THREATS AND THEIR RELATIVE SEVERITY TO WILDLIFE PROTECTED AREAS OF KENYA

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Abstract. Little information is available on the threats against biodiversity in Kenya. This is critical in prioritizing conservation strategies and instituting mitigation procedures to contain and or eliminate these threats for the survival of biodiversity in protected areas. This study aimed at documenting relative severity of threats and how serious protected parks are threatened. Two hundred protected area officers were interviewed. The most relatively severe threat factors were bush meat trade; poaching for trophies; human – wildlife conflicts; human population encroachment; loss of migration corridors and dispersal areas. Thirty-two (64%) protected areas were susceptible to over half of the threat factors, while over 70% of them were threatened by an index over 0.5. All marine and nearly all forested/montane protected areas were highly susceptible to the identified threat factors. Further, protected areas popular with tourists were also highly susceptible and threatened. Protected areas around urban/industrial and agricultural areas were threatened mostly by a variety of threat factors. These findings imply that threats to Kenya's protected areas are serious. They are critical in helping the Kenya government to prioritize its strategies in protected areas management, rather than the current haphazard approach.
Keywords: *biodiversity, conservation, ecosystems, dispersal areas*

Introduction

Conservationists viewed the establishment of the first protected area in Kenya in the mid-1940 as a milestone towards preserving diminishing wildlife species and their habitats. Since then, a chain of such areas has been designated in various parts of the country encompassing ecologically diverse ecosystems specifically for biodiversity conservation (KWS, 1990; Sindiga, 1995; Mugabe *et al*. 1998; Mugabe, 1998; Kameri, 2002). Going by the economic returns from wildlife based tourism and tremendous loss of biodiversity globally; one appreciates Kenya's initiative to designate rich biota landscapes exclusively for nature preservation (Mugabe *et al*., 1998; Mugabe, 1998; Kameri, 2002). Further, since Kenya's national economy is predominantly hinged on biological resources, wildlife protected areas are an important asset from which a significant amount of foreign exchange has been derived in the past few decades (Okello *et al*., 2001). Even though tourism has recently declined for a variety of reasons, and the country currently faces a myriad of wildlife conservation challenges (Sindiga, 1995; Mugabe *et al*. 1998; Mugabe, 1998; Smith, 1999; Johnstone 2000; Okello & Kiringe 2004) conservation of biological resources still remains one of the key national obligations of the Kenya Government (Mugabe *et al*. 1998; Kameri, 2002).

The current biodiversity conservation problems and largely unviable of protected areas in Kenya are partly precipitated by the government's protectionist approach and local communities alienation before and after independence (Mugabe *et al*. 1998; Kameri, 2002). Kenya Wildlife Service (KWS), which has been the custodian of the countries biodiversity since 1990, and its predecessor institutions have not taken any meaningful initiative to critically review the conservation strategies of the country. A

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protectionist approach towards conservation and failure to address the plight of rural communities has strongly been engrained since the pre-independence days (Beresford & Phillips, 2000). There is also a tendency to mitigate superficially and in isolation threats to survival of protected areas without any clear goals.

In the last century, increased human population has created a high demand for land as well as exerting an incredible amount of pressure and threat to wildlife and other biodiversity types in Kenya (Mwale, 2000). For instance, in high potential areas of Western Kenya, Nyanza, Central and parts of the Rift Valley Provinces where agriculture is the predominant land-use, most biodiversity types have nearly been exterminated including substantial alteration and loss of wildlife habitats (Kameri, 2002). Human encroachment on critical biodiversity depository sites in search of agricultural land has since the 1970's and 1980's shifted to low potential rangelands which coincidentally are the prime wildlife ecosystems (Sindiga 1995; Mwale 2000). This has created a myriad of problems like competition for water resources, human-wildlife conflicts, habitat fragmentation and blocking of wildlife migratory routes and dispersal areas and negative perception towards conservation (Sindiga, 1995; Norton-Griffiths, 1997; Ottichillo, 2000). Similarly, mountain Ecosystems like Aberdare National Park, Mt. Kenya National Park, Mt. Elgon, the Mau Escarpment among others have in the past few decades seen substantial human influx for subsistence farming opportunities, collection of both animal and plant resources. The Forest Department and more recently Kenya Wildlife Service have been faced with a new challenge of regulating and containing this encroachment as a means of minimizing habitat degradation, loss and subsequent biodiversity destruction.

Institutions that have been in-charge of wildlife conservation and management of protected areas have taken little proactive approach to regularly evaluate status and threats of these areas. Various research works (Nyeki, 1993; Sindiga, 1995; Mwangi, 1995; Western, 1997; Smith, 1999; Ottichilo, 2000), have outlined some of the critical threats to protected areas that need to be seriously addressed. Attempts have been made to address and mitigate these threats but with mixed success. Consequently, the Kenya Wildlife Service and the government in particular should; re-examine wildlife conservation approaches, policies and objectives. They should urgently undertake a comprehensive or holistic assessment on threats undermining biodiversity conservation initiatives within and outside protected areas as well as their genesis. The findings will provide key insights on the formulation of a workable conservation action plan specifically targeting conservation problems of each protected area. The current approach of applying the same strategies across the existing protected areas network to mitigate threats to biodiversity and associated habitats or ecosystems will not have any meaningful gains even in the years to come.

The objectives of this study were to:

- Establish the relative severity of previously identified threat factors to protected areas in Kenya (see Okello & Kiringe 2004)
- Prioritize and rank protected areas based on the relative severity of threat factors operating against them.
- Make appropriate recommendations on prioritization of management actions and activities in mitigating threats to protected areas of Kenya.

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Study country

This study focused on threats to biodiversity within and outside the current network of protected areas of Kenya, which is one of the three countries that make up East Africa *(Figure 1)*. Kenya is located within latitudes 4° 40' to the north and 4°20' to the south. It shares a common border with other countries of the larger Eastern Africa Region namely; Sudan, Somalia and Ethiopia. The landscape from Lake Victoria to the Indian Ocean in the East is extremely diverse. Further, the Great Rift Valley, which traverses from Lake Turkana in the North West to Tanzania and its associated features like Mt. Kenya, Mt. Elgon, the Mau Escarpment and Aberdare Ranges adds a complex landscapes comprising of various vegetation associations and biota types.

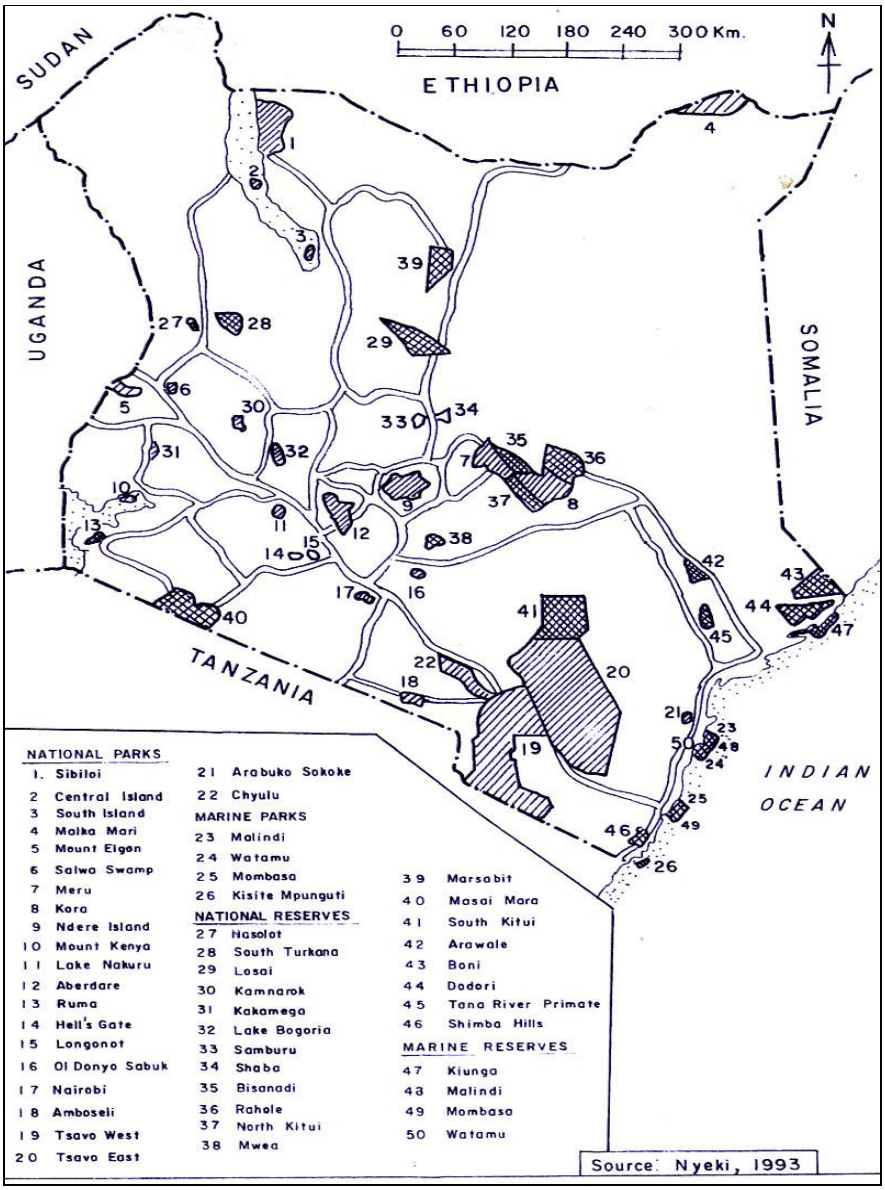

Figure 1. *A network of protected areas in Kenya. Most protected areas are small in size and quite representative of geographical areas in Kenya.*

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Kenya is endowed with an enormous diversity of ecosystems and wildlife species. In particular, it is renowned for its diverse assemblage of large mammals like elephant (*Loxodonta africana*), black rhino (*Diceros bicornis*), leopard (*Panthera pardus*), buffalo (*Syncerus cafer*) and lion (*Panthera leo*) numerous species of ungulates. This rich wildlife together with other attractions has for decades made the country an important tourist destination and hub for the lucrative tourist industry. The rich biodiversity is partly attributed to diversity in landscape, ecosystems, habitats and convergence of at least seven bio-geographic units (IUCN, 1990; Young, 1996; Medley & Hughes, 1996). Overall, the interactions between relief, geology, climate and soils have a profound influence on the types of habitats, ecosystems and biota life forms within the country (IUCN 1990; Young 1996; Medley & Hughes, 1996). Thus, most landscapes are characterized by peculiar climatic factors, wildlife life forms and vegetation associations which give rise to distinguishable geographical regions in the country (Grove, 1978; Leifer, 1977; Ojany & Ogendo 1973).

Methods

Information on threats to Kenya's protected areas was collected from field officers as a first preliminary step by Okello & Kiringe (2004). This work was followed up by a deeper probing of the opinions of the protected area officers on magnitude of each of the threat factors to their protected area using a brief questionnaire. Fifty protected areas (parks and reserves) in Kenya were included in this survey. The protected area officers who were interviewed or who provided information through the questionnaire were considered knowledgeable in view of their involvement in protected area management over time. These were long serving overall wardens, community wardens, law and policy enforcement ranger, and a research scientist.

The primary four protected area officers were asked, independent of each other, to rank from one (lowest threat level) to five (highest threat level) the key ten threats to protected areas identified from an initial preliminary survey (Okello & Kiringe, 2004). Each protected area officer was only allowed to provide ranks for the threat factors on the protected area under which they served. Scoring for each threat factor on ordinal scale by protected area officers was assumed to be adequate for the purpose of assessing status and threat index of each protected area.

Data analysis

A tally of the threat factors mentioned for each protected area was computed, and the proportion of the sum of the threat factors in each protected area out of the total ten was considered a measure of the ***Protected Area Susceptibility Index (PASI)*** to the threat factors. The following were calculated as indicators of how serious a threat factor was against protected areas, and vulnerability of protected areas to these threats:

- ***Mean score of each threat factor*** = (sum of all the scores for that particular threat factor) / (the total number of respondents, 200)
- ***Relative Threat Factor Severity Index, RTFSI*** = (The mean score for a particular threat factor) / (the maximum possible score, 5)
- ***Protected Area Relative Threatened Index, PARTI*** = total score of the ten threat factors from the interviewed officers of a given protected area) / total responses (40)

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A ranking system based on RTFSI showed which of the threat factors was more serious across protected areas in Kenya, while a ranking based on both PASI and PARTI showed which protected areas were most vulnerable to the identified threat factors. The relationship of the each of the ten threat factors with the protected area relative threatened index (PARTI) was determined by performing a non – parametric Spearman Rank Correlations (Zar 1999) to determine key threat factors that influence the threat vulnerability of the protected areas. Analysis was done using STATIGRAPHICS (Version 4.0 for Microsoft Windows 1999) software. Comparisons of protected area vulnerability in terms of dominant ecosystem types they have, and the predominant adjacent land use was done by a non-parametric Kruskal – Wallis test followed by a Box – and – whisker Multiple Comparison Procedure (Zar, 1999).

Results

The protected areas are faced by threat factors operating at relatively higher relative threat factor severity (RTFSI) level of 0.57, and ranging from 0.51 to 0.63 *(Table 1)*. Specifically, the threat index of illegal killing of wildlife for local and regional bush meat was highest (0.84) across protected areas *(Table 1).*

Table 1. *Threat factors that operate against biodiversity in Kenya's protected areas, their perceived threat index and Prevalence.*

Threat Factor identified by protected area officers	Mean threat factor score (Mean ± SE)	Relative Threat Factor Severity Index (RTFSI)
Illegal killing of wildlife for their bush meat for the local or regional markets	4.20 ± 0.12	0.84
Large mammal poaching for international commercial purposes	3.70 ± 0.20	0.74
Direct and indirect danger to biodiversity arising from the nature and intensity of human – wildlife conflicts	3.40 ± 0.17	0.68
Loss, conversion and degradation of wildlife migration and dispersal corridors important for the protected area	3.34 ± 0.19	0.67
Human encroachment in terms of their densities and distribution around protected areas	3.26 ± 0.21	0.65
Unsustainable use, demand and exploitation of natural resources (e.g. water, plant resources and minerals) by local communities surrounding protected area	2.94 ± 0.24	0.59
Recent agricultural expansion and other incompatible land use changes to biodiversity requirements	2.60 ± 0.22	0.52
Pollutants from external sources of a protected area that harm biodiversity directly or indirectly	1.84 ± 0.21	0.37
Negative and persistent tourism impacts to the welfare of biodiversity and their habitats	1.66 ± 0.20	0.33
Fencing of a protected area entirely or in part by certain form of fencing materials	1.44 ± 0.17	0.29
Mean value (± SE)	2.84 ± 0.09	0.57 ± 0.06

Killing of wildlife for their trophies for international commercial trade (poaching) had a threat index of 0.74, followed by negative consequences of human – wildlife conflicts that had a threat index of 0.68. The loss, conversion and degradation of migration corridors and dispersal area had a threat index of 0.67, while human density

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and encroachment had a threat index of 0.65. Unsustainable use, demand and exploitation of other natural resources had a threat index of 0.59 while recent agriculture expansion and other land uses had a threat index of 0.52. Other threats had a threat index less than 0.5 across protected areas *(Table 1).*

A majority of Kenya's protected areas were highly susceptible to most of the ten threat factors identified. Thirty-two (64% of protected areas in Kenya) were susceptible to over half of the identified threat factors. Twenty-seven (54% of the protected areas) were susceptible to over 60% of threat factor types. Sixteen (32% of the protected areas) were susceptible to over 70% of the threat factor types, and three (6% of protected areas) were susceptible to over 80% of the threat factor types. The protected areas most susceptible to the majority of the threat factors were Maasai – Mara National Reserve, Ndeere Island National Park, Lake Nakuru National Park, Aberdares National Park, Mount Elgon National Park, Kiunga Marine Park, Mt. Kenya National Park, Mombasa Marine Park, Watamu Marine Park, Ruma National Park, Kisite - Mpunguti Marine Park, Malindi Marine Park, Mwea National Reserve, Kamnarok National Reserve, Rimoi National Reserve, and Nairobi National Park *(Table 2).*

Table 2. *Kenya's protected areas and the major threat factors against biodiversity in and around them with Vulnerability Index (PAVI)*

Protected Area	Protected Area Relative Threatened Index, PARTI (rank)	Predominant ecosystem type	Adjacent predominant land use
Masai-Mara National Reserve	0.88 (1)	Savanna rangelands	Traditional pastoralism and Agriculture
Ndeere Island National Park	0.78 (2)	Inland wetland	Urban and Industrial
Lake Nakuru National Park	0.72 (4)	Inland wetland	Urban, Industrial and Agriculture
Aberdare National Park	0.74 (3)	Montane / Forested	Agriculture
Mt. Elgon National Park	0.66 (13)	Montane / Forested	Agriculture and Traditional pastoralism
Kiunga Marine	0.72 (4)	Marine	Urban and Industrial
Mt. Kenya National Park	0.68 (11)	Montane / Forested	Agriculture
Mombasa Marine	0.72 (4)	Marine	Urban and Industrial
Watamu Marine	0.72 (4)	Marine	Urban and Industrial
Ruma National Park	0.72 (4)	Savanna rangelands	Agriculture
Kisite-Mpunguti Marine	0.72 (4)	Marine	Urban and Industrial
Malindi Marine	0.72 (4)	Marine	Urban and Industrial
Mwea National Park	0.66 (13)	Savanna rangelands	Agriculture
Kamnarok National Reserve	0.62 (16)	Savanna rangelands	Agriculture
Rimoi National Reserve	0.62 (16)	Savanna rangelands	Agriculture
Nairobi N. Park	0.62 (16)	Savanna rangelands	Urban, Industrial and Traditional pastoralism
Tana River Primate National Reserve	0.62 (16)	Forested	Agriculture and Traditional pastoralism
Ngai Ndeithya National Reserve	0.68 (11)	Savanna rangelands	Agriculture
Saiwa Swamp National Park	0.64 (15)	Inland wetland	Agriculture
Kakamega Forest National Park	0.60 (21)	Forested	Agriculture
Oldonyo-Sabuk National Park	0.56 (30)	Savanna rangelands	Traditional pastoralism and Agriculture
Shimba Hills National Park	0.62 (16)	Forested	Agriculture

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Protected Area	Protected Area Relative Threatened Index, PARTI (rank)	Predominant ecosystem type	Adjacent predominant land use
Amboseli National Park	0.52 (22)	Savanna rangelands	Traditional pastoralism and Agriculture
Tsavo-West National Park	0.58 (22)	Savanna rangelands	Traditional pastoralism / ranching and Agriculture
Nasalot National Reserve	0.58 (22)	Savanna rangelands	Traditional pastoralism
Chyulu National Park	0.58 (22)	Savanna rangelands	Traditional pastoralism and Agriculture
South Turkana National Reserve	0.58 (22)	Savanna rangelands	Traditional pastoralism
Arabuko-Sokoke National Park	0.56 (30)	Forested	Agriculture
Tsavo-East National Park	0.58 (22)	Savanna rangelands	Traditional pastoralism / ranching and Agriculture
South Kitui National Reserve	0.58 (22)	Savanna rangelands	Agriculture
Hell's Gate National Reserve	0.52 (32)	Savanna rangelands	Agriculture and Traditional Pastoralism
Lake Bogoria National Reserve	0.58 (22)	Inland wetland	Traditional pastoralism
Sibiloi National Park	0.46 (38)	Savanna rangelands	Traditional pastoralism
Marsabit National Reserve	0.44 (39)	Savanna rangelands	Traditional pastoralism
Losai National Reserve	0.44 (39)	Savanna rangelands	Traditional pastoralism
Bisanandi National Reserve	0.50 (33)	Savanna rangelands	Agriculture and Traditional pastoralism
North Kitui National Reserve	0.50 (33)	Savanna rangelands	Agriculture
Kora National Park	0.50 (33)	Savanna rangelands	Traditional pastoralism
Rahole National Reserve	0.50 (33)	Savanna rangelands	Traditional pastoralism
Meru National Park	0.50 (33)	Savanna rangelands	Agriculture and Pastoralism
Samburu National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Shaba National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Buffalo Springs National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Malkamari National Park	0.42 (41)	Savanna rangelands	Traditional pastoralism
South Island National Park	0.38(48)	Inland wetland	Traditional pastoralism
Central Island National Park	0.38 (48)	Inland wetland	Traditional pastoralism
Arawale National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Boni National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Dondori National Reserve	0.40 (42)	Savanna rangelands	Traditional pastoralism
Mt. Longonot National Park	0.38 (48)	Savanna rangelands	Traditional pastoralism and Agriculture

Thirty-seven (74%) of protected areas in Kenya had a relative threatened index of 0.5 and above. Twenty-one (42% of the protected areas) had a threat index of over 0.6, while ten (20% of the protected areas) has a threat index of over 0.70. The ranks of protected areas, in terms of susceptibility index, were different (paired Wilcoxon Signed Rank test, $T = 2.25$; $n = 50$; $p = 0.025$) from their ranks based on the threatened index. The fifteen most threatened protected areas in Kenya were: Masai – Mara National Reserve, Ndeere Island National Park, Aberdares National Park, Lake Nakuru National Park, Kiunga Marine, Mombasa Marine, Watamu Marine, Ruma National Park, Kisite –

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Mpunguti National Park, Malindi Marine, Mt. Kenya National Park, Ngai Ndeithya National Reserve, Mt. Elgon National Park, Mwea National Park and Saiwa Swamp National Park *(Table 2).*

All (100%) marine protected areas in the country were very susceptible and threatened by the threat factors (with both PASI and PARTI of over 0.7). Another group of highly susceptible and threatened protected areas were the natural / montane forests, with all of them (100%) having a susceptibility index of over 50%. Three of them (Aberdares, Mt. Elgon and Mt. Kenya, 43% of protected natural forests) were highly susceptible (with a PASI of over 0.7 and PARTI of over 0.65), while two more (Kakamega and Shimba Hills) natural forests (bringing to about 75% of protected natural forests) were also susceptible and threatened (with both PASI and PARTI of over 0.6). Only two protected forest ecosystems (Chyulu Hills National Park and Arabuko – Sokoke) had a susceptibility and threat index of less than 0.6. Of the twenty protected areas with a high ranking as tourist destinations (Okello *et al.* 2001), a majority of them were highly susceptible and threatened by the factors. Eighty percent (80%) of the top twenty protected areas for tourism were both susceptible and threatened (both PASI and PARTI of over 0.5), with half of them (50%) having susceptible and threat indices both of over 0.6.

The susceptibility to threat factors (PASI) differed (Kruskal – Wallis, KW = 11.92, p = 0.0077) among protected areas classified as Savanna Rangelands (0.49 ± 0.03), Inland Wetlands (0.60± 0.09), Forested and Montane Ecosystems (0.63 ± 0.03), and Marine Ecosystems (0.70 ± 0.01). Significant differences in susceptibility occurred only between Marine Ecosystem and Savanna Rangelands (from Box – and – whisker graphical distribution). Susceptibility to threat factors (PASI) among protected areas surrounded by urban / industrial areas (0.73 ± 0.02), agriculture (0.59 ± 0.03), and pastoralism (0.42 ± 0.03) land use practices differed (K-W= 24.07, $p < 0.001$). The protected areas surrounded by these land use practices were all significantly different from each other.

The severity of threat factors (PARTI) differed (K-W = 15.68, p = 0.0013) among protected areas classified as Savanna Rangelands (0.52 ± 0.02), Inland Wetlands (0.60± 0.07), Forested and Montane Ecosystems (0.64 ± 0.02), and Marine Ecosystems (0.72 ± 0.01). This difference was between Marine Ecosystem and Savanna Rangelands, but others had similar threatened index. Relative Threatened Index among protected areas surrounded by urban / industrial areas (0.72 ± 0.02), agriculture (0.61 ± 0.02), and pastoralism (0.47 ± 0.02) land use practices differed (KW = 28.0029, $p < 0.001$). The protected areas surrounded by these different land use practices were all significantly different from each other.

There was a positive and significant correlation between the protected area threatened index (PARTI) with the following threat factors: Human encroachment ($r = 0.90$, $p < 0.001$), agriculture expansion and other land use changes ($r = 0.75$, $p < 0.001$), unsustainable over - utilization of other protected area resources ($r = 0.73$, $p < 0.001$), discharge of pollutants from external sources into the protected area ($r = 0.59$, $p < 0.0001$), negative impacts of tourism ($r = 0.46$, $p = 0.012$), negative effects of fencing to wildlife movements and ranging ($r = 0.38$, $p = 0.0084$), and presence of human – wildlife conflicts ($r = 0.28$, $p < 0.0049$). Prediction of protected area relative threatened index had its important predictors as Human encroachment (explaining the majority of variability in the threat index of 75.73%), followed by unsustainable over-utilization of resources (9.01%) and human wildlife conflicts (4.94%).

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Discussion

Even though the ten threat factors are identified, findings identify human encroachment and threats directly related to actual killing of wildlife (bush meat, trophy poaching, and human – wildlife conflicts) as the main threats while those indirectly affecting them through habitat conversions and harassment are relatively less serious. This means that even though most protected areas are susceptible to all of the threats, dealing with human encroachment around protected areas and dealing decisively with poaching (for bush meat trade and commercial trophies) would secure most protected areas. Controlling human encroachment and associated activities is a difficulty endeavour (Osemeobo, 1993), yet critical in avoiding insularization of protected areas in Kenya (Western & Ssemakula 1981). Further, human – wildlife conflicts which is a function of human population increase and encroachment to protected areas, arises from conflicts between human and wildlife needs. Incidences of these conflicts are now considered the biggest threat to protected areas in Kenya (KWS, 1994). Any action such as controlling problem animals as well as reconsidering compensation to property as well as increasing compensation amounts would reduce negative attitudes to protected areas (Sindiga 1995, Seno & Shaw 2001).

The findings that a majority of Kenya's protected areas are threatened by a majority of threat types implies that conservation in the country is more at crisis than previously thought. The ever-increasing land demand in the country due to the increasing human population in rural areas, and especially in marginal arid and semi - arid lands, has put more pressure on biodiversity and protected areas. The list of protected areas most susceptible is important in focusing conservation action. Mismanagement of funds that could be used for conservation, changing land uses and human encroachment, and uncontrollable off – road driving are some specific issues the Mara needs to address in order to survive. Lake Nakuru is dealing with pollution from Nakuru town, shrinking lake due to negative land use changes catchments of the rivers that drain into it, as well as ecological changes within the park as a result of insularization by the town and electric fencing. These need to be addressed to save this ornithological world heritage site. Most forest and montane parks are critical water catchments areas and sources of most important rivers (Tana and Athi) but illegal logging, forest cultivation and poaching of plant and large mammal resources are threatening their status as biodiversity areas.

These few examples illustrate the importance of these findings in that they can be used to identify specific problems ailing each conservation area in a prioritized manner and deal with them on individual basis based on their severity indices (such number of snares, illegal poachers arrested, and cases of human - wildlife conflicts) or relative threat factor severity index (RTFSI). It is critical for any conservation agency to have structured and focused priorities for its protected areas. We therefore recommend that most of management actions should be based on actual measurement of threat indices or a reliable index such as RTFSI in addressing specific threat factors. Further prioritization of parks most affected should be done based on a threatened status using indices such as PARTI, rather than on susceptibility which is simply a catalogue of threats recorded without considering its magnitude or severity. From our findings, the tourism industry, often times strongly accused to have negative impacts on biodiversity in protected areas seemed to be a less important threat factor. This is possibly because only 32 % of Kenya's protected areas have a meaningful tourism potential, and only 24% of them have achieved or exceeded this potential (Okello *et al.*, 2001). Tourism is

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low in most of Kenya's protected areas, but is concentrated heavily in a few of them, which are accessible and are endowed with tourist facilities and large mammal diversity. However, the potential of negative tourism impacts as a threat factor was identified by its significant correlation with the threat index of protected areas and the fact that a majority of popular tourist destination protected areas seems to rank highly as threatened and susceptible protected areas in Kenya. As tourism activities have revealed in Maasai Mara and Amboseli, luck of active management of negative tourism impacts can pose immediate and severe threats to a protected area (Smith, 1999). It is therefore important to reduce the negative impacts of tourism by managing tourist behaviour and impacts of tourist facilities such as lodges and campsites. Diversifying tourism attractions to target cultural, physical features, historical and archaeological sites (and not only wildlife –based) attractions can help reduce pressure on protected areas (Okello *et al.* in press). The use gate fee adjustments periodically to target few but high paying tourists in order to limit tourist traffic would be a worthwhile idea. Small and over sold popular protected areas such as Amboseli, Nairobi, Nakuru, and Maasai Mara could benefit from these strategies. When tourism activities are high, with a high number of lodges and related activities, with diminishing migratory routes and dispersal areas for wildlife, the cumulative effects on biodiversity conservation become more pronounced and serious, especially in relatively small – sized protected areas (Johnstone, 2000). This is the dilemma facing Amboseli, Nairobi and Lake Nakuru National Parks where ecosystems are not large enough to cushion the impacts of multiple threats to their biodiversity and viability as conservation units. Therefore controlling tourism impacts is another critical step in maintaining ecosystem and biodiversity integrity of Kenya's protected areas.

Management actions can effectively deal with threats if it also focuses mainly (but not entirely) on protected areas that are highly threatened. Results suggest that one of the most threatened protected areas is natural forests and mountainous ecosystems. Natural forests and mountainous protected areas are critical for ecological services (such as air purification, water catchments, reservoir for biodiversity resources) but are now increasingly becoming endangered ecosystems. They have faced numerous excisions in the recent times for mundane purposes such as resetting the landless people, and for rural based agriculture (Rodgers, 1997). Further, they are getting degraded through a variety of land uses such as livestock grazing, deforestation and charcoal burning. The net result has been serious threat to biodiversity and wildlife habitats, ecosystem degradation and loss of ecological services (such as water availability). Conservation authorities and the government have a responsibility to conserve and protect the country's ecosystems and associated biodiversity as both a national service and contribution to global biodiversity conservation. Laxity however is compromising the Kenyan government's achievements on this (Chapman & Chapman, 1996; Rodgers, 1997).

Similarly, wetlands are also endangered ecosystems in Kenya and are in danger of being converted, drained and lost together with their biodiversity and ecological services (Cooper 1996). These ecosystems need focused attention to prevent biodiversity loss. An important initial step is to stop further land excisions of forests and wetlands for alternative land uses by enlisting the cooperation of local communities around them. Next is to outlaw any activities in these ecosystems that impact negatively on biodiversity (such as over – exploitation by the timber industry, charcoal burning, shifting cultivation, drainage and conversion of swamps for horticultural production or

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over – extraction of water resources from swamps and rivers feeding them). Appropriate legislation may be in place, but putting in place competent and efficient institutions to manage and enforce the laws is lacking. Non – governmental organizations can help to create awareness about the status of Kenya's natural resources, disseminate information, and educate rural communities on environmental ethics and conservation. This should be supplemented with a cohesive non – governmental and professional advocacy network in environmental conservation that will establish checks and balances on mismanagement of natural resources and install responsible custodianship.

One of the striking finding of this study is the fact that all marine protected areas in Kenya are threatened and highly susceptible to threat factor types. Marine protected areas face a multiplicity of threat factors. The coast is one of the hubs of tourism activities in Kenya. The sunny beaches and high class international hotels makes it a tourism heaven only comparable to Costa Rica, the Caribbean islands and Australia. Tourists dive and snorkel close to the ocean floor and enjoy observing the diversity in coral reef and marine life. But most of this marine biodiversity is very fragile and sensitive to human impacts (McClanahan, 1996). Special nesting sites for endangered species like turtles are some of the key and sensitive habitats, which could do with less tourist numbers. Estuaries and river entry points in the sea are silted as deforestation of riverine vegetation along major rivers (such as Tana and Galana) upstream becomes increasingly severe. Such rivers are also loaded with domestic and industrial pollutants from local and upstream sources that eventually get discharged into the ocean.

Another threat facing marine protected areas is pollution (sewage and litter discharges) from lodges and hotels, and over – crowding along beaches. A ring of tourist lodges and hotels and associated high human traffic to marine protected areas is a threat to marine biodiversity. Many of the protected areas are subject to disasters of the high seas such as pollution from ocean sea liners and accidental spillage of oil and petroleum products, including biological disasters such as proliferation of sea algae and micro – organisms that are fatal to fish and other marine biodiversity (McClanahan, 1996). These pollutants are washed ashore and often into marine protected areas. Collection and sale of marine biodiversity and products (such as cowry shells) is also a major threat to marine biodiversity conservation. Since many tourist towns (such as Mombasa, Lamu and Malindi) have historical and archaeological sites, business investment has been high and supports many workers and visitors. These businesses (such as tourism related industries) threaten coastal biodiversity because of associated negative impacts. Marine protected areas in Kenya are therefore faced by threats of a multiple nature and sources (from inland and sea sources, and urban communities along the beaches). A solution must be multi – faceted, targeting many sources of impacts and involving all the stakeholders.

It worthy noting that the less threatened protected areas are in arid and semi – arid parts of the country and surrounded by pastoralists whose population is relatively sparse and low. Pastoralism as a land use is more compatible with wildlife conservation compared to heavily settled areas that have both intensive subsistence and commercial agriculture, or urban centers of high industrial and human activities. Nevertheless, protected areas surrounded by pastoralists are not entirely free from threat as pastoral tribes (such as the Maasai, Samburu, Turkana) are having an influx of immigrants from other Kenyan tribes, and also their own population growth rate is increasing. These pastoral communities are also embracing previously foreign land use types such as agriculture. Where livestock and human numbers are high, then human – wildlife

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conflicts and environmental degradation becomes a concern, as has been the case among the Maasai of Tsavo – Amboseli ecosystem. Protected areas, when surrounded by agricultural activities and urban centers, become more threatened as human – wildlife conflicts intensify and wildlife dispersal areas and habitats become lost, converted or degraded (Okello & Kiringe 2004, KWS 1994). In Northern and North – Eastern provinces of Kenya, insecurity and remoteness makes conservation of biodiversity in that area difficulty and hence uncertain.

No control of prevalence and impact of threats to protected areas will succeed if the local communities are not socio-economically empowered and resource management policies made to include their needs and aspirations. If they do not benefit, are marginalized and are not compensated for opportunity costs and harm incurred as a result of resource conservation, then threat to biodiversity may be carried to the ultimate conclusion; extinction of species. In Kenya particularly, wildlife conservation must provide controlled and monitored user rights where tourism is non – existent for wildlife to be a credible land use in communal wildlife dispersal areas outside protected areas. Where tourism is well developed, local people need to be empowered to benefit directly from it rather than made to accept monetary tokens and hand – outs.

Lack of involvement of local communities in wildlife conservation as well as providing them economic interest in resource conservation will be reason for their continued indifference to poaching and bush meat trade, or concern for the plight of wildlife migration corridors and dispersal areas (Sarkar, 1999). On a national scale, it may be useful to formulate the a national land use plan to spell out the appropriate regional land use practices that will be compatible with the socio - economic potentials, resource base, ecological and climatic constraints within the country. Kenya is just in the processes of formulating such policies that have been lacking in the country.

A proactive strategy is needed, but must begin with identifying the threat factors as done by Okello & Kiringe (2004), formulating indices of levels and magnitude of threat (as done in this study) and then move finally into field sampling of appropriate indicators of each threat in each protected areas to quantify actual severity of threats. In this respect, this study builds on work done by Okello & Kiringe (2004) in providing information on relative threat severity and providing a ranking of Kenya's protected areas in terms of relative severity of threat. These two contributions can already help focus management actions in addressing each threat in each protected area, as well as prioritizing which protected areas need immediate attention. However, the final step is to take each protected areas and quantify levels of threat such as surrounding human density and related park encroachment issues, poaching incidences, density of snares, economic value of human crops and property destroyed, wildlife speared or poisoned by local communities around most threatened protected areas.

It is also our opinion that future protected areas should not be based blindly on the Yellowstone model, but on other alternative models that involve and enlist community support such as anthropological reserve or protected landscape model (MacKinnon *et al.,* 1986; Beresford & Phillips, 2000).

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The protected area losses reflect in part their poor coverage of seasonal ungulate migrations. The losses vary among parks.Â Research priorities have focused on charismatic species and the most urgent conservation threats.Â We also compare the importance of Kenya's protected area system relative to country-wide wildlife numbers and trends. Wildlife audits of the rangelands have been conducted by the government's Department of Remote Sensing and Resource Surveys (DRSRS) since 1977.Â The large fluctuations outside protected areas is likely due to their greater proportion of wet season range than parks and their more episodic use, especially with increasing settlement [27].