The impact of climate variability on the ecology of a lion (Panthera leo Linnaeus 1758) population and lion livestock conflicts in the Amboseli ecosystem – Kenya

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Local Knowledge and Attitudes towards Livestock Predation by Large Carnivores in the Amboseli Ecosystem (Southern Kenya)

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Abstract

Our paper assesses if a severe drought that occurred in 2009 had any the impact on large carnivore livestock predation trends. We also studied the local knowledge of local communities (Maasai pastoralist) about large carnivores and how that influences the attititude towards them in residents of two communal group ranches of Olgulului/Oloolarash and Kimana, situated adjacent to Amboseli National Park, Kenya. We conducted interviews with the heads of 294 households in 2011. This was done while the effects of the drought were still fresh in the peoples mind, in order to assess their knowledge and attitudes in relation to large carnivores and factors that influenced predation levels. We used large-carnivore-livestock predation incident reports around Amboseli over a period of five years data, thus covering the period before/during (2008-2009) and the post-drought period (2010-2012), to quantify livestock predation trends. We also assessed if there was any relationship between rainfall variability, wild herbivore abundance and livestock predation trends.

We found that the 2009 drought was so severe and it had painful memories among the pastoralists in the Amboseli ecosystem. Livestock and wild herbivores in the region were severely affected too, which led to 75% of the wildebeest population and 60% of the zebra population perishing as a result of the drought.

Some 34.7% of respondents suggested that lions caused most problems, while 50.7% suggested that the spotted hyena caused most problems, in terms of loss of livestock. The fact that lions are less perceived as causing problems can be explained by the compensation scheme that reduced losses related to predation. We found that there was an increase in carnivore predation and risk of repeated attacks when a livestock carcass was taken for human consumption after a kill.

Livestock predation predation was very high, with 4553 head of livestock killed over a five-year period, 2008-2012. In total, 3497 of the kills consisted of sheep and goats, 742 of cattle and 295 of donkeys. Livestock predation incidences for both the periods before and after the drought were higher during the wet season except during the drought year (2009). We also found that herbivore abundance within the park had a significant effect on livestock predation trends. Livestock predation increased exponentially during and after the drought, when wild herbivore abundance was low.

5.1 Introduction

Protected areas in Africa are important for the conservation of biodiversity. In spite of the presence of a protected area network, many of these areas have experienced a decline in large carnivore species (Weber & Rabinowitz, 1996; Geldmanna et al., 2013). During the last decades, natural resource management policies have changed dramatically from a pure preservationist model or a "fences and fines" approach, to more decentralized approaches (Gibson & Marks, 1995; Hulme & Murphree, 2001; Songorwa, 1999). Brüner et al. (2001) suggested that direct benefits for local communities would contribute to biodiversity conservation in national parks. Benefit sharing has been a popular strategy designed to offset conservation costs and motivate local people to support conservation (Archabald & Naughton-Treves, 2002; Brockington, 2006). This is done by aligning communities with conservation goals through the benefits they receive from the protected areas, which can be provided as a share of the park fees or in kind (Borrini-Feyerabend et al., 2012; Gibson & Marks, 1995; Hulme & Murphree, 2001; Brockington et al., 2006; Newmark & Hough, 2000). Several approaches are used, therefore, with the intention of creating good relationships by influencing local peoples' attitudes and perceptions to engender support for biodiversity conservation. Large carnivores, humans and their livestock have coexisted for millennia, but recent decades have seen dramatic increase in the frequency of human-carnivore conflict. The exponential increase in the human population and an expansion of the use of natural resources, which has resulted in encroachment on the habitats of large carnivores (Woodroffe, 2000; Treves & Karanth, 2003). Although habitat conversion, declining natural prey populations, and commercial exploitation have contributed to carnivore losses, active persecution and retaliatory killing by humans, based on real or perceived threats to themselves and their livestock, appears to be the most important factor in observed declines (Woodroffe, 2001). For example, many large carnivores tend to move beyond the boundaries of protected areas, triggering conflicts with people (Gusset et

al., 2009; Patterson et al., 2004). These conflicts are a major source of mortality for large carnivores (Woodroffe & Ginsberg, 1998; Woodroffe, 2000). Retaliatory killing of carnivores occurs in many cases, in community areas surrounding protected areas, which have become population sinks, especially for species with a large range home range in relation to the size of the protected areas (Marker et al., 2008; Woodroffe & Ginsberg, 1998).

Protected areas are becoming the last refuge for many large African predators, all of which have experienced significant declines in recent times (Riggio et al., 2013; Woodroffe & Ginsberg, 1998; Linnell et al., 2001; Woodroffe, 2000). It is widely understood that even within protected areas, humans often remain the main source of mortality for large carnivores (Woodroffe and Ginsberg, 1998). The situation is rather serious in smaller protected areas surrounded by dense human populations (Brashares et al., 2001; Parks & Harcourt, 2002). In this context, the unprotected buffer zones become an important part of predator home ranges, and variations in habitat quality of the surroundings of a protected area could affect the dynamics of populations (Tuqa et al., 2014). Few of Africa's existing reserves are large enough to maintain viable populations of wide-ranging predators. Therefore conservation of large carnivores depends on networks of smaller reserves and private and communal lands. In these areas successful conservation is closely linked to the ability of people to resolve human-carnivore conflicts and minimize numbers of carnivores killed by people (Brashares et al., 2001; Woodroffe, 2001). Therefore park managers, biologists and indigenous people should coordinate efforts to understand the circumstances surrounding carnivore – livestock conflict. They should combine empirical data with local experience to define appropriate solutions (Tumenta et al., 2013; Treves & Karanth, 2003). Although much work has been done on large carnivore-livestock predation and mitigation thereof, there has been limited research on the role of climate variability and severe droughts on trends in carnivore-livestock predation over a period of several years.

Our study focused on livestock predation trends in the group ranches surounding Amboseli NP over a period of five years (2008-2012) before, during and after a severe drought in 2009. We covered seasonal patterns of predation, spatial distribution of predators, relationship between predation and wild prey abundance and finally we looked at community attitudes and local knowledge. The results of our research will be used by Amboseli NP management to develop large carnivore management strategies and conflict-mitigation measures within the Amboseli ecosystem.

5.2 Study area: the Amboseli Ecosystem

The Amboseli ecosystem covers approximately 6,000 km^2 and is situated across the border of Kenya and Tanzania (Figure 5.1). The area is generally arid to semi-arid with an average rainfall of 340 mm per annum (Moss et al., 2011). The ecosystem is more suitable for pastoralism and conservation of wildlife and tourism enterprises than for crop farming (Moss et al., 2011). Administratively, the Amboseli ecosystem consists of Amboseli National Park (Amboseli NP) (392 km^2) and the surrounding six group ranches, namely; Kimana/Tikondo, Olgulului/Olararashi (North, East, South and West), Selenkei, Mbirikani, Kuku, and Rombo. These group ranches cover an area of 5,063 km^2 in Kajiado County (Figure 5.1). It also includes the former 48 individual ranches located in the foothills of Kilimanjaro, which are now under rain-fed crop production and no longer utilized by wildlife. All six Group Ranches are owned by Maasai communities who have been pastoralists and relied primarily on cattle, goats and sheep for their livelihood. Much of the landscape is arid and semi-arid and rainfall is scarce and unpredictable. Under these conditions livestock herding is an efficient form of land use.

Livestock for beef production is the dominant socio-cultural and economic activity in this ecosystem and centers around cattle, goat and sheep. This is at both subsistence and commercial level. Crop farming is becoming an economic activity in the dispersal area, particularly in the eastern part of ANP, where irrigated agriculture is practiced along the swamps and rivers. Very limited commercial agriculture takes place along the slopes of the Kilimanjaro (Campbella et al., 2000). Some members of the local Maasai community are changing their lifestyles from nomadic pastoralism to sedentary subsistence and mixed farming. The diversity of the ecosystems enables the utilization of a wide variety of natural resources. The major activities are related to the area's geographical location or geological characteristics.

In the Amboseli ecosystem, prey dispersal and abundance is subject to rainfall (Western & Nightingale, 2005; Altman, et al., 2002). For the migratory grazing species, such as zebra and wildebeest, the distribution and densities differ during the dry and the wet season. In the dry season, both species concentrate inside the park and densities are high, while there is a much wider dispersal and overall lower densities during the wet season. This implies a lower availability of the preferred prey species during the wet season.

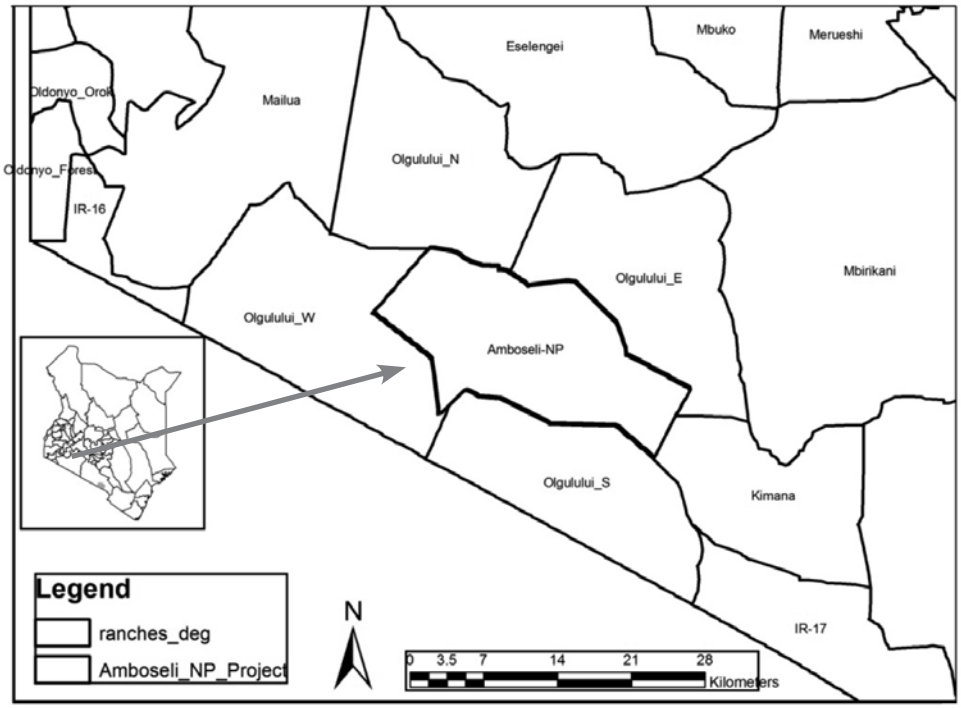


Figure 5.1
Amboseli National Park and surrounding group ranches which together form Amboseli ecosystem.

5.3 Methods

5.3.1 Assessment of livestock predation trends

All incidences of human-carnivore conflict (attack of large carnivores on livestock) occurring in the two group ranches, adjacent to Amboseli NP, Olgulului and Kimana were investigated jointly and separately this researcher, by the Kenya Wildlife Service (KWS) problem-animal control unit and staff of the Ogulului predator compensation scheme. All data on carnivore-livestock predation were entered in the KWS patrol register and occurrence Book (OB) for future reference. The following details were recorded; date and time of occurrence, livestock owner, Place name/GPS coordinates, livestock type(s) and age, predator species involved. Because Olgulului is very large, it has been sub-divided into four administrative zones (Olgulului North, Olgulului West, Olgului South and Olgulului East); conflict data were collected and analysed for each zone.

5.3.2 Wild herbivore abundance measure

The general trend of prey abundance within the park and neighbouring group ranches was established using distance measured in meters (Bushnell Yardage Pro Trophy Rangefinder) during the transect counts. The exact distance of the herbivores was determined within the distance of 500 meter. We conducted 60 annual and seasonal transect prey counts , to determine the distribution and density of potential lion prey. Five transects (2 × 1 km) along a park track (500 m on each side) were semi-randomly selected to cover a number of habitats, to include short and tall grasslands, alkaline plains, *Acacia* woodlands, Phoenix mixed woodlands and freshwater Papyrus swamps (Moss, 2011). The transects covered a total of 10 km^2, which were representative for the rest of the park (396 km^2).

These transect counts were conducted once every week, when possible at the same time, alternating between 08:00-10:00 and 16:00-18:00 hours, both during the wet and dry season. These times were chosen so that animals seeking shade during the warmer periods of the day were not overlooked. All herbivores larger than ~5 kg were recorded. Additional data included numbers of neonates within the group, habitat type, and weather and grass conditions. Complementary data from counts conducted by the KWS and previous studies were added to assess the size of the wild prey population and how this changed over previous years. Transect counts were used to classify prey species in weight/size groups to estimate the available biomass of prey species in the national park.

We also used ANP data from aerial and ground wildlife censuses which were carried out twice each year, in the wet and dry seasons. The aerial counts are done for the whole ecosystem while the ground total count was done within ANP. We used these data along with transect counts to evaluate animal seasonal abundance.

5.3.3 Survey on attitudes

We conducted semi-structured interviews with a total of 294 respondents in the two group ranches surrounding Amboseli NP during 2011. The information we gathered, mostly from heads of households, was to assess local community attitudes, knowledge and practices in relation to wildlife conflict, drought and the impact of the predator consolation scheme.

The target population of this study consisted of all households in Kimana/Tikondo and Olgulului group ranches. We considered the head of the household as the unit of analysis. Deliberate sampling was used to draw the sample of 294 households in total, based on place of residence. Only adult men and women, ranging in age from 18 to 68 years, were selected to participate as they traditionally make the livestock, pasture - and social decisions. The respondents were 85.4% men and 14.6% female.

5.3.4 Methods of data collection

The semi-structured interviews were conducted with the help of a local research assistant and translator fluent in the local language. The interviews were either conducted in English or in the traditional Maa language, depending on the participant's preference and comfort level. Supplementary sources of data included in-depth discussions with key informants, direct observations, and participation in local meetings with community members and local non-governmental conservation organizations.

5.3.5 Data analysis

Data collected were statistically summarized and presented using frequency tables in Excel and charts in Word. For the descriptive data, descriptive statistics were used for analysis utilizing frequency distributions, percentages and mean scores.

Data involving livestock losses, characteristics of attacks and attitudes were summarized using SPSS, IBM 2.0 proportions. Normal distribution was checked with a Shapiro-Wilkes test. Relationships between ecological variables and monthly attack frequencies were investigated using Pearson's χ^2 non-parametric test. To identify whether large carnivore spatial and temporal predation patterns were associated with rainfall, settlement patterns (Maasai Boma) or prey abundance. For association between spatial predation patterns and seasonality we used monthly rainfall index to classify rainfall into wet-month and dry-month categories. The months of May–October was classified as dry months while November – April was wet months. All tests were considered statistically significant at $P< 0.05$. Finaly we applied principal component analys to get derterminant factors.

5.4 Results

5.4.1 Part I: Seasonal incidence of livestock and the influence of severe drought on livestock attacks

We found significant differences when we compared the number of livestock attacks per predator species, during the year before the drought (2008), the drought year (2009), the year immediately after drought (2010), the recovery year (2011) and the post-recovery year (2012) (Pearson χ^2 (16) = 796.1733, P< = 0.000; Table 5.2). Livestock predation was significantly higher during the severe drought than in other years for lion, spotted hyena, cheetah and jackal, with a total of 1543 livestock kills in 2009. The year before the drought (2008) and the post recovery year (2012) experienced lower predation incidence.

Table 5.2
Annual predation trends before/during the drought (2008-2009) and after the drought (2010-2012) and as per predator species.

Carnivore species	Before drought (2008)	During drought (2009)	Immediately after drought (2010)	Recovery after drought (2011)	Post recovery after drought (2012)	Total
Lion	32	91	243	134	125	625
Cheetah	37	240	122	145	125	669
Hyena	204	1014	337	426	348	2329
Jackal	98	176	137	221	172	804
Leopard	68	22	7	3	0	100
Total	439	1543	845	929	770	4526

All predator species had the highest livestock predation rates during the drought and lower predation rates during post-recovery and before the drought period, except for lions which had low predation rates during the drought (Table 5.2). The data showed the highest predation rates for lions during the period immediately after drought (2010) but also showed lower predation rates during the post recovery year (2011-2012) and before the drought period (2008).

There was a significant seasonal difference in predator species on livestock (Pearson χ^2 (4) = 51.2001, P< 0.000) for dry and wet season. Livestock pre-

dation was higher during dry season for all large carnivores except for lion and leopard (Table 5.3).

Table 5.3
Seasonal livestock predation incidences by large carnivores around Amboseli NP

Season	Cheetah	Hyena	Jackal	Leopard	Lion	Total
Dry season	358	1336	525	47	299	2565
Wet Season	311	993	279	53	326	1962
Total	669	2329	804	100	625	4527

Influence *of drought on specific livestock predation in relation to wild prey* abundance *and rainfall*

The numbers of livestock species killed by the various large carnivores in the years 2008-2012 are indicated in (Figure 5.2).

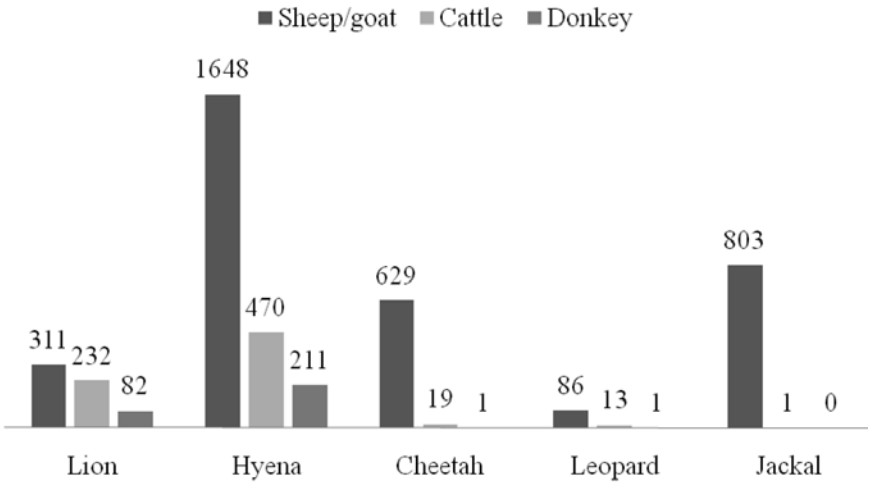
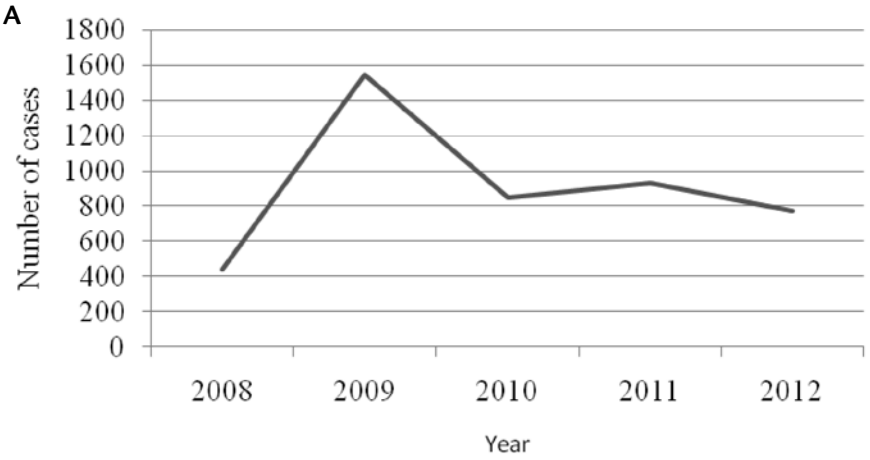
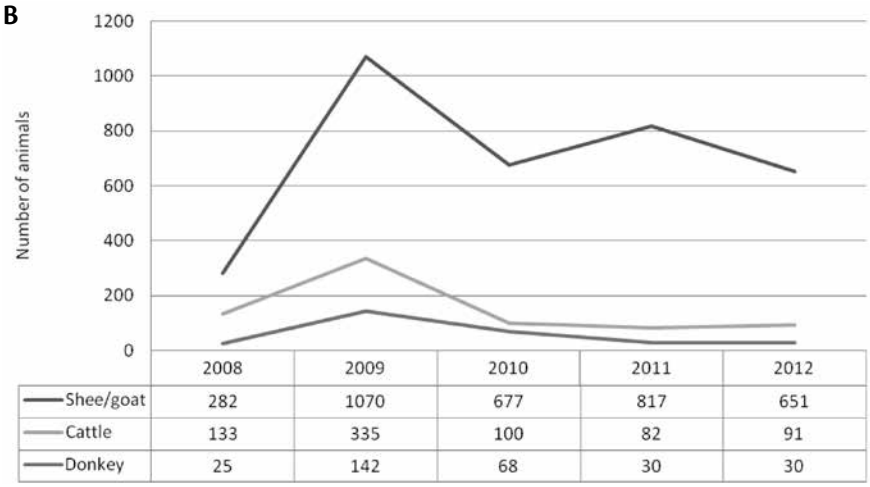


Figure 5.2
Livestock species killed by specific large carnivore species

A comparison was made of all the livestock killed by predators per year (Figure 5.3).





	2008	2009	2010	2011	2012
Shee/goat	282	1070	677	817	651
Cattle	133	335	100	82	91
Donkey	25	142	68	30	30

Figure 5.3
Actual number of livestock species killed by large carnivores in the Amboseli Ecosystem during 2008-2012: Number of annual livestock kills divided according to sheep/goats, cattle and donkies.

After a peak in 2009, the number of attacks decline to similar levels after the drought (2010-2012) compared to the pre-drought year (2008). All attacks occurred in the group ranches surrounding Amboseli NP and this pattern was consistent during the years.

There was a significant decline in herbivore number during 2009 (Figure 5.4) due to effects of drought particularly for wildebeest and zebras.

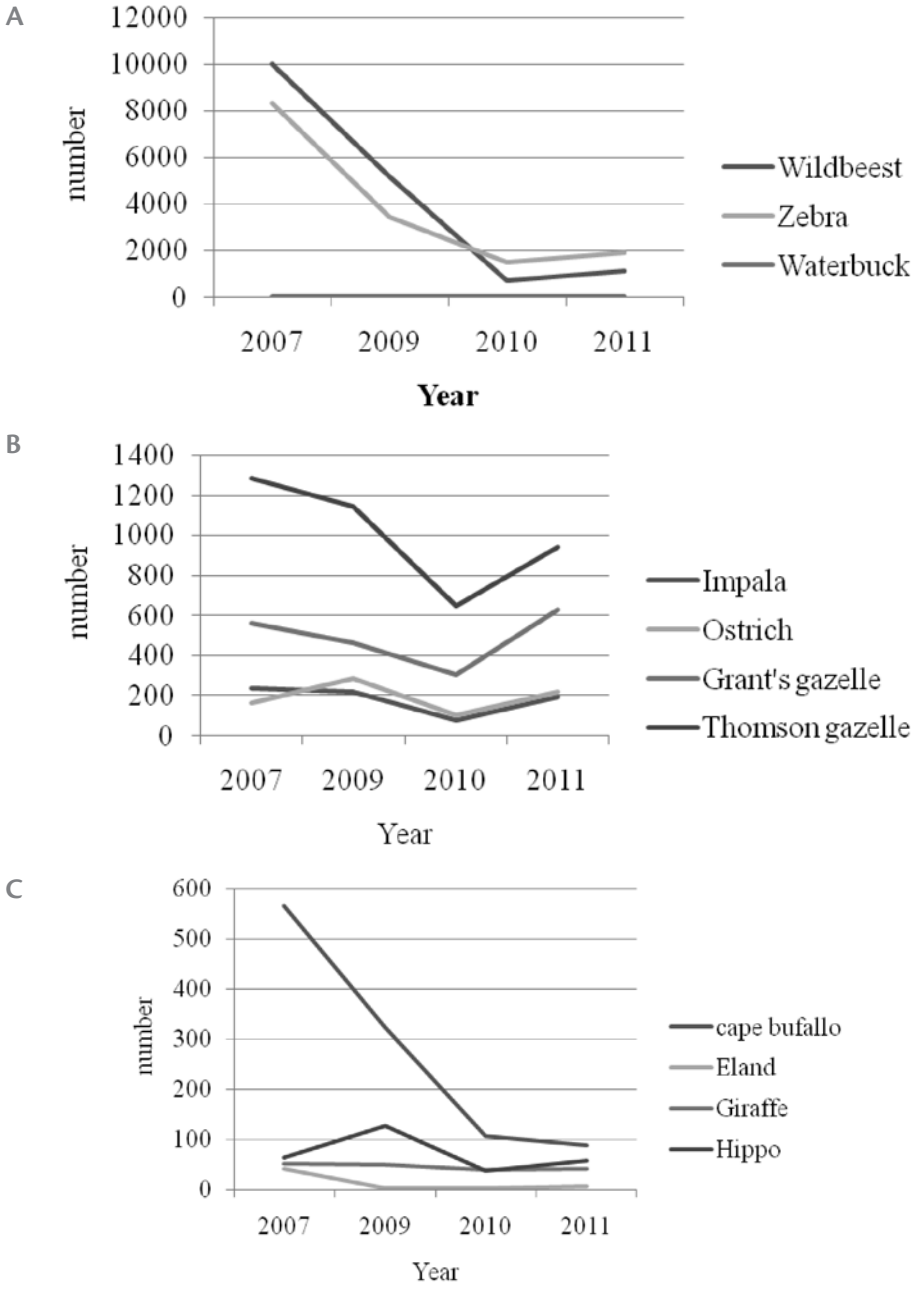
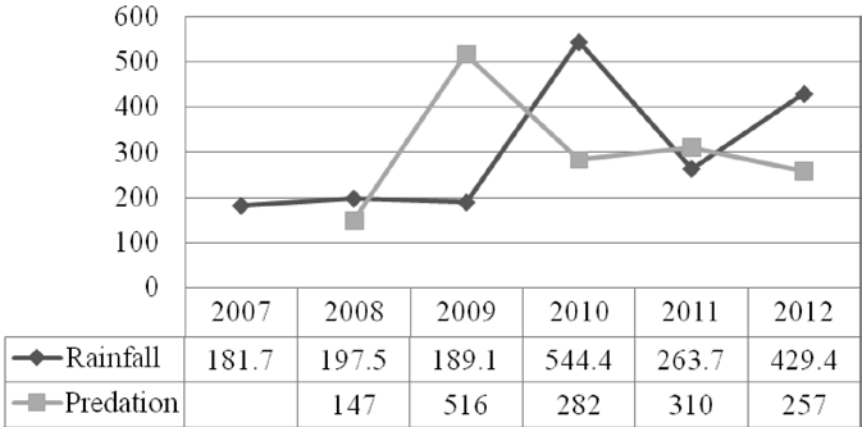


Figure 5.4
Annual herbivore population trends in Amboseli National Park 2007-2009 (pre-drought and drought period) and 2010-2011 (post drought) of medium-sized herbivores (A), small-sized herbivores (B) and large-sized herbivores (C). Small size was <50 kg body mass, medium size was between 50 kg and 200 kg body mass and large was >200 kg body mass (Estes 1995).

There was no direct relationship between mean annual rainfall and mean annual predation rates both before and after the drought (Figure 5.5)



	2007	2008	2009	2010	2011	2012
Rainfall	181.7	197.5	189.1	544.4	263.7	429.4
Predation		147	516	282	310	257

Figure 5.5
Pattern of rainfall in mm and yearly livestock predation for the period 2008-2012 in the Amboseli ecosystem.

5.4.2 Part II: Community attitudes

There was convergence in the result from community attitude and knowledge and the predation monitoring results with both indicated similar pattern of high livestock predation aspects.

Major *sources of livelihoods*
Most of the residents were livestock keepers, atotal of 83.3% of the respondents kept livestock, 8.2% were involved in trade, and 4.8% practiced some form of agriculture and 3.7% of the respondents held paying jobs (Figure 5.6).

Some 46.9% of the respondents keep sheep and goats, 44.6% of the respondents keep cattle and 8.5% of the respondents keep donkeys (Figure 5.7).

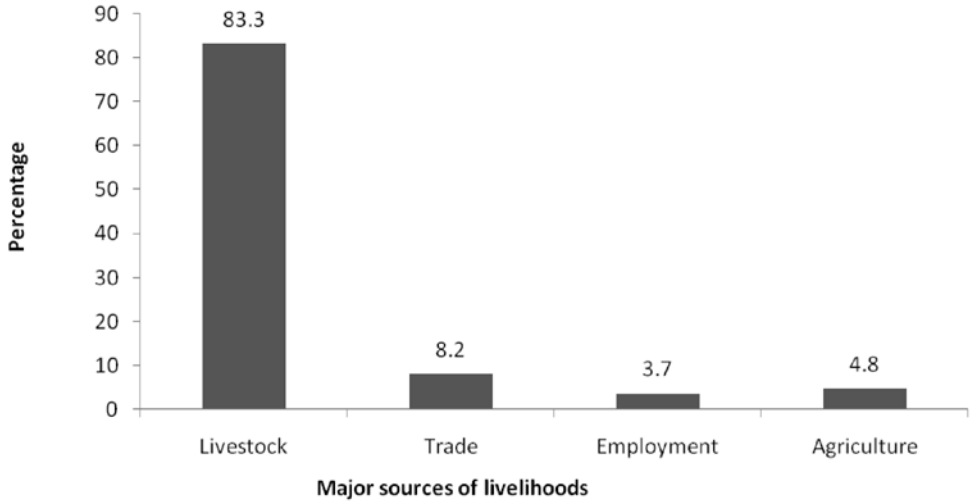


Figure 5.6
Major sources of livelihoods of respondents

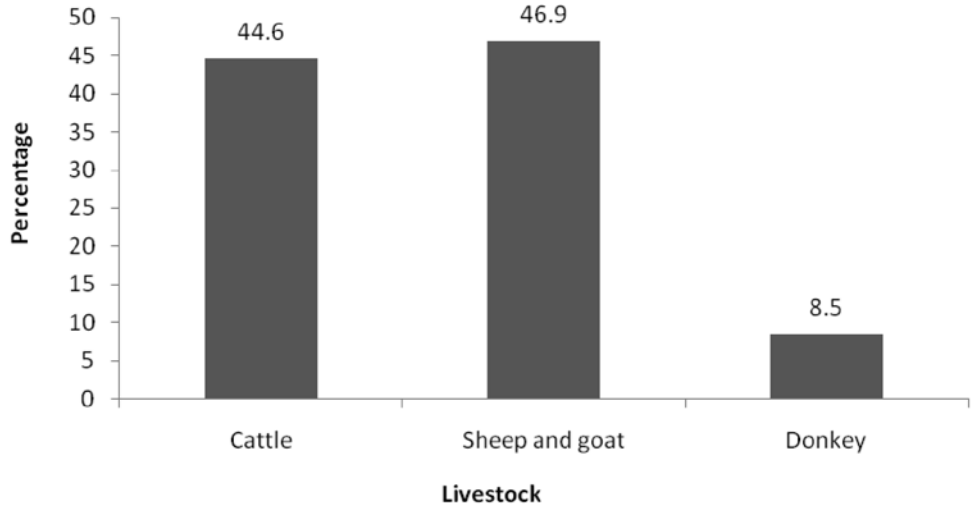


Figure 5.7
Percentage of respondents who keep cattle, sheep and goat or donkey

Problems *with wild carnivores*

All respondents indicated that they have problems with wild carnivores. The major problem mentioned was predation on livestock, while human injury/death and general threat to human life were also seen as causes of conflicts (Table 5.4).

Table 5.4
Main problem concerning wild carnivores according to respondents

Problems mentioned	No. of respondents	Percentage
Predation on livestock	236	80.3
Cause human injury/death	46	15.6
Threat to human life	12	4.1
Total	294	100

Carnivores *species that often causes problems.*

Table 5.5 shows that the spotted hyena was seen as most problematic of the predators, with lions taking a second place and other carnivores having smaller roles in conflicts. The respondents further explained that destruction of property during the night is common, and restrictions in movement of school-going children in the morning and evening restriction for those attending social gatherings is worrying.

Table 5.5
Carnivore species that often cause problems according to respondents

Carnivores causing problems	No. of respondents	Percentage
Hyenas	149	50.7
Lions	102	34.7
Leopards & Jackal	32	10.9
Cheetah	11	3.7
Total	294	100

Season *when problems are more prevalent*

A majority of the respondents indicated the predation problem is more prevalent during wet season as opposed to the dry season throughout the year (Table 5.7).

Table 5.7
Season when predation problem is more prevalent according to respondents

Seasonal livestock predation	No. of respondents	Percentage
Wet season	173	58.8
Dry season	65	22.1
The same throughout the year	56	19.0
Total	294	100

Major *benefits of living next to Amboseli National Park*

Respondents indicated that there are some benefits to living next to Amboseli National Park, such as the fact that the park attracts tourists, the park provides bursaries for schools, employment, social projects grazing and water for livestock (Table 5.8).

Table 5.8
Major benefits of living next to Amboseli National Park according to respondents

Benefits of living next to ANP	No. of respondents	Percentage
Attracts tourists/ foreign exchange earner	112	38.1
Provide bursary for schools	55	18.7
Employment	48	16.3
Provide social projects	30	10.2
Livestock/grazing and watering	29	9.9
No benefits	20	6.8
Total	294	100

Major *problems of living next to Amboseli National Park*

There were varied responses on the part of respondents on what they perceived as the main problem associated with living next to Amboseli NP, such as attacks by problem animals, restricted movements, rarrest/harassment by rangers, and 4 loss of grazing land (Table 5.9).

Table 5.9
Major problems associated with living next to Amboseli National Park according to respondents.

Problems of living next to ANP	No. of respondents	Percentage
Problem animals	227	77.2
Restricted movements	36	12.2
Rangers arrest/harassment	17	5.8
Loss of grazing land	14	4.8
Total	294	100

Disposal *of carcass/meat or predators kills*

Nearly all respondents (94.6%) indicated that they eat livestock killed by predators, while only 5.4% of the respondents' indicated other forms of disposal of livestock kills.

Patterns *and circumstances of repeat predator attacks*

According to respondents, there was a variety of circumstances under which repeated predator attacks on livestock took place. Table 5.10 shows that a majority of the respondents (46.6%) indicated that immediate attacks by predators happen when predators are chased, shortly after they started feeding on livestock kills, 40.1% of the respondents indicated that a repeated attack happens when predators are chased away immediately after killing livestock before they are able to feed, 7.1% indicated that repeated attacks happen when predators are chased away after they started feeding, but before they were fully fed and 6.1% indicated that repeated attacks happen when predators are chased after being fully fed.

Table 5.10
Circumstances under which respondents experience repeated predator attacks

Circumstances of immediate predator repeat attack	No. of respondents	Percentage
Predators chased away shortly after they started feeding on killed livestock	137	46.6
Predators chased away immediately after killing livestock, before feeding	118	40.1
Predators chased away after they started feeding but before fully fed	21	7.1
Predators chased when fully fed	18	6.1
Total	294	100

Major *obstacles to pastoralism in the future*

A majority of respondents (62.6%) consider drought to be major obstacle for pastoralism in the future; 13.3% of the respondents indicated predation by animals, 9.9% of the respondents indicated diseases, and 7.8% of the respondents indicated lack of pasture and 6.5% of the respondents indicated climate change as the major obstacles for pastoralism in future

Actions *taken in case of serious drought*

Table 5.11 summarizes that the respondents mentioned several options in case of serious drought: 66.3% would migrate to other areas in search for pasture for their livestock, 23.5% indicated that they would sell off their livestock, while 10.2% indicated they would diversify to other income-generating activities (Table 5.12). Some of the respondents further said they buy hay for their animals during periods of drought.

Table 5.11
Actions taken in case of serious drought by respondents

Actions to be taken in case of serious drought	No. of respondents	Percentage
Migrate	195	66.3
Sell livestock	69	23.5
Diversification to other income-generating activities	30	10.2
Total	294	100

5.5 Discussion

5.5.1 Livestock predation trends

Our results show a significant variation in livestock predation figures when we compare the year before the drought with the drought year (2009) and the years immediately after the drought per predator species. All attacks occurred in the group ranches surrounding Amboseli NP and this pattern was consistent in all the years. We had no data on wether attacks occurred within boma's or during grazing outside boma's. Livestock predation was significantly higher during the severe drought in 2009 than in the years before and after the drought. Our findings are confirmed by several other studies which have demonstrated that livestock depredation is more common in areas with low prey abundance (Sillero-Zubiri & Laurenson, 2001; Polisar et al., 2003; Treves et al., 2004; Rabinowitz, 2005; Bagchi & Mishra, 2006; De Iongh & Bauer, 2008). Many studies have suggested that local environmental conditions such as rainfall correlate with increased livestock predation during the wet season (Patterson et al., 2004; Woodroffe & Frank, 2005, Tumenta et al., 2012). Furthermore, livestock husbandry practices (Stahl et al., 2001; Madhusudan, 2003; Ogada et al., 2003; Polisar et al., 2003; Rabinowitz, 2005) and the characteristics of villages attacked and livestock enclosures used (Van Bommel et al., 2007; Ogada et al., 2003) have been found to influence livestock depredation.

In our study, the period before the drought and the post-recovery year 2012 can be characterized by a lower incidence of predation. All predator species except for lions, had the highest livestock predation rates during the drought and low predation rates before the drought period and during post

recovery. Although multiple studies on Kenyan rangelands concluded that lions are the most serious livestock predator, and that predation by hyenas is relatively infrequent (Ogada et al., 2003; Patterson et al., 2004, Sogbohossou et al., 2011), we found relatively lower predation rates by lions compared to hyenas. In addition, jackal and cheetah were responsible for more attacks than lions. Lion had highest predation rates during the year immediately after the drought (2010) but also had low predation rates in the year before the drought period (2008) and during post recovery (2012). Livestock depredation by these large predators could be attributed to a depletion of natural prey and loss of habitat due to the severe drought. In the northern region of Ethiopia, where the natural prey base was depleted, spotted hyenas were highly dependent on anthropogenic food sources (Kolowski & Holekamp, 2006; Abay et al., 2011; Yirga et al., 2012). The relative availability of stock animals may also have influenced the involvement of predators. Patterson et al. (2004) reported low hyena depredation on ranches on which the majority of stock animals were cattle. The low frequency of hyena and leopard depredation in some areas may thus result from the rarity of their preferred livestock prey size (sheep and goats).

We found significant differences between dry and wet seasons in predation incidence per species of large carnivores. Livestock predation was high during wet season for lion and leopard, whereas the opposite was true for hyena, cheetah and jackal. Rudnai (1979) was unable to associate rainfall with predation frequency, while others found higher predation rates during the dry season (Butler, 2000; Ikanda, 2005).

5.5.2 Influence of drought on specific livestock predation in relation to wild prey abundance and rainfall

Our data support the important relationship between livestock predation, rainfall and prey abundance. Patterson et al. (2004) and Woodroffe & Frank (2005) suggested that the seasonal local availability of natural prey is the main factors influencing livestock predation. Whether the wet or dry season brings increased depredation is then likely to be dictated by the regional relationship between rainfall and natural prey. Whereas the dry season in some regions is associated with increased natural prey and reduced livestock depredation, the inverse has been shown in areas where prey numbers peak in the wet season (Ikanda, 2005; Kolowski & Holekamp, 2006; Ottichilo et al., 2000). Our result shows similar trends, directly relating prey abundance with rainfall, while lack of wild prey also influences livestock

predation rates. Our study also shows that most livestock attacks by carnivores, particularly hyena's, occurred during the severe drought year of 2009. This happened for all livestock types (goats/sheep, cattle and donkeys) with lower predation in the years before and after the drought.

We found that when annual herbivore numbers showed a significant decline during the drought year (2009) and directly after the drought (2010), large carnivore livestock predation increased simultaneously. Wild herbivore decline due to the impact of the drought was evident for all herbivores. There was a slight recovery during the 2011 and 2012 post-drought periods, when livestock predation declined substantially.

Our findings contradict those of Woodroffe & Frank, (2005) and Patterson et al. (2004), who conducted research in Laikipia and Tsavo National Park and found fewer livestock losses to predators during a severe multi-year drought and more predation during the rainy season. Conversely, we found higher livestock loss due to large carnivores (except for lion) during dry season and our results also show an overall negative relationship between mean annual rainfall and mean annual predation rates both before and after the drought except for hyena. However, there was a positive relationship between mean annual rainfall and mean annual lion predation rates. In the Makgadikgadi and Ngorongoro Conservation Area, clear seasonal trends in livestock predation were recorded (Kolowski & Holekamp, 2006). These were related to wild prey availability and stock raiding, which decreased when migratory wild prey were present in large numbers, despite local increases in lion populations. As migrant zebra and wildebeest moved to other areas, local livestock predation increased despite a local decline in lion density (Hemson et al., 2009; Ikanda, 2005). In this case some lions remained resident in areas in which they could kill wild prey when it was abundant and livestock when migrants were scarce. The predominance of jackal, spotted hyena and leopard as livestock-killing predators has been reported in many areas (Yirga et al., 2012; Hawkes, 1991; De Iongh et al., 2009; Abay et al., 2011; Sogbohossou et al., 2011).

5.5.3 Community attitudes and views

Livestock continue to be a major source of livelihoods for the Maasai community around Amboseli NP. Our results show that a majority of the respondents depend on livestock (cattle, goats, sheep and donkeys). A few respondents depend on trade, whereas a limited number of respondents

depend on agriculture. The major issue identified by all respondents was the problem of livestock predation by large carnivores. Hyenas were identified as the most problematic animals, followed by lions and cheetahs in that order, while an insignificant number of respondents perceived jackal to be a problem animal. This is contrary to the findings of Tumenta et al. (2012) who suggested that in north Cameroon, lions were the most important predator from an economical point of view, mainly killing cattle. We found that lions killed 232 heads of cattle during the study period, compared to 480 killed by hyenas.

Our results on predation trends show that jackal kills more livestock than lions in absolute numbers because of the large number of goats and sheep they killed. Livestock predation remains a significant problem around the park. Other researchers also found predation by lions and other predators (hyenas and jackals) to be a serious issue around Waza National Park in Cameroon (Bauer & Kari, 2001; Bauer, 2003; Van Bommel et al., 2007). The respondents further explained that destruction of property during the night is common, and that they worry about restrictions in movement of school-going children in the morning and evening restriction for those attending social gatherings.

Respondents indicated that there was a seasonal variation in livestock predation, indicating more predation during the wet season than in the dry season. Our findings were similar to the predation patterns described by Bauer (2003), during the dry season around Waza NP. In Amboseli NP, prey normally congregate at the swamps during the dry season, resulting in temporary residence of lions around these swamps. This result in lower livestock predation rates by lions during the dry season. However, during the wet season, when wild prey migrates outside Amboseli NP, the frequency of livestock predation by lions increases. This is however, the opposite of the predation pattern of spotted hyenas, which shows a relatively constant livestock predation rate in both wet and dry season. This could be due to intrusions into the park by pastoralists, resulting in an almost permanent presence of livestock within the park during the dry season (De Iongh et al., 2008).

Our results show that major community benefits of living next to Amboseli NP are the attraction of tourists, and provision of bursaries for school children, employment and social projects such as health care and water provision. It has been suggested that "the success of any community-based wildlife conservation will depend on ensuring that individuals derive ben-

efits from conservation and sustainable management of the resource" (Gillingham & Lee, 1999; Brüner et al., 2001). Tourism is often seen as effective mitigation for human–wildlife conflict by conservation authorities and organisations; however its scope as such has been questioned (Gillingham & Lee, 1999). Indeed, our respondents also reported problem animals, restricted movements, arrest/harassment by ranger, loss of grazing land to be disadvantages of living adjacent to the park. It does seem possible that there is weak link between benefit accrued from the park through tourism that could act as a catalyst for pro-wildlife attitudes around Amboseli NP. Tourism in the area does not seem to be having a wider effect on community attitudes towards all large carnivores. There is a need to clarify to the community these important linkages, however, it may be that they are already aware and are not satisfied.

Increasing the resilience of carnivore populations by increasing the area in which people can co-exist with large carnivores is a logical strategy for large carnivore conservation (Linnell et al., 2001; Sillero-Zubiri & Laurenson, 2001). By doing so, protected carnivore populations separated by land utilised for livestock or agriculture may re-establish connectivity and gene flow. Of considerable concern is that in many cases at present, lion populations outside protected areas are absent or threatened (Woodroffe & Ginsberg, 1998; Woodroffe., 2000).

Management of the predation sites (disposal of kills), and prompt response to community distress and predator kills are very important measures in resolving conflicts and reducing the frequency of predator attacks. Our results show that nearly all (94.6%) of the respondents consume livestock meat killed by predators. This probably had a significant impact on the number of immediate repeated attacks by lions, depending on whether the predator in question had fed on the kill or not.

The greatest impediment to pastoralism was identified as recurrent drought, predation by large carnivores, livestock diseases, and diminishing pasture. The drought-coping mechanisms identified were migration to other areas, sale of livestock and diversification of livelihoods. The drought of 2009 was identified as the worst in terms of livestock loss and poverty in history.

We conclude that large carnivores create problems because of their feeding habits, wide-range requirements and the need for substantial prey populations, which inevitably brings them into conflict with people. Large

protected areas or well-managed landscapes with corridors and conservation-friendly local communities can provide relative long-term security to predator populations.

To manage wildlife outside protected areas effectively, or even to secure protected areas themselves, the benefits from wildlife must outweigh the costs to neighbouring local communities. The compensation schemes introduced earlier have a relatively positive impact on community attitudes and reduced retaliatory lion killing in Amboseli. The government of Kenya recently initiated a change in policy and introduced further compensation for damages caused by wildlife, including human death and injuries. It is expected that this change will have a significant positive impact on the attitude of the communities and promote more tolerance for lions and other carnivores.

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Questionnaires

To **whom it may concern**

I am a student at Leiden University, Institute of Environmental Sciences, The Netherlands, pursuing a Doctor of Philosophy degree (PhD) in conservation biology.

As part of the course requirements, I am undertaking a research project on the interaction between lions, livestock and people around Amboseli National Park. As such, I am administering a questionnaire on local community involvement with wildlife, particularly large carnivores such as lions, and their views towards conservation and management.

Please assist by taking time to fill out the attached questionnaire as sincerely as possible.

The results of the questionnaire shall not be used for any other purpose except the one for which the data has been collected.

Thank you in advance.

Date _____

1 Gender
2 Village name
3 Cultural boma
4 District
5 Age
6 What is the size of your household?
7 Could you rank Forest found in your area in order of importance to you?
8 Could you rank Wildlife found in your area in order of importance to you?
9 Could you rank Water found in your area in order of importance to you?
10 Could you rank Pasture found in your area in order of importance to you?
11 How do you rank the status of the natural resources in your area in the last 10 years?
12 How often do you see lions in your area during wet season?
13 How often do you see lions in your area during dry season?

14 How often do you see Hyena in your area during wet season?
15 How often do you see Hyena in your area during dry season?
16 How often do you see Leopard in your area during wet season?
17 How often do you see Leopard in your area during dry season?
18 How often do you see Cheetah in your area during wet season?
19 How often do you see Cheetah in your area during dry season?
20 How often do you see Wild dog in your area during wet season?
21 How often do you see Wild dog in your area during dry season?
22 How often do you see Jackal in your area during wet season?
23 Does your village have any problem concerning wild carnivores?
24 If yes: what are the major problems?
25 When did you experience last incident?
26 Which carnivore species often cause problems?
27 Where were livestock preyed on?
28 When is the problem more prevalent?
29 What would you do once you encounter livestock killed by predators?
30 Do people eat livestock meat kiled by predators?
31 Under what circumstance do you experience predator immediate repeat attack?
32 What preventive measures do you personally use to mitigate cattle and donkey attacks in your boma?
33 What preventive measures do you personally use to mitigate calves attacks in your boma?
34 What preventive measures do you personally use to mitigate shoats attacks in your boma?
35 What preventive measures do you personally use to mitigate cattle and donkey attacks on grazing grounds?
36 What preventive measures do you personally use to mitigate calves attacks on grazing grounds ?
37 What preventive measures do you personally use to mitigate shoats attacks on grazing grounds ?
38 What preventive measures do you personally use to mitigate shoats attacks on grazing grounds ?
39 What preventive measures do you personally use to mitigate shoats attacks in your boma?
40 What preventive measures do you personally use to mitigate calves attacks on grazing grounds ?

41 What preventive measures do you personally use to mitigate calves attacks in your boma?

42 What would you do once you encounter livestock killed by predators?

43 When is the problem more prevalent?

44 Which carnivore species often cause problems?

45 To whom do you report the problem of predation?

46 Where were livestock preyed on?

47 If yes: what are the major problems?

48 Are you aware of Olgulului predator compensation scheme?

49 Have you benefited from the predator compensation scheme?

50 What were the benefits?

51 Are you happy with the predator compensation scheme?

52 Is there anything you are not happy about predator compensation scheme?

53 What are they?

54 How would you like the compensation scheme be improved?

55 If you are asked to contribute towards compensation scheme would you?

56 If yes, in what ways?

57 What do you consider as the major obstacles for pastoralism in the future?

58 Do you see any solution for these problem?

59 If yes, what are the solutions?

60 Who should solve these problems?

61 What are your plans for the future in relation to livestock?

62 In other parts of Kenya pastoralism has changed significantly. sedentarization, decrease of herds, etc. 63. What is your opinion about these changes?

64 What do you do in case of serious drought?

65 How did drought of 2009 affect you?

66 How did you cope?

67 Would you do the same in case serious drought occurs again?

68 If no give reasons