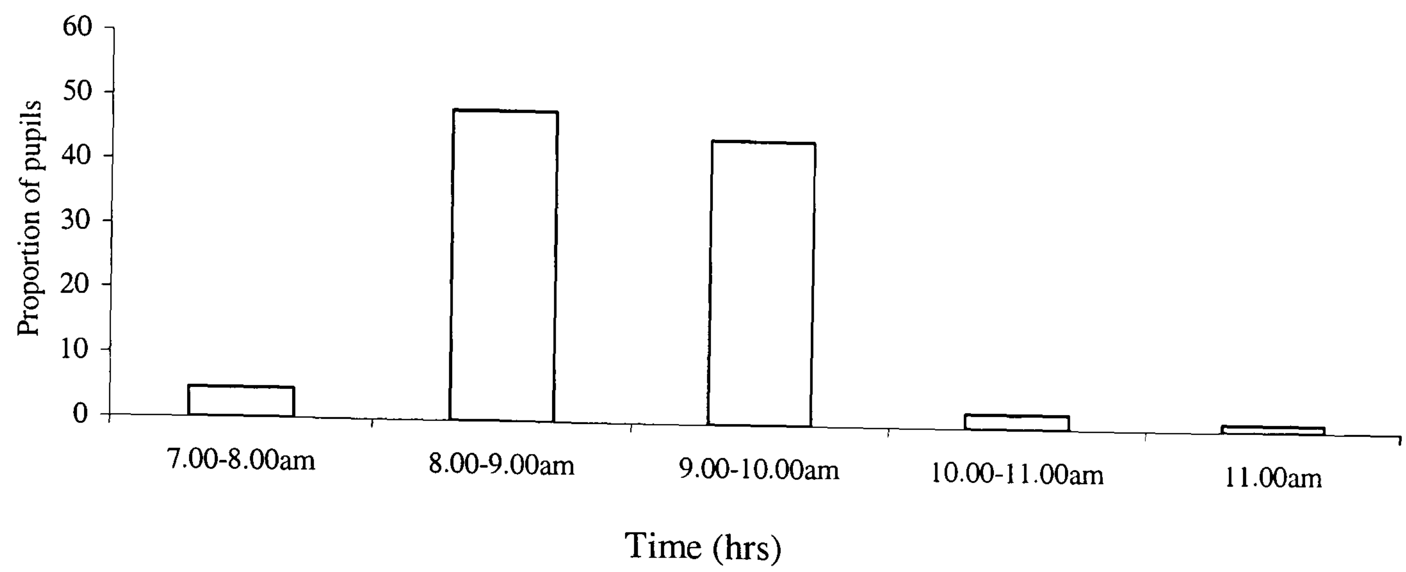
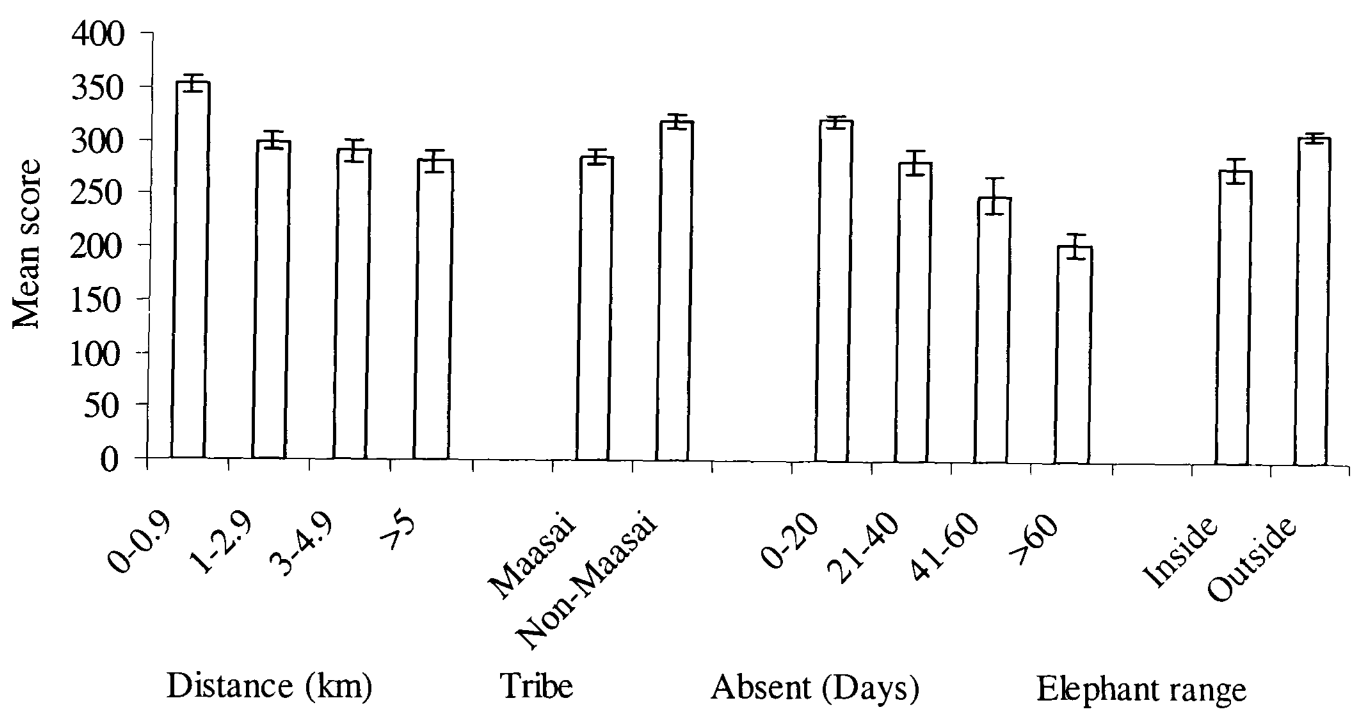


Figure 7.24 Mean ± SE scores of pupils in relation to distance from school, tribe, days absent and elephant range in TM District in 1999.



Further analysis of scores versus tribe showed that the mean score of non-Maasai and Maasai pupils differed both inside elephant range ($F_{1,60}$ = 7.233, p=0.009) and outside the elephant range (Figure 7.25; $F_{1,212}$ = 5.25, p=0.023). However, the mean score of Maasai pupils from outside the elephant range was higher than of those inside the elephant range ($F_{1,131}$ = 9.47, p=0.0025). In contrast, the mean score of non-Maasai pupils from both inside and outside the elephant range did not differ ($F_{1,141}$ = 0.60, p=0.437). The distance travelled also differed with absenteeism (Figure 7.26; $F_{3,261}$ = 9.46, p=0.032) and whether or not inside elephant range (Figure 7.27; $F_{1,263}$ = 6.47, p=0.001). No difference was noted between tribe and absenteeism ($F_{1,263}$ = 11.48; p=0.309); tribe and distance ($F_{1,275}$ = 1.855, p=0.174); and, tribe and whether or not inside elephant range ($F_{1,275}$ = 0.333, p=0.564). Absenteeism of pupils from elephant and non-elephant range did not differ ($F_{1,263}$ = 0.260, p=0.610).

Figure 7.25 Mean ± SE scores of pupils from different tribes in relation to elephant range in TM District in 1999.

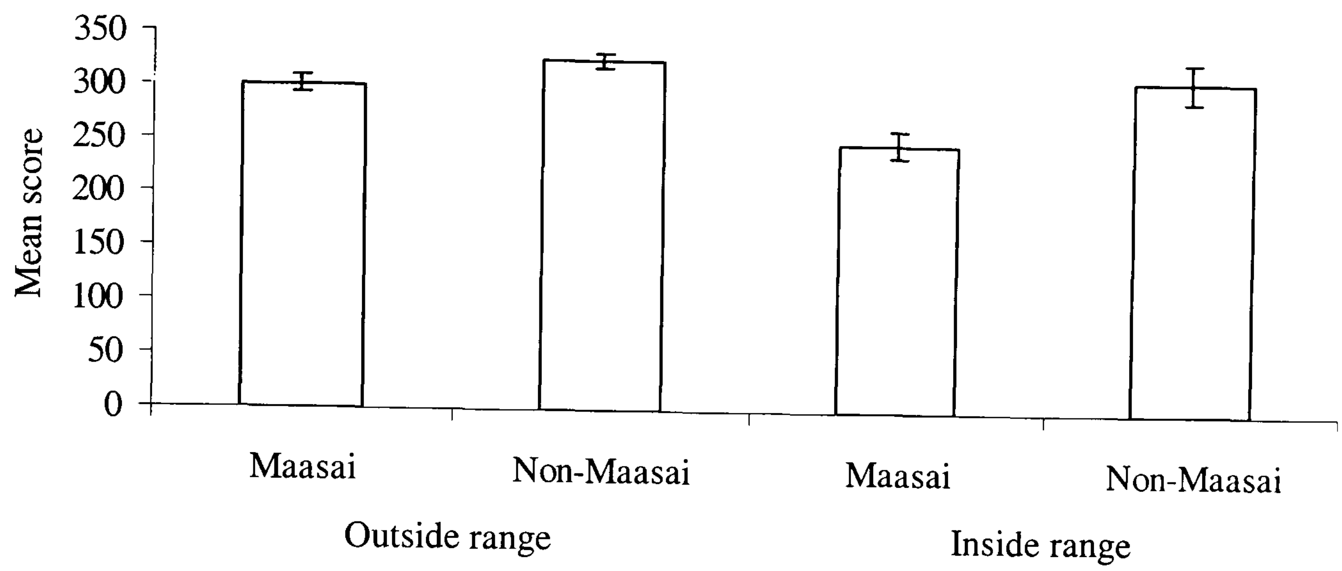
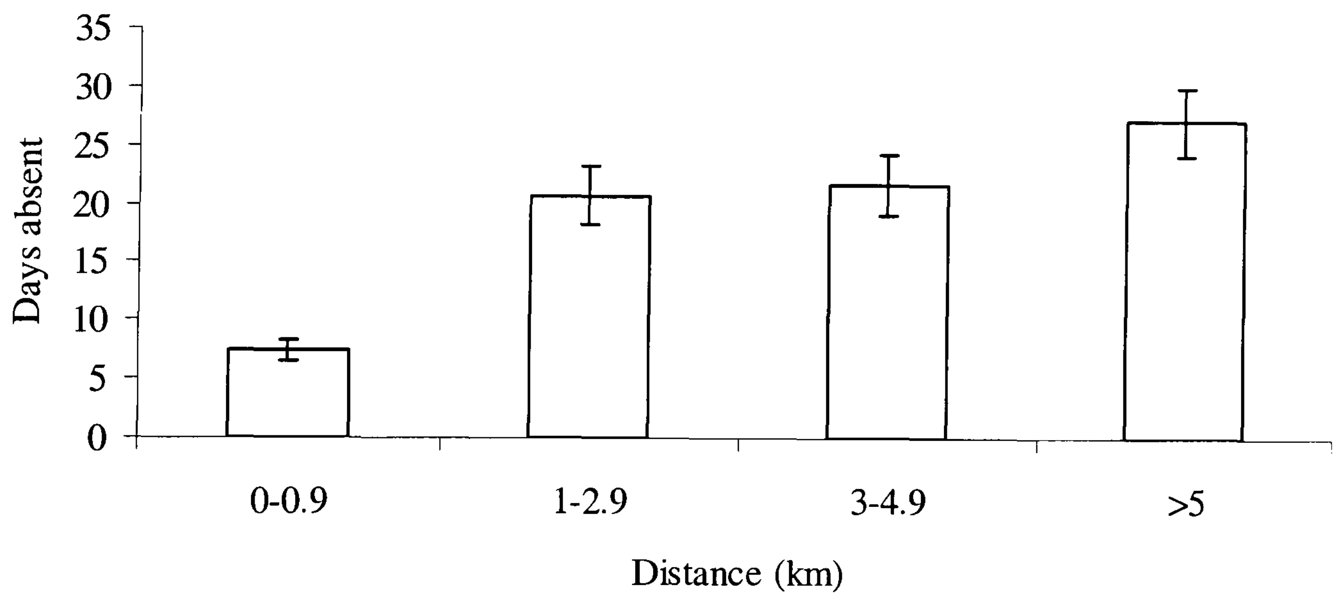
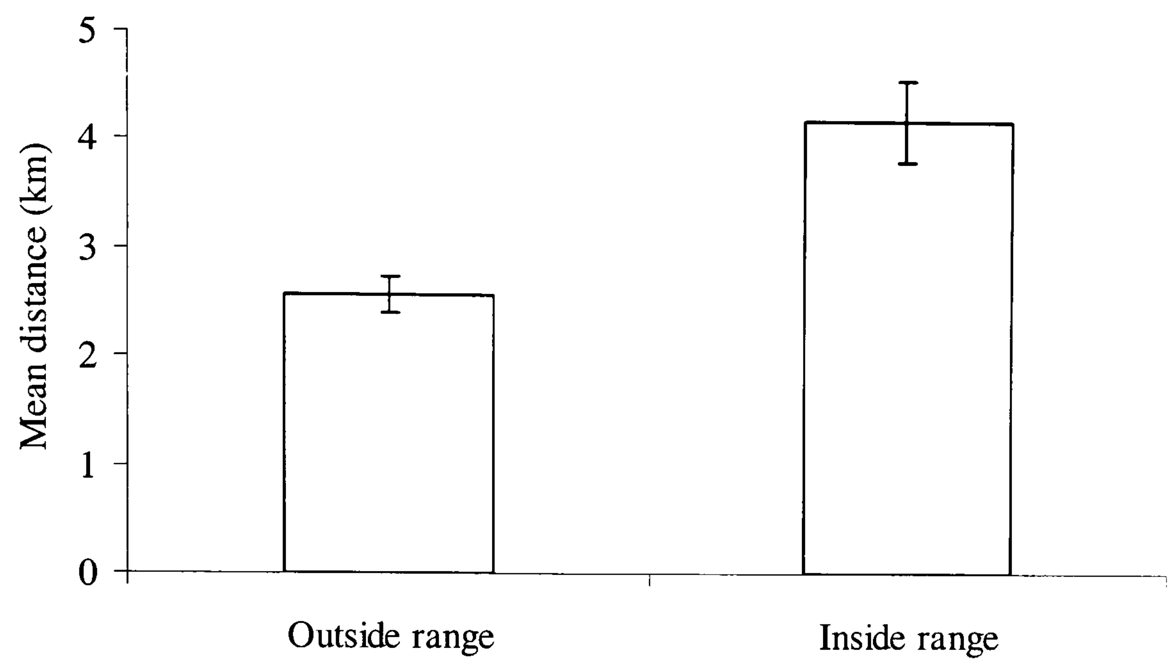


Figure 7.26 Mean ± SE days absent and distance covered by pupils in TM District in 1999.



The regression model for factors that might have determined pupils score was significant ($F_{4,260}$ = 13.22, p=0.001) and explained 16% of the variance (Table 7.7). The t-values of all variables met the guideline of being above +2 or below –2, and hence were considered in the model. Significant relationships were observed between pupils mean score and distance, tribe, absenteeism and elephant range respectively. Thus, the score of pupils decreased with: increasing distance from schools; among Maasai pupils; increased absenteeism; and from inside elephant ranges.

Figure 7.27 Mean ± SE distance travelled by pupils and elephant range in TM District in 1999.



Tables 7.7 Factors determining pupils mean score in TM District, based on linear regression.

Variable	B	SE	t	Sig	Beta
Constant	306.79	16.62	18.46	0.001***	
Distance	-16.55	4.59	-3.61	0.001***	-0.213
Tribe	33.26	9.45	3.53	0.001***	0.200
Absent	-16.67	5.48	-3.04	0.003**	-0.174
Elephants	29.96	12.40	2.42	0.016*	0.142

Level of significance shown with *=p<0.05, **=p<0.01, ***=p<0.001

7.4 Discussion

Previous studies have documented HEC in Kenya (Nguru 1992, Thouless 1994, Kiiru 1995, Kangwana 1995, Kasiki 1998). These studies were based on questionnaire and interview surveys, which can provide valuable insights into human perceptions of crop loss. However, relying entirely on interviews can introduce inaccuracies, as farmers tend to inflate the amount of crop damage in anticipation of compensation (Tchamba 1995, Kakira 1996). This is the first detailed HEC study in the Mara ecosystem, one of the three areas designated by KWS as serious conflict zones in Kenya. It is the only study in which all destroyed farms were spatially recorded and the amount of damage assessed by observation. Equally, it is the first study to have shown the spatial distribution of attacks on human by elephants, and the factors that are most significant in determining such attacks. Therefore, unlike most previous studies, which focused on crop raiding, this study has also explored other forms of conflict that affect both humans and elephants. For instance, this study has shown the impact of elephants on education of primary school children. Many factors other than elephants contribute to low performance in education. In addition, a detailed analysis of KWS OBs records has produced findings that are important for policy formulation and management purposes. Many reported cases of human wildlife conflict are not attended, and there is variation between response to cases according to division, KWS station and wildlife species. Equally, a variation was noted between the period taken to respond to cases and division, KWS station and wildlife species. These findings are important for development of an effective conflict mitigation strategy.

7.4.1 Human deaths and injuries

Human death and injuries are a major form of conflict in elephant ranges, yet these have only been simply described in most studies (Sukumar 1989, Kasiki 1998) or totally avoided. Generally hundreds of people have been killed by elephants in heavily populated areas (Sukumar 1990, KWS 1994, Kailas 2000), while the lack of human deaths and injuries in Zaire was attributed to the low human population (Kakira 1996). However, Tchamber (1998) believes most figures are exaggerated, and loss of human life is actually rare and negligible. Today, however, elephant-caused human deaths and injuries often result in a more vociferous public outcry than when a person is killed by other causes (Sukumar 1990), because elephants have become highly politicised species.

While human death and injuries decreased in TM District from the 1960s to 1980s, it increased in the 1990s (Figure 7.3). This trend fits perfectly with the decline of the elephant population as a result of poaching, and their seeking of 'safe havens' in the MT (Chapter 6). However, the elephant population was recovering from poaching by the 1990s and had started to re-establish itself on CLs, while human encroachment increasingly blocked traditional movement routes and increased the chances of conflict. While the censused elephant population in the Mara ecosystem has not changed since the mid-1980s (Ottichilo 2000), localised changes might have occurred (Chapter 6). However, since most of TM District was not covered in previous aerial surveys, the overall trend in elephant numbers cannot be ascertained with certainty, but it is generally believed that the Mara elephant population has increased (Njumbi 1995).

The circumstances under which people are attacked by elephants vary. In Tsavo, 11 people were killed while guarding crops (Kasiki 1998) and generally more men than women were killed by elephants (Sukumar 1989, Kasiki 1998). This was attributed to a high frequency of contact of men with elephants during crop vigilance, livestock herding and night walks from social functions (Kasiki 1998). In Asia, people have been killed and others seriously injured while play-acting with elephants, and in attempting to capture them for domestication. In TM District, only one person was injured while guarding crops and more men than women were killed. However, drunkards were more likely to be attacked by elephants when returning at night from social functions (Table 7.3).

7.4.2 Elephant deaths and injuries

In Zimbabwe, poachers took the advantage of the land crisis to slaughter elephants (BBC NEWS, 10 Nov 2000), while elephant populations dwindled in countries experiencing political crisis and turmoil. Between 1992 and 1996, KWS introduced the policy of shooting problem elephants, a method KWS thought was effective in controlling conflict. Thus 104 elephants were killed in Tsavo (Kasiki 1998), and 23 were killed in Taita over 5 years (KWS 1994). However, killing of females causes stress to the remaining population, increases calf mortality (Poole 1989), and reduces the reproductive potential of the remaining group (McComb *et al* 2001). A more recent policy of translocation and construction of electric fences has come into effect to minimise shooting of elephants. Some buildings in TM District and of the neighbouring districts were financed allegedly from ivory sales. However, poaching was not evident during the ground surveys. According to Waithaka (1998), all dead elephants are recorded in the KWS database. However, three dead elephants were not recorded during this study probably due to the poor reporting system between TMCC and KWS. Again, this is not possible in an area that is not managed by KWS whose interests are only centred within the National Parks. Similarly, the noted increase in elephant mortality after the 1999 aerial surveys was due to increased search effort. Generally, the increase in elephant mortality from 1991 may be explained by: (a) the increased shooting of problem elephants; (b) increased elephant mortality as a result of killing the matriarchs during PAC and poaching; and, (c) increased poaching resulting from the poachers taking advantage of the volatile situation during the first multi-party elections in 1992.

A new form of human-caused conflict is the snaring of elephants, also reported in Mt Kenya (Vanleeuwe 2000). Elephants with cut trunks and injured legs were observed within the MT and during a snare "sweeping" exercise in MT, 48 snares were collected. The elephants accidentally caught snares intended for other wildlife species targeted for the pot. Elephants dying in Kenya from other causes, such as spear or arrow wounds and gunshots, are also on the increase. Ten cases of spear or arrow wounds and six cases of gunshots in different parts of the country were reported between January and August 2000 but they all had intact tusks. Three elephants were electrocuted and a train in Tsavo killed five, while elephant mortality increased in Laikipia, with the invasion of the area by herdsmen during severe drought.

7.4.3 Crop raiding in TM District

Crop raiding has been reported to be either mainly by family herds (Balasubramanian *et al* 1995, Naughton-Treves 1998, Sam 1998, Kasiki 1998) or by bulls in some areas (Bell 1984, Sukumar & Gadgil 1988, Sukumar 1990, Sukumar 1991, Hoare 1997, Bhima 1998, Hoare 1999). Sukumar (1995) noted that two bulls in one herd were responsible for most crop raiding in southern India. In contrast, one notorious female crop raider was translocated in Laikipia, Kenya, together with bulls (Omondi pers com.). However, no single adult female raids crops

(Sukumar 1989, Kasiki 1998). The family herd is sensitive to insecurity, and only raids farms that are not heavily guarded, while the bulls are bolder and raid crops for reproductive gain (Sukumar 1989). While the bulls did most crop raiding in Liwonde National Park, Malawi, the mean areas damaged by both male and females were not different (Bhima 1998). In TM District, crop raiding was mainly undertaken by mixed herds with only fewer bull herds also involved (Figure 7.19).

Crop raiding in many areas has mainly been by elephants originating from PAs (Kasiki 1998, Hoare 1998, Osborn 1998) and occurred mainly at night (Hoare 1997, Osborn 1997, Kasiki 1998). However, Ndung'u (1998) reported unusual daytime raids, especially during foggy weather. In TM District, crop raiding occurred mainly at night and was undertaken mainly by the resident elephant population, and by the population from the adjacent Koiyaki-Lemek and Olchoroiuwa wildlife associations in Emarti. Small herd of elephants were usually involved, but large herds were involved in farms near MMNR and in Emarti. Elephants often joined up to form big groups when going to CLs (Chapter 6). During the 1994 elephant survey, a herd of 200 elephants was observed in the Koiyaki-Lemek and Olchoroiuwa areas, which is a threat to the increasing cultivation. Hence, the area has been designated as one of the key HEC zones in Kenya (Chapter 1). Elephants from the MT destroyed only the new farms established about 15 km away at the end of the corridor. Destruction of grain stores by elephants has been reported (Waithaka 1993, Sam *et al* 1997, Hoare 1999) but none was destroyed in Tsavo (Kasiki 1998). In TM District, a few cases of elephants pulling down grain stores were reported, but only during droughts.

There was marked increase in the number of reported cases of human wildlife conflict in 1991, which coincided with establishment of KWS. This could have reflected excitement and renewed expectations of reporting, recording and responding to conflict by KWS and the locals (Njumbi 1995). Although KWS records do not live up to standard scientific procedures, they provide useful information for conservation decisions, because they authentically express practical management issues on the ground (Waithaka 1999) and are now becoming increasingly used (Thouless 1994, Njumbi 1995, Kasiki 1998). In India, good records are kept because of compensation (Kailas 2000), which was abolished in Kenya in 1989. The fact that numbers of cases recorded by KWS was lower than the actual number of cases meant most farmers do not report crop-raiding incidents. This may be due to: (a) a lack of compensation; (b) the long distance that must be covered to report; (c) lack of immediate response by KWS personnel; and, (d) most farms being small. Thus, most reports were by farmers with larger farms, which may incur large economic losses. In such cases, a local administrator was often sent to report on the behalf of large farms, which was recorded as a single case. The reported cases dropped again in 1994, probably either as a sign of success of the PAC unit, crop failure due to 1993 drought and/or the abandonment of farms. Some notorious crop raiding elephants could have been eliminated through PAC, while the others may have kept away (Sukumar 1989).

Reports of conflict increased again after 1995, probably because: (a) elephants had become conditioned to available scaring techniques; (b) of an increase in farming following the return of the Kisii tribe after ethnic violence; (c) of the recovery of elephant population; and, (d) of the re-establishment of the elephant population into their former ranges. These factors, combined with increased human population density and increased settlement, have reduced elephant range, requiring the elephant to become bolder in order to survive (Njumbi 1995, Kangwana 1995). However, there is no evidence to show that elephants have become bolder and no longer fear people, but it could be due to the limited space increasing the chances of contact. Some authors argue that there is no evidence to show that the intensity of HEC has increased, and the increase in reporting is due to increased publicity and political interest in the problem, or to increased awareness among the local communities of the compensation (Hoare 1999). The reported conflict reduced in 1997, as seen in other areas, which was attributed to crop failure because of heavy rainfall (*El Nino*) (Kasiki 1998, Sam 1998, Kailas 2000). In the case of TM District, it could additionally have been due to reduced areas under farming as a result of ethnic fighting between the Maasai and the Kisii and/or a prolonged dry season resulting in crop failure.

Several studies have established that crop raiding was mainly undertaken by species of wildlife other than elephants. For instance, baboons and wild pigs were ranked as the most destructive species of wildlife (Kasiki 1998, Naugton-Treves 1998), while primates were reported as frequent raiders (Kakira 1996). Equally, lions caused more economic loss than elephants (O'Connell-Rodwell *et al* 2000), but elephants are feared the most because of the difficult in stopping them and the dangers involved (Kasiki 1998) and the great damage they cause in a single attack (Naughton-Treves 1998).

7.4.4 Performance of schools and pupils

Elephants are often mentioned as interfering with learning activities (Ngure 1995, Munyugi 1997, Mwathe *et al* 1998), an allegation that has not been explored previously. It has been alleged that school children and teachers lose many hours as elephants block all routes between home and school. Some schools also close earlier than usual, to enable children to look for safer routes back home, while social and economic activities of adults are hampered by escorting children to school. Such factors could definitely have a negative impact on both school and pupil performance (Tables 7.3 & 7.4). This is the first study to consider these allegations, and their importance cannot be ignored, given their contribution in promoting negative attitudes towards elephants. The study showed that the mean score of schools outside the elephant range was higher than schools within the elephant range (Figure 7.24). However, distance from school emerged as the most important factor in determining pupil performance as pupils are possibly exhausted from a long walk and cannot concentrate in class, are often absent, and do not have enough time to finish their assignments (Table 7.4). Equally, pupils with unfinished assignments avoided school. Elephants were often used as an excuse for absenteeism and late arrival in schools (Figure 7.23), which was difficult for teachers to verify, but was regarded as valid excuse. Elephants also destroyed school facilities such as goal posts and demonstration farms.

Pupils from Emurtoto Primary School are the most affected by elephants because of the location of the school near dispersal areas above the corridors, and the relatively short distance to Nyakweri forest where elephants from MT sometimes take refuge. Climbing the escarpment is very strenuous for young pupils from the MT area, and elephants move in the opposite direction increasing the chances of conflict. An attempt to re-locate the community from the corridor has been resisted because of their earnings from tourism activities. However, a temporary measure would be for pupils to be escorted by rangers to school.

Some Maasais have resorted to having two homesteads as a coping strategy. One homestead is near a school that the children attend while the other homestead is for livestock in the elephant areas. Other Maasai send their children to boarding schools. The establishment of a fence by the Naari community to keep off elephants did not improve on school attendance. Hence, elephants alone were not responsible for pupils' absenteeism. In contrast, it resulted in decreased attendance by adults in education, as people shifted to crop farming (Mwathe *et al* 1998). Generally, most schools in TM District lack basic facilities, while the remote conditions discourage many teachers. Poverty impacts negatively on the ability to access quality education, and TM District is one of the poorest districts in Kenya. At recent international meetings on education, including World Education Forum in Dakar, Senegal, UN's 2000 Millennium Summit and the G8 Summit, the global commitment to expanding basic education was underscored through providing funds to developing countries (Daily Nation, Monday, Dec 11, 2000b). Furthermore, the 14th Commonwealth Education Ministers Conference in Halifax, Canada, proposed that donors should release resources required for implementing critical policies in education sector. Equally, at none of these meetings was it recognised that elephants might be an important factor impacting school or pupil success.

7.4.5 Implications for management

Attack on humans by elephants and vice versa is on the increase. People walking late hours of the night have been victims, a need to create awareness. The incidences of elephants being lost as a result of snares and or PAC are increasing calling for urgent intervention. Crop raiding by elephants is high while KWS does very little to mitigate conflict because of inadequate personnel and other necessary facilities.

The study on education is novel, but nevertheless was not able to consider other important factors that could affect pupil performance, for example, the impact of crop guarding by pupils during the night. In the event of elephants raiding crops, tins and drums are beaten, which again could interfere with pupils' sleep and or night-time study. Absenteeism could also be a factor, when guarding crops during the day against other wildlife species. Hence, there is still need to establish the relationship between absenteeism, crop growing periods, and elephant presence among farming families. According to some studies, children remain at home to guard crops (Bell 1984, Thouless 1994, Ngure 1995, Naughton-Treves 1998). Other factors that may affect performance include: school facilities; teachers' qualifications; attitude towards school-work, and education; and, in the case of Maasai, *moranism*. However, these findings of this study are an important pointer to further research and resource allocation that might influence attitude towards elephant conservation. A Maasai politician said: "*Maasai schools have a perennial shortage of teachers, learning facilities and are not even accessible to inspectors making it difficult to compete equally. There are no roads while the terrain is difficult*" (William Ole Ntimama, MP for Narok, in the Daily Nation 2001). Yet, wildlife was not mentioned as a major hazard to academic performance.

The findings of this data chapter show that human-elephant conflict exist in various forms and occurred at different times of the year. In the next chapter, I analyse and discuss some of the factors determining this seasonal patterns of crop raiding.

CHAPTER EIGHT

Determinants of seasonal pattern of crop raiding

8.1 Introduction

There is increasing interest in determining the various factors that underlie the seasonal differences in patterns of crop raiding by elephants, since they seem to vary from region to region. Understanding the forces that drive crop raiding, and of their interactions in space and time, is important in predicting the future patterns of crop raiding and hence mitigation. Seasonal patterns of crop raiding have been examined in parts of Cameroon (Ekobo 1996), Kenya (Njumbi 1995, Kasiki 1998, Ndung'u 1998), India (Kailas 2000), and Zimbabwe (Osborn 1998). These studies have established that crop raiding may exhibit either a seasonal pattern (Ekobo 1997, Kasiki 1998, Osborn 1998) or an irregular pattern (Njumbi 1995, Ndung'u 1998, Kailas 2000) in different locations. These different patterns are attributable to seasonal differences in environmental conditions that may influence elephant movement patterns, through which conflict arises.

Some studies (Iringia 1990, Thouless 1994, Ndung'u 1998, Sam *et al* 1998, Kasiki 1998) showed that crop raiding occurred when crops were mature during the dry season. At a time when natural forage is in short supply, mature crops may provide an important dry season food source (Osborn 1998). In contrast, one study (Hoare 1997) showed that crop raiding did not necessarily occur when crops were mature, while another study established that crop raiding occurred throughout the year because crops were irrigated all year round (Kailas 2000). Therefore, these contradictory findings suggest that crop raiding may either be opportunistic, implying a preference for, rather than reliance upon, crops as a source of food or vice versa. Contradictory findings show the importance of understanding the factors that underlie the seasonal patterns of crop raiding, in order to improve conflict management. However, the factors that influence patterns of crop raiding have not been fully explored or understood. Hence, this chapter explores some of the factors that may influence the seasonal pattern of crop raiding in Transmara (TM) District as a basis on which to improve mitigation strategies. This chapter aims to answer the following questions:

- Is there a seasonal pattern to crop raiding?
- If so, do underlying environmental factors or patterns of crop maturity influence seasonal pattern of crop raiding?
- Do crops represent a significant seasonal source of food at times of natural forage scarcity?

In this chapter, I describe the seasonal patterns of crop raiding (8.3.1.), environmental parameters including rainfall pattern (8.3.2.1), grass height (8.3.2.2) percentage cover (8.3.2.3), dry grass biomass (8.3.2.4), level of maize maturity (8.3.3) and dung diet composition (8.3.4). I then describe the relationships between crop raiding, seasonal patterns of crop raiding and environmental parameters and levels of maize maturity (8.3.5). Finally, I examine the factors determining seasonality patterns of maize raiding (8.3.6). This chapter concludes with a discussion of these results (8.4).

8.2 Methods

8.2.1 Measuring seasonal patterns

8.2.1.1 Crop raiding

Field assistants were located in 10 strategic locations at which records were collected daily on raided farms. Other raided farms away from these locations were also sought and recorded, using the detailed survey methodology described in Chapter 7. A monthly total of raided farms was derived by adding up all the raided fields.

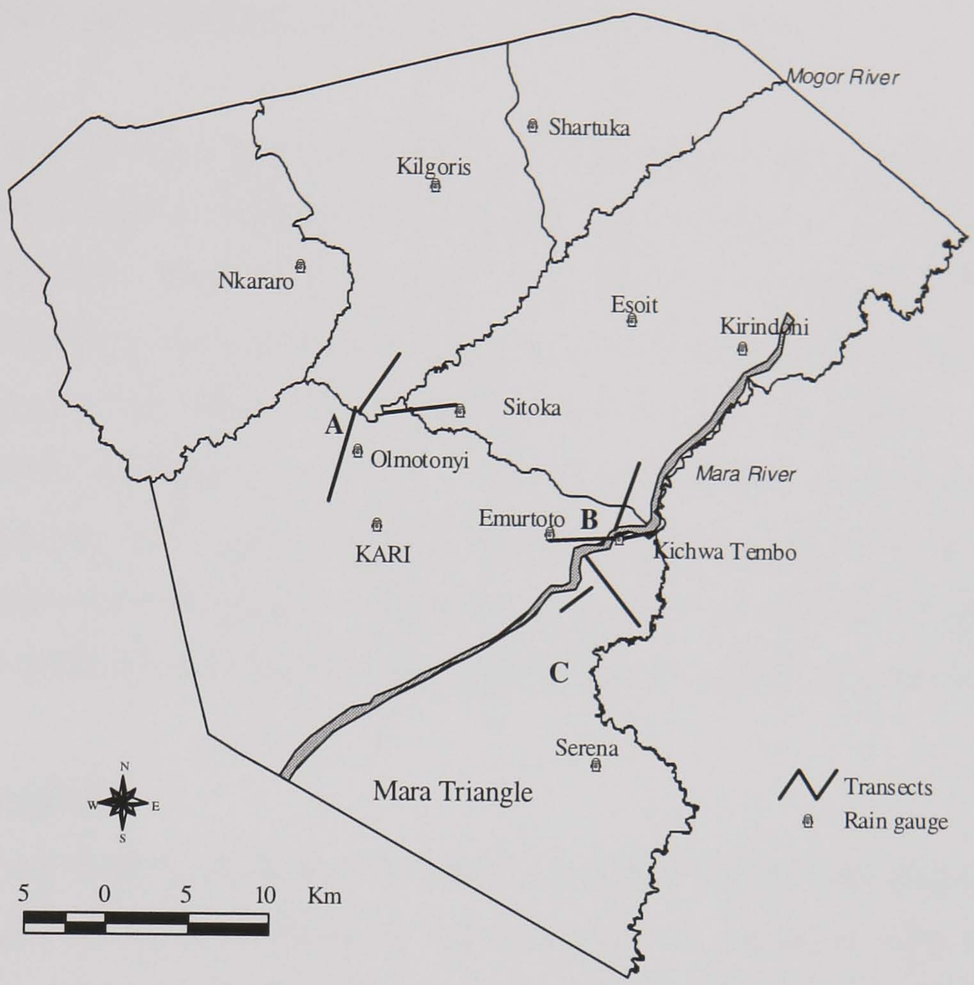
8.2.1.2 Rainfall pattern

Rainfall records were obtained from nine different locations in the TM District (Figure 8.1). Five rain gauges were installed at five schools in Olmotonyi, Esoit, Nkararu, Kirindoni and Emurtoto, where a teacher was assigned to keep daily records of rainfall from May 1999 to July 2000. Further longer term rainfall data were obtained from three stations. First, from the Kenya Agricultural Research Institute (KARI) at Lolgorian and from the Ministry of Agriculture at Kilgoris over the period 1989-1999. Second, from the ecological monitoring project records collected by WWF at Mara Serena Lodge and Kichwa Tembo over the period 1989-1999.

8.2.1.3 Seasonal changes in grass height, weight and percentage cover

The percentage cover of grass in each plot was determined using a pin frame that was placed randomly in 15 places. One vegetation plot of 50 m by 50 m was located in each of the three habitat types (Figure 8.1) namely: Forest (A); *Acacia* woodland (B) along the escarpment; and, open grassland (C) in MT. Data were collected at one monthly intervals on: grass height; percentage cover; and, fresh and dry weights. Grass height was measured using a ruler at five randomly located sites within each plot. Forty-five random sub-plots of 0.5 m^2 were clipped to ground level in each plot, and the fresh weight of grass was weighed in grams using a spring balance. The samples of grass were then air dried and re-weighed to obtain the percentage moisture and the dry weight. MT was not included in any analysis since crop raiding was mainly undertaken by the resident elephant population.

Figure 8.1 Map showing the locations of rain gauges, vegetation plots and dung sampling in the study area.



8.2.1.4 Level of maize maturity

During visits to raided maize fields (Chapter 7), further information were collected on the level of maize maturity, using four categories: "young" comprised of maize fields without tassels; "middle" comprised tasselled maize with immature cobs; "mature" comprised maize that was ready for consumption as green maize; and, "dry" comprised maize that was getting ready for harvesting.

8.2.2 Dung analysis

Because the digestive system of the elephant is relatively inefficient (Benedict 1936), much coarse undigested material remains in their droppings. Hence, most of the material in recently deposited droppings can be classified as herbaceous, or woody or grass, and individual species can easily be identified (Wing & Buss 1970). Faecal analysis also allows dietary analysis without disturbance to its normal behaviour (Dalke 1935). Nevertheless, a limitation of faecal analysis is that the differences in assimilation of various food materials could bias what appears in the droppings in terms of relative contribution to the diet. However, seasonal patterns of intake for each food type would not be affected by this bias.

Therefore, dung samples were collected from locations A, B, and C from July 1999 to June 2000. Thirty samples were collected opportunistically each month, 10 from each location. The age of the dung was estimated subjectively based on the relative dryness of the surface of the bolus. Only elephant dung piles determined to be fresh were collected. One bolus was collected from a pile by a "blind grab" (Osborn 1998) and labelled with the location and date. The dung samples were latter sun dried and taken to the laboratory for analysis.

Since each sample was large for analysis, three smaller blind grabs were taken to minimise bias. These three grabs weighing 100 gms each were then sieved separately, using a 0.2 cm sieve to remove the very small particles. The samples were then further separated using forceps, into: crops; grass; wild fruits; browse; woody materials; and, unidentified materials. Browse, wood materials and grass were fairly easy to identify. Browse was considered to be composed of leaves, masticated twigs and bark. However, crops were difficult to distinguish from grass and browse, so they may have been underestimated. The different categories of sorted materials were then weighed on a balance to the nearest gram and recorded for statistical analysis. An average was obtained for each plant component for the three grabs from each sample.

8.2.3 Data analysis

ANOVA was performed to determine the seasonal variability in rainfall, grass biomass, cover, and grass height. Bivariate correlations between pairs of variables were examined using Spearman rank correlation and seasonal patterns were displayed for each significant factor.

Means of rainfall per month was calculated for all nine stations from July 1999 to June 2000. However, because of the unusual prolonged dry spell in TM District during the study period, a long term data were used to determine the usual rainfall pattern, through a 10-year running mean (10YRM).

Grass biomass was determined according to the procedure of Thurrow (1996). The total fresh weight of grass in g per 0.25 m^2 was converted into tonnes per hectare. The positive increments in the total biomass, representing the net primary production, were related to the total rainfall during the same interval (Whittaker 1970, Phillipson 1975, Sinclair 1975).

Mean percentage of crops (C), fruits (F), grass (G), browse (B), woody material (W) and un-identified materials (U) in the diet of the elephant in riverine forest, wooded grassland and open grassland from July 1999 to June 2000 was estimated from faecal samples. Since data did not conform to a normal distribution, the relative proportions of each plant item were transformed using a square root transformation to allow statistical analysis (Zar 1984). The averages from the three grabs samples per faecal sample were obtained while an overall mean was based on the total number of faecal samples analysed. Multiple comparisons among mean percentage of crops, fruits, grass, browse, woody material and un-identified materials in the diets of the elephant between July 1999 and June 2000 in three habitat types were done. Values shown are the overall mean consumption from all faecal samples analysed using ANOVA. The test was based on unequal sample sizes (Sokal & Rohlf 1969).

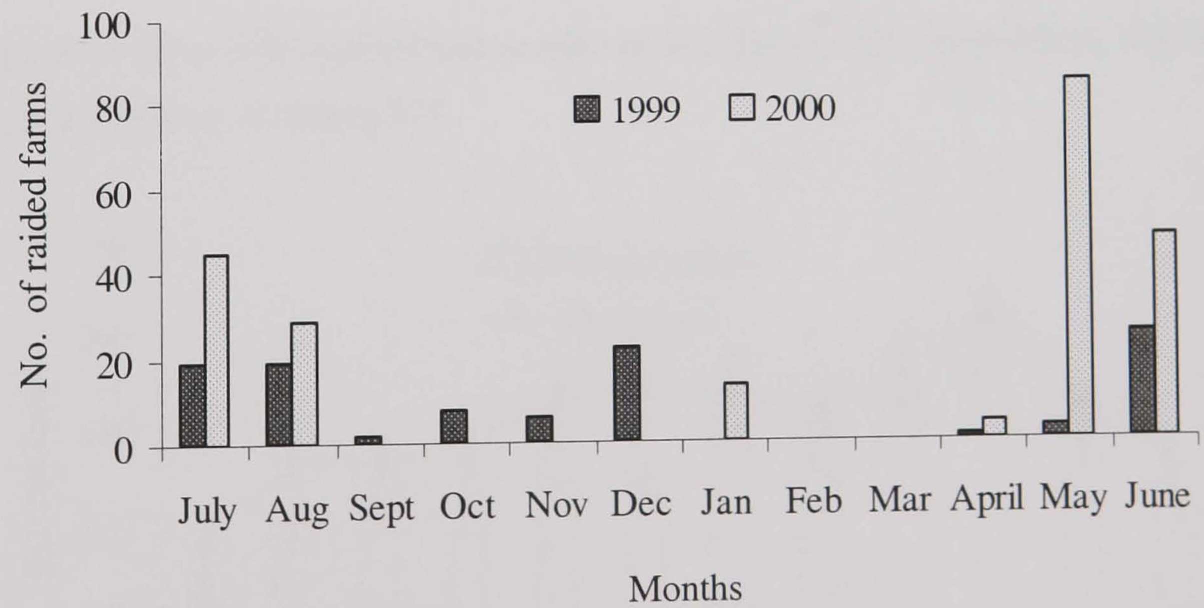
Factors determining seasonal patterns in crop raiding were determined using a logistic regression. Highly skewed variables were transformed using arcsine and logarithmic transformations. The dependent variables were months when crop raiding occurred and were coded as '0' for raided and '1' for no raiding. This was tested against six independent variables namely: biomass; grass height; rainfall; grass cover; moisture; and, crop maturity (young, middle, mature and dry).

8.3 Results

8.3.1 Seasonal pattern of crop raiding

The number of farms raided differed over the year, with one pronounced peak from May to August 2000, during the season of long rains, and in December-January, during the season of short rains (Figure 8.2). Fewer conflict incidents were recorded during December-January, probably because fewer farms were cultivated. More incidents of conflict were recorded in 2000 than in 1999 because Emarti area was included in 2000, but was excluded in 1999 because roads were impassable during wet conditions.

Figure 8.2 Seasonal pattern of crop raiding in TM District, based on field records from January 1999 to August 2000.



8.3.2 Environmental parameters

8.3.2.1 Rainfall pattern

Rainfall did vary in nine stations over the year, from May 1999 to July 2000. Less rain was recorded in July, January and February, while more rain was recorded in August, October and March (Figure 8.3). However, the variations did not differ ($F_{11,104} = 0.426$, $p>0.05$) across the year. Rainfall varied among the nine stations ($F_{9,106} = 53.79$, $p<0.001$) and the overall mean gives a wrong impression of the rainfall pattern in TM District. Also, due to an unusual period of prolonged drought in 1999, the two peak rainfall patterns are not distinct.

A clear picture of the rainfall pattern in TM District emerges from examining rainfall in four stations over a 10-year period (Figure 8.4). Over the 10-year period 1989 to 1999, there was a difference in mean rainfall ($F_{11,226} = 5.26$, $p<0.001$) and the mean number of days that rain fell ($F_{11,228} = 4.99$, $p<0.001$) per month. June to August emerges as the driest months, while most rains fall from March to April is what are termed the long rains, and a lesser peak in rainfall occurred from November to January is what are termed the short rains (Figure 8.4).

Figure 8.3 Mean ± SE rainfall amounts based on data for nine rainfall stations in TM District collected from July 1999 to June 2000.

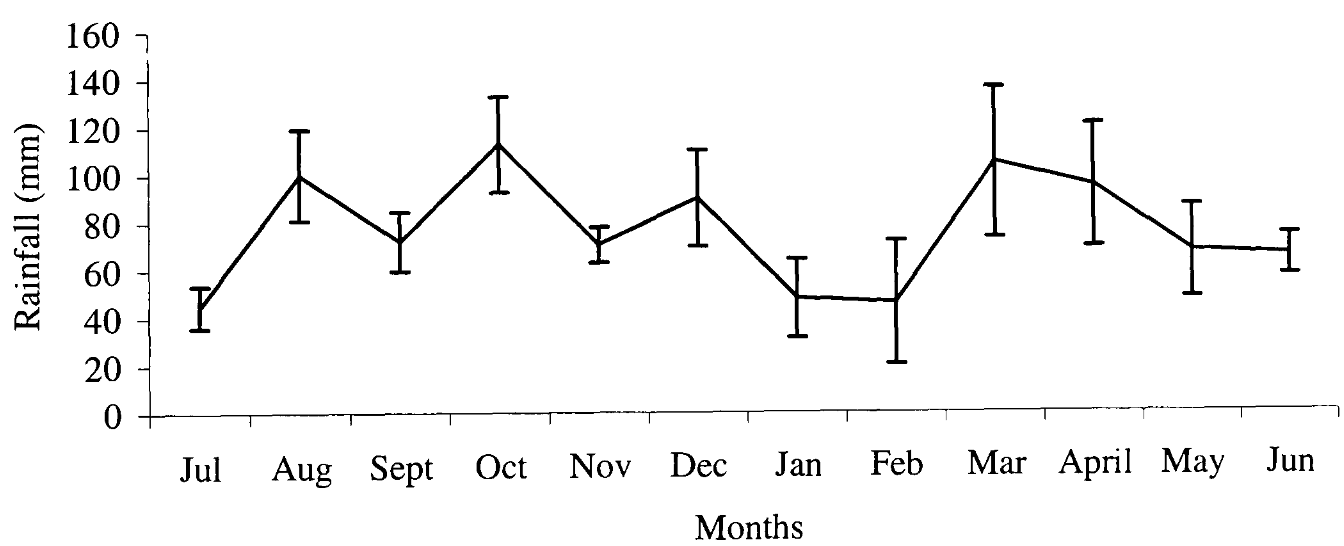
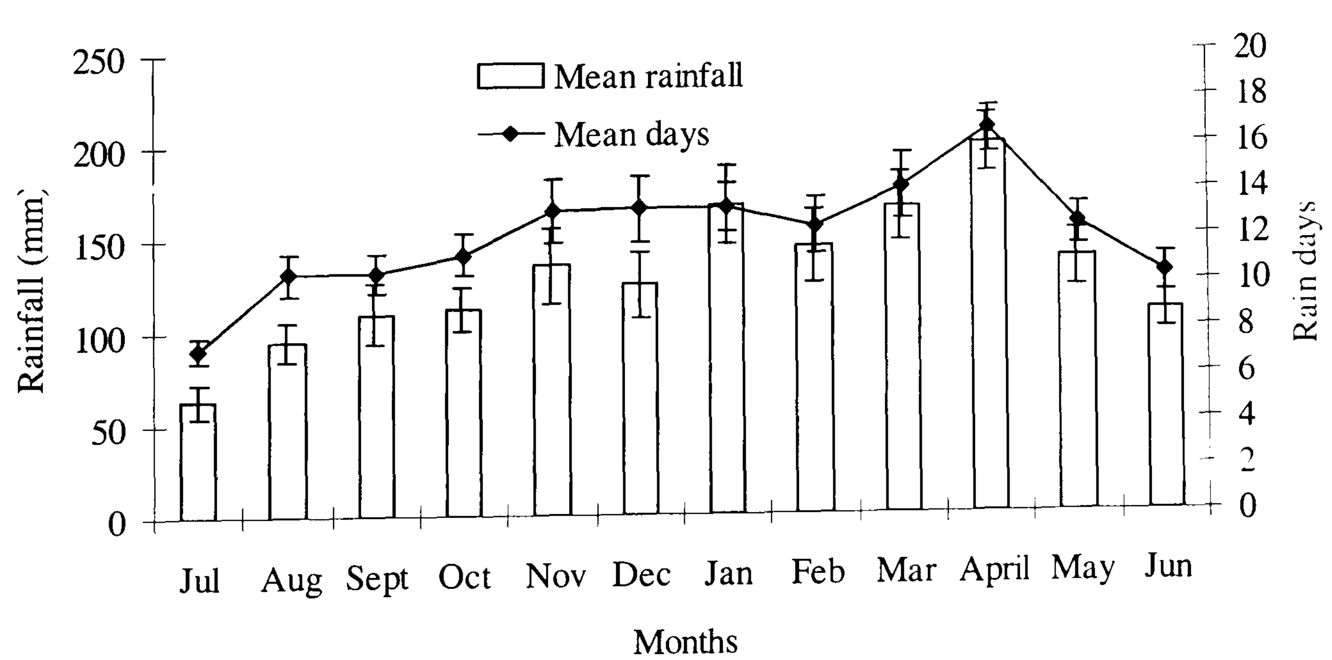


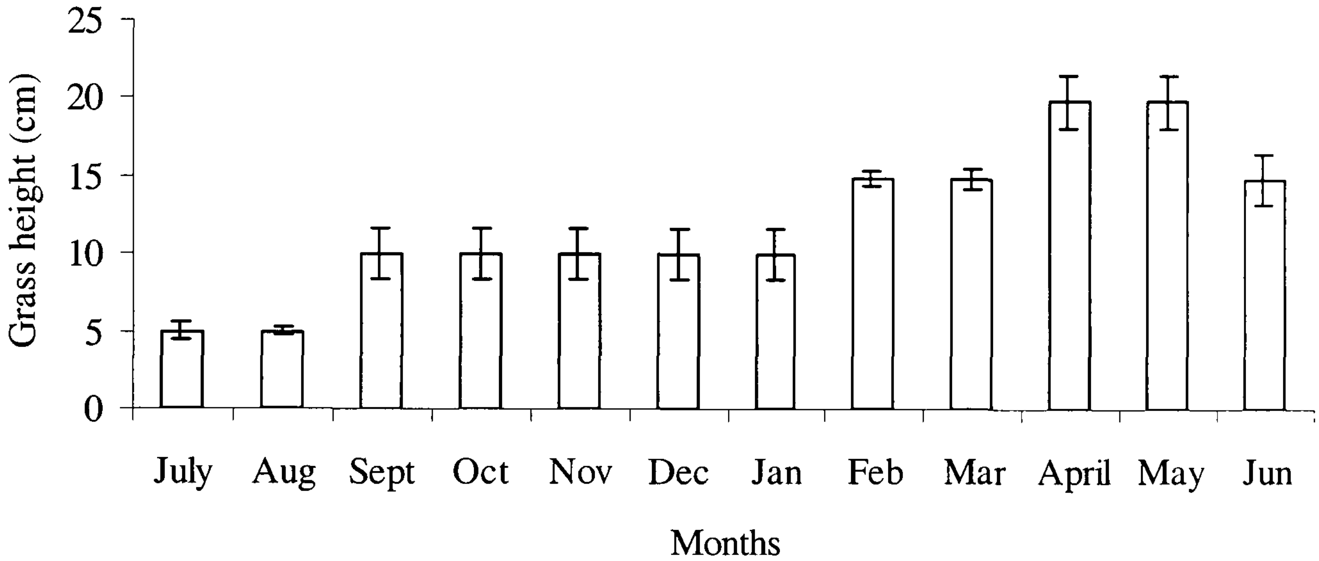
Figure 8.4 Mean ± SE rainfall and number of rain days in TM District from 1989 to 1999 based on seven stations excluding MT.



8.3.2.2 Grass height

Grass height varied seasonally in the CLs above the escarpment ($F_{11,108}$ = 15.95, p=0.000) and peaked in April and May (Figure 8.5) once the rains had also peaked (Figure 8.4). Grass height was at its lowest on CLs in July and August (Figure 8.5).

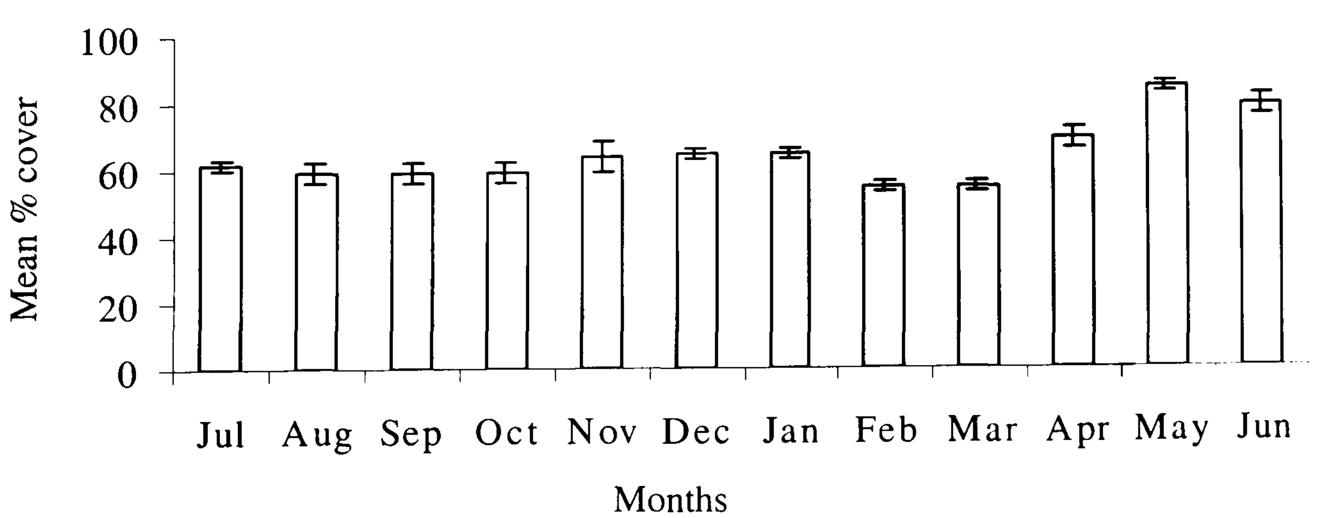
Figure 8.5 Mean ± SE grass height on CLs in TM District from July 1999 to June 2000.



8.3.2.3 Percentage grass cover

The percentage grass cover differed across months ($F_{11,180}$ = 21.514, p<0.001), and the highest cover occurred after rains in May (Figure 8.6). MT was again excluded from the analysis, but a decline in percentage cover was observed from July when migratory wildebeests and zebras moved into the MT. The percentage cover increases on CLs in April, May and June and decreases in February and March.

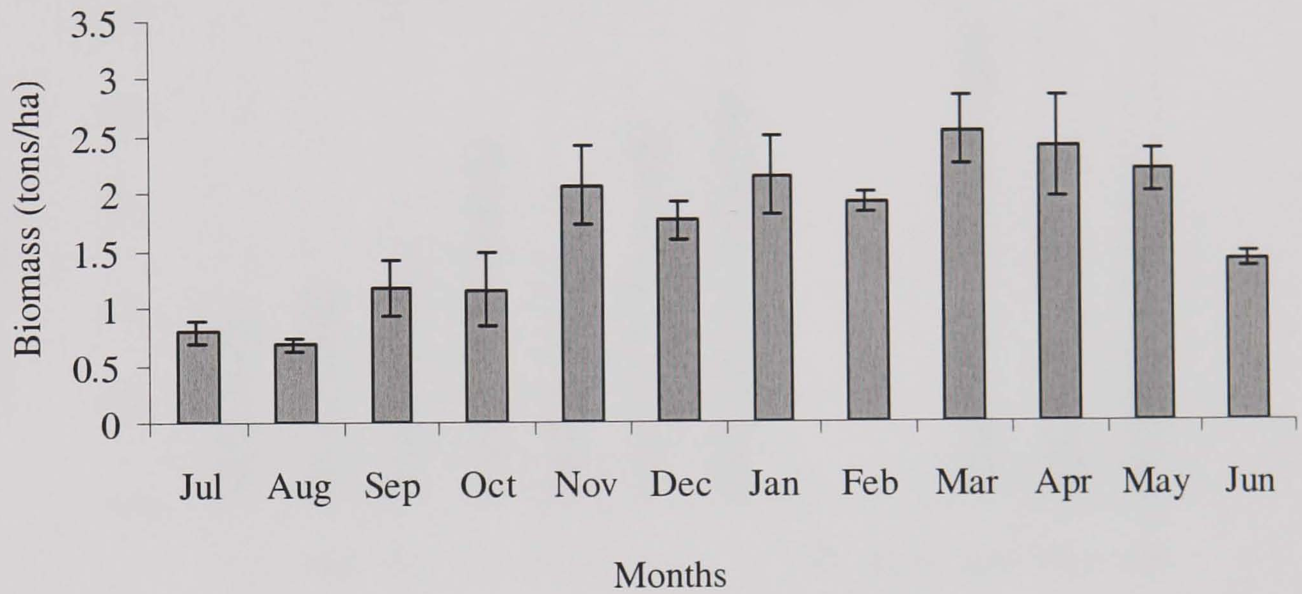
Figure 8.6 Mean ± SE percentage cover of grass in TM District on CLs in TM District from July 1999 to June 2000.



8.3.2.4 Dry grass biomass

The mean grass biomass differed ($F_{11,24} = 6.257$, p=0.001) across months, and was highest in March-April and November-January, probably because of the influence of the long and short rains respectively (Figure 8.7). The decline of biomass on the CLs above the escarpment in July and August also corresponds with wildebeest and zebra migration into the MT.

Figure 8.7 Mean ± SE dry biomass production on CLs in TM District from July 1999 to June 2000.



The percentage moisture content of grass followed the rainfall pattern with low moisture level during the dry low rainfall period of January and February and differed ($F_{11,24} = 26.537$, p=0.001) between months (Figure 8.8).

Figure 8.8 Mean ± SE moisture content of grass on CLs in TM District from July 1999 to June 2000.

8.3.3 Level of maize maturity

Data on levels of maize maturity were normally distributed (Kolmogorov-Smirnov z=4.57, p=0.000). The planting season of maize was in February and March, and elephants raided no farms, as maize was very young. All maize is young or middle in April, and from May to

September maize is mainly mature or dry. Second planting season is September and October leading to a mix of maturity from November to January (Figure 8.9). Surveys of raided farms showed that elephants attacked more mature and dry maize (χ^2=177.565, df=3, p=0.000) than young or middle maturity maize crops (8.10).

Figure 8.9 Changes in the levels of maize maturity on the raided farms between January 1999 and August 2000.

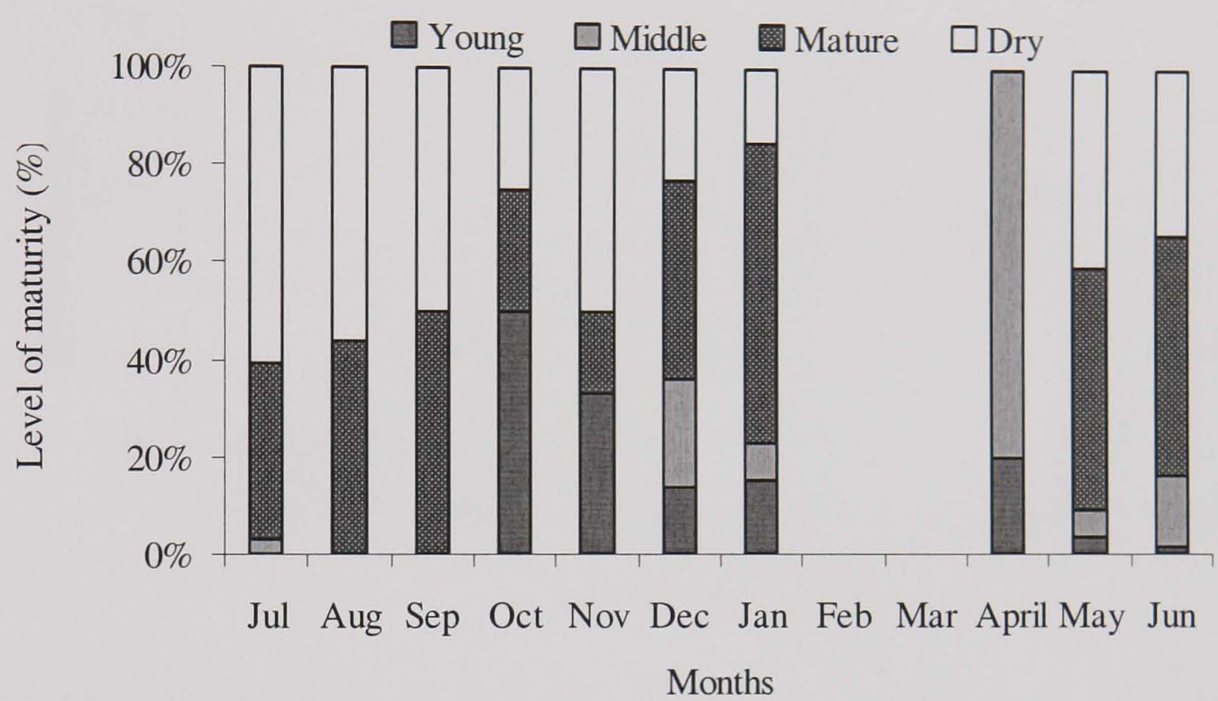
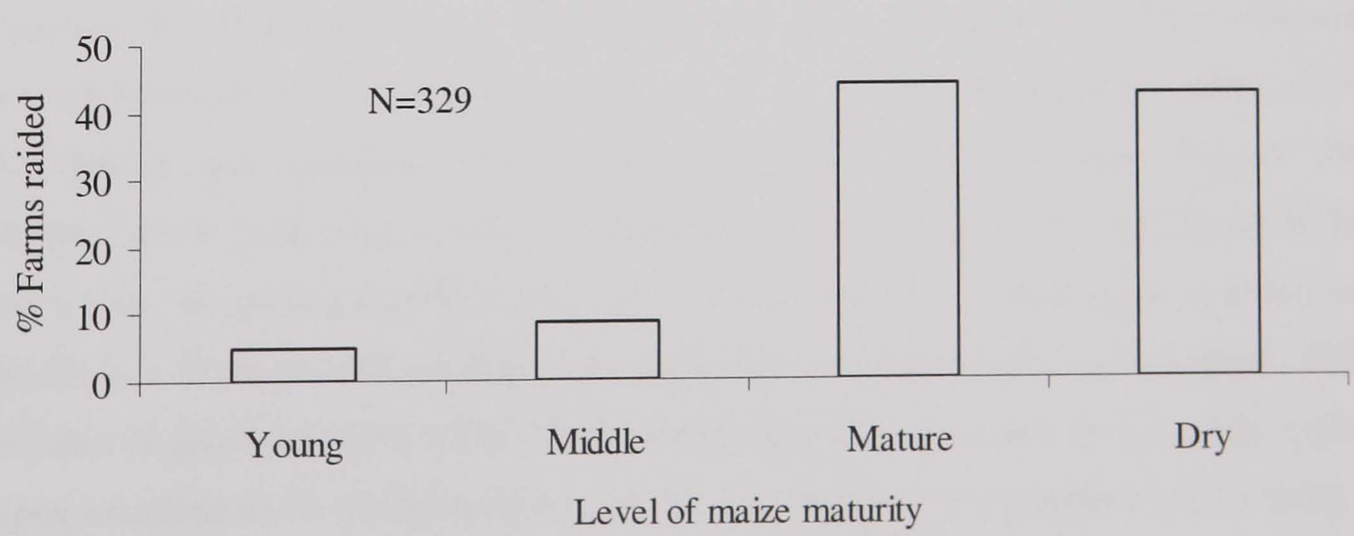


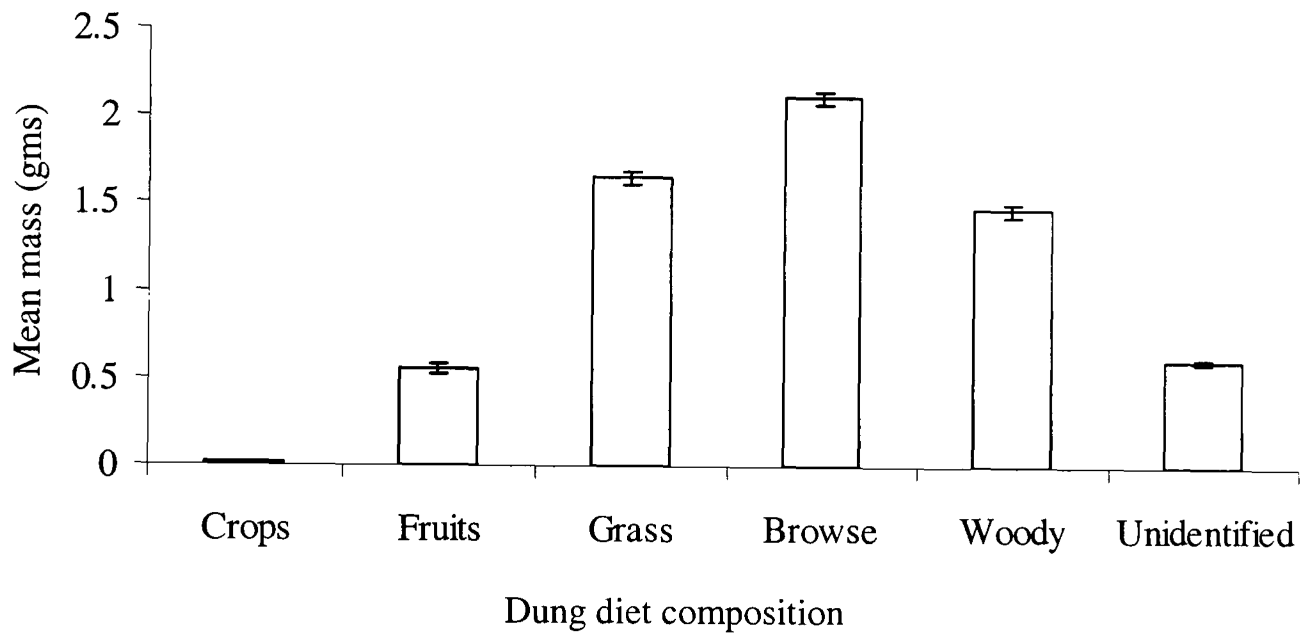
Figure 8.10 Maize maturity level and percentage composition of raided farms between January 1999 and August 2000.



8.3.4 Elephant diet analysis based on dung

Overall by weight, browse and woody material was the most component of elephant dung, followed by grass (Figure 8.11). Crops formed a negligible proportion and low fruits because of its seasonality. The proportion of each dung dietary component differed (($F_{5,841}$ = 34.631, p=0.000).

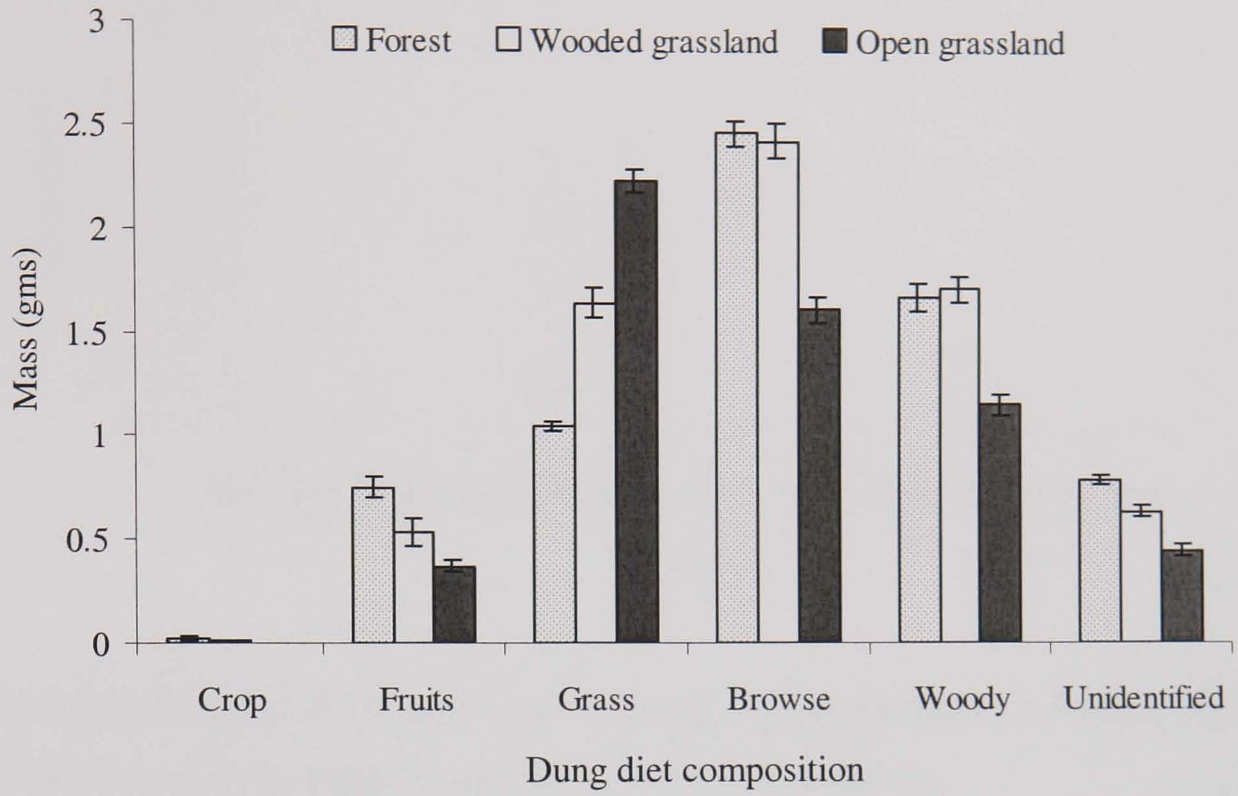
Figure 8.11 Mean ± SE weight of different materials in elephant dung.



8.3.4.1 Differences between dietary composition and habitat

In different habitat types, there were variations in the amounts of crops ($F_{2,841}$ = 6.663, p=0.001), fruits ($F_{2,841}$ = 16.659, p=0.000), grass ($F_{2,841}$ = 126.177, p=0.000), browse ($F_{2,841}$=54.33, p=0.000), and woody ($F_{2,841}$ = 27.714, p=0.000) materials in elephant dung (Figure 8.12). There were more crop components in dung collected from forest habitats ($F_{2,198}$ = 6.87, p=0.003) (0.40 ± 0.01) than in open woodland (0.38 ± 0.0) or grassland (0.38± 0.00) Fruits also occurred most in forest (0.66 ± 0.02) than in open woodland (0.57 ± 0.03) and grassland (0.55 ± 0.02) which were not different. Grass occurred more($F_{2,195}$ = 43.17, p=0.001) in grassland habitat (0.95 ± 0.02) than in open woodland (0.84 ± 0.01), respectively. There was more ($F_{2,194}$ = 105.1, p=0.001) browse component in dung collected from open woodland (1.2 ± 0.02) than in forest (0.98 ± 0.01) or grassland (0.90 ± 0.01), respectively. However, woody plant materials were more ($F_{2,194}$ = 12.05, p=0.001) in dung collected from forest (0.87 ± 0.01) and woodland (0.87 ± 0.01) than in grassland (0.79 ± 0.02). Unidentified materials were more ($F_{2,194}$ = 4.61, p=0.01) in open woodland (0.73 ± 0.01) and forest (0.70 ± 0.01) than in open grassland (0.67 ± 0.02).

Figure 8.12 Mean ± SE dung composition in the three habitats A (forest in the interior of TM District), B (wooded grassland along the escarpment) and C (open grassland in the MT).



8.3.4.2 Seasonal differences in elephant dung dietary composition

In different seasons, there were variations in the amounts crop ($F_{11,832} = 2.049$, p=0.02), fruits ($F_{11,832} = 64.477$, p=0.000), grass ($F_{11,832} = 10.555$, p=0.000), browse ($F_{11,832} = 26.089$, p=0.000) and woody material ($F_{11,832} = 19.103$, p=0.000) and unidentified ($F_{11,832} = 28.714$, p=0.000). The amount of food types in elephant dung varied (Figure 10.13). The amount of maize in dung differed (Figure 8.14; $F_{11,832} = 18.534$, p=0.000).

Figure 8.13 Changes in the amount of food types in elephant dung between July 1999 and June 2000.

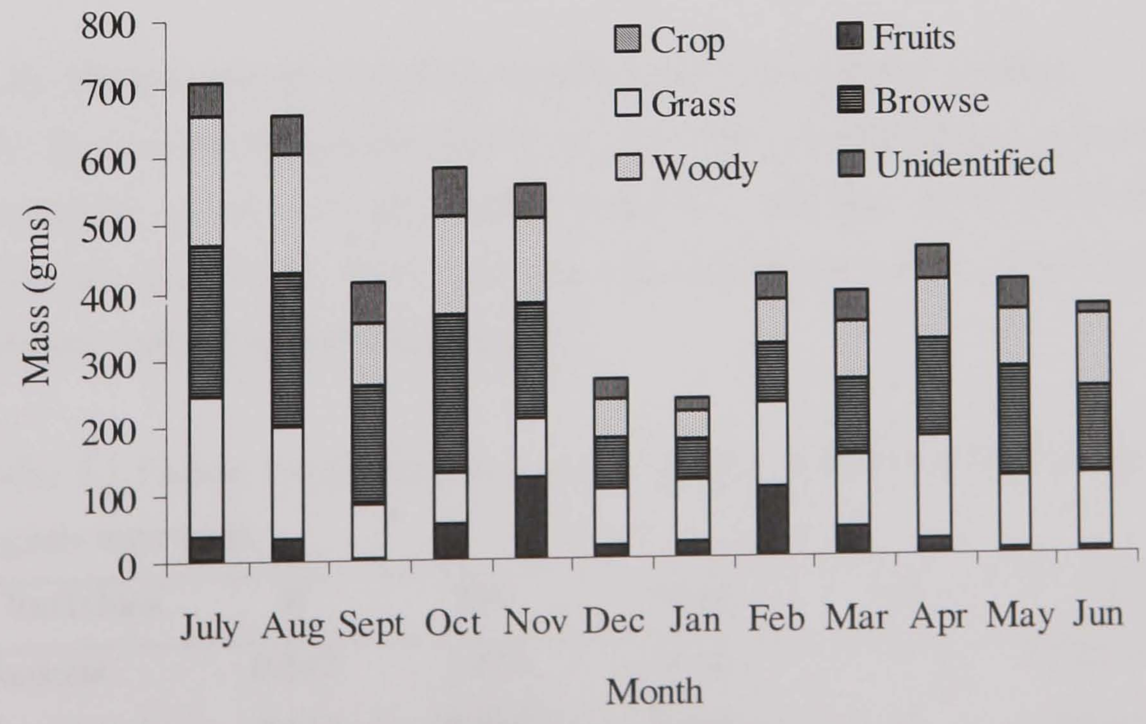
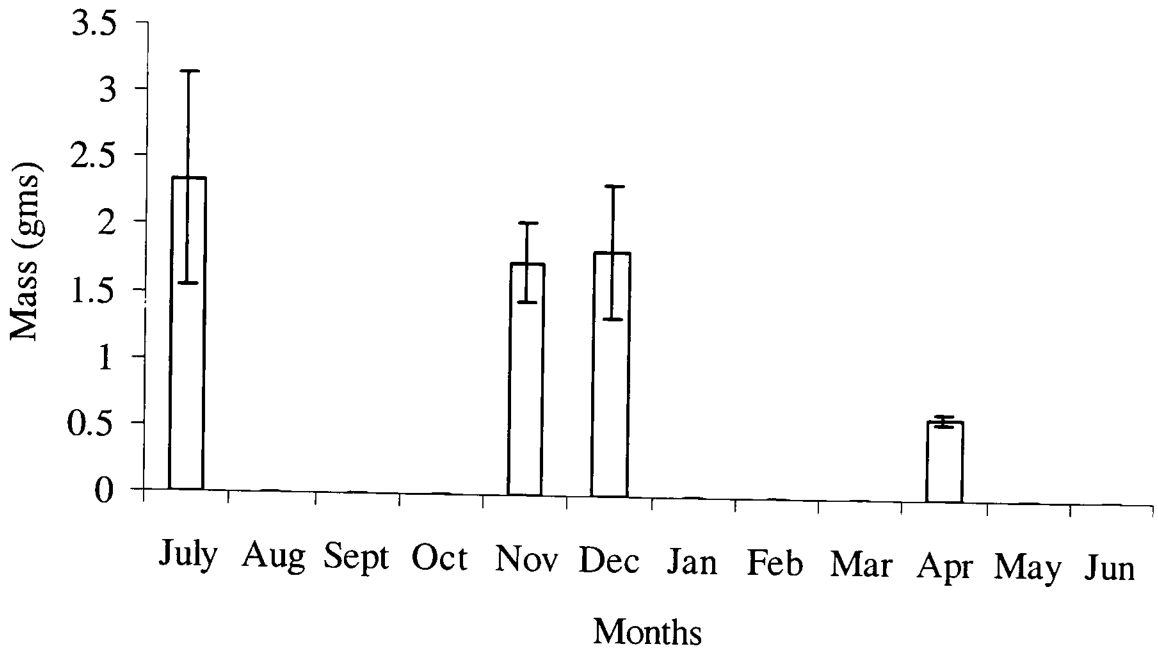


Figure 8.14 Changes in the amount of crop in the elephant dung.



8.3.5 Relationships between maize raiding, seasonal patterns of maize raiding and environmental parameters and levels of maize maturity

An increase in percentage grass cover was related with an increase in the number of raided farms with middle level maize (Figure 8.15 (a); r_s=0.626, p=0.029). The amount of grass in elephant dung increased with an increase in raided farms with middle level maize (Figure 8.15 (b); r_s=0.791, p=0.002). Similarly, the total number of raided farms increased with the number of raided farms with mature level maize (r_s=0.604, p=0.037) while the amount of fruits in elephant dung also increased with the number of raided farms with mature level maize (Figure 8.15 (c) & (d); r_s=-0.617, p=0.032). However, at low grass biomass, more farms with dry level maize were raided (Figure 8.15 (f); r_s=-0.698, p=0.012). Nonetheless, an increase in woody material in elephant dung coincided with an increase in the number of raided farms with dry level maize (Figure 8.15 (f); r_s=0.73, p=0.007).

8.3.6 Factors determining seasonality patterns of maize raiding

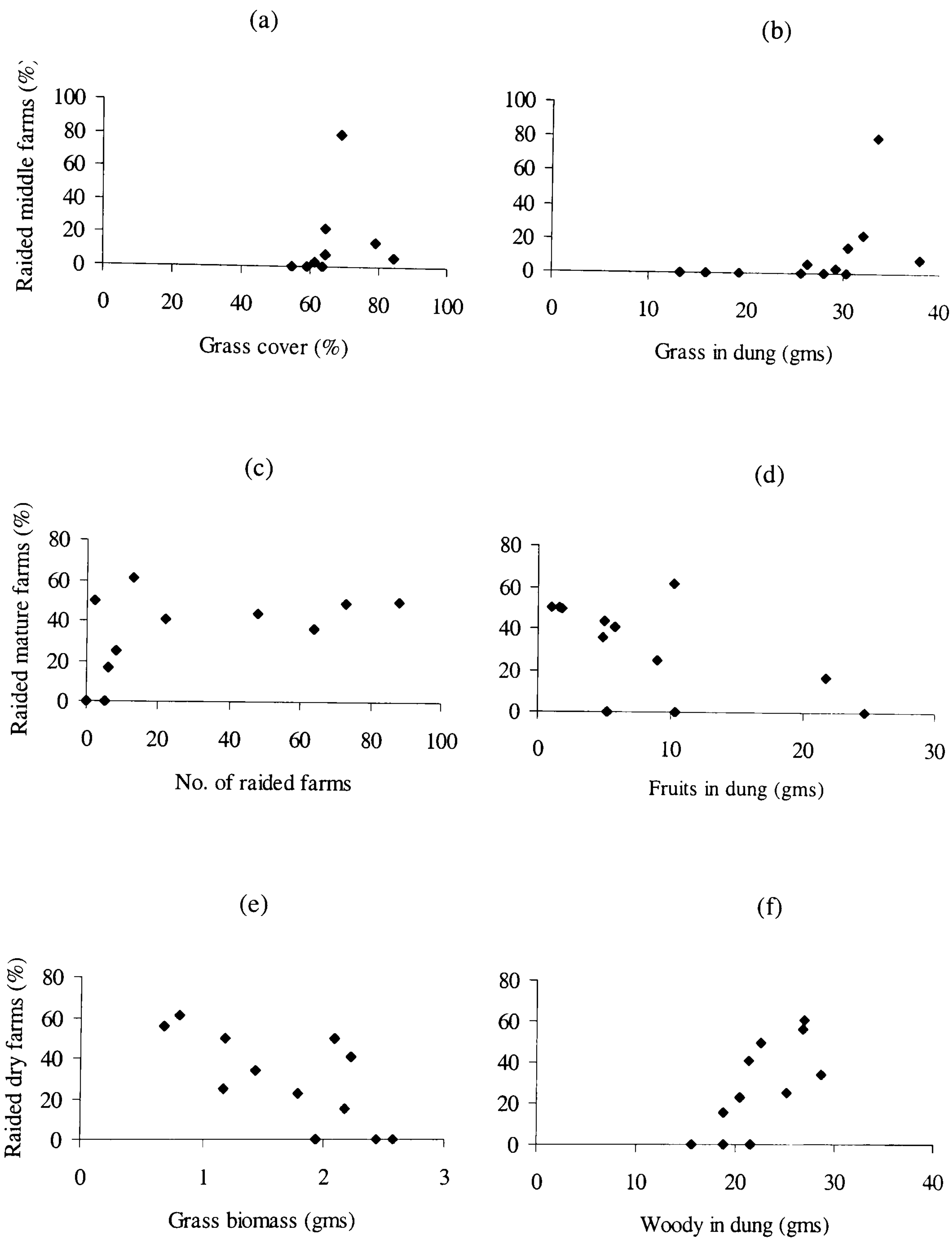
The logistic regression model for factors that might have explained the factors determining the seasonality pattern of maize raiding produced a goodness of fit of 91.7% of observed to expected values (Table 8.1). Significant relationships were observed between crop raiding and only one variable namely mature crop.

Table 8.1 Factors determining the seasonal pattern of maize raiding in TM District, based on logistic regression.

Variables	B	SE	Wald	df	Sig	r
Constant	0.693	1.225	0.320	1	0.000***	
Mature maize	-0.613	7.034	0.008	1	0.000***	0.542

Level of significance shown with ***=p<0.001

Figure 8.15 Correlation coefficients between seasonal dietary patterns. environmental parameters, the level of maize maturity and crop raiding.



8.4 Discussion

Kasiki (1998) reported a seasonal pattern of crop raiding in Tsavo. In some parts of Kenya, variations were also reported in periods of peak attack in different regions. For instance, June is the peak raiding season in Kericho, September and January in Nakuru, and June–July in Narok (Njumbi 1995). Ndung'u (1998) also noted seasonal variations in crop raiding peaks in different years. In Cameroon, a cyclical pattern of crop raiding was observed with three peak seasons (Ekobo 1997) but no seasonal pattern was observed in India because irrigation resulted in a variety of crops maturing at different times (Kailas 2000). Osborn (1998) observed one peak season of raiding in Zimbabwe. Most HEC studies have visually shown the relationships between crop raiding and dry season (Kasiki 1998, Sam 1998), crop maturity level (Iringia 1990, Sam *et al* 1997, Kasiki 1998) and changes in biomass (Ndung'u 1998, Osborn 1998). However, none of the studies on crop raiding has ever measured crop phenology of damaged farms to show whether it is related to elephant presence or crop selection. Therefore, this study is the first to determine the proportions of crop damage in relation to maize maturity level. The study has shown that TM District experienced two peak seasons of crop raiding from June to August, mainly in the long growing season, and in December and January, for the short growing season (Figures 8.2). Fewer crop-raids in the short growing season was probably due to the fewer farms being planted, and these were mainly concentrated in the western part of TM District. Most crop raiding occurred during the dry season when there was low grass height, low percentage cover, low biomass, and low grass moisture content. Changes in environmental parameters determine maturing of maize and diet of elephants, which may result in conflict.

8.4.1 Changes in environmental parameters as indicators of maize raiding

Rainfall influences the natural cycles of forage production. Rainfall determines grass growth (height and cover) and therefore biomass production. The rainfall regime in TM District derived from long-term monitoring, which showed that January-February and May-June-July are the driest months, which coincides with the period of crop ripening and crop raiding. The percentage grass cover might not be a good indicator because of overgrazing resulting in invasion of new grass species as established by other studies (Ngure 1995, Kasiki 1998). According to Kailas (2000), there is no association between rainfall and crop raiding but a closer look shows some relationship. In some areas, the *El nino* phenomena of 1997, caused drought, which resulted in little conflict because of crop failure (Sam 1998, Kailas 2000). In Tsavo, Kenya, the *El nino* caused heavy rainfall that also resulted in crop failure (Kasiki 1998). Little conflict was also reported in TM District during *El nino* (Chapter 7). Seasonal and climatic differences have caused different patterns of crop raiding by elephants in Kenya since the 1920's (Melland 1938). More raids occurred during high rainfall and fewer raids occurred during low rains because of high crop failure (Barnes *et al* 1995, Ndung'u 1998, Hoare 1999). However, this reporting was based on the fact that the success of cultivation was dependent upon the amount of rainfall. In areas where irrigation is practised, crop raiding is not related to the rainfall pattern (Mwathe *et al* 1998, Kailas 2000).

The levels of maize maturity determined the seasonal patterns of crop raiding in TM District during the study (Table 8.1). This was noted especially when elephants visited some areas only when maize was mature and revisited the same area the following season. This was probably an intentional move by elephants. The young and middle level maize farms were raided mainly when: (a) the fields were located along the elephant routes; (b) an area had both young/middle and mature maize; and/or, (c) elephants went out to inspect the level of maize maturity. In this last case, maize maturity raiding appears explanatory. Elephants come in contact with agricultural land more easily during their natural movement patterns and not necessarily to raid crops (Sukumar 1989, Nath & Sukumar, 1998). Opportunistic crop raiding has been reported in other studies (Hoare 1997, Osborn 1998, Kasiki 1998, Kailas 2000). A few elephants went out probably to explore the level of maize maturity in April and November and later attacked in big numbers. This ability to sense the maturity level of maize has not been understood. Unexpected was lack of a relationship between the number of raided farms and farms with dry maize, which can be explained by (a) pre-mature harvesting of farms as a protection measure before maize reaches the dry level, (b) elephants kept off from farms after their first raid attempts when maize was at a mature stage, and/or (c) ripening of fruits, which substituted maize keeping elephants away. Preference for mature maize can be based on the fact that the high nutritive value is worth the risk of harassment. The maize cob being the storage organ of the maize plant is rich in starch and oils. According to Osborn (1998), crops have a higher percentage of moisture and crude protein during the dry season than grass and browse. Maize matured when grass height, dry grass biomass and percentage cover were low due to the dry spell forcing elephants to change their diet from grass dominant to browsy.

8.4.2 Changes in dietary patterns

Crops only formed a small proportion of the diet of elephants in TM District (Figure 8.11), which may be explained by a number of reasons. First, there may be successful protection of crops. Second, crop raiding may be opportunistic rather than being an important dietary component of the elephant because of the rich and diverse natural resources. Lastly, there could be a limitation in the logistics of dung collection and or analysis that results in under-representation of crops relative to amounts consumed. Elephants from the adjacent Narok District heavily raided crops in Emarti, which was excluded from dung collection because of the distance and inaccessibility. Most crops were seen in dung that was collected when the elephants visited the farms during early in the night and remained until early hours the morning. The crops eaten had enough time to pass through the digestive system before the elephants returned to the forest. The crop content in the dung of elephants that visited the farms late at night and returned immediately could have improved probably if dung collection was extended into the forest areas but this could have biased the results apart from risks and expenses involved to hire rangers. The elephants might have receded back into the forest faster before most of the crop had passed through the digestive system. This partly explains why November-December-January had fewer farms raided but more crops in the dung compared to May-June-July with many farms but fewer crops.

From this analysis, it is apparent that in areas where both immature and mature maize was destroyed either elephants do not feel insecure while on CLs and feel free to roam anywhere and eat anything, or there is a massive decline in biomass and young crop become the only source of rich nutritional value. In some studies, crop raiding was as a result of crop preference and not a decrease in natural food (Ngure 1992, Ndung'u 1998).

Raiding of mature crops was also reported in some areas (Iringia 1990, Sukumar 1990, Thouless 1994, Hillman-Smith *et al* 1995, Balasubramaniam *et al* 1995, Sam *et al* 1997, Ndung'u 1998, Kasiki 1998). Other studies reported selection of young, intermediate, and mature crops (Bhima 1998, Hoare 1999). However, the ability of elephants to sense maturity level of maize over long distance has never been explained.

The transition from raiding farms with mature maize to farms with dry crops occurred when rainfall was low, therefore low biomass and percentage covers. Therefore, elephants switched from grass to browse and woody material (Figure 8.12). Generally, animal activity increased with increased grass height and percentage cover (Osborn 1998). Fruit content in dungs may vary due to differences in ripening period. Variations in grass cover are not distinctly clear because of the invasion by new grass species as a result of overgrazing by livestock. This study also established that elephant movement from the MT into the wooded habitats on CLs increased during the dry season (Chapter 6). However, an interesting observation was noted when browse content of dung was higher in open woodland than in forest strongly suggests that elephants prefer browse to grass when the two food types occurred in the same habitat (Figure 8.11). If this was the case, then elephants should utilise more browse when in the forest. However, if this was not the case then that suggests that the forest was mainly used as refuge. According to Barnes *et al* (1994), fruits represented an unpredictable source of food, which elephants on occasion exploit to excess. Higher proportions of crops could have probably been recorded if farms were not guarded while the time spent by elephants on maize farms was generally short.

A number of studies have attempted to assess the factors that influence diet selection in different habitats (Jachmann 1989, De villiers *et al* 1991, Lindsay 1994). Elephants shift from grass in wet season to browse in dry season (Laws *et al* 1979, Lewis 1986b, Dublin 1986). Elephants consume more browse when grasses dry and become more fibrous and less nutritious (Vessey-Fitzgerald 1973) because of increased amount of silica. Essentially, elephants can be specific about which part of a plant they eat and when (Osborn 1998). The complex nature of interaction between the seasonal patterns that influence crop raiding complicates the understanding of the pattern in relation to other studies. This study could be limited by the fact that elephants could have fed in one habitat and dropped dungs in different habitats especially between woodland and open grassland. Again, during examination of the dung content, some plant items could not be identified and classified accordingly hence, were categorised as unidentified, a problem also reported by Osborn (1998). If these materials represented crops, then the findings may have underestimated the effect of elephants on crop raiding. A similar caution can be said for other food types. However, this anomaly may not mar the general findings of the study. The differences in assimilation of various food materials and the variable size and state of undigested materials in droppings would obviously affect faecal analysis.

8.4.3 Implications for management

The complex nature of interaction between the seasonal patterns that influence crop raiding complicated the understanding of the pattern in relation to other studies. This study has shown that crop raiding occurred mainly during the dry season when grass biomass, grass height and percentage cover have declined while the crops have matured with high nutritive value. Declining habitat quality demands that elephants spread further out and in the process come across farms resulting in crop raiding. These findings are important in resource allocation especially human resource that is concerned with problem elephant control. This is particularly important especially to the traditional communal guarding groups who have to increase their efforts to protect their farms during this particular time. However, the changes in ecological conditions demands more room for elephants otherwise crops will be a better alternative for them.

After having explored the issue of factors determining seasonal pattern of crop raiding, I will now examine how a combination of factors discussed in all data chapters determine the spatial distribution of crop raiding in the next chapter.

CHAPTER NINE

Determinants of spatial distribution patterns of crop raiding

9.1 Introduction

The problem of crop raiding in Transmara (TM) District started long ago. Two main factors appear responsible: the introduction of crop farming by immigrants (Chapter 5); and, the return of the Moitanik and Uasin Gishu Maasai clans from the western part of Kenya (Chapter 2), who intermarried where they settled with the Luhyia and Nandi farming tribes. With the adoption of an agro-pastoralist system by the Siria Maasai clan and the penetration of immigrants further into Maasai occupied areas, crop raiding spread to most parts of the elephant range on communal lands (CLs). However, some parts under farming do not experience crop raiding although within the elephant range. Therefore, the susceptibility of farms to elephant destruction appears to differ in relation to their geographical location. Various underlying factors may be responsible for any differing susceptibilities, and these can best be extrapolated and tested using remote sensing and Geographical Information Systems (GIS) applications. While many studies have been conducted on Human-elephant conflict (HEC) in different elephant ranges, they have used only limited GIS facilities, with consequent limitations on the showing clearly the geographical patterns of crop raiding. Hence, Kasiki (1998), Hoare (1999) and Kailas (2000) were only able to use study blocks to determine the intensity of conflict, while specific sites of conflict were not displayed. Nevertheless, contemporary students of HEC consider GIS applications to be a very important tool in HEC study (Smith & Kasiki 2000).

Some spatial and statistical analyses of crop raiding, using either GIS or extrapolation, have already been applied to different areas in Kenya (Thouless 1994, Kasiki 1998, Smith & Kasiki 2000, Low 2000), India (Kailas 2000), and Zimbabwe (Osborn 1998, Hoare 1999). These authors attempted to identify predictors of the location of farms with the greatest propensity of crop raiding. For example, Kasiki (1998), found a strong relationship between crop raiding in the Tsavo ecosystem and the percentage of land under cultivation, land ownership, vegetation type, and fencing. On the other hand, Hoare (1999) found no relationship between crop raiding and elephant density, proximity of protected area (PA), area of human settlement, human density and rainfall. Other more descriptive studies have suggested factors such as changing biomass and distance to PA (Ndung'u 1998, Osborn 1998). The differences in the results illustrate either: (a) a strong difference in the factors determining spatial distribution of crop raiding in different areas, habitats and parts of the elephant range; and/or, (b) differences in survey and analysis methodologies. Therefore, an understanding of the spatial patterns of conflict, and their possible determinant factors, can help in deriving better HEC mitigation strategies and policy formulation.

This chapter attempts to determine both the spatial distribution patterns of crop raiding in TM District, and the possible determinant factors. This chapter aims to answer the following questions:

- What are the spatial distribution patterns of crop raiding incidents?
- What differences can be discerned between the years 1999 and 2000?
- What underlying factors determine the spatial distribution patterns of crop raiding?

In this chapter, I describe the multivariate analysis technique used in this study. The technique is based on a logistic regression that follows an ecological design, where crop raiding incidents were mapped in independent units (9.2). Based on this analytical technique, I then describe the spatial distribution patterns of crop raiding (9.3.1) and explore the factors that influence the spatial distribution of crop raiding in TM District (9.3.2). This chapter concludes with a discussion of these results (9.4).

9.2 Methods

To analyse spatial patterns, it is necessary to divide the area under investigation into separate units or study blocks. Previous studies have allocated crop raiding incident to large sub-locations (Smith & Kasiki 2000), to villages (Kailas 2000), or to relatively large study blocks (Hoare 1999). This study has adopted an even finer scale approach, by dividing the area into regular 1 km by 1 km grid cells, with the aim of better separating out explanatory variables.

9.2.1 Mapping of crop raiding incidents as independent variable

Preliminary studies using a participatory approach through RRA (Chapter 3) identified locations with conflict incidents. Subsequently, 10 scouts were identified in strategic locations over the entire study area, and they were trained to collect information on crop raiding. This was necessary both to ensure full coverage of the entire area experiencing crop raiding, and for the establishment of a reliable reporting system with independent reporters (Hoare & Mackie 1993, Hoare 1999), since the use of reports from farmers (Hawkes 1991, Newmark *et al* 1994, Thouless 1994) can be inaccurate and exaggerated (Hoare 1999). All reports were mapped with a Geographical Positioning System (GPS), as outlined in detailed method sections in Chapters 2 and 7. The GPS points were entered into the Arcview GIS program for map production and analysis.

The dependent variable was derived from the recorded GPS points of raided farms within the elephant range. However, 18 farms destroyed during unusual elephant movements were excluded from the analysis because they lay outside the normal elephant range (Chapter 6). A total of 329 farms were destroyed, of which 311 inside the elephant range were used in the analysis. The GPS locations of crop raiding were assigned to their respective grid cells to produce a density map of conflict, which proved highly clustered.

9.2.2 Mapping of independent variables

Nine independent variables were used, comprising distances from: small rivers; main rivers; major roads; market centres; salt licks; slope (elevation); areas under forest; bushland; and, area under farming. These ecological and anthropogenic factors that might have played a role in determining the spatial pattern of crop raiding were used to derive the independent variables in this analysis using raster data model of grid cells. A Digital Slope Model (DEM) was used to derive the slope, based on the 1 km resolution data available from the Eros Data Centre at *http://edcwww.cr.usgs.gov/landdaac/gtopo30/gtopo30.html.* Other spatial data was obtained from previous chapters on land use (Chapter 5) and elephant numbers and distribution (Chapter 6). The factors were extrapolated into individual thematic layers within a GIS, using remotely sensed and GPS information. These independent variables consisted of two types (a) vector polygons of area, such as areas of forest, and bushland, and under farming (b) vector point and line files, which consisted of distances to rivers, salt licks, roads and market centres. The independent variables to be included in the analysis were distance from each of these features and the areas of the vector polygons. It was therefore necessary to create distance maps.

9.2.3 Creating a GIS model

Using the GIS software package Arcview 3.1, the vector data model, which represents space as a series of point, line or polygon units, was converted to a raster data model to be used in this analysis. In this model, space is represented as a grid of equally sized squares. The raster model operates on the principle that each square, or *pixel*, in the grid has a numeric value of the measured phenomena at that point (Smith & Kasiki 2000). A raster model was therefore used in this study because of its strength in representing a continuous surface, while a vector model can only represent this surface by dividing them into polygons that share a range of values. A 100 m resolution, 1 km^2 grid, raster template was therefore created, with 800 columns and 1140 rows covering the entire study area. This was overlaid with the present elephant range (Chapter 6), which was used as the main study block in which conflict occurred. A 1 km^2 grid was used because small *pixels* are more accurate at representing spatial data with finer resolution. Therefore, 966 *pixels* of 1 km^2 were created with individual *id* numbers for each cell. Using the 'find distance' feature in Arcview, this template was converted into a raster distance image in which each 100 m^2 pixel contained a distance value in metres. This was overlaid with the 1 km^2 grid to obtain mean distance from each feature (river, salt licks, roads, market centres) for each 1 km^2 grid cell using the 'summarise zones' routine in Arcview. The 1 km^2 grid was again overlaid with each vector polygon file in order to calculate the area of forest and bushland and under farming within each grid cell using the 'intersect feature' in Arcview followed by the x-tools extension to calculate areas.

The GIS data were imported into a Excel Windows 97 spreadsheet to fill blank cells with zeros. The data were summarised as presence/absence, with crop raiding coded 1 and cells without raiding coded 0. Finally, data were imported into SPSS version 9.0 for analysis using logistic regression. Out of 966 *pixels*, 104 had conflict incidents and 862 were without conflict. As a result, the data were highly skewed. To balance presence and absence cells, 104 *pixels* without conflict were selected randomly using the random number selection function. Therefore, 208 cells were chosen based on 104 presence cells and 104 randomly chosen absence cells, to fit the logistic regression model, which performs better with an even split of presence and absence.

9.2.4 Statistical analysis

Forward stepwise logistic regression (SPSS 1999) was used to determine factors that best explain the spatial distribution patterns of crop raiding. Logistic regression was used, with criteria for entry and exit specified as significance levels of 0.05 for the score statistic and 0.1 for the Wald statistic, respectively. Logistic regression, a type of generalised linear model, estimates directly the probability of an event occurring (Hosmer & Lemeshow 1989), and is well adapted when the response variable is binary with presence or absence data (Higgins *et al* 1999).

The equation for the logistic model is:

$$\log [P(y = 1)/P(y = 0)] = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots + B_iX_i \quad (9.1)$$

Where X_1 ..... X_i are explanatory variables and $B_1 \ldots B_i$ are coefficients

While using standard statistical tests that assume independence between different data points, there is a likelihood of 'spatial autocorrelation', where neighbouring squares may share values, and so are not independent during spatial analysis (Koenig 1999). In turn, this can affect the significance of the correlation coefficients in regression analysis, making them appear more significant and so resulting in potentially spurious models. This effect can reduce the degrees of freedom and thus increase the chances of type 1 errors (Legendre & Legendre 1998). However, no satisfactory method to correct for this exist at present, so caution is needed in the interpretation of results (Osborne *et al* 2001). However, as a way of getting around the problem, an autologistic regression procedure (Augustin *et al* 1996) was used whereby an additional variable is added to the standard logistic regression to take account of spatial autocorrelation. This extra term is an inverse distance weighted mean of the values in the cells directly adjacent to each cell of the matrix, as used by Augustin *et al* (1996). Therefore, a spatial autocorelation statistic, Moran's I (Cliff & Ord 1981) was calculated using a kind of spatial weighting function and SPSS was used to calculate this spatial autocorelation statistic.

9.3 Results

9.3.1 Spatial distribution patterns of crop raiding in TM District

The distribution of crop raiding is shown both as the locations of farms that were raided (Figure 9.1a), and as *pixels* of the total number of raids during 1999 and 2000 (Figure 9.1b). Overall, the distribution of crop raiding shows a clustered distribution, indicating considerable spatial autocorrelation, related to where farms occur. The density of conflict also varied, with some areas showing a high incidence of conflict, both signs of repeated raiding of many farms and of the close proximity of raided farms. There were 42 squares with conflict in 1999 and 82 squares in 2000 (Figure 9.1 b).

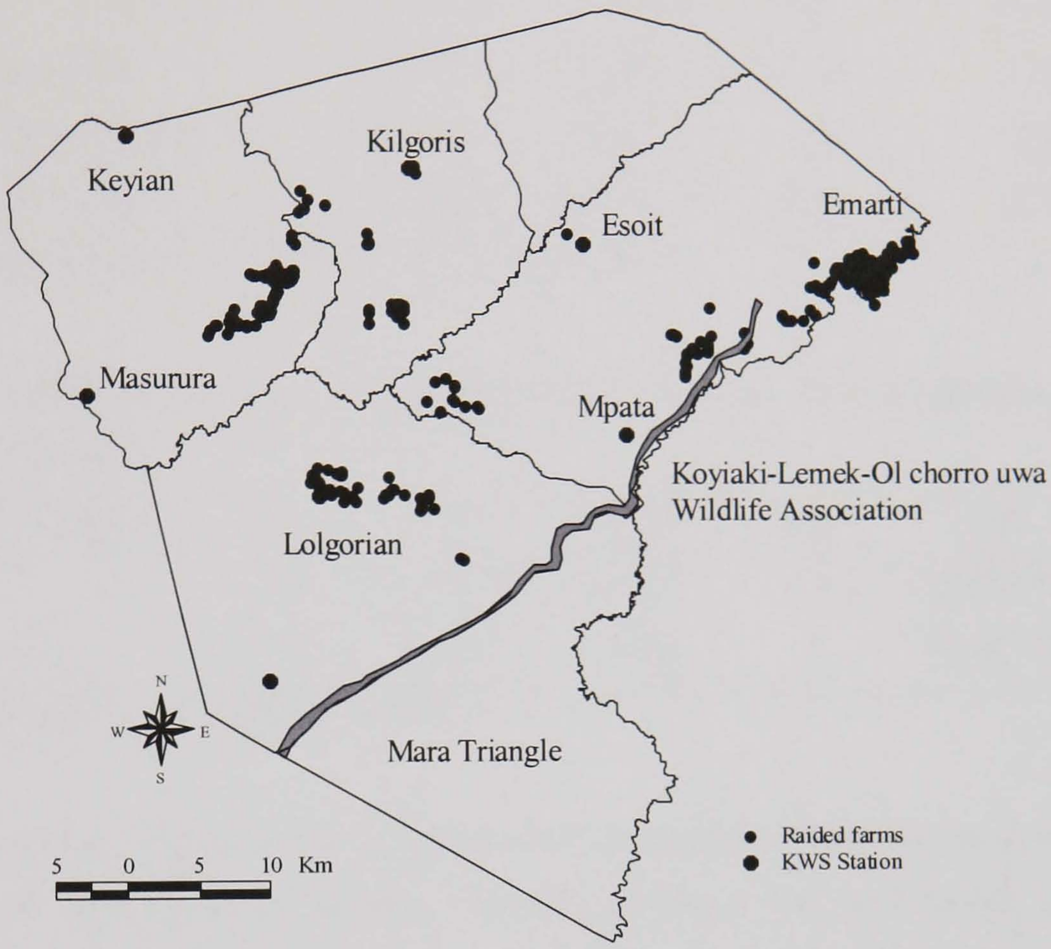
9.3.2 Factors determining spatial distribution of crop raiding

The logistic regression model for factors that might have determined the spatial distribution pattern of crop raiding produced a goodness of fit of 73.56% of observed to expected values. This means that 74% of the 208 *pixels* were predicted correctly. Significant relationships were observed between present and/or absent of crop raiding and three explanatory variables all anthropogenic factors, namely: distance from nearest roads; distance from nearest market centres; and, area under farming (Table 9.1). Equally, a number of factors did not appear important in determining spatial distribution patterns of crop raiding, including: distances from nearest major or minor rivers, salt licks, slope and areas under forest and bushland.

There was a positive relationship between crop raiding and distance from roads. Therefore, farms located further from the roads were more likely to be raided than farms near the roads. There was a negative relationship between crop raiding and distance from the market centres, in which crop raiding was more likely near market centres than further away. Finally, there was a positive relationship between crop raiding and the area under farming. Large areas under farming were more likely to be raided than small areas. However, this model suffers from spatial autocorrelation that affects the legitimacy of the findings. Autologistic regression on the 1 km^2 grid cell showed that the autocovariate term was significant and produced a goodness of fit of 82% of observed to expected values (Table 9.2). Hence, when all the explanatory variables were removed from the model, clustering appeared more important than the underlying variables at the 1 km^2 grid cell scale.

Figure 9.1 Maps of the locations of (a) raided farms, using GPS points, and (b) the density patterns of crop raiding using *pixels*, in TM District in 1999 and 2000.

(a)



(b)

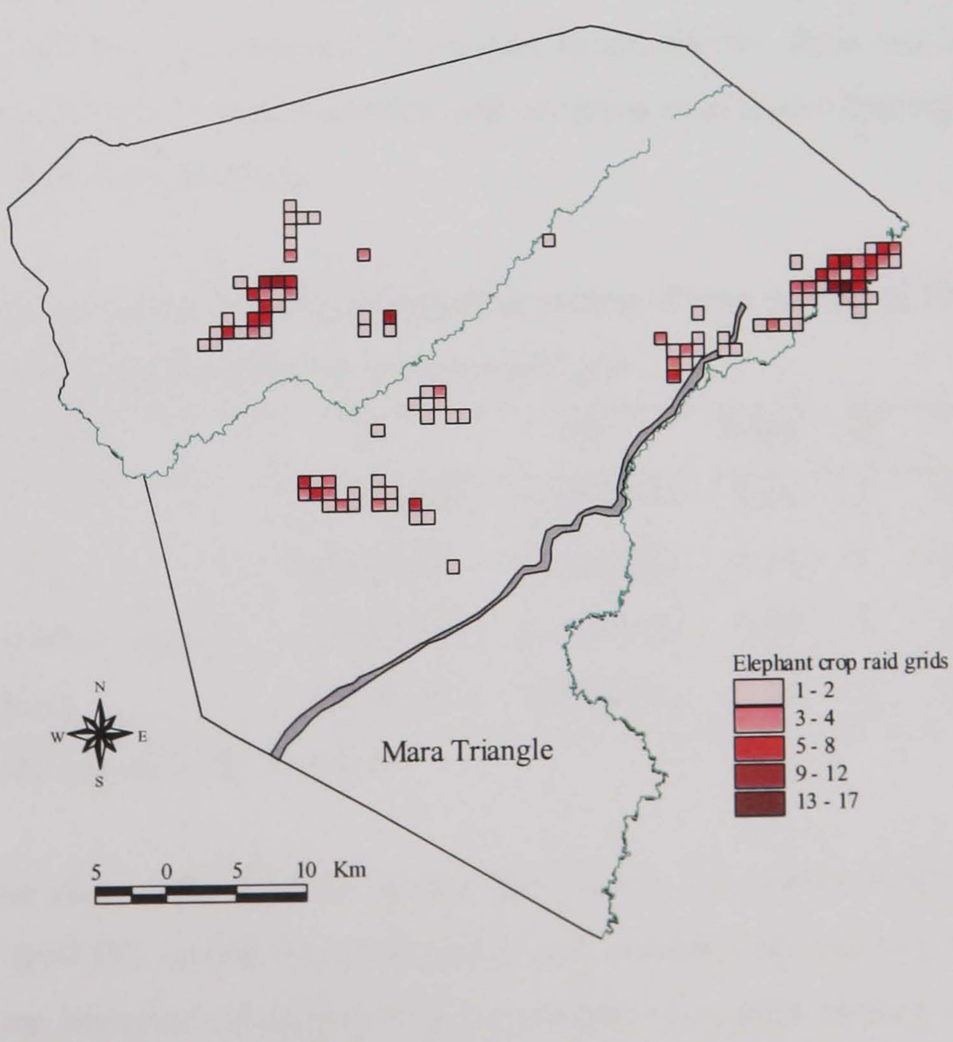


Table 9.1 Factors determining spatial distribution pattern of crop raiding in TM District in 1999 and 2000, based on logistic regression using a 1 km^2 grid.

Explanatory Variables	B	SE	Wald	df	p	R
Constant	0.045723	0.3922800	0.01	1	0.907	
Distance from roads	0.000244	0.0000491	11.40	1	0.0007***	0.18
Distance from market centres	-0.000417	0.0001350	9.99	1	0.002**	-0.17
Area under farming	0.000002	0.0000005	18.56	1	0.000***	0.24

Level of significance shown with **=p<0.01, ***=p<0.001

Table 9.2 Autologistic regression of presence and/or absence of crop raiding and the various explanatory variables.

Explanatory variable	B	S.E	Wald	df	Sig.	R
Constant	-1.658	0.260	40.837	1	0.000***	
Auto presence	6.545	0.856	58.456	1	0.000***	0.442

Level of significance shown with ***=p<0.001

To compensate for this spatial autocorrelation, a 5 km^2 grid method was used, in which spatial data was not autocorrelated (Moran's I=0.007). In the 5 km^2 grid model, the same three variables were included in the model, namely: distance from roads; distance from market centres; and, area under farming (Table 9.3). This logistic regression model for the factors that night have explained the spatial distribution patterns of crop raiding at a 5 km^2 grid produced a goodness of fit of 69.1% of observed to expected values. Hence, there was more crop raiding further from roads, closer to market centres, and on larger areas under farming but only distance from market centres was significant.

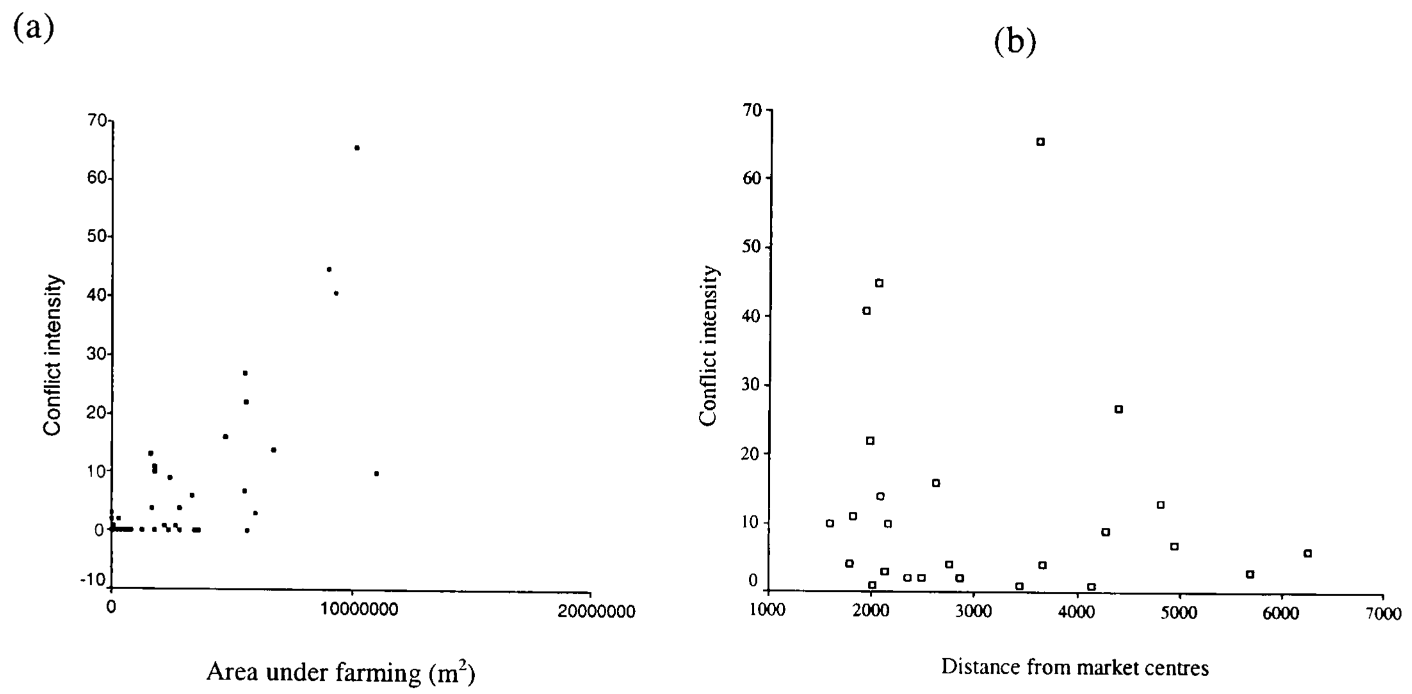
Table 9.3 Factors determining spatial distribution pattern of crop raiding in TM District in 1999 and 2000, based on logistic regression using a 5 km^2 grid.

Explanatory variables	B	S.E	Wald	df	Sig.	R
Constant	1.5673300	1.0032000	2.44	1	0.118	
Distance from roads	0.0003431	0.0002430	3.78	1	0.051	0.154
Distance from market centres	-0.0009266	0.0004420	6.86	1	0.009**	-0.254
Area under farming	0.0000002	0.0000001	3.25	1	0.071	0.129

Level of significance shown with **=p<0.01

There were also clear relationships between the number of conflict incidents and both area under farming (r=0.578, p=0.000) and distance from market centres (r=-0.356, p=0.000). The two variables are important in determining the amount of conflict in each 5 km^2 grid cell, in addition to their effect on the presence or absence of raids as shown by the logistic regression (Figure 9.2).

Figure 9.2 Scatter graphs showing the relationship between conflict intensity and (a) area under farming, (b) distance from the market centres using Spearman correlation.



9.4 Discussion

Previous studies have documented the factors determining spatial distribution of crop raiding at a coarse resolution and ignored the possibility of spatial autocorelation (Kasiki 1998, Hoare 1999, Kailas 2000). This is the first HEC study conducted at a finer resolution (1 km^2 grid) and shows how spatial autocorrelation can be removed using a 5 km^2 grid cell. Equally, this is the only HEC study that has documented accurate locations of raided farms, that in turn offers the opportunity for a more accurate predictive model. Previous studies have only displayed raids as filled patterns within study blocks of different sizes, which gives the impression of crop raiding occurring in the entire filled block (Kasiki 1998, Smith & Kasiki 2000). The establishment of markets, which acts as an indicator of immigrants, has emerged as a key determinant factor of crop raiding in TM District. The predictive model can be used to monitor future changes and effectively target management actions.

9.4.1 Scale of analysis

Most contemporary HEC studies have tried to identify the proximate and ultimate causes of crop raiding (Naughton-Treves 1998, Kasiki 1998, Osborn 1998, Hoare 1999, Smith & Kasiki 2000, Kailas 2000, Low 2000). However, the varied findings from each study might in part be explained by the lack of a standard study design and analytical procedures. For instance, according to Smith & Kasiki (2000), the use of study blocks (Kasiki 1998, Hoare 1999, Kailas 2000) with varying sizes and shapes makes comparisons between blocks less valid, reducing the value of conclusion that can be derived from these studies. This previous approach has been used because of limitations in the spatial referencing of conflict incidents, which are often reported at the village or location level. This study used GPS to accurately locate all conflict incidents and therefore offers the opportunity to develop more accurate predictive models.

Building on this, a standardised procedure and analysis has been designed by the Human-Elephant Conflict Task Force (HECTF) to measure conflict in six areas in Africa for comparison and subsequent determination of the overall factors that determine crop raiding and possible suggestions of conflict mitigation strategies (Hoare 2000, Smith & Kasiki 2000).

Although these variables were identified at the 1 km^2 scale, it suffered from spatial autocorrelation and may therefore be too fine a scale for this type of analysis. The three factors were retained by the model, however, distance from the market centres was significant. The fact that the same independent variables were retained when collapsed to the coarser 5 km^2 scale, suggests that this scale is sensitive enough for such analysis. The positive value of the Moran's I statistic, suggests that there were real geographical patterns characterised by clusters of pixels with relatively similar raiding incidences. The localised and persistent distribution of crop damage parallels observations from other studies (Bell 1984, Hawkes 1991, Lahm 1994, Tchamba 1995, Languy 1996, Winer 1996, Naughton-Treves 1998).

9.4.2 Factors important in determining crop raiding

This study has shown that three factors appeared important in determining spatial distribution patterns of crop raiding in TM District between 1999 and 2000. These three factors comprised: (a) distance from roads; (b) distance from market centres; and, (c) area under farming. Studies in Tsavo, Kenya (Kasiki 1998) and in Zaire (Kakira 1996), established the preference of elephant for raiding large farms, as also found in TM District. The elephants may prefer large cultivated areas in order to maximise their foraging efficiency, while small farms are not worth the risk. Equally, the elephants may not be noticed as easily while in big farms, reducing the risks of crop raiding. Hence, it is more difficult to chase away elephants on large than small farms. Therefore, with increasingly large areas under farming within the present elephant range, more conflict can be anticipated in TM District.

There are contradictory findings on the relationship between conflict and human density. While some studies have shown that there is no relationship between human density and crop raiding (Kasiki 1998, Hoare 1999, Smith & Kasiki 2000), other studies have shown that crop raiding increased with increasing human population density (Kiiru 1995, Hoare 1997, Ndung'u 1998). New settlements were heavily raided in Kenya (Ndung'u 1998), while elephants in Sebungwe, Zimbabwe learned to avoid long settled areas (Hoare 1997). The unplanned, mushrooming of small market centres in TM District are more likely to attract crop raiding, since non-Maasai immigrants mostly engage in cultivation. Notable market centres are in Lolgorian, Nkararu, Olopikidong'oe, Kirindoni, Esoit and Sitoka. Essentially, this factor in the model is an indicator for increasing human population density that implies increasing cultivation. While market centres provide important services to the local community, they also attract immigrants who start farming small plots and expand gradually.

In India, no relationship was observed between conflict and distance from the roads, because elephants are used to human disturbance and proximity to roads (Kailas 2000). With more crop raiding occurring with increasing distance from the roads, this suggests either that elephants avoid the roads or that there is no farming near the roads. However, elephants of TM District like following the roads and destroying the few farms next to the roads. Instead, most farms are located in areas near the forest where elephants reside. Most farmers avoid cultivating in areas where they can be noticed easily by government agents, because the Chiefs Act empowers local administrators to stop tree felling on private land. For instance, a strip of forest along Kirindoni-Kilgoris roads give a false impression of the existence of the forest when in reality the inner core is destroyed out of the view of those who might stop tree-felling under the Chiefs Act (Chapter 5). Nevertheless, farming far from the roads hinders quick action by KWS because of inaccessibility.

9.4.3 Significant factors in determining crop raiding but not entered in the model

Although not entered in the model, there was a positive relationship between distance of KWS stations from incidents of crop raiding. However, this does not suggest the success of KWS in PAC in areas close to their outposts. Instead, it suggests that the stations are located far from the conflict zones. Therefore, with raided farms mainly located far from KWS stations and from roads, PAC becomes difficult. This probably explains why few cases of elephant conflict were attended to by KWS relative to the total number of reports, and the long period taken by KWS to respond (Chapter 7). This situation could have arisen because the initial purpose of locating the stations has been overtaken by events. While the present locations of the stations may still be important generally for all wildlife protection, there is need to establish new stations and/or create temporary stations in elephant conflict zones. This represents a cheaper option than constructing new roads to conflict zones, which in turn might open up areas for further development and increasing conflict.

Crop raiding has been reported to mostly occur near the frontage of PAs (Bhima 1997, Ndun'gu, 1998, Nath & Sukumar 1998, Bhima 1998, Kailas 2000) and to decrease further away. However, in Zimbabwe, crop raiding elephants moved further away from PAs when confronted with better protection measures (Osborn 1998). In contrast, other studies have established that there is no relationship between crop raiding intensity and distance from PAs (Naughton-Treves 1998, Hoare 1999, Smith & Kasiki 2000), while terrain determined the intensity of conflict in India (Kailas 2000). However, in TM District most crop raiding incidents were by the resident elephants or by elephants from neighbouring group ranches, but not by elephants from MMNR. Although farming in TM District extends close to the MMNR, especially in the south, the elephants cannot access these farms because of the steep escarpment. However, any attempt to start farming next to the MMNR will result in even more conflict because of the daily movement of elephants to CLs (Chapter 6). Already, the new farms at the end of the corridor have attracted the Mara elephants, and this is a potential new conflict zone.

9.4.4 Factors not significant in determining crop raiding

There was no relationship between crop raiding and any ecological factor: distance from rivers or salt licks; slope; forest area; and, bushland area. In Tsavo, the location of water points determined crop raiding, especially during the dry season, since Tsavo receives a low annual rainfall (650 mm annually), making water availability an important factor (Kasiki 1998). In India, there was no relationship between permanent water and conflict intensity, because of high rainfall and irrigation (Kailas 2000). Crop raiding in TM District was not influenced by permanent water, because two permanent rivers run through the elephant range and annual rainfall is high (>1500 mm). The un-encroached salt licks do not determine crop raiding because they are located far from farming areas, while there is little variation in altitude within the present elephant range. In contrast, crop raiding in Tsavo increased with increasing slope (Smith & Kasiki 2000) but altitude served as a surrogate for traditional migration routes (Low 2000).

Kasiki (1998) noted that most crop-raiding incidents in Tsavo were highest in areas with open forest or wooded bushland and fewest occurred in bushed grassland. Few crop raids were also reported in areas where forest cover was absent (Nath & Sukumar 1998, Kailas 2000). Proximity to the forest was the strongest predictor of damage where farms on the edge absorbed disproportionate amount of damage (Lahm 1996, Naughton-Treves 1998). However, crop raiding in TM District was not related to area under forest, probably because of the highly fragmented nature of the forest and because most farming occurs in non-forested areas. Also, not all forest areas are utilised by elephants (Chapter 6). Most farming occurs on bushed grassland, which is utilised by elephants during the night, since the forest where they stay during the day has grassland.

Nevertheless, other factors that were not tested but can influence the spatial distribution pattern of crop raiding. These include: (a) changes in vegetation biomass; (b) seasonal movement patterns; (c) elephant density; (d) status of poaching; (e) migration of other tribes; (f) peoples' attitudes towards elephant; (g) protection measures employed by the local people; (h) human density; (i) and, ethnic distribution. These data were either not available nor existed in a form that was not compatible with the other spatial data. Elephants do come in contact with cultivation in the cause of their movement for foraging, while extending their natural foraging strategy, and the availability of palatable and nutritive foods resulting to HEC (Sukumar 1990). Some studies have documented that crop raiding is not related to elephant density (Nath & Sukumar 1998, Hoare 1998, Smith & Kasiki 2000) and that poaching pressure kept elephants close to villages and explored areas with crops (Ekobo 1996). In contrast, elephants in TM District hide in the thick forest during the day and come out to raid crops at night (Chapter 6).

9.4.5 Implications for management

This study has shown that, with the increasing area under farming, the mushrooming of market centres, and the establishement of farming in the forest away from roads, the likelihood of crop raiding will increase. Crop raiding was not dependent on the underlying ecological factors, but instead seemed to be clustered around farming areas, and at the end of traditional corridors. Elephants seem not to penetrate further because of prevailing crop protection measures. This analysis was done in an area suggested for designation as a multiple land use for livestock-wildlife in the proposed Land Use Management Plan. Therefore, there is an urgent need to speed up its implementation, before it is overtaken by events and declared obsolete by agricultural expansion.

The clustered pattern of crop raiding is best explained by clustered pattern of farming, and probably by the localised movements of elephants, which was not investigated in this study. From a land use planning perspective, it is necessary to determine whether farms experiencing conflict are on natural elephant routes, as established in Tsavo by Low (2000), or whether elephants make special journeys to those areas to raid crops. If the former is true, then farmers should avoid routes where elephants travel naturally. If the latter is true, then the only solution lies in defending farms effectively or stopping elephants from going there. However, the two scenarios may be at play in TM District. Therefore both solutions are imperative, and more research is needed on elephant movement patterns.

The issue of defending farms from raiding will be explored in the next chapter. Although there is an observed spatial pattern to conflict, it is also clear in all HEC areas that some few farms receive conflict and some do not. Hence, I will examine the differences between raided and non-raided farms in HEC zones at a finer scale, with the aim of identifying ways to mitigate HEC.

CHAPTER TEN

Protection measures and other farm-based factors affecting crop raiding

10.1 Introduction

Farmers in elephant ranges usually attempt to protect their crops against attack by elephants using cheap and simple traditional methods and complex and expensive methods. The success of these methods varies depending on a number of factors. Hence, different communities around Africa employ different approaches to protect their crops (Ngure 1992, Tchamba 1995, Thouless 1994, Hoare 1997, Kakira 1996, Ndung'u 1998, Kasiki 1998, Osborn 1998, Naughton-Treves 1998). Researchers are also devising innovative strategies and adopting conventional field trials to determine the degree of success of different approaches such as the use of: electric fences, warning calls and trip alarms (O'Conell-Rodwell *et al* 2000); capsicum spray (Osborn 1998); HATE 4C extract chemical deterrents; planting of *Eucalyptus camaldulensis* (Bell 1984); and, tea zones (Ndung'u 1998). One strategy cannot apply to all elephant ranges because of differences in resources, in ecology of crop raiding elephants, and in government policy towards elephant conservation, among other factors. Even the conventional approach of electric fencing has not been successful in some areas (Bell 1984, Thouless 1994, Kasiki 1998). Therefore, most methods employed are short-term control methods that are ethically problematic and possibly inefficient (Hoare 2000). No single, or a combination of, mitigation measure(s) has(ve) proved fully effective and/or without drawbacks (Sukumar 1989, Kasiki 1998). There is need for efficient options that should maximise benefits, minimise costs, and foster the long-term sustainability of any community and elephants among which it lives. This chapter attempts to present the various techniques used in the protection of crops in TM District, and to assess their level of success. The chapter aims to answer the following questions:

- What methods do the local community currently employ to protect crops in TM District?
- What factors determine the success of such measures used to protect crops?
- What factors determine the area of farms damaged?
- What is the temporal relationship between abandoning of farms and KWS policies?

In this chapter, I describe the logistic regression analysis, that in turn compare the likelihood of crop raiding on farms in relation to crop protection measures taken by farmers (10.2.1) and the area of farms actually damaged in relation to crop protection measures taken by farmers and the size of the raiding herd (10.2.2) and ANOVA to determine the trend of abandoning of farming (10.2.3) and a χ^2 analysis to determine reported cases to KWS and area coverage by rangers in response to problem elephants (10.2.3). I then describe the methods employed to protect crops (10.3.1), factors determining the success of crop protection measure (10.3.2) and area of farm damaged (10.3.3), abandoning of farms (10.3.4) and reports to KWS (10.3.5). This chapter concludes with a discussion of these results (10.4).

10.2 Methods

10.2.1 Determinants of crop raiding

A multivariate analysis using forward stepwise logistic regression was performed to determine which of the most commonly used crop protection measures are most likely to deter crop raiding. A total of 23 independent variables were subjected to analysis as described below.

10.2.1.1 Crop raiding as the dependent variable

Details of raided and the adjacent non-raided farms were collected by a questionnaire survey as outlined in the methodology sections of Chapters 2 and 7. Raided or non-raided farms were considered as the dependent variables. Each farm was coded as (0) raided and (1) non-raided. A total of 329 farms were attacked in 1999 and 2000. However, only for 2000 were there matching numbers of raided and non-raided farms. Therefore, the analysis included a total of 314 cases, with 157 raided farms and 157 non-raided farms.

10.2.1.2 Independent variables

The community employed many different methods to keep the elephant away from their fields (Figure 10.1). These included: fencing; abandonment; noise from tins, pipes, or shouting; bee hives; tobacco; lighting fires; burn elephant dung; communal farming and guarding; premature harvesting of maize; and, use of used oil. Other less commonly used methods included: blowing a whistle; throwing embers; use of a sling; effigies; and, driving a tractor into the field. Therefore, during field measurement of both raided and non-raided farms, a number of independent variables were recorded to determine the success of the most commonly used protection measures in deterring raiding. The variables included: date of planting; level of maize maturity; farmers' ethnicity; farm size; human settlement; types of fences; previous number of attacks; use of torch; guarding; farm based deterrent methods; and, degree of farm abandonment. The variables were both continuous and categorical.

- Date of planting

Dates of planting were categorised as (1) January, (2) February, and (3) second planting, to determine whether protection measures were influenced by the date of planting.

- Level of maize maturity

The level of maize maturity was categorised as (1) young, (2) middle, (3) mature and (4) dry (Chapter 8), to determine whether protection measures were influenced by the level of crop maturity.

- Farmers' ethnicity

Farmers' ethnicity was categorised as (0) Maasai, or (1) non-Maasai, to determine who is involved in farming and if protection measures used depended on the tribe.

- Farm size

The sizes of the farms under cultivation were either measured or approximated as a continuous variable in acres, which is the most commonly used and known unit of land measurement by the local community.

- Distance from farm to nearest house

The distance of the farm from the house was categorised as (1) located on the farm, (2) located within 50m of the house, and, (3) located over 50m away, to determine whether the distance between the house and the farm impacts on the success of crop protection.

- Types of fences

Six types of fence were categorised based on the predominant type of fence as follows: (1) dry vegetation; (2) poles; (3) barbed wire; (4) live fence of *Amaranthus;* and, (5) live fence of sisal; and, (6) no fence.

- Previous number of attacks

Details of the number of times that a particular farm had been attacked between 1995 and 1998 was recorded as a continuous variable to determine if elephants habitually raided specific farms.

- Use of torch

The farms that use torches as a protective measure were recorded as (0) yes or (1) no. If yes, then the number of torches used on each farm was recorded to determine whether protection measures depended on the use of torches and/or the number torches used.

- Guarding

The farms that were guarded as a protection measure were categorised as (0) guarded or (1) not guarded. If guarded, further data were collected including: the time guarding began, the duration of guarding; and, the number of guards on each farm, all of which were entered as continuous variables.

- Farm-based deterrent methods

Farms that were protected by any of burning elephant dung, lighting fire, beating tins or drums and /or by shouting were recorded as (0) yes or (1) no, respectively.

Other methods employed to protect the crops were recorded as other methods and coded as (0) yes or (1) no, since these methods were not commonly used. The success of these methods could have been measured in terms of how long elephants spent on the farm or how much was damaged. However, most farmers noticed elephants once already on the farm, and before they started to apply their protection measures. Hence, such measures were discarded as incomplete.

10.2.2 Determinants of farm area damaged

A multivariate analysis using forward stepwise logistic regression was performed to determine what factors influenced the farm area damaged by elephants. A total of 16 independent variables were subjected to analysis as described below but only eight factors were retained after analysis.

10.2.2.1 Area damaged as the dependent variable

A similar approach using logistic regression to that described in 10.2.1 was used to determine the factors that determined the area of farm damaged. The area of each farm damaged was estimated, and these data were later converted into m^2 since some farms only had a small area damaged by elephants. However, it should be noted that the assessment of the area damaged was at the discretion of the field assistant and variations in assessment were inevitable. This anomaly was reduced by subjecting field assistants to assessment tests until a more uniform assessment result was derived. These data were recorded as a continuous variable and they were used to calculate the percentage of the crop damaged by elephants. The area of farm damaged as the dependent variable was coded (0) for an area less than 5000 m^2 and (1) for an area greater than 5000 m^2 and the sample size was 157.

10.2.2.2 Independent variable

Many of the variables described in 10.2.1.2 were used for this analysis, comprising: fencing; poles; noise from tins or drums, pipes, or shouting; tobacco; lighting fires; burn elephant dung; communal farming and guarding; guard duration; number of guards; farm size; and, use of used oil. In addition the following variables were also included: date of planting; level of maize maturity; farmers' ethnicity; farm size; distance from house; previous number of attacks; use of torch; and, number of torches. The variables were both continuous and categorical.

10.2.3 Abandoned farms

All farms reported to have been abandoned as a result of elephant raids were mapped and other details obtained by interview, such as: the year farming was started; the year of abandonment;

the crops grown; and, the size of the farm. A total of 738 abandoned farms were located and mapped. ANOVA was performed to determine the differences in the variables.

10.2.4 Reports to KWS

Farmers whose farms were raided by elephants were asked whether they reported to KWS. The number of KWS personnel in each station was derived from KWS District headquarters and the area covered by two rangers was determined by GIS extrapolation based on divisional boundaries.

10.3 Results

10.3.1 Methods employed to protect crops against damage

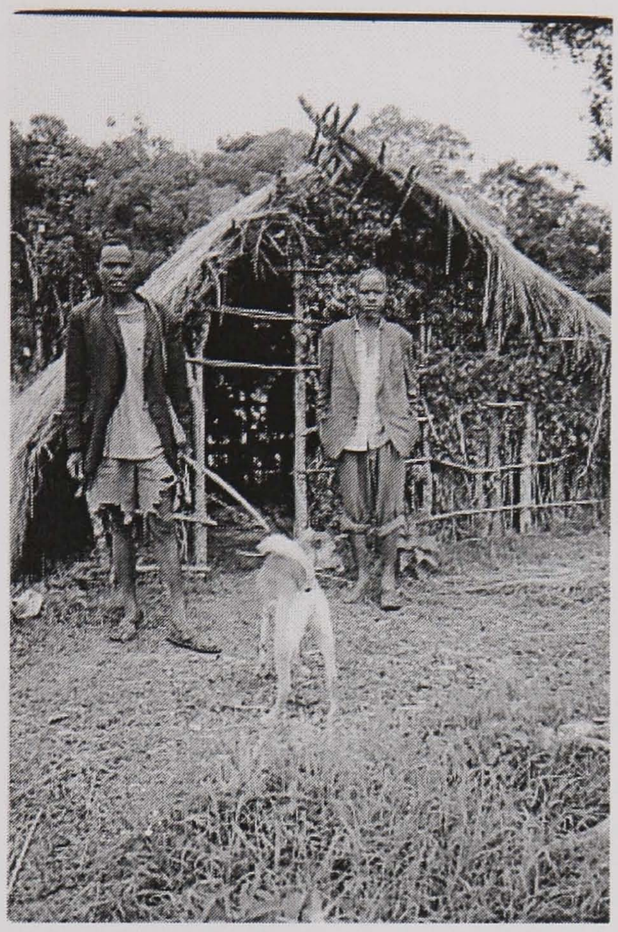
Eighteen methods were employed by the local community to deter elephants from damaging their crops (Figure 10.1). However, the degrees of success of the methods employed are described in section 10.3.2.

10.3.2 Factors determining the success of crop protection measures

The stepwise logistic regression model for factors that might have influenced the crop raiding produced a goodness of fit of 93.55% of observed and expected values. Significant relationships were observed between crop raiding and 11 independent variables (Figure 10.1). The variables comprise: date of planting; lighting fire; guard time; human settlement; beating of tins or drums, number of torches; farm size; communal guarding; lack of fence; the level of maize maturity; and, use of fencing poles. The last four variables, although significant, did not contribute greatly to improving the goodness of fit of the model.

Farms that are planted in February and with dry maize are more likely to be attacked than farms planted later. The use of fire and the length of guarding reduced the likelihood of crop raiding. In contrast, farms near houses or settlements were more likely to be raided than farms far away. Most guards noticed the presence of the elephant while already on the farm (χ^2=135.32, p=0.001) suggesting that guards were not alert to keeping elephants off the farms. The use of noise from beating tins and the use of torches increased the likelihood of raiding. There was more chance of big farms being raided than of small farms, and a communal guarding strategy reduced the likelihood of crop raiding. According to the model, farms with fences were more likely to be raided than farms without, while there were more chances of farms with dry maize crop being raided. Finally, pole fences were used more often on raided farms than non-raided farms, suggesting the ineffectiveness of the pole fences.

Figure 10.1 Some of the crop protection measures used on the farms in TM District in 1999 and 2000.



(a) Makeshift structure and bow and arrow

(b) Sling

(c) Premature harvesting and either burning or burying of maize stalk

Table 10.1 Factors determining the success of crop protection measures and other farm-based factors, based on logistic regression.

Independent Variables	B	S.E	Wald	Sig.	R
Constant	-25.39	8.95	8.06	0.0045**	
Date of planting			19.68	0.0002***	0.175
January	1.52	1.42	1.15	0.2829	0.000
February	8.32	2.36	12.46	0.0004***	0.153
Secondary planting	3.63	1.61	5.07	0.0244*	0.083
Maize maturity level			7.10	0.0689	0.049
Middle	-8.30	37.06	0.05	0.8220	0.000
Mature	-6.39	33.68	0.04	0.8496	0.000
Dry	-1.67	0.63	6.99	0.0082**	0.105
Lighting fire	-4.16	1.00	17.40	0.0001***	-0.174
Guard time	1.72	0.47	13.47	0.0002***	0.160
Human settlement (on farm)			17.18	0.0002***	0.171
50m away	-3.51	0.86	16.70	0.0000***	-0.181
>50m away)	-2.99	0.89	11.44	0.0007***	-0.145
Beating of tins or drums	-5.01	1.27	15.60	0.0001***	-0.174
Number of torches	-0.66	0.21	10.22	0.0014***	-0.135
Farm size	-0.0002	0.00004	13.75	0.0002***	-0.160
Communal guarding	-4.11	1.51	7.43	0.0064**	-0.110
Lack of fence	-2.65	1.15	5.33	0.021*	-0.860
Fencing poles	1.948	0.97	4.02	0.0449*	0.067

Level of significance shown as *=p<0.05, **=p<0.01, ***=p<0.001

10.3.3 Factors determining the area of farm damaged

The logistic regression model for factors that might have determined the area of maize farm damaged produced a goodness of fit of 80.6% of observed to expected values (Table 10.2). Significant relationships were observed between the area of farm damaged and 8 independent variables. These comprise: elephant numbers; beating of tins and drums; communal guarding; guard duration; number of guards; farm size; use of poles; and, maize maturity level.

Large farm areas were recorded in the event of attack by a big herd of elephants relative to a small herd. In contrast, farms where there was beating of tins and drums were most damaged. Farms that exhibited communal guarding were less damaged unlike farms with individual guards. However, the size of the area damaged was more closely related to the duration of guarding. In contrast, farms, which were less guarded, experienced less damage than more guarded farms. Large farms experienced most damaged than small farms. Farms that were fenced with poles experienced more area damage than those without. Finally, elephants preferred mature and dry maize, which therefore suffered much area damaged than young or middle level maize.

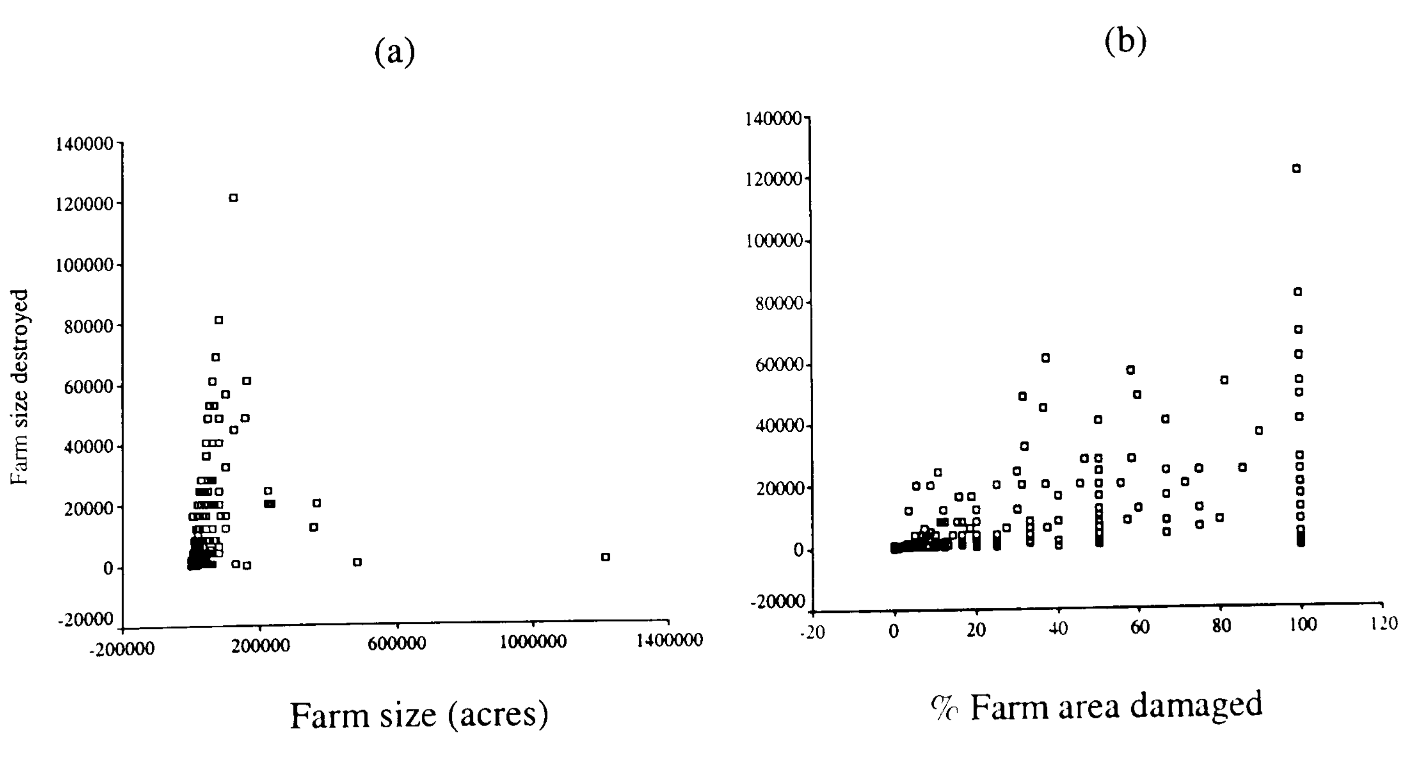
Spearman correlation test, there was a correlation between farm area damaged and percentage farm area damaged (r_S=0.701, p=0.000) and between farm size and the area damaged (r_S=0.608, p=0.000) (Figure 10.2). However, there was no correlation between percentage area damaged and farm size (r_S=-0.032, p=0.563).

Table 10.2 Factors determining the size of the farm area damaged by elephants, based on logistic regression.

Variable	B	S.E	Wald	df	Sig.	R
Constant	-4.728	1.245	14.422	1	0.0001***	
Number of elephant	0.106	0.031	11.563	1	0.0007***	0.153
Beating of tins or drums	-7.707	0.632	7.290	1	0.007**	-0.114
Communal guarding	2.001	0.562	12.694	1	0.0004***	0.162
Guard duration	0.250	0.102	5.974	1	0.0145*	0.099
Number of guards	0.108	0.057	3.603	1	0.0577	0.063
Farm size	0.000035	0.000008	21.502	1	0.000***	0.219
Use of fencing poles	-1.069	0.405	6.959	1	0.008**	-0.110
Maize maturity level			11.147	1	0.011**	0.113
Middle	-8.312	17.846	0.217	1	0.641	0.000
Mature	-1.928	0.893	4.657	1	0.031*	-0.080
Dry	-0.906	0.323	7.890	1	0.005**	-0.120

Level of significance shown with *=p<0.05, **=p<0.01, ***=p<0.001

Figure 10.2 Spearman correlation between farm size destroyed and (a) farm size and (b) % farm area damaged.

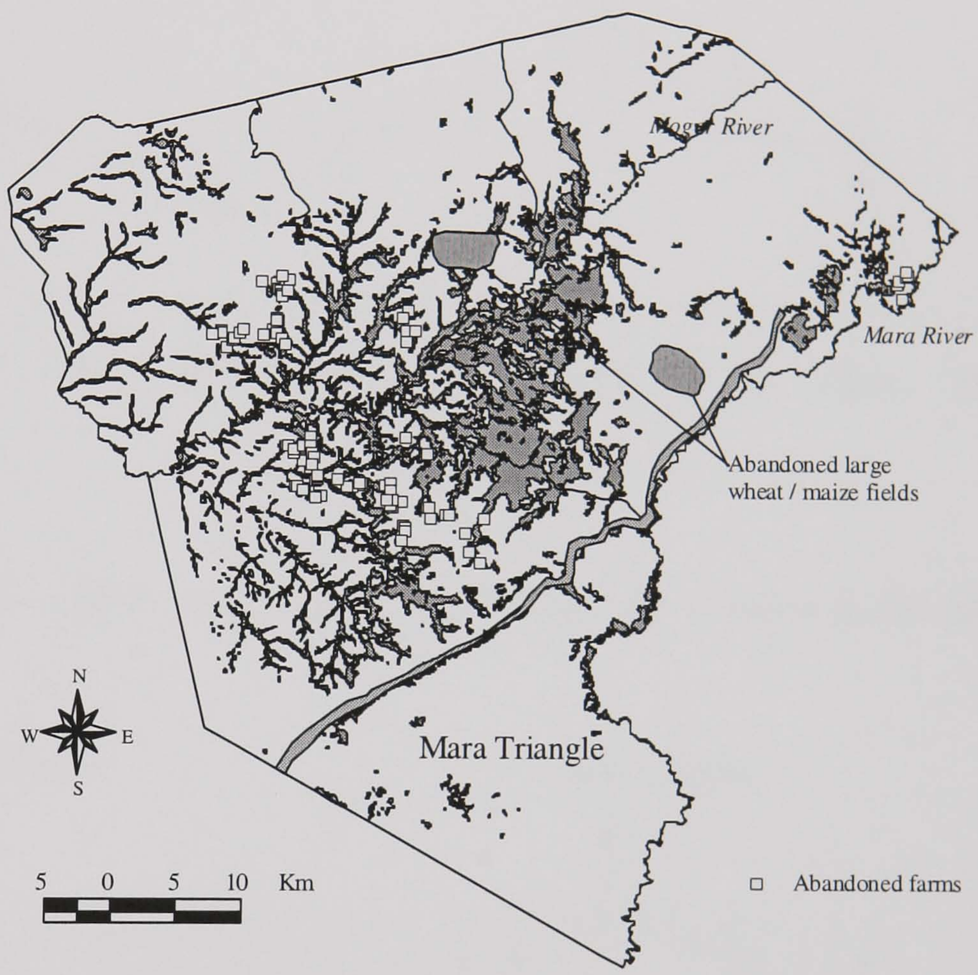


10.3.4 Abandoned farms

10.3.4.1 Spatial distribution of abandoned farms

Most abandoned farms were located next to forest areas with high elephant densities and where crop farming was intense (Figure 10.3). The 738 farms covered total area of 2.986 km^2. A total of 110 farms were mapped in detail for analysis.

Figure 10.3 Spatial distribution of abandoned farms as a result of elephant damage in TM District between 1986 and 2000.



10.3.4.2 Determinants of the rate of abandoning farms

The size of abandoned farms did not vary ($F_{7,102} = 0.352$, p=0.927) but showed fluctuations over time (Figure 10.4). The size of abandoned farms declined between 1992 and then increased steadily upto 1997. This was again followed by a steady decline between 1997 and 1999. There was a difference between the mean size of abandoned farms during compensation for crop damage and after compensation was stopped ($F_{19,90} = 4.129$, p=0.001).

Many farms were started in response to the compensation scheme for crop loss to wildlife offered in 1980s and they were subsequently abandoned when compensation was stopped in 1989 ($F_{19,90} = 45.016$, p=0.001). The period taken to abandon the farms differed ($F_{19,90} = 45.016$, p=0.001) during compensation and after compensation was stopped but the mean size of abandoned farms did not differ ($F_{21,88} = 1.04$, p=0.427). The period taken to abandon the farms remained steadily between 1992 and 1994 and started to increase to 1997 (Figure 10.5). This was followed by a steady decline between 1997 and 1999.

Figure 10.4 Mean ± SE size of farms abandoned in TM District between 1992 and 1999.

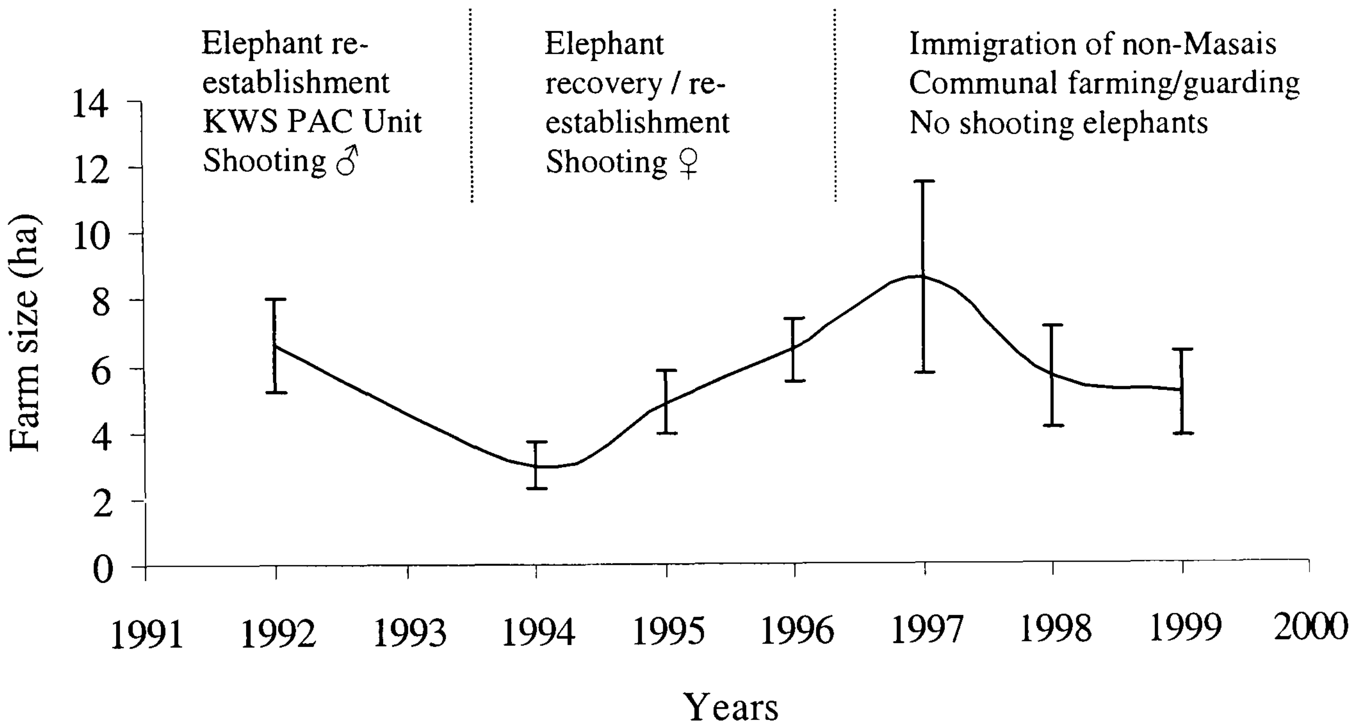
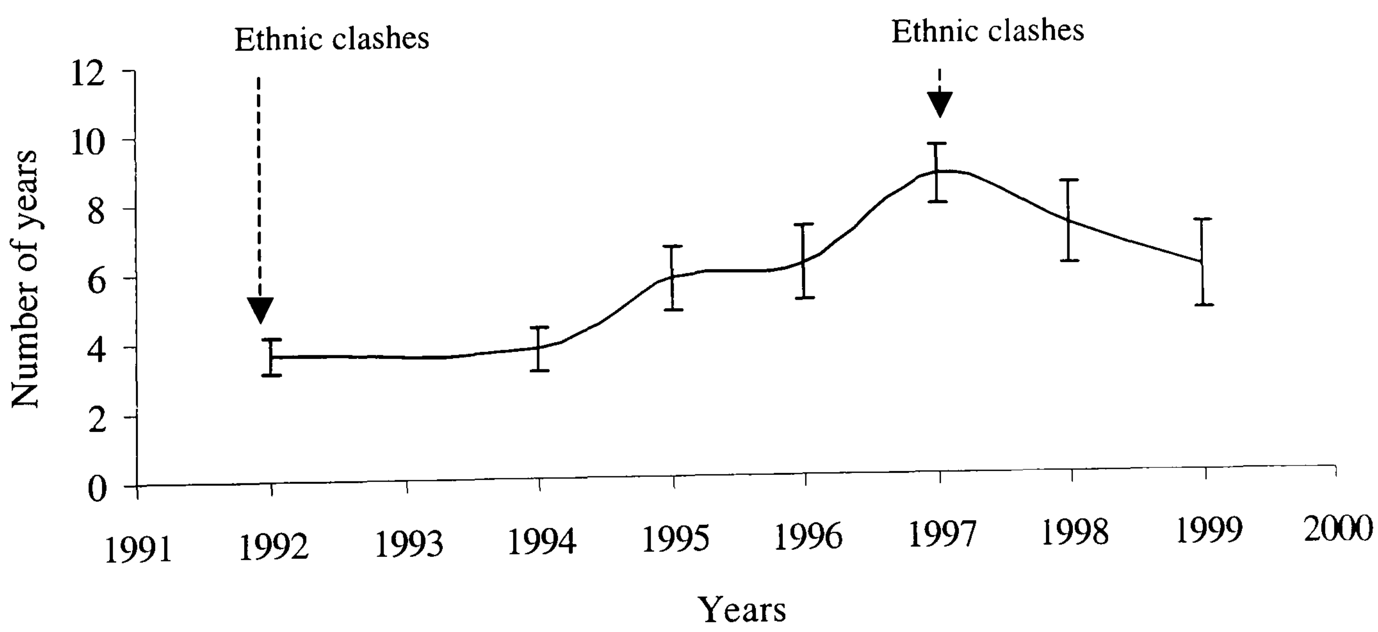


Figure 10. 5 Mean ± SE number of years taken for abandonment of farms in TM District between 1992 and 1999.



10.3.5 Reports to KWS

Most farmers did not report incidents of crop raiding to KWS (χ^2=172.14, p=0.000). However, there are only 16 KWS rangers who cover large areas (Table 10.3) a factor that contributes to inability to attend to some reported cases.

Table 10.3 The areas covered by the KWS rangers in each division of TM District.

Division	Area (km^2)	KWS post	Number of rangers	Area covered (km^2/2 rangers)
Kilgoris	151	1	6	50
Lologorian	429	1	3	143
Keyian	185	2	4	93
Kirindoni	255	2	4	128
Pirrar	81	0	0	-

10.4 Discussion

Traditional methods of crop protection have often been described simply through questionnaires that show the most commonly used methods (Kasiki 1998). Some studies have used more sophisticated conventional mitigation strategies as experiments that have not proved effective and are therefore difficult to apply in all conflict zones (Thouless 1994, Osborn 1998, O'Conell-Rodwell *et al* 2000). Most previous studies on traditional crop protection methods have never tested the success of different traditional crop protection strategies (Bell 1994, Hoare 1995, Ngure 1995, Lahm 1996, Tchamba 1996). Such tests are vital if the most effective combination of methods is to be identified. This is the first study to offer an in situ test of the traditional crop protection methods by comparing the various methods used on both raided and non-raided farms to determine the degree of success of each method. From this, simple and cost effective mitigation strategies can be designed and tested effectively. This study has shown that crop damage depended on the date of planting, level of maize maturity, use of fire, duration of guarding, distance between the farms and settlement, beating of tins and drums, number of torches, farm size, communal guarding and lack of fence. The size of the farm area damaged depended on number of elephants, beating of tins and drums, communal guarding, guard duration, number of guards, farm size, use of pole fences and maize maturity level. However, increased efficiency to control problem elephants might motivate more people to farm.

10.4.1 Traditional crop protection measures

In TM District, a variety of methods were employed to minimise crop loss as a result of elephants. Eighteen different methods were used, and more new methods are being adopted to cope with the ever changing behaviour pattern of the elephant and its habituation to traditional methods. Kasiki (1998) reported fifteen traditional methods in Tsavo. While some methods have proved to be successful, and basically based on trial and error, the risks involved are quite high.

Farms that are planted early in January were more likely to be attacked than late farms. Elephants seem to exploit the first opportunity before intensive crop protection measures are put in place and/or get most farmers unaware. Crop raiding decreases later when farmers become more alert and when KWS scare elephants away. Similarly, farms that are planted either very late, out of the season and during the second growing season were more likely to be raided probably because many farms would have been harvested making it difficult for fewer farmers to keep off rather forceful elephants.

In contrast, farms near houses (settlement) were more raided than farms away from settlements. Most farmers due to either fear or inadequate personnel to guard crops prefer to farm next to their houses and hope to hear and scare elephants while in their houses in the event of crop raiding and to seek refuge in the event of elephant aggression. 'Intermittent guarding' where guards came out occasionally to patrol was not effective and more risky especially when elephants were already on the farm. Guards on farms located away from houses need to be extra alert because of the risks involved since the makeshift structures cannot guarantee protection from elephants.

Since more torches were used on raided farms than on non-raided farms, this could imply that the torches could not effectively keep off elephants from the farms contrary to the findings by Kasiki (1998). However, it should be noted that torches were only used whenever elephants appeared and/or during patrol making it difficult to measure its impact. However, elephants were aggressive when single torches were used and a communal lighting and hence guarding strategies have been devised and proved successful.

Elephants generally raided bigger farms than smaller farms probably because they were not easily noticed while on big farms, to maximise the nutritional gain as small farms are not worth the risk and finally due to easy access because of many unguarded gaps. Elsewhere, preference of big farms have been reported but the reasons were not explored (Kakira 1996, Kasiki 1998). Farms with dry maize were most raided, a conflicting finding with the seasonality factors that determined crop raiding (Chapter 8), where most crop raiding occurred on farms with mature maize. Maize on some farms was harvested prematurely reducing the number of farms with dry maize and hence reducing the chances of dry maize being raided. However, crop raiding could have also occurred in areas where it has never occurred before and farmers had left their maize to dry on the farms. This could also be explained by the prolonged drought that was experienced in Emarti area, which resulted, in premature drying of maize, in which case the original definition of dry maize was distorted, which was related to an advanced stage of maize. Equally, farms with mature maize may be better guarded.

Guarding, though very risky, is the main strategy employed by farmers to protect crops from elephants and other wildlife species was used alongside other many deterrent methods such as shouting, whistling, and blowing horns, use of a sling, throwing embers, and shooting apart from beating of tins and drums from all over. Communal farming and communal guarding strategy was effective in protecting the crops. Guard duration was higher on non-raided farms than raided farms and guarding was abandoned once the new farms buffered old farms. Farms were guarded longer because of the difficult in predicting elephant attack. However, guarding was intensified with the ripening of maize and/or whenever a few elephants went to 'survey' on the maize maturity level, which signalled farmers of the possibility of subsequent raids.

Despite the risks involved, only one person was injured in 1999 by an elephant while guarding crops unlike in Tsavo (Kasiki 1998). Lack of active defence of farms increased the opportunity of crop raiding (Lahm 1996, Sam 1998) while increased investment in guarding did not reduce crop loss (Naughton-Treves 1998). Guarding did not predict patterns of crop raiding, but it is a complex behaviour that is difficult to monitor accurately (Naughton-Treves 1998) since many different methods are used to reinforce it. Equally, testing the alertness of farm guards is difficult since most guarded farms were raided unaware. Perhaps it is the elephant that has devised a silent system of getting into the farms unnoticed (O'Connell-Rodwell *et al* 2000).

The noise resulting from beating of tins and drums to scare elephants was used mainly on non-raided farms. In the event of the presence of elephants, the whole village engaged in beating tins and drums to scare them. However, this succeeded in alerting other farmers but was a bit difficult once elephants were already on the farm. The success also depended on other factors already discussed such as farm size and the distance between the farm and the house. However, this could be short lived once elephants get habituated to noise since elephants are not harmed to associate noise with danger. Elephants responded quite fast to human noise while out of the farms but put up some resistance while already on the farm. Noise and fire are leading control strategies in most areas (Kakira 1996, Ekobo 1996, Kasiki 1998). But because of constant harassment of elephants by farmers, elephants attempt to sneak into the farms unnoticed and appear like 'thieves', feeding on maize while watching over their shoulders and ready to run away if they sense they have been noticed. Therefore, elephants discriminate between crop raiding on the basis of security. While simple protection techniques like noise and torches were enough to drive the resident elephants away, elephants from Narok side, just like elsewhere (Kasiki 1998, O'Connell-Rodwell *et al* 2000), responded aggressively. Therefore, crop raiding is a high-risk-high-gain venture motivated by insufficient forage to promote reproductive success (Sukumar 1989, Else 1991).

Lanterns are used for lighting incase of shortage of wood in Tsavo (Kasiki 1998), which is however still abundant in TM District. There were more chances of using fire on non-raided farms than on raided farms hence fire was a good protection measure, because smoke keeps elephants away apart from fire improving visibility. However, fire cannot be effective with fewer fire points or when fire is not maintained throughout the night. The direction of smoke is important in crop protection especially if it is towards the direction from which elephants emerge, a difficult thing to determine since most farms can be raided from any direction. These underlying reasons probably explain why some farms with fire were raided.

According to the model, elephants preferred farms with fences than farms without implying that fences were not effective in keeping elephants away from farms. Generally, in TM District, the intensity of fencing increased with decreasing distance to the forest edge. Farms that were raided in TM District included those near the forest, hence plenty of wood and heavy fencing but were most raided and those farms away from the forest, where wood is therefore limited for fencing and were not heavily raided. With the expansion of farms towards the forest, the old farms gradually loose their fences as firewood. Farms with fence made of poles were not effective probably because poles were repeatedly used to reinforce raided farms as better barriers. Therefore, these ineffective traditional fences only offer psychological satisfaction to farmers and alerts farmers when being broken. In TM District there is no single electric fence around the MT or farms. However, an electric fence on the opposite side of Emarti along the Mara river, proved very successful.

The Maasai encourages other tribes to clear the forest and burn charcoal and to farm in order to keep off elephants and share the harvest. The Maasais leases the most vulnerable section of the farm to non-Maasais in order to buffer their farms. The lease is not based on monetary value but on understanding that the non-Maasai will care for the crop but the harvest is shared, a strategy that was also noted by Naughton-Treves (1998). Elimination of patches of wilderness as a protection measure against raiding has been reported (Bell 1984) or hunters invited to kill elephants after frustration of crop damage (Sam 1998).

Maize was occasionally harvested prematurely and stalks burned to keep off elephants and where elephants sometimes raided maize stores, farmers resorted to keeping their maize in non-elephant reach zones. However, maize harvested prematurely suffered from rotting, another source of crop loss just as reported elsewhere (Thouless 1994, Kakira 1996, Kasiki 1998).

In Emarti area of TM District, farming occurs along the Mara River, which is an important source of water for elephants. Elephants crosses through the gently sloping riverbanks to raid farms and attempts to block the entry routes with branches of thorny trees did not succeed. Equally, steeping the gently sloping riverbanks by digging did not succeed as elephants re-levelled the banks using tusks. The use of a tractor by driving through the farm to chase elephants was effective but also damaged the maize. Grown tobacco was trampled on hence not effective, a scenario that was reported by Bell (1984). The use of licensed firearm by some farmers seem to have worked very well though there was no enough data to derive meaningful conclusions.

Once elephants are on the farms, the crop protection methods like fire and noise seem to be less effective, so it is imperative to detect and deter elephants before they get on to the farm. More elephants and bigger farms generally mean more damage, but communal guarding may help.

10.4.2 Farm abandoning strategy as the last resort to crop protection

Many other studies have reported farm abandoning as the last option of HEC (Grinsdell & Bell 1975, Bell 1981a, Bell 1984, Tchamba 1995, Kakira 1996, Kasiki 1998). Farms in TM District were abandoned as a result of increasing cases of crop raiding (Chapter 7, Figure 10.3) apart from other factors such as tribal fighting between the Maasai and non-Maasai, other wildlife species, emigration of people and lack of farm manpower and finance. Most farms were in partnership between the Maasai and the non-Masai immigrants that were subsequently abandoned when the immigrant left. It would have been of great importance for this study to establish the factors that determined the abandoning of farms in TM District other than just focusing on one factor as other possible explanatory variables contributing to changing land use patterns which was discussed in Chapter 5. The size of abandoned farms decreased between 1992 and 1994 (Figure 10.4) when KWS PAC unit was established and shooting of problem elephants was encouraged, which was re-establishing back after poaching was stopped on CLs only to find their ranges under farming (Chapter 6). Hence, the already scared elephants went back to safer havens while the notorious ones were shot lowering crop raiding and encouraged people to farm. However, an increase in the mean size of abandoned farms between 1994 and 1997 can be explained by a complete re-establishment and recovery of the elephant population and repeal of shooting policy resulting to increased crop raiding and hence increased cases of abandoning. The decline in the mean farm size abandoned between 1997 and 1999 can be attributed to the influx of non-Maasai who tried to farm but could not succeed because of lack of traditional crop protection skills since they have no experience with elephants.

Farmers had shown a determination to crow and protect crops despite increasing cases of crop raiding because of increasing food demand due to human population increase (Chapter 5) and lowered livestock numbers, which can no longer sustain the family unit (Chapter 6). This is supported by the increased period taken to abandon farming (Figure 10.5). Equally, abandonment was not related to the overall size of the farm but many smaller farms have evolved compared to the fewer, large farms in 1970s and 1980s. However, bigger farms were abandoned much earlier while smaller farms persisted for longer period. This could be explained by the high investment in big farms and inability to protect big farms adequately. In early 1970s to mid 1980s, many farms were established because of compensation scheme (Figure 10.4 & 10.5). By then, the elephant population had declined significantly due to poaching only to start re-establishing and recovering after poaching was controlled.

10.4.3 The role of KWS in crop protection

Njumbi (1995) cited inefficiency and low morale by KWS rangers as an important consideration in conflict mitigation. Generally, PAC unit responded quickly in near places while poor reporting occurred in distant places Ndung'u (1998). Therefore, recruitment of more PAC personnel might lower HEC (Njumbi 1995, Ndung'u 1998, Kasiki 1998). In TM District paired rangers are supposed to cover an approximate area of 112 km^2 (Table 10.3). Due to limited personnel, no vehicles in most stations, lack of ammunition and generally low morale of KWS rangers while reported cases are on the increase, a "wait and see" approach was often adopted by the rangers until the number of complaints increased where many cases went un-attended (Chapter 7). This probably explain why most farmers gave up in reporting crop raiding. Other reasons might include the long distances to KWS stations are not worth the effort due to small farms and farmers get discouraged when rangers fail to attend to previous reports. KWS stations are located far from HEC areas, which are again located far from roads hindering accessibility (Chapter 9). However, rangers responded quickly to areas where the community provided food since the rangers do not get the ration supply, an observation that was also reported by Ndung'u (1998). As a result, the community has no regard for KWS rangers since only the able ones are assisted and hence prefer not to report since no action will be taken.

10.4.4 Implications for management

This study has shown the different farm-based crop protection strategies employed by the local community in TM District and the factors determining success of farm protection from elephants. The variations in these strategies and their success in relation to other strategies practised elsewhere imply that generalised PAC cannot address HEC best and therefore solutions specific to different areas need to be developed. Crop damage cannot be managed by a single management strategy and there is need to raise general tolerance among farmers and enhance their methods of defence to lessen the impact of severe losses by elephants. TM District being a high altitude zone with high rainfall is suitable for growing profitable unpalatable crops like pyrethrum and tobacco, which are not preferred by elephants. By planting crops at the same time for easy elephant control since only few elephant groups were noted (Chapter 6) while seasonal and spatial patterns of raiding (Chapters 8 and 9) can assist in resource allocation. The inefficiency from KWS who are the custodians of wildlife on behalf of the government due to many cited factors is a step backwards in the effort to conflict mitigation and elephant conservation in general. Because of the already declined elephant range surrounded by farms, scarring elephants in TM District only shifts crop raiding from one area to another, causing not only increased disturbance to elephants but making them more aggressive to people. This strategy is finally recognised by elephants as just a scare tactic and makes elephants bolder to the local people.

After having explored land use changes, elephant status, the arising conflicts, people's attitudes and perceptions towards elephants and finally local mitigation strategies, the next chapter gives an overall discussion and general conclusions and recommendations.

CHAPTER ELEVEN

Discussion and conclusions

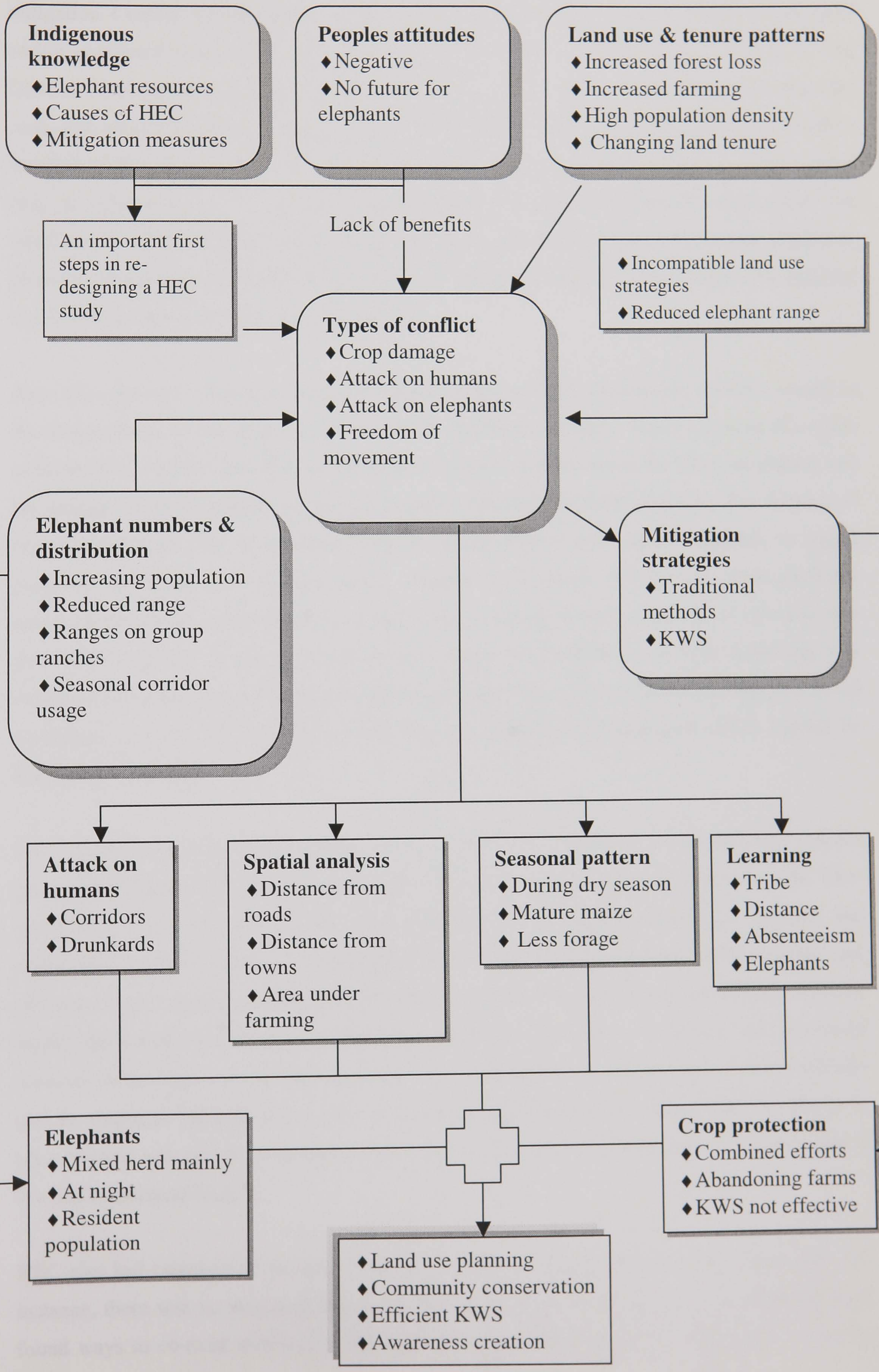
11.1 Research findings and conclusions

For proper understanding and management of Human-elephant conflict (HEC), there is a need to understand land use and cover change (Chapter 5), elephant numbers and distribution (Chapter 6), types, and seasonal and spatial patterns of conflict (Chapters 8 & 9), protection measures (Chapter 10) and finally peoples' attitudes perceptions towards elephants (Chapter 4). A summary of findings are illustrated in Figure 11.1. Previous studies on HEC have not considered land use changes that introduce incompatible land use strategies, which are the main source of conflict. This knowledge is imperative for land use planning, which has been recommended by all studies as the best strategy to mitigate conflict. However, this study was limited by data on actual elephant numbers and their distribution patterns. Instead, only patterns of elephant density and range are available. Nevertheless, this is the first study to have: farm-based measurement of conflict; determined seasonal and spatial factors underlying HEC; and, measured the success of the traditional crop protection measures from which better conflict management options can be derived.

Compared to the surrounding areas, Transmara (TM) District is an important area for both resident and migratory elephants because of its forest vegetation cover, climate, and other important natural resources like salt licks. Equally, the fairly fertile soils and good climate are also ideal for human settlement and farming, and have attracted many immigrants. As a result, there is rapid encroachment and conversion of the former elephant range into cultivation. This has resulted in a great reduction of elephant range, which together with the increasing human and elephant population, has put humans into direct contact with elephants. The reduced elephant ranges are an equally important dry season grazing area for livestock and other wildlife species from the adjacent Narok District. Again, the range faces serious degradation because of the high animal density during the dry season.

The increasing human population, changing land tenure patterns from communal group ranch to individual holdings and the changing land use patterns from pastoralism to agro-pastoralism, complicate the pattern of HEC in TM District. The issue has been further complicated because few monetary benefits accrue to the people of TM District from wildlife who have developed a negative attitude towards elephants (Chapter 4). Simultaneously, people are killed and crops are destroyed, but people are not compensated for this, which causes them to view elephants as a liability. Previous studies of HEC were biased towards the elephant caused distractions, and the impact of people on the elephant was rarely addressed. This study has attempted to give a balanced view of both human and elephant caused problems.

Figure 11.1 A diagrammatic model showing findings of a HEC study in Transmara District, 2000.



11.2 Types of HEC in TM District

This study has documented the various physical types of HEC (Chapter 7). However, emotional feelings were also observed which must be addressed to arrive at any meaningful conflict mitigation. Conflict occurs whenever disagreement exists in a situation over issues of substance and/or emotional antagonism. Both substantive and emotional conflicts were evident in TM District. The substantive conflict resulted from disagreements over resource use and destruction, crop and property damage, human and elephant death and injury, distribution of wildlife revenue to non-deserving groups, policies on elephant ownership on private land, low and/or lack of compensation, and delayed compensation, among others. On the other hand, the emotional conflict resulted from feelings of anger and fear between people and elephants, distrust, resentments and personality clashes over wildlife related activities, which was directed at wildlife and the responsible wildlife authority.

Also observed were destructive and constructive forms of HEC. Destructive conflict worked to the disadvantage of the local community and/or elephants involved. These appeared two types of destructive conflict. One form of destructive conflict occurred when the local community and the elephant showed inability to co-exist because of human-elephant hostilities. For instance, if people shouted or shot at elephants with bows and arrows, this caused elephants to regard people as dangerous and worthy of attack (Chapter 6). However, this has also made elephants remain in the forest during the day and only come out at night when people have retreated into their houses, giving people the opportunity to attend to their daily activities. Rumbling was considered important by the local community because they could tell their location and avoid elephants. However, if rumbling ceased, this was beneficial to elephants, which cannot be detected by poachers.

The second form of destructive conflict is when the local community, conservationists and the government failed to agree on conservation goals and human needs. For instance, the local community was evicted to create land (MMNR) for wildlife conservation and yet the community members were not compensated for allowing wildlife to remain on their private land or for any consequent loss of life and property. This kind of conflict has resulted in unnecessary stress, decreased communication, increased suspicion, reduced co-existence and decreased concern for any common goal between the local community, the government, conservationists and the elephant. The presence of any government and conservation officials in TM District is often viewed with suspicion that their land could be annexed for conservation purposes, which is a highly political issue.

HEC also had constructive elements benefited both the elephant and the local community. For instance, there was an increased creativity and innovation whereby people and elephants have found ways to co-exist without coming into contact with one another. Conflict has overcome apathy and encouraged affected people to work towards communal goals. This is exemplified in the communal farming and guarding strategies that are employed by many farmers (Chapter 10). In turn, this has resulted in rekindled importance of communal ownership formerly practised by the Maasai. Conflict has therefore increased cohesion and group identity but generally the issue of HEC in TM District still remains very complex.

11.2.1 Crop raiding

Crop raiding in TM District, which mainly involved mixed herds (Chapter 7), exhibited both clustered (Chapter 9) and seasonal (Chapter 8) patterns, an important finding for conflict mitigation strategies especially on resource allocation. Clustered raiding pattern was related to areas under farming and relative closeness to market centres and far from roads network. Seasonal pattern was directly related to dry spell followed by a decline in grass biomass and ripening of maize. Elephants preferred maize being the dominant crop grown in TM District mostly when mature and took only the cobs, with high nutritive value and mainly by the resident elephant population.

11.2.2 Human and elephant attacks

Attack on humans by elephants in TM District showed an increasing pattern along with other wildlife species, which can be attributed to an increase in human and wildlife populations followed by reducing wildlife range resulting from increasing cultivation (Chapters 5 & 6). The chances of elephants and people coming in contact are quite high especially when elephants attempt to utilise human settlement areas at night where late arrivals in the homes have been victims especially after a drinking spree. Most attacks on humans occurred in the traditional elephant corridors (Chapter 7) and next to forest reserves with high elephant density (Chapter 6). Because of increasing attacks on human by elephants, the local community also resorts to attacking and injuring elephants using poisoned arrows and spears and/or are killed during PAC by KWS. Elephant mortality in TM District by KWS during PAC and by the local community fluctuates depending on the patrol efforts by KWS and their policy on shooting problem elephants (Chapter 7). The future of elephants in TM District remains tricky with increasing human and elephant populations while elephant ranges are declining yet the policy of shooting of problem animals has been abolished.

11.2.3 Disruption of education activities

Many studies on HEC have never considered the impact of elephant on learning activities despite many complaints from people living in elephant ranges. The mean scores for schools and pupils living within the elephant range was generally lower (Chapter 7). However, other factors apart from elephants contributed to the low mean scores and there is need for further research to that effect. Distance travelled by pupils to school was a more significant factor especially for those who came from elephant range implying fewer schools within the elephant range. This calls for the need for boarding schools and additional schools closer to the people.

Generally, elephant problems in TM District are enormous and some cannot be easily quantified because conflict occurs whenever elephants are in the midst of settlements either with the people, people's property or shared natural resources.

11.3 KWS policies and HEC mitigation in TM District

This is the first study on HEC in TM District, where the history of conflict has not been previously documented. In an attempt to tackle problem elephant control to minimise conflict, a series of strategies have been attempted over time. Initially, Wildlife Conservation and Management Department (WCMD) was insensitive and reluctant to reported cases of HEC (Kasiki 1998). Between 1980 and 1990, elephant population on CLs declined as a result of poaching and the remaining elephants seeking safer havens in the MMNR. Poaching occurred at a time WCMD was poorly funded, and its staff had low morale (Kasiki 1998). It also coincided with a period of high demand of highly priced ivory. Farms rapidly increased on the former elephant range in early 1980s, while big farms were established mainly to claim for compensation payments. The big farms were abandoned once the government discontinued compensation in 1989. This decision was taken because of the expenditure resulting from many highly exaggerated and fraudulent applications for compensation.

Also, in 1989 the government established KWS to replace WCMD and with good funding, KWS offered better terms of service that boosted the staff morale. The formation of an anti-poaching unit, the presidential burning of stockpile ivory, and the listing of the African elephant on Appendix 1 by CITES in 1989, all resulted in a tremendous decline in poaching. The elephant population in TM District started to increase in number as well as to re-establish their former ranges on CLs, which by now were being turned into cultivation. By 1992, HEC started to escalate where most farms were abandoned. A PAC unit was established to attempt to resolve conflict as KWS adopted a policy to shoot elephants. It was thought that shooting an elephant could discourage other elephants from visiting the same area (Buss 1961, Douglas-Hamilton 1972, Croze 1974a, Laws *et al* 1975, Moss 1988, Poole 1990) because elephant emit low frequency distress calls when shot that repels others from the area (Whyte 1993). However, this was not effective in Tsavo (Kasiki 1998), but effective in Asia (Sukumar 1989) and Amboseli (Kangwana 1995).

Cessation of control shooting led to a notable increase in elephant movements into CLs adjacent to Garamba NP and to increased reports of crop damage (Smith *et al* 1995). Shooting elephants was not effective and they still even frequented farms where carcasses lay. The possible explanation is that elephants visit to gain highly nutritious forage, which outweighs the risk of being killed. According to Vanleeuwe *et al* (1997), elephants may also be attracted to the carcass or may not associate the carcass with danger. The use of thunder flashes and firing blanks have become ineffective (KWS 1992, Ndung'u 1998). While shooting elephants in TM District did not provide enough data to draw any meaningful conclusions, elephants still visited farms with carcasses. Elsewhere, it discouraged subsequent raids somewhat (Kiiru 1995) or had unpredictable outcome (Kasiki 1998, O'Connell-Rodwell *et al* 2000).

Crop raiding escalated as mixed herds dominated after security was restored. In 1994, KWS changed its policy to shoot female elephants (Kasiki 1998). This was probably based on the assumption that the matriarch determines the movement pattern of the family unit and its elimination will keep the rest of the family away (Laws 1972). However, Kasiki (1998) established that shooting a female elephant does not discourage elephants from crop raiding. Before too long, KWS realised the negative implications of killing females, which determine population growth as elephants were just recovering from poaching. Equally, loss of the matriarch disoriented the entire family, resulting in increased mortality of the remaining family members (Poole 1992). A recent study on the social intelligence of the Amboseli elephant population (McComb *et al* 2001) has revealed enhanced discriminatory abilities on the part of the oldest females, which can influence the social knowledge of the group as a whole. This may result in reproductive success for female groups led by older individuals. Hence, the authors argue that the removal of older, more experienced females could seriously negative affect the elephant population.

Because of the political nature of the elephant and the ethics of killing, other protection measures have been sought to minimise killing. A fencing unit was therefore established by KWS in 1995, and fences were erected in some HEC zones. However, a proposal only was made for Emarti in 1997 and no elephant fences have been erected in TM District. Fencing is not only expensive (Thouless 1994), but has other ecological problems and requires community support. KWS has a new policy of translocating elephants from high density and high conflict areas to low density areas whose population was severely reduced by poaching. However, the Mara population is still considered to be too low for translocation, while this is simply a short term but very expensive measure that transfers a long-term problem to a new area.

With the increasing demand for food, farmers in TM District have started resisting attempts to abandon farms while more area is being cleared for farming (Chapter 10). At the same time, the increasing elephant population is increasing the chances of HEC. However, the current policy of KWS tries to discourage shooting problem elephants, because of its behavioural impact on the family and on the elephant population, and because of potential negative political consequences. Killing problem animals has been considered wasteful and uneconomical since it involves loss of life and considerable costs, in terms of manpower and materials. Scaring is not effective

(Ngure 1995, Kangwana 1995, Kasiki 1998). An attempt by the local community to kill an elephant is a criminal offence, and yet crop damage is not compensated apart from an elephant intruding on private land. This scenario complicates human-elephant interaction and conflict mitigation. The intense competition between the two is serious. According to the competitive exclusion principle (Hardin 1968, Parker & Graham 1989b), the elephant stands to lose, and indeed it has already lost most of its former range (Chapter 6). The frequent ethnic fighting in TM District (Chapter 5) and scrapping of compensation for crop damage have contributed significantly to the slow pace of human encroachment on the elephant ranges in TM District.

11.4 Human-elephant conflict management strategies

There are three ways in which conflict can be addressed. Firstly, a policy of inaction to be followed, in which there is no direct attempt to deal with a manifest problem and conflict is left to proceed. This has been the case in TM District especially in areas far from KWS outposts. Secondly, a policy of suppression can be followed, which involves decreasing the negative consequences of a conflict but does not address or eliminate the root causes. This includes scaring elephants away from the fields or compensation. Finally, a policy of resolution can be followed, where the underlying reasons of conflict are removed. These may include driving out elephants into a PA or fencing off an elephant sanctuary from farming areas. An aim of this study is to provide the necessary information that help in addressing the issue of conflict in TM District. This will not only help to save the elephant but will also assist in conserving the fragmented forest remnants in the Mara ecosystem. This can only be achieved through a solid proactive social, economic and biological analysis that strikes a balance between elephants securing the core areas and corridors they need, while people can pursue agriculture and other forms of land use.

Many studies have outlined direct and indirect strategies for HEC mitigation, but the key recommendations have often been benefits, compensation and a land use plan. This study makes similar recommendations, but they are at an advanced stage because TM District is a step ahead with a 'paper' Regional Development Plan (Figure 11.2). This is the only way forward for a complex conflict scenario, like the TM District. One management option cannot completely address the issue of HEC. There is need for collaborative problem solving involving all stakeholders. A combination of prevention and reduction strategies including land use planning, fencing, PAC, benefit sharing and compensation are the best strategy for managing wildlife (KWS 1994). The PAC unit has no clear strategies and resources are insufficiently allocated (KWS 1994). This has never been effective after recommendations were made by a task force six years ago. Compensation should be run by KWS and they also proposed compensation insurance, land use planning, and land and tourism development and benefit distribution (KWS 1994).

11.4.1 Land use planning and conflict mitigation

Land use planning was suggested by many HEC studies (Ekobo 1997, Njumbi 1995, Kiiru 1995, Kasiki 1998, Hoare 1999, Ottichilo 2000). Studies in TM District have proposed the establishment of a 5-km stretch from the escarpment (Thurrow 1993) for conservation purposes. The management of elephants in TM District should first deal with human related problems, since most elephants are found on private land and cause problems to landowners. The local community does not receive any benefits from elephant conservation, and yet their areas are important for elephant conservation, both the resident population and the Mara elephants. Most conflicts arise as a result of increasing incompatibility in land use, such as crop farming that is encroaching on former elephant dispersal areas. There is a need for a review of land use policy and planning, and a thorough understanding of current land use practices, so as to adopt the best land use strategy to harmonise elephant management and peoples' needs, in order to minimise conflict. These data were instrumental in drafting the Regional Development Plan for TM District (Figure 11.2). However, this plan might never be implemented because of lack of a clear land use policy on private land. Hence, the plan has a few limitations. The issue of conditional title deeds has already been overtaken by events, since most crucial areas have already acquired title deeds. The already overcrowded northern and southern parts of TM district are under heavy farming and settlement (Chapter 5). Therefore, wildlife conservation is not possible in those areas, even though the improved range is also suitable for wildlife. Hence, much finer land use plan is necessary for the area zoned for livestock-wildlife-tourism development. Areas where land is still owned communally is fairly intact, unlike areas settled by non-Maasais. The district is undergoing land sub-division whose impact on wildlife, and especially on elephants, can be detrimental because of the increasing interest in farming activities on small parcels of land. The elephant range on private land is already lost.

11.4.2 Establishment of an elephant sanctuary

The concept of establishing an elephant sunctuary to act a "trans-frontier area" between the CLs and the MT may be important, because of the greater biological diversity on CLs, and to maintain the traditional movement routes. This is one of the sure ways of deriving monetary benefits from conservation of natural resources. Negotiation of benefits for the local community on CLs should be a priority, because TM District has lost most of its elephant range in the recent past. This loss has probably arisen because the economics of conservation have not allowed landowners to realise benefits, such that farming and elephant poaching are seen as the only options. Therefore, economically favourable land use patterns have quickly emerged that are incompatible with elephant conservation. At this rate, the future survival and existence of the elephant population both inside and outside the MMNR is threatened. An area where revenue is shared with group ranch owners probably has fewer elephants than other areas where no revenue is received. This means that the future of the elephant in TM District will depend on benefits accrued to landowners through establishment of a sanctuary on CLs since the resident elephant population is far from MMNR where land owners do not derive benefits from conservation.

11.4.3 Legal protection of the forest

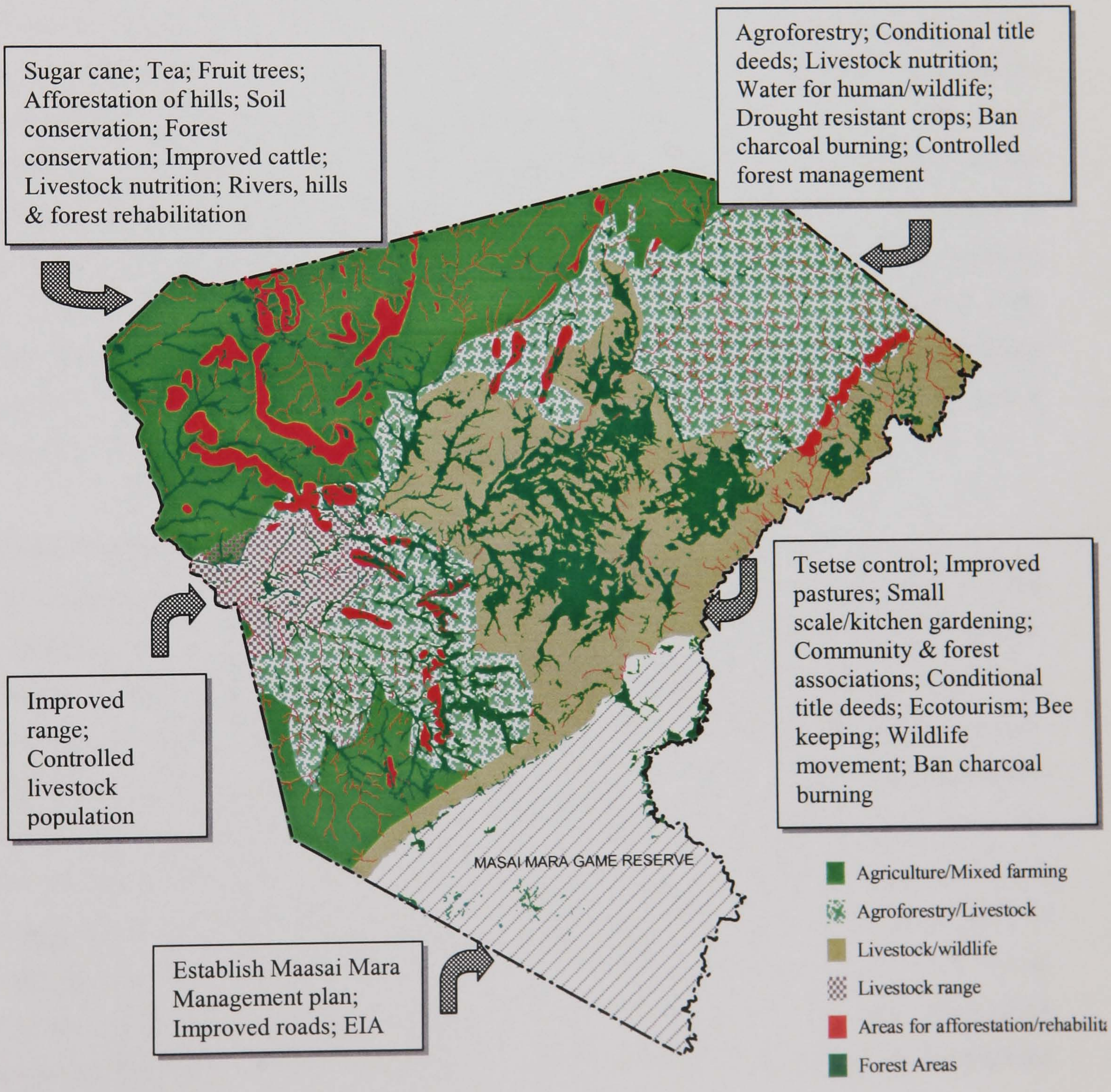
The conservation of elephants in TM District concerns the indirect impact of man on the elephant through encroachment on its habitat, and conversely on the impact of elephants on human activities. The ultimate cause of decline of elephant population throughout TM District has been habitat loss, and this is bound to increase with changing land tenure and land use patterns, and with increasingly negative attitudes towards the elephant. Since elephants inhabit these legally unprotected forests, they currently enjoy little legal protection. Elephant habitat is undergoing serious change as a result of the human quest for natural resources, as well as human occupation or settlement. The Maasai, who traditionally were not crop farmers, are now engaging in small scale farming practices. Together with immigrants, TM District forests and the remaining elephant areas are being exploited for cultivation. The TM District forest is owned by communities, individuals and the County Council (Chapter 5) and cannot resist encroachment on elephant ranges. With increasing deforestation, the remaining elephant range will be lost, and elephants on CLs will have no option but to move into the MT.

Njumbi (1995) proposed complete removal of elephants from TM District. Elephant translocation is tricky because the Mara elephants seasonally visit CLs, especially during the dry season (Chapter 6) and the Mara population has not recovered to its former status. However, the remaining elephant range is unsuitable for large scale wheat and maize farming (Figure 2.4) and has been recommended for livestock-wildlife use and tourism development (Figure 11.2). This appears a better land use option, since the only forests in the area will be converted to farming if elephants are removed. The daily and seasonal movement of elephants (Chapter 6) and other wildlife species including livestock signifies the importance of this part of the ecosystem in wildlife conservation and pastoral way of life.

11.4.4 Erection of barriers

Electric fencing has succeeded in Malaysia (Sukumar 1990) and at Ndare Ngare (KWS 1992). Communities have adopted a positive attitude towards wildlife where fences have been erected (KWS 1992). Whilst agriculturists favour fencing, pastoralists fear their inability to access grazing and salt licks in PAs (KWS 1992) even though it is illegal. Because fencing alone was not effective. Thouless (1994) and Bhima (1998) suggested construction of a fence and killing of some rogue bulls. Other cases of fence failures have been reported (Jenkins & Hamilton 1982, Bell 1984). Fencing becomes effective in the initial phase but elephants soon learn how to go round them (Kasiki 1998). Fencing has resulted in increased cultivation and crop diversity, low conflicts, less time spent in guarding crops and a positive attitude towards KWS, while access to the forest was decreased (Mwathe *et al* 1998). Fencing also blocks other resources and traditional movement routes and can result in more conflict (Kasiki 1998). Therefore, fence construction requires an understanding of elephant movements and their underlying causes (Douglas-Hamilton *et al* 1994) and acceptance and support by local community (Kasiki 1998, Daily Nation 1999) to avoid expensive mistakes (Ngure 1992, Douglas-Hamilton *et al* 1994). For instance, the bid by KWS to construct an electric fence around Aberdares forest was rejected by the community, claiming there was no human-wildlife conflict, and that they had never requested for a fence (Daily Nation 1999) because they needed access to the forest. An assessment of the impact of fencing on elephant survival is also important (Kasiki 1998), since elephants may move out of PAs for essential resources like food and water (Leopold 1933).

Figure 11.2 Proposed regional development plan for TM District (Source: DDP 2000).



RRA participants and social survey respondents (Chapter 3 & 4) proposed fencing of MMNR. However, electric fencing could be a possible solution to resolving HEC in Emarti because of high human density and the intensive crop farming upto to the Mara River. In 1997, KWS proposed a 10-Km electric fence to mitigate crop damage in areas adjacent to Emarti. This was to be the first fencing exercise by KWS in the Mara but the project was suspended because no thorough study had been undertaken on HEC in the area. It was further anticipated there would be resentment by farmers elsewhere in TM District, including those who were not benefiting from wildlife, especially those expanding their farms around Kirbwet and Oloonkolin forests.

Equally, partial fencing of the MT will deny elephants access to important resources on CLs, apart from creating additional management problems in the MMNR. A shift in elephant migration, especially during wildebeest migration, possibly into (a) Serengeti might expose them to poaching, or into (b) Koiyaki-Lemek and Olchoro uwa Wildlife Associations will re-direct conflict. The local community will not access the salt lick in the MMNR and benefits from wildlife. While farming is not a feasible land use option in CLs forests, even if the elephant was removed, pastoralism and wildlife conservation may be the best and only land use options. Therefore, fencing may not be a solution, since fence construction and maintenance is costly, requires community support and co-operation for success, and may be tricky to maintain in a multi-tribal area like TM District. The local people should hence tolerate elephants while costs incurred can be offset by starting income generating activities. Equally, scattered farming system will definitely expand into the remaining forest fragments resulting in forest loss, a threat to the areas hydrology.

11.4.5 Compensations related to elephant problems

The compensation scheme for crop damage was abolished in 1989 due to fraudulent and exaggerated claims, apart from being too low. However, the claims are never paid promptly, sometimes taking up to 10 years to come through. Furthermore, compensation remains very controversial, as the figures are just too low, creating a lot of resentment from the local people. Meanwhile the Maasai demand a traditional compensation of 49 heads of cattle for human death (KWS 1994). Despite the current low levels of compensation, Kenya appears to be one of the few countries that pay any compensation for human deaths. In India, crop damage is also compensated based on a five-step bureaucracy (Kailas 2000). The Kenya government is working out a way of increasing compensation to Ksh 1 million (US$ 13,333) for loss of human life, and ways to pay the compensation fee promptly. In Britain, Howletts Wild Animal Park was ordered to pay £ 28,000 (US$ 40,923) fine for the keeper's death caused by an elephant (Adscene 2001).

11.5 Unstudied factors that may affect or explain HEC in TM District

HEC in TM District is problematic for a number of reasons. The Mara Triangle (MT) is managed by the County Council, while wildlife outside MMNR, is managed by KWS. Very little and/or none of the benefits accrued from the MT sector of MMNR goes to the people living with elephants, or to elephant conservation outside the MMNR. There is a poor relationship between the two County Councils of Narok and TM districts, and KWS, because of suspicion after an attempt by KWS to declare MMNR as a National Park in 1992. This makes the prevailing situation difficult for KWS to operate. An attempt to sign a memorandum of understanding between KWS and the County Council in 1996 never succeeded. Indeed, management of wildlife especially of elephant outside the MMNR has been hindered by lack of monetary benefits and misunderstanding. Poachers have wiped out almost all the wildlife species on CLs and are now operating in the MMNR where snares are endangering elephants further. Other factors include the increasing number of stakeholders in HEC, the highly politicised nature of the elephant, contradictory policies, contravention of human rights to food, security, and education, among others.

11.6 Conclusion

The potential of HEC in TM District is high due to changing land use patterns, declining elephant range while both elephant and human populations are increasing, resulting in high competition. There is need for a concerted effort by local people and KWS to find ways of "sustainable conflict mitigation". However, specific detailed recommendations based on workshop feedback are outlined in appendix 4. A follow up of this study should design a HEC-Community Action Plan to be in-co-operated in the MMNR Management Plan and land use planning. The inventory of the physical and biological resources, types and patterns of conflict and land use management plan are already in place, negotiations must follow to save the dwindling forest in order to minimise conflict and conserve the elephants while minding about human needs hence cultivate a positive attitude of the local people towards elephants.

11.7 Research and further studies

- The TM District elephants should be fitted with GPS and standard radio collars for monitoring their movements and possibly identifying the notorious crop raiding herds. In this way, the needs of the elephant can be determined and ways to manage them can be deduced.
- Establish elephant movement patterns of the resident population and the current population status.
- Further research on the differences in schools and pupil performance within the elephant range and outside.
- Develop a TM District-HEC-Community Action Plan

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Appendix 1. (a) RRA questionnaire guideline in Swahili version

Mwongozo wa maswali ya kikundi cha jamii.

Ndovu

1. Unaweza kueleza historia ya mabadiliko kuhuzu ndovu katika wilaya ya Transmara kwa njia sifuatazo:
   (a) Idadi ya ndovu
   (b) Sehemu ya ndovu
   (c) Tapia ya ndovu
2. Unaweza chora vile sehemu ya ndovu imendelea kupadilika kwa wakati huu wote.
3. (a) Tofautisha na uchore rasilimali muhimu ya ndovu katika wilaya ya Transmara. Kwa mfano chumvi, mahali jemijemi, njia zao, mimea, na kathalika.
   (b) Kwa kila rasilimali, eleza kama imefamiwa na watu kwa kuishi au la.
4. (a) Ni vitu gani muhimu katika historia kuhusu ndovu vimetendeka katika wilaya ya Transmara?
   (b) Kwa kila jambo, eleza ni mwaka gani ilitendeka, mathara kwa ndovu na vile ndovu waliweza kuepuka.
5. Ndovu wana faida gani ya kienyeji kwa jamii?
6. Wamasaai wana amini nini juu ya ndovu?

Rasilimali

7. Unaweza chora vile rasilimali imepadilika kwanzia mwaka wa 1950s na 1990s katika wilaya ya Transmara. Kwa mfano idadi ya ndovu, kilimo, idadi ya mifugo, malisho, maji, idadi ya nyazi ngumu, msitu, idadi ya watu, uindaji haramu wa ndovu na elimu.
8. Ni wakati gani ambapo vitendo kama upandaji wa vyakula, uivaji wa vyakula, uvunaji wa vyakula, mvua, shida ya ndovu vinatendeka katika wilaya ya Transmara..

Shida kutokana na ndovu na jinzi ya kuepuka

9. (a) Kuna shida gani inayotokana na ndovu katika wilaya hii ya Transmara?
   (b) Kwa kutazama shida mbili kwa kila wakati, unaweza kupanga shida gani ndio mpaya saidi kuliko ingine.
10. (a) Njia gani sinaweza tumika kupunguza shida sinazotokana na ndovu?
    (b) Kwa kutazama njia mbili kwa kila wakati, unaweza kupanga njia gani ndio muhimu sana kuliko ingine
11. Ni nini imesababisha uongezaji wa shida sinazotokana na ndovu.
12. Unaweza kumpuka mtu yeyote ambaye aliwuawa au kujeuriwa na ndovu? Tafathali eleza: mahali ilikuwa, mwaka, mwezi, maumbile, wakati, na kathalika.

Maasai

13. Tambua nambari unaweza kupeana kwa kila ukoo ya wamasaai katika elimu, idadi ya watu, idadi ya ndovu kwa shamba yao na ukulima.

Appendix 1. (b) RRA questionnaire guideline in English version

Questionnaire guideline for RRA survey with the local community.

Elephant

1. Can you give the historical account of the elephant related changes that have occurred in TM District in the following aspects:
    a. Elephant numbers
    b. Elephant distribution
    c. Elephant behaviour
2. Can you draw a sketch map depicting how the elephant range has changed over time.
3. (a) Identify and map some of the important elephant resources found in Transmara District e.g. Salt licks, swamps, corridors, vegetation, etc.
   (b) For each resource, state whether it is intact or encroached.
4. (a) What are the major elephant related historical events that occurred in TM District?
   (b) For each event, state the year it happened, the effect on elephants and the survival strategies employed.
5. What are the traditional values of elephants to the community?
6. What beliefs and taboos do you have about elephants?

Resources

7. Can you draw how the following resources have changed between 1950s and 1990s in TM District. Elephant numbers, agriculture, livestock, pasture, water, wiregrass, forest, human population, elephant poaching and education.
8. Which months are the following seasonal activities undertaken in TM District: Crop planting season, crop ripening, crop harvesting, rainfall, HEC, etc.

Conflict and conflict mitigation

9. (a) What types of HEC do you experience in TM District?
   (b) By comparing two types of conflict at a time, can you rank the most serious type of conflict and the least type.
10. (a) What types of conflict mitigation strategies can reduce HEC?
    (b) By comparing two types of conflict mitigation strategies at a time, can you rank what you think is the most effective type of mitigation strategy and the least effective.
11. What factors have contributed to increased HEC in TM District.
12. Do you remember of any person that was killed or injured by an elephant? Please provide the following details: location, year, month, sex, time, etc.

Maasai

13. Can you rank between the three Maasai clans the position they hold in terms of education, population, elephant density on their land and participation in farming.

Appendix 2. Specific questions for KWS personnel.

1. How many problem elephants are shot every year and which areas are commonly affected.
2. What problems do you encounter while attempting to control problem elephants?
3. How do you normally go about the problem and what could be done to improve its operation?
4. How many rangers and vehicles are assigned for this duty?
5. Do you have a defined patrol pattern or how do you respond to the arising conflicts?
6. How do you normally identify the problem elephant to kill or you kill any?
7. Do you kill any problem elephant that is reported to you or you spare some?
8. Do you keep records of problem elephants killed (sex, age, location, time etc)?
9. How do you handle cases of people killing problem elephants?
10. What is the reaction of the local people towards elephant conservation and effectiveness of KWS in handling problem animals?

Appendix 3 (a). Questionnaire survey in Swahili version.

Maswali ya kuangalia hali ya maisha na uchumi ya jamii ya wilaya ya Transmara na uifadhi wa ndovu.

Nambari: Divisioni: Kabila: Kiumbe: Tarehe:

Kijijie: Locationi: Umri: Elimu:

1. (a) Kazi yako ni gani?
2. (a) Umehishi hapa muda gani? 1. Miaka 0-5 __ 2. Mwaka 6-10 __ 3. Mwaka 11-19 __ 4. Miaka >20 __

   (b) Muko wangapi katika familia yenu? 1. 1-3 __ 2. 4-6__ 3. 7-10__ 4. > 10
3. Ulizaliwa hapa? Ndio ____ La ____

   Kama la (a) Tofautisha 1. Kijiji 2. Divisioni 3. Wilaya

   (b) Kwa nini ulihamia hapa? (c) Ulihama mwaka gani?
4. Unapanda chakula? 1. Ndio ___ 2. La ____

   Kama ndiyo (a) Unapanda chakula gani?

   (b) Kwa nini unapanda chakula? 1. Ya kuuza __ 2. Ya kula __ 3. Yote __

   (c) Ulihanza kulima mwaka gani?

   (d) Unalima hekari ngapi? 1. Chini ya moja__ 2. 2-4 __ 3. 5-10__ 4. > 10 __

   Kama la (a) Ni kwa nini?

   (b) Unafikiria kwanza kulima mwaka tano ijao? 1. Ndio___ 2. La___

   Kwa sababu gani?
5. (a) Ndovu huvika kwa shamba yako? 1. Ndio ____ 2. La ____

   Kama ndio (a) Wanakuja mwezi gani?

   (b) Wanakuja saa ngapi? 1. Mchana __ 3. Uziku __ 3. Mchana na uziku __

   (c) Ni kwasababu gani wanakuja?

   Kama la (a) Kwa nini hawaji?

   (b) Ndovu wanakuja mahali hapa? 1. Ndio __ 2. La __

   Kama ndio, wakati wa mwisho ilikuwa lini? Mwaka Mwezi

   Ni nini iliwavutia kukuja? Wanakuja mwezi gani? Wanarudi mwezi gani?

   Kama la, umewayi kusikia kutoka kwa mtu yeyote ya kwamba walikuwa wakija? 1. Ndio __

   2. La _

   (c) Ni kwa nini waliacha kukuja?
6. (a) Idadi ya ndovu katika mahali hapa 1. Inaongezeka ___ 2. Inapunguka ?__ 3. Sina habari_

   Unaweza kueleza ni kwa nini?

   (b) Shida kutokana na ndovu 1. imeongezeka ____ 2. imepunguka? _____

   Unaweza kueleza ni kwa nini?
7. Ndovu huaribu chakula chako? 1. Ndio ___ 2. La ___

(a) Unatumia mbinu gani kuwazuia wazile chakula chako 1. Kuchunga shamba 2. Kuwasha moto 3. Mitaro 4. Kupika mayowe 5. Njia zingine (tofautisha).

(b) Wanapenda chakula aina gani?

(c) Waliharibu mimea kiazi gani mwaka uliopita? (hekari) au nambari ya mimea ___.

(d) Umefunga shamba lako? 1. Ndio ___ 2. La ___

Kama ndio, umezingira na nini? 1. Miti iliyo kauka ___ 2. Seng'enge ___ 3. Seng'enge ya stima__ 4. Singine (tofautisha)

8. Ndovu wangapi huvika mahali hapa? 1. Moja __ 2. 2-5 __ 3. 5-10 __ 4. 10-20 __ 5. >20 __

9. Wanyama gani wengine huharibu mimea kwanzia na yule mharibivu zaidi?

10. (a) Kando ya kuharibu chakula, ndovu husababisha shida gani zingine?

(b) Huwa untatuwa hizo shida kwa njia gani?

(i) Pika reporti kwa 1. KWS__ 2. polisi __ 3. County Council __ 4. Sipiki reporti __ 5. Ingine (Tofautisha) __

KWS hujukua hatua namna gani? 1. haraka __ 2. Pole __ 3.Hawachukui hatua ___

Wanachukua masaa mangapi _______ au siku ngapi ______

Wanachukua hatua gani? 1. Wanaua ndovu 2. Wanafukuza ndovu 3. Nyingine (Tofautisha)

(c) Kunao mtu wa jamii yenu wala jirani ameawai 1. kuwawa ___ 2. kumizwa ___ 3. kufukuzwa __ na ndovu.

Eleza ilikuwa nini na ilikuwa mwaka gani.

(d) Ndovu wanafaida yeyote kwa jamii? 1. Ndio __ 2. La ___ Kama ndio, eleza ni faida gani.

11. Unaweza kujua mtu yeyote ambaye amilipiwa kwa uharibivu ya mali yake na ndovu?

1. Ndio ____ 2. La ____ Kama ndio amelipiwa gani? Alilipwa pesa ngapi (Shilingi)

12. Umewai kupadilisha mimea wala kuwacha ukulima juu ya uharibivi na ndovu?

1. Ndio ___ 2. La ___

13. Shida baina ya binadamu na ndovu inaweza kutatuliwa kwa njia gani?

14 (a) Umpele ya ndovu katika mahali hapa ni? 1. Nzuri 2. Mbaya Kwa sababu gani?

(b) Ungependa kuendelea kuishi na ndovu kama samani? 1. Ndio ___ 2. La ___

Kama la, ni kwa nini?

15. (a) Unapata faida yeyote kutoka kwa utali wala county council? 1. Ndio __ 2. La _

Kama ndio, eleza ni faida gani.

(b) Ni faida gani unapata kutoka kwa wanyama wengine wa msituni?

(c) Ni rasilimali gani unaweza kufaidika kutoka kwa mpuka ya wanyama?

(d) Unapata faida gani kwa msitu? Eleza ni msitu gani

16. (a) Shamba lako ni kiazi gani? (hekari).

(b) Uko na jeti cha kumiliki? 1. Ndio ___ 2. La____ Kama ndio (a) Ulipata mwaka gani?

Kama la (a) Uko na mpango ya kupata moja? 1. Ndio ____ 2. La ____

(c) Uko ya mifugo ngapi? 1. Ng'ombe _______ 2. Mbuzi na kondoo _____

Appendix 3 (b). Questionnaire survey in English version.

Questionnaire survey on socio-economic factors and elephant conservation in TM District.

NO: Division: Tribe: Sex: Date:

Village: Location: Age: Level of education:

1. (a) What is your occupation?

3. (a) How long have you lived in this area? 1. 0-5 years__ 2. 6-10 years__ 3. 11-19 years__ 4. >20 years __

   (b) How many are you in your family? 1. 1-3 __ 2. 4-6__ 3. 7-10__ 4. > 10

3. Were you born in this area? Yes____ No____

   If No (a) specify 1. Village 2. Division 3. District

   (b) Why did you move to this area?

   (a) When did you move in this area?

4. Do you grow crops? 1. Yes___ 2. No____

   If Yes (a) specify the crops grown

   (b) Why do you grow crops? 1. Commercial__ 2. Subsistence__ 3. Both __

   (c) When did you start farming?

   (d) How much land is under farming in hactares? 1. Less than 1__ 2. 2-4 __ 3. 5-10__ 4. > 10 __

   If No (a) state reasons why?

   (b) Do you intend to start farming in the next 5 years? 1. Yes___ 2. No___

   Can you give reasons why

5. (a) Do elephants come over to your farm? 1. Yes____ 2. No ____

   If Yes (a) What month do they come? ______________________________

   (b) What time do they come? 1. Day __ 3. Night __ 3. Both day/night __

   (c) Can you give reasons as to why they come?

   If No (a) Why don't they come?

   (b) Do elephants come to this area? 1. Yes __ 2. No __

   If Yes, when did elephants last come to this area? Year _______ Month___________

   What do you think attracted them to come?

   Which month do they come? Which month do they go?

   If No, Have you ever heard from anybody that elephants used to come? 1. Yes__ 2. No _

   (c) Why did they stop coming?

6. (a) Is the population of elephants in this area 1. increasing ___ 2. decreasing?___ 3. No idea__ Can you explain why?

   (b) Has the frequency of problem elephant 1. increased ____ 2. decreased? _____

   Can you explain why?

7. Do elephants destroy your crops? 1. Yes___ 2. No ___

   (a) How do you prevent elephants from destroying your crops 1. Guarding farms

2. Lighting fires 3. Moats 4. Making noise 5. Others (specify).

(b) Which crops do they prefer most?

(c) How much crops were destroyed last time? (hectares) or number of stems

(d) Is your farm fenced? 1. Yes ___ 2. No ___

If Yes, What kind of fence? 1. Dry vegetation ___ 2. Barbed wire ___ 3. Electric fence__

4. Others (specify)

8. How big are the herds of elephants that come to your area?

1. Singles __ 2. 2-5 __ 3. 5-10 __ 4. 10-20 __ 5. >20 __

9. List other animals that destroy your crops starting with the most destructive?

10. (a) Besides crop raiding, what other problems do you encounter from elephants?

(b) How do you normally deal with such problems?

(c) Report to 1. KWS__ 2. police __ 3. County Council __ 4. Do not report__ 5. Others (specify) What is the response of KWS? 1. Quick__ 2. Slow__ 3.No response___

How many hours _______ or days ______ taken.

What action is taken after reporting? 1. kill the culprit 2. Chase them away 3. Others (specify)

(c) Has any of your family member or neighbour been 1. Killed ___, 2. Injured___ 3. Attacked/chased __ by an elephant. Specify the event and the year.

(d) Are elephants of any importance to the community? 1. Yes __ 2. No ___ If Yes Specify

11. Have you or do you know someone that has been compensated for other elephant damages? 1. Yes ____ 2. No_____ If Yes which ones How much is paid (Ksh)

12. Have you been forced to change your crops or abandon your farm due to elephant destruction?

1. Yes ___ 2. No ___

13. How best can human-elephant conflict be resolved?

14 (a) What is the future of elephants in this area? 1. Good___ 2. Bleak___ Give reasons

(b) Do you wish to continue living with elephants as before? 1. Yes___ 2. No ___

If No why

15. (a) Do you receive any benefits from tourism or county council? 1. Yes __ 2. No _

If Yes specify

(b) What benefits do you get from other wild animals?

(c) What resources can you benefit from the Reserve?

(d) What benefits do you get from the Transmara forest? Specify the forest

16. (a) What is the size of your land (hactres).

(b) Do you own land title deed? 1. Yes___ 2. No____

If Yes (a) When did you acquire it?

If No (a) do you have intentions of acquiring one? 1. Yes____ 2. No ____

(c) What is the number of your livestock? 1. Cattle _____ 2. Sheep/Goats_____

Appendix 4. Specific recommendations based on workshops proceedings after the study

Specific recommendations were derived from the four workshops that were held after completion of the study to share research findings with the local community and other interested stakeholders in September 2001. Research results were presented at a two day workshop attended by all stakeholders and held at Dream Camp followed by another two day workshops with the communities in Transmara District. The questions deliberated at the workshops to derive the recommendations included:

1. Traditional community-based methods

(a) What existing methods should be continued?

(b) What new methods should be tried?

2. Official (KWS) intervention

(a) What methods should KWS be implementing?

(b) How can reporting and follow up procedures be improved?

3. Fencing

(a) Where and how could fences be used to good effect?

(b) What types of fences would be used?

(c) Who would be responsible for construction and maintenance?

4. Education

(a) What can be done to lessen the effects of elephants on children's education

Below is a summary of the recommendations from the four workshops.

I. Tourism development and revenue generation

- Establish a community wildlife association to plan and manage sustainable utilisation and benefit distribution.
- Encourage special interest groups such as GTZ that may also contribute to conservation and community development activities.
- Develop other compatible revenue generating activities such as bee keeping, butterfly farming, etc.
- Increase the 19% dividend from MMNR revenues that is distributed to communities.
- Develop alternative community-based tourism activities in the forest and on the escarpment, such as bird watching, horseback safaris and escarpment climbing.
- Ensure flow of benefits from wildlife-related activities, to provide services such as schools and health centres.
- The TMCC should provide an enabling environment for development of tourism and other alternative economic activities that are compatible with wildlife conservation.

II. Land use change to minimise HEC

(a) Human immigration and land conversion

- Provide incentives for landowners not to convert land.
- Promote livestock and wildlife as alternative land use options to cultivation.
- Harmonise government department policies on land use.
- Improve local education and awareness regarding forest conservation.
- Protect the forest and establish community-based forest protection action plan.

(b) Farming practices

- Consider alternative crops such as tobacco that are rejected by elephants.
- Synchronise planting and harvesting seasons to limit individual risk of crop raiding.
- Consolidate farms in cultivation zones away from elephant corridors and critical ranges.

III. Declining elephant range

- Create a community forest and manage it for conservation.
- Generate benefits from elephants, other wildlife and the forest.
- Extend benefit distribution from wildlife over the whole elephant range.
- Discourage forest encroachment through effective and appropriate rural planning.
- Reduce elephant numbers

IV. Mitigating HEC

(a) Official KWS intervention

- KWS should increase its deployment of field staff in the area.
- Some KWS stations should be relocated or temporary stations should be established to high conflict zones.
- KWS should assist the community to establish a HEC insurance scheme in which all farmers would have a stake.
- A joint KWS/community HEC board should be established to plan and manage local mitigation activities.
- KWS should train a local community rapid response unit, equipped with bicycles and watchtowers to augment official units.
- A mobile HEC mitigation unit should be established, that could be deployed to front line areas in high conflict seasons for rapid response. The unit should be provided with a motorbike, handset radios, powerful torches and enough ammunition.
- If compensation can be shown to be effective and workable, it should be administered by and through KWS rather than government ministries less connected with wildlife.

- The working conditions of KWS rangers should be improved to motivate them such as high allowances and sufficient field ration.
- Cultural awareness to improve KWS attitudes to local people.

(b) Community-based methods

- Train and use game scouts and retired military personnel in elephant areas to assist in carrying out control work.
- Avoid cultivating near elephant traditional routes and corridors.
- Maize should be planted at the same time for easy elephant control.
- Farmers should use a mixture of traditional methods during the conflict period ranging from noise, light and deterrents such as chilli, tobacco etc.
- Defences should be concentrated along a front line of farms closest to the point of origin of elephants.
- Communal guarding in teams should be employed during the conflict period to ensure rapid response to elephant presence.
- Provide barriers such as moats, construction of cliffs, etc to prevent incursions of elephants from Narok District to farming areas.

(c) Education activities

- More boarding schools with bursaries funded by the council from wildlife benefits should be established.
- Equip some schools within elephant zones and support some pupils to grow with a mind that they have succeeded as a result of revenue from elephants.
- Transport or guarded group travel should be provided for children in high risk elephant areas.
- Change hours of school
- Create awareness on the importance of education and discard traditions that hamper education.

(d) TM County Council (TMCC)

- TMCC should plough back part of their earnings from wildlife into community projects and elephant conservation.
- Seek ways of working collaboratively with KWS.
- Establish a consolation fee for loss or damage to livestock by elephants