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Climate Change and Human Population Increase Impacts on Swayne's Hartebeest (Alcelaphus buselaphus swaynei) Conservation in Senkele Swayne's Hartebeest Sanctuary, Ethiopia

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Natural Resources Management
Submission date: July 2015
Supervisor: Eivin Røskaft, IBI

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ABSTRACT; Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) is an endangered endemic antelope found in Ethiopia. The only viable population found in Senkele has been threatened by anthropogenic activities. Contemporary climate change together with an alarmingly increasing human population is becoming a principal conservation challenge worldwide. Therefore, assessing the extent of impacts of these contemporary factors on local protected areas is crucial to find ways to mitigate such impacts. This study evaluated the impacts of climate change and human population increase on the hartebeest conservation in Senkele Swayne's hartebeest Sanctuary. Some socioeconomic, environmental and the hartebeest behavioural components were integrated in the study. Precipitation, temperature, flight initiation experiments and questionnaires data were collected during the summer of 2014. There was a fast human population growth rate (reached more than 42% within ten years), characterized by high level of illiteracy, agriculture dominated livelihood with presence of a large cattle population. Livestock grazing remains the principal conflict source in the sanctuary, and it is more intensified by longer drought periods and absence of alternative foraging places. The hartebeests are imposed to high level of disturbance by local people. However, the absence of lethal activities, and the frequent contact between hartebeest and local people have allowed them to adapt the presence of local people. In flight distance experiments, they showed higher flight distance to strangers than to local people. Precipitation of all months showed either increasing or decreasing trends, and the annual precipitation showed an insignificant decline trend from 1984 – 2013. Months from December to January showed a significant decline trends with high variation. The seasonal lag and decline in precipitation amount together with an increase in temperature, affected the rain-fed dependent livelihood of local people. Moreover, such climatic variability has a potential to distress the physiology of the hartebeest. The accelerated demographic and environmental changes in the area are escalating challenges to conservation of an already endangered antelope. Fine-tuned and incentive-based approaches have been implemented to minimize human impacts, however, far from bringing the significant conservation tips. An urgent conservation measurement is needed from local and global conservation communities to ensure the survival of this antelope.

Keywords: Swayne's hartebeest, human population, climate change, behaviour

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Trondheim, Norway, July 2015 - Aman Desta

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1. INTRODUCTION

Natural resource conservation is facing a growing pressure from a growing human population and a changing climate (Cincotta et al. 2000, Newbold et al. 2015). The large-scale climatic change has been observed and documented since the mid-twentieth century and, nowadays have become a major global concern. The change in global temperature is affecting climatic variables and resulting in the change of global precipitation amount and distributions (Hulme et al. 2001, Houghton 2009). Combined with an ongoing fact of climate change, it is widely believed that anthropogenic activities are major driving factors in challenging wildlife conservation from the pole to tropics (Travis 2003, Dalelo 2012, Kaeslin et al. 2012). The global human population is increasing at an alarming rate and exerting significant pressures; altering and deteriorating sustainability of natural environments (Kideghesho 2010).

It has been estimated that 20-30 percent of the plant and animal species are at a higher risk of extinction due to global warming and related changes, and that a significant proportion of endemic species may become extinct by 2050 (Travis 2003, Kaeslin et al. 2012). Precipitation is one of a principal elements of the weather system alongside with the temperature, they highly vary spatially and temporarily at local, regional and global levels (Karabulut et al. 2008). Human population increase and related land use change are more aggravated by the ongoing climate change pressures. As a result, species and their ecosystems' distribution, composition and interactions are already under risk in most protected areas worldwide (Meyer and Turner 1992, Thuiller et al. 2006). Moreover, it intensifies the extent of human-wildlife conflict, occurrence of wildfires, and prevalence of diseases, distributions of invasive species and pests (Parmesan and Yohe 2003, Kumssa and Afework 2013). The untouched and marginal landscapes of the planet are under mark of anthropogenic impacts (Heller and Zavaleta 2009, Kaeslin et al. 2012).

The climate change and human population increase impacts on biodiversity are becoming more complicated in developing countries. Such countries are known for their massive biodiversity hotspots, fast human population growth and are the most vulnerable global regions when it comes to the climate change (Cincotta et al. 2000, Thuiller et al. 2006, Penuelas et al. 2013). For instance, East Africa will experience warmer temperatures and a 5 - 20%

increased rainfall from December - February and 5 - 10% decreased rainfall from June -August by 2050 (Hulme et al. 2001). It likely occurs in sporadic and unpredictable events; with large rainstorms during the already wet season, less precipitation during the already dry season, may cause more frequent and severe droughts and increase desertification in the region (Weltzin et al. 2003, Hussein 2011). Changes in regional precipitation will ultimately affect water availability, which in turn lead to decrease in agricultural security, human health, biodiversity conservation; socioeconomic and environmental crisis in general (Gereta 2010, Müller et al. 2011).

Ethiopia, the second most populated country in the continent of Africa, is experiencing many conservation challenges related to climate change and a fast human population growth (Birhanu 2014). The country possesses a unique and characteristic fauna and flora with a high level of endemic species. The geographical location and large altitudinal difference, which ranges between altitudes 4600_m to -125_m, allows the country to possess mosaic environment (Hillman 1986). In an effort to conserve natural resources, since the late 1960^{ties}, Ethiopia has established many protected areas primarily to ensure conservation and, secondly to promote tourism based income (Shanka and Frost 1999, Dalelo 2012). The Ethiopian human population is growing with in an alarming rate with an average annual rate of 3.02%. However, this figure varies highly at a local level due to variation in family planning, local migration, etc. The average family planning rate of the country reached 27 %, 50 % in urban and 23% in rural areas (EDHS-ICF 2012).

As studies shown in developing countries, human population growth and settlements near protected areas have accelerated and doubled since early 1980s due to different reasons (Campbell 2000, Cincotta et al. 2000). In Senkele Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) Sanctuary area, there is fast human population growth rate, which has reached more than 30% growth within five years (Kumssa 2006). In addition the household settlements doubled within eight years (Nishizaki 2004). The 1991 political unrest, failure in fine and fence conservation approach, the establishment of a state farm nearby sanctuary, decrease in grazing place and degradation in natural resources within the district are among the major causes for such a fast changes (Gebre and Yirga 2005, Kumssa and Afework 2013).

The Ethiopian rift valley is among the drought-prone areas of the country. Currently due to effects of climate change, erratic rainfall is challenging the long adapted rainfed agricultural system of the country (Cheung et al. 2008). Crop and livestock become victims of the drought shock which increase the unsecured farmers' livelihood enforcing them to look for resource in nearby protected areas (Korecha and Barnston 2007). As animals in general are consumers of higher trophic levels, highly influenced both by the climate that potentially limits physiological processes, and vegetation that determines resource availability and habitat (Grayson 2000). Endemic species with strict ecological constraints are likely to be most vulnerable and affected by climate change (Kaeslin et al. 2012). Moreover, a decrease in the absolute range of a species is likely to lead to an increased risk of local extinction (Thomas et al. 2004).

The combined and continued effect arising from contemporary climate change and human population increase to wildlife conservation is a bottleneck problem. The change obviously affects human-wildlife interaction and leads them to compete over the resource due to an increasing demand and decreasing environmental productivity. Under such a regime, the wildlife becomes more vulnerable and sensitive to extinction since it affects individual and/or population interaction within the ecosystem in general. In an area like Senkele, which is known for the high human population with presence of a large livestock population, with a limited range size to the hartebeest, locals' deep-rooted grazing interests, and change in environmental resource (Nishizaki 2004, Kumssa and Bekele 2008) and perhaps in climate, a study to understand such factors is crucial. Understanding the magnitude of ongoing changes to the ecosystem is therefore very important. The Arsi Oromo, one of the ethnic groups, is widely occupying the area along the Sidama ethnic group. Both of these ethnic groups have previously been pastoral, but since the late 19th century both tribes have practiced mixed agriculture. They have been repeatedly described in many studies for their influence on the hartebeest conservation due to their land use and hunting practice (Bolton 1971, Messana and Netsereab 1994).

Livestock and crop cultivation are major sources of income for local people around Senkelle and, more than 10,000 cattle depends on the area during the rainy season for grazing and compete with the hartebeests (Kumssa 2006). The rapid human population growth and

increasing need for settlements nearby are other factors that challenge the sanctuary management. These factors have been promoted by local cultural factors (polygamy style of marriage) and livelihood style (Nishizaki 2004). Most of the settlers have land and homestead in other places, use the nearby sanctuary newly occupied land between the state farm and sanctuary as transit, grow crop and graze in the sanctuary during the wet season, and go back to their main place during the dry season (Nishizaki 2004). During the absence of the settlers the hartebeests have been expanded from their home range in the state farm / fallow land (Gebre and Yirga 2005). Knowing the existing situation of such trends and associated changes within the last decade is very important. With such an alarmingly increasing human population, changing climate and related environmental degradation, these are changes that might affect adversely the conservation. As a result with the existing and ongoing management problems, climate change and human population increase are becoming a bottleneck problem of conservation in Senkele and in Ethiopia. Various approaches should be implemented and used to understand and minimize further impacts on the hartebeest population. These may include understanding of animal behaviour, environmental and climate change pressures, and the ongoing trends of the human pressure to the protected areas.

1.1 Animals Flight Behaviour

Humans and climate change could exert a variety of direct and indirect impacts that change animals' behaviour, therefore it is a need to identify and quantify the effects for further protection (Rubenstein 1992, Tarlow and Blumstein 2007). The flight initiation distance is among the best and easiest method in this regard that could be used in wildlife conservation. '*Flight initiation distance is the distance at which an animal begins to flee from an approaching predator or potential disturbance*' (Ydenberg and Dill 1986). It is an excellent method to quantify an individual's fearfulness in a particular circumstances (Blumstein et al. 2005). Disturbance is a potential threat that cause stress to in all animals. Human impacts can modify the benefits or costs associated with a particular mechanism of mate choice, or they can influence the expression of a condition-dependent trait, group composition and size, sex ratio, etc. (Andersson 1994, Tarlow and Blumstein 2007). The animals' flight distance response to

human disturbance depends on (1) biological factors, (2) disturbance type and (3) experience with humans (Ikuta and Blumstein 2003, Tarlow and Blumstein 2007, Hollén et al. 2011).

Ungulates are generally shay; Swayne's hartebeest is a non-cryptic species and prefer open areas, uses shrill alarm-snort for communication and response to any approaching potential threat (Messana 1993). Adult males are territorial (clusters or single), and bachelors are strongly repelled from entering a territory. This peak during the mating season (April-June) (Messana 1993); most of the time males spent with each other. Females (oestrous) aggregate to male's territories, to safely graze and may be to avoid sexual harassment from non-territorial males, which are usually aggressive toward them. Hartebeest's group size and composition, as well as ranging ability vary seasonally. They use different habitats which are affected by presence or absence of local settlers, who use seasonal migration patterns to the area (Messana and Netsereab 1994, Nishizaki 2004, Gebre and Yirga 2005).

By keeping impacts of human activities to animal behaviour constant, ungulates in areas with frequent contact with humans have been shown to have a reduced flight responses compared to animals in areas where human contact is rare (Stankowich and Blumstein 2005). However, understanding the level of adaptation or elasticity of individuals' behaviour (Dingemanse et al. 2010) is crucial, if not it may develop to a chronic stress level. Therefore such a study needs some standards or relative comparisons to evaluate the animal's response to disturbance. For instance, flight distance can be used by comparing 'disturbed' and 'undisturbed' populations (Ikuta and Blumstein 2003, Runyan and Blumstein 2004). However, hartebeests' in Senkele sanctuary have similar exposure to the disturbance and, it is therefore better to expose the same population to different stimuli, such as using mimicked approaches of 'local people vs strangers' and then measuring distance and disturbance response.

The unique wearing style of the local people makes the outlook of such people different from stranger person entering the area. If the hartebeest have been exposed to serious disturbances and impacts from local people (such as hunting, chasing etc.), they may act more aggressive to the locals' approach, since animals could quickly learn and respond to potential threats (Hollén et al. 2011, Tarakini et al. 2014). If they have been receiving moderate and inhabitable pressures, they will accept local people more and fly from locals as shorter distance

than any stranger due to habituation. In addition to this, the animals may give less FID due to adaptation arises from absence of alternative place to escape from human caused pressures.

1.2 Problem Statement and Justifications

Due to rapid environmental change, adequate and continuous information on wildlife conservation areas have not been generated. Recent change in climate, including the rainfall pattern and distribution is common scenario to many global places (Penuelas et al. 2013), and an exceptional impacts on species (Hof et al. 2011). The hartebeests and local people's lives in Senkele are highly dependent on the climatic cycle. Any change obviously strains the local people and hartebeests' interaction and co-existence, which would affect physiological and behavioural functions of the hartebeests. Animal behaviour is often considered a sensitive index of impacts (Beale 2007), its use requires detailed understanding of the context-dependent decisions animals make to human disturbance and activity. As a result studying climate change associated fluctuations and impacts, assessing hartebeests' behavioural reaction and flight distance response to local people interaction will have invaluable applications.

The local people have negative perceptions and are generally considering wildlife as a liability, source of poverty and that restrict free access of grazing and the use of natural resources (Kumssa and Afework 2013). Overstocking, un-prescribed fire, illegal grass cutting, demand for new settlements, negative attitudes toward conservation, as well as an agricultural expansion were the listed problems in the area. As a result, it was reported that, there is complex and continuous conflicts within the sanctuary. Most of such problems are caused by and aggravated following the human population increase. Evaluating and, understanding the extent of such problems, intentions of local people and contemporary management approaches to deal with the problems within the conservation is crucial. The understanding of the pattern of the seasonal settlers' migration, local's perceptions towards hartebeests, their dependency of grazing in the sanctuary area urgently needed study.

Therefore, the proposed study carried out to test the extent and direction of the so far referred problems alongside with the climate change and human population increase. Multiple

data from socioeconomic, environment and animals' behavioural point are integrated in the study.

1.3 Objectives

The general objective of the study is to investigate and assess the trend and effort of Swayne's hartebeest conservation in the context of an alarmingly increasing human population and climate change in Senkele Swayne's hartebeest Sanctuary. The specific objectives are:

- To assess the impacts of climate change on Swayne's hartebeest conservation.
- To assess the Swayne's hartebeest flight behaviour due to human interactions.
- To assess the impacts of human population increase in the study area.
- To assess local people perception towards Swayne's hartebeest conservation.

1.4 Hypotheses

This research was designed and carried out to test four main hypotheses:

1. The local climate of Senkele Sanctuary has changed over the last 30-years indicated by a more variable rain pattern as well as an increase in the mean annual temperature.
2. The local people interaction's with Swayne's hartebeest influence the flight behaviour on the hartebeests in a way that the animals flee at a shorter distance when approached by locals than by strangers.
3. There has been a significant increase in the human population in the study area which has significant impacts on the Swayne's hartebeest conservation in the Senkele sanctuary in a way that humans use the sanctuary for grazing purpose and other resource access.
4. The local people in the Senkele sanctuary possess positive perceptions towards Swayne's hartebeest conservation, however, only when they have their own economic benefits by supporting the conservation.

2. METHODOLOGY

2.1 Study Species

Swayne's hartebeest (Fig. 1) is one among 39 endemic mammals species of Ethiopia (http://lntreasures.com/ethiopia.html , Bolton 1971). At the beginning of the 19th century, it was reported that Swayne's hartebeest was abundantly distributed from Somalia up to the eastern part of the rift valley lakes of Ethiopia (Bolton 1971). However, because of habitat fragmentation, poaching and other anthropogenic activities, the ungulates lost their natural habitat range and, is therefore now found only in Ethiopia within limited protected areas (Bolton 1971, Lewis and Wilson 1977). The hartebeest is listed as an endangered species (IUCN 2008) and, a viable population is found only in the Senkele Swayne's hartebeest Sanctuary (Mamo et al. 2012). The Swayne's hartebeest use to range in groups, male hartebeests are known to form clusters or single territories. Reproduction in Swayne's hartebeest is timely sequential and dependent on the climatic cycle. About 89 % of calving occurs between December and March in the sanctuary following the availability of fresh grass from 'belg' rainfall (Messana, 1993). The hartebeest species in the sanctuary is known for its a historic and ongoing absolute decline of its population and habitat range (Nishizaki 2004, Gebre and Yirga 2005).

Figure 1: Group of female hartebeests in the Senkele Swayne's hartebeest sanctuary

2.2 Location and Topography

The Senkele Swayne's Hartebeest Sanctuary is one of the protected areas in Ethiopia. It is located on the western side of the Great Rift Valley, 320 km south of Addis Ababa, from Shashemene to Alaba road. The Sanctuary is currently administrated by Ethiopian Wildlife Conservation Authority. It is located between $7^0$10' N and 38^0 15' E. The Sanctuary was established in 1976 to protect the Swayne's hartebeest. The 200 km^2 area occupied by the hartebeest in 1972 was reduced to about 58 km^2 in 1973, and then to 36 km^2 and 28 km^2 during the 1991 political unrest (Messana and Netsereab 1994, Nishizaki 2004). The recent official report (Mamo et al. 2012) was that the sanctuary is about 57km^2. However, in the summer of 2014 it was tracked by GPS to officially known and the proposed boundary gives an estimate of 48.8km^2 (Fig.2). To the east, the range of Tesisa, Borena and Lalima hills are human settlements free boundary of the sanctuary. The topography within the Sanctuary is characterized by a gently undulating plain dissected by a number of valleys and the altitude ranges from 2000 to 2100 m asl (Messana 1993).

2.3 Climate Information

The average rainfall at Senkele, measured over four years (1991-1994) is 1,116 mm. It has a moderately bimodal pattern of rainfall typical of the 'Woinadega' agro-ecological zone of Ethiopia (1700-2700 m altitude; 600- 1200 mm annual rainfall). The three-month dry season, from November to January, is followed by the 'Belg' rains, in March - April, and the 'Kremt' rains, from June to September. The mean monthly temperature is relatively constant throughout the year but diurnal variations can be considerable. Monthly maximum temperatures range between 26^0C in the dry and early wet seasons and 21^0C in the late wet season. Monthly minimum temperature is lowest during the dry season, falling to 8-9^0C on some occasions and rising to their maximum values of 14-15^0C between March and May. Predictably, the relative humidity follows the rainfall pattern. Monthly minimum values increase from 30-40% in the dry season to 50-60% in the wet season. Mean maximum values fluctuate slightly around 80%. During the dry season, cloud cover is at a minimum and wind speeds are at their annual

maximum contributing to the high levels of evapotranspiration associated with tropical climate patterns (Messana 1993).

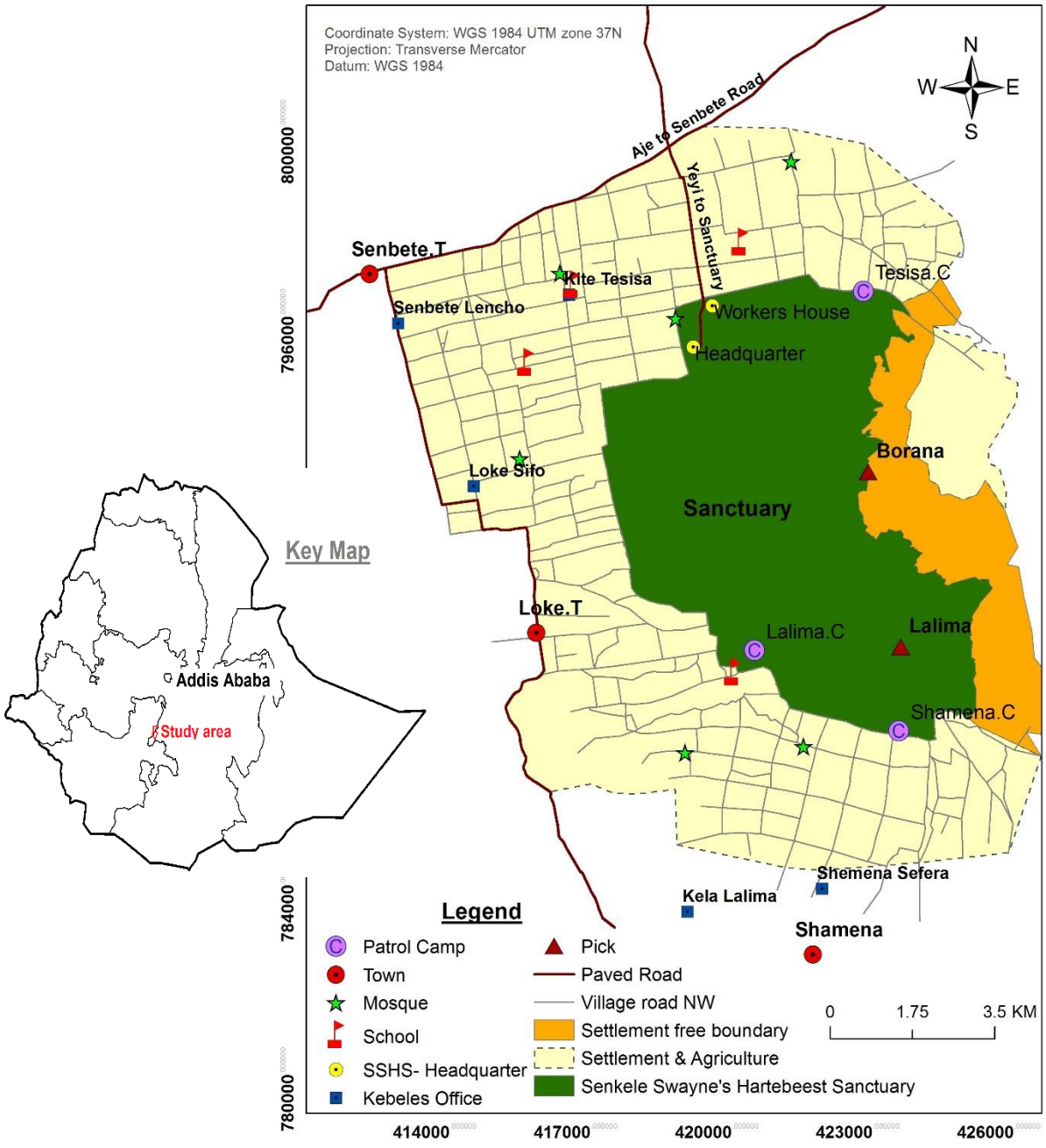

Figure 2: Map of the sanctuary and surrounding area: land use, human settlement, public and the sanctuary office infrastructures.

2.4 Data Collection

The study was carried out from June to August of 2014, which is summer, the wettest and busiest season of a year in the sanctuary. During these months it receives a high amount of precipitation. In this season, a lot of local people use to enter the sanctuary for grazing purposes (Nishizaki 2004, Kumssa and Afework 2013). Primary data on socioeconomic, rainfall and animal's flight distance response were collected through interviews, field surveys and flight distance initiation experiments. In addition to these data, precipitation and temperature data were collected with other secondary data from respective offices and literature reviews.

2.5 Climatic Data and Spatial Survey

Data on monthly rainfall for the past 30 years, and on temperature for the past 25 years were collected from the nearest available metrological stations at Alaba and Bilito State Farm. The world meteorological organization has recommended 30 years as a minimum data set required for searching evidence of climatic change in hydroclimatic time series (IPCC-TGCIA 1999). However, for the study area temperature data were available for only the last 25 years, and used alongside with rainfall data to test climate change within the past two- three decades in the study area. In addition to this, qualitative data on rainfall change trend and its consequences on the Swayne's hartebeest conservation and local people livelihood were collected through household questionnaires. Spatial data on current land use, size of the sanctuary and nearest public services were surveyed. The GPS points collected from the ground survey and google earth were used on the satellite image to sketch the current geographical feature map of the sanctuary and surrounding area (Fig. 2).

2.6 Flight Initiation Experiment

An experimental approach was conducted to record the flight distance of hartebeests. Two type of experiments were carried out, 1) mimicking a local people and 2) dressed as a strangers. In flight experiments different distances has been known commonly: 1) the alert distance, 2) the flight initiation distance (FID), and 3) the distance moved (Stankowich 2008). However, in

these experiments only FID was used. The common seasonal clothing (usually the bright and thicker upper cloth) and used by local people was carefully identified and used as the local person during the experimental data collection. The strangers' style was like a researcher or tourist, with a carried bag, camera, binoculars and other data recording materials with a normal westerner like wearing styles (See Appendix 5 for the two different clothing styles). Accordingly the experiments were conducted by approaching a single and/or group of hartebeests. We carried out as many experiments as possible, however, by using a single wearing style during one day. The FID experiments started from some point close to the border and continued across the sanctuary by initiating flight of targeted individuals or a single group per time. Further reconsideration of experimental animals to avoid replications within the same day was controlled by increasing the distance between each experiment and, also by carefully following the final destination of the displaced hartebeest. All approaches were done by two people and, there was almost no vocal communications during the approach. The factors that could affect the flight distance of animals, such as wind direction, distance from the core habitat, etc. (Stankowich 2008), were not considered in this study. However, a direct approach was used; time of day, group composition, group size and activity pattern were recorded from a distance before the disturbance started for the targeted individual/group. In case of sleeping hartebeests in the grass which are less visible from distance, identification was recorded during the flight initiation distance experiment. Due to lack of a rangefinder, a GPS was used to record hartebeest flight distance in the field. While approaching targeted individuals, the initial point of each recorded flight distance was taken by GPS at a time the last individual from the group started to fly. The second point of the flight distance was recorded from the exact place where the animal started its initiate flight. Natural marks such as vegetation, animal droppings (faces and urinate) and physical changes in the vegetation in cases where individuals were sleeping were used to identify the starting point. In this respect we were able to obtain the "accurate" FID. In the case of hartebeests in a group, FID for the group was considered for the distance that the last individual from the group initiate it's flight. Eighty experiments were done in total (40 for each clothing style). For flight distance measurements a GPS Garmin 78s was used, in addition we used a binocular and a camera recorder to support data quality.

2.7 Household and Key Informant Interviews

The sampled households and key informant interviews were conducted using structured and detailed questionnaires. The respondents were selected from the neighbouring kebeles, local woreda/ district offices and the workers in the sanctuary. The sanctuary was bordered by six peasant associations, four of which are from the Oromia regional state and the remaining two belongs to SNNPR regional state. Household respondents were selected from four kebeles (see Appendix 1). Accordingly, the interview was conducted to selected household members within an interval of approximately six kilometres from the edge of the sanctuary. Total 186 respondents were interviewed by a systematic random and stratified selection to collect both qualitative and quantitative data on local people perceptions towards the sanctuary. In addition, local people interactions with the sanctuary, their livelihood strategy and their expectations from and toward the sanctuary were included in the interview. Two field assistants, who speaks the local language and went through a detailed training, carried out the household interviews. Key informants were informally selected from different stakeholders groups based on their age, public role, administration and conservation position they have within and around the sanctuary.

2.8 Data Analysis Techniques

SPSS software (version 21) was used for statistical data analyse; frequencies, means and cross tabulations were conducted to determine the degree of dependence between independent variables. The mean test (t-test) was carried out to compare and test significance variation of the hartebeest FID and, ANCOVA was computed for model fit (R^2). Precipitation and temperature, monthly and annual trends were tested to Mann-Kendall and Sen's slope estimators. A linear regression model was used to define the slope of mean monthly and annual precipitation and temperature change rate to the observed time series. Mann-Kendall's test, this technique is based on the detection of trends and change point(s) and attaching to it a probability significance level in a time series. The test examines whether a random response variable monotonically increases or decreases with time (Partal and Kahya 2006). In case of missed monthly rainfall data, interpolation was used. '*Interpolation is a method that can be used to replace missed/ doubtful climatic data from last measurement or use the trend from previous*

sets of measurements'(Olsson et al. 2005). Totally precipitation data for seven months and temperature missed for two months in the data were adjusted by using interpolation method. Spatial data processed on ArcGIS 10.2 and satellite image acquired for March-2015, used from earth explorer to sketch current feature of the sanctuary and surrounding land use (Fig.1).

3. RESULTS

3.1 Rainfall Data Analyses

Statistical properties of the annual and monthly rainfall series were tested and are presented in Appendix 2. All months showed positive or negative trends over the 30-years study period (Table 1). The declining trends observed in February, March and December were statistically significant (Table 1). Only July month was indicated a statistically significant positive trend (Table 1). The local people's perception towards the total rainfall trend and seasonal variation was similar as the meteorologically recorded trend. 85.5% (Appendix 1) of the respondents believed that there has been an overall decline in rainfall amount, with later and more variable rainfall starting seasons.

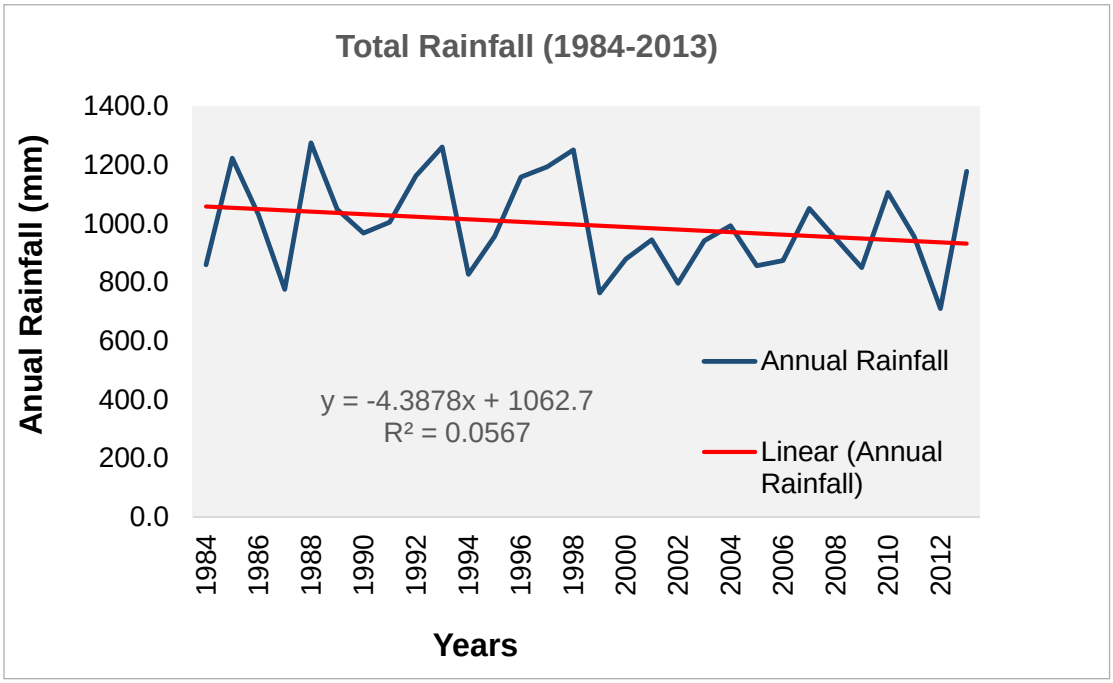

Figure 3: Annual precipitation trends in the study area.

Coefficient of variation (CV) was calculated to evaluate the variability of the rainfall and its characteristics in the study area. Months from March to September represented smaller CV. Mean rainfall variations in these months were more homogenous during the 30-years. Whereas the rest of months indicated higher CV; November (150%), December (132%) and January (112%) represent the highest CV (See Table 1 and Fig. 4 for trends and annual variation in rainfall).

Table 1: Monthly and annual precipitations trends with Mann-Kendall and Sen's slope estimators for the study area.

Months	1984-2013		
	Mann-Kendall Test (Z_s)	P-value	Sen's Slope estimator (Q_{med})
January	- 0.14	0.27	- 0.99
February	- 0.26*	0. 03	- 2.29*
March	- 0.26*	0.04	- 1.73*
April	- 0.20	0.13	- 1.90
May	- 0.15	0.26	- 1.45
June	0.17	0.18	1.30
July	0.30*	0.02	1.96*
August	0.15	0.26	0.82
September	0.06	0.63	0.50
October	- 0.11	0.38	- 0.85
November	0.17	0.20	1.27
December	- 0.26*	0.04	- 1.01*
Annual	- 0.15	0.23	- 4.39

* Statistically significant trends at the 5% significance level

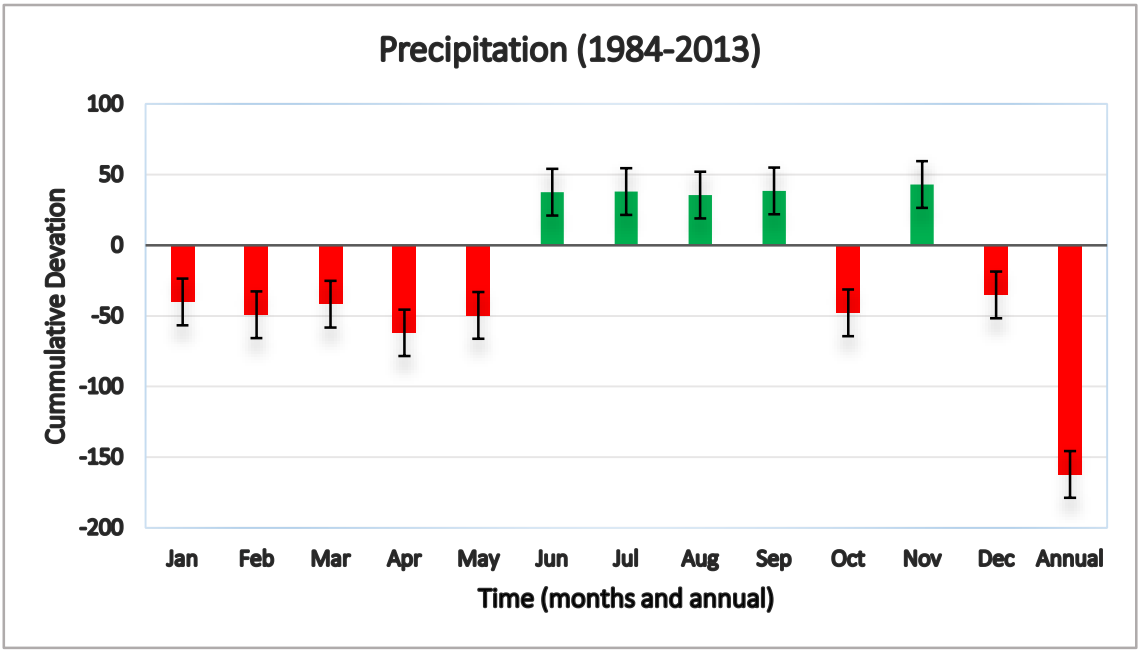

Figure 4: Cumulative deviation from mean monthly and annual precipitations in the study area.

3.2 Temperature Data Analyses

A temperature trend analysis during the period of 1989-2013 for the study area showed that there was a statistically significant increase in the annual mean temperature (MK = 0.74, $P < 0.001$, Fig. 5). A linear regression model was used to define the slope of the mean annual temperature change rate, and it was 0.16. Thus the mean annual temperature during the last twenty five years has increased by $0.16C^0$ (Fig. 5, Table 2). During the same period the mean monthly temperatures have a significant increasing trend for all months ($P < 0.001$). February, March, April, October and November showed the highest mean monthly temperature increases (Table 2).

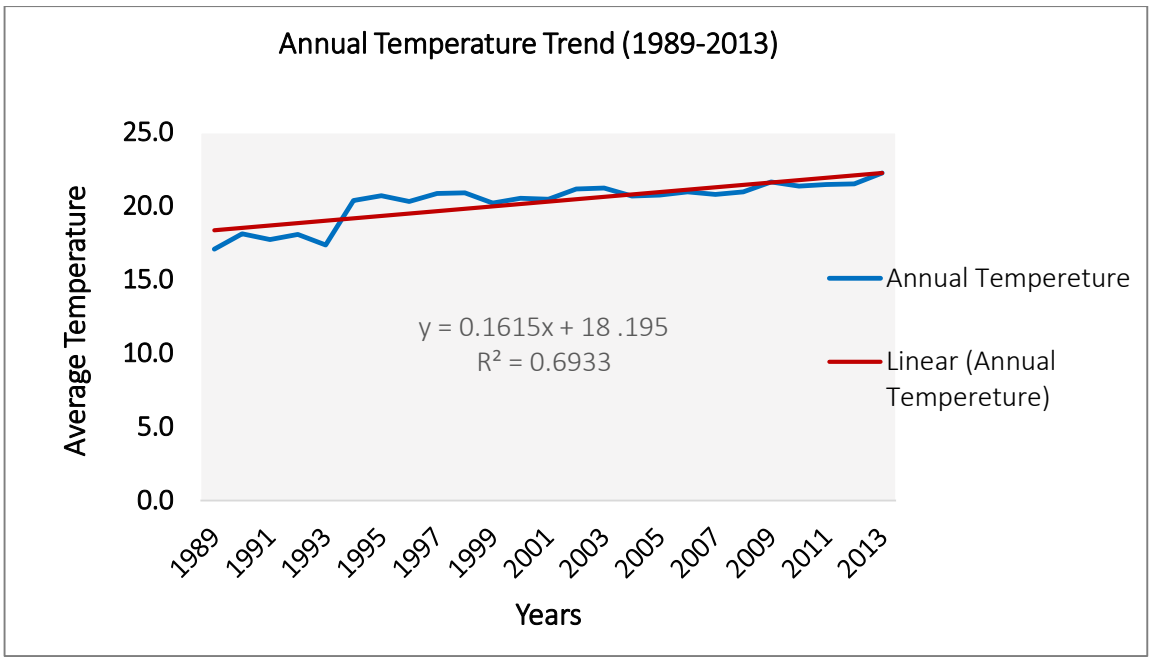

Figure 5: Mean annual temperature trends in the study area.

Table 2: Monthly and annual temperature trends with Mann-Kendall and Sen's slope estimators for the study area.

Months	1989-2013		
	Mann-Kendall Test (Z_s)	P-value	Sen's Slope Estimator (Q_{med})
January	0.63	0.001	0.15
February	0.55	0.001	0.17
March	0.57	0.001	0.18
April	0.55	0.001	0.17
May	0.57	0.001	0.16
June	0.60	0.001	0.14
July	0.57	0.001	0.16
August	0.73	0.001	0.15
September	0.62	0.001	0.16
October	0.68	0.001	0.18
November	0.63	0.001	0.18
December	0.57	0.001	0.14
Annual	0.74	0.001	0.16

3.3 Flight Initiation Distance

More than 96% of the sampled household respondents reported that the hartebeests used to be more scared in the past than they are nowadays (Appendix 1). They believed the contemporary absence of hunting and chasing practice has caused these chances among the hartebeests (Appendix 1). However, the hartebeests have had to leave their old places and needed to move to new places/territories where people can approach them beyond their limit. During field flight initiation disturbances, hartebeests recorded for fight or sexual harassment in new territories at destination of flight by other male hartebeests. Fighting was related to presence of adult male hartebeest (x^2 = 10.3, df = 2, P = 0.006), and sexual harassments was strictly related with the presence of female hartebeests (x^2 = 35, df = 2, P < 0.001), between the disturbed hartebeests (Table 3).

Table 3: Frequency of recorded fighting and sexual harassments outcomes to disturbed hartebeests.

Variables	N	Recorded outcomes	Frequency	Percent (%)
Fighting	80	Fighting	13	16.3
		No-fight	67	83.8
Sexual harassment	80	Sexual harassment	17	21.3
		No-sexual harassment	63	78.8

The mean flight initiation distance (FID) was longer towards strangers (mean FID = 65.6m ± 6) than towards local people (mean FID = 54.4m ± 4) (t = -9.7, df = 60, P < 0.001). ANCOVA model fit for FID were computed (adjusted R^2 = 0.54, P < 0.001). This means that 54% of variability in the FID is accounted by experiment type (local vs strangers). The local people interaction with the hartebeest has affected their flight behaviour significantly. Fig. 6 indicates the daily variation in the initial behaviour when hartebeests were targeted for disturbance (x^2 = 20.4, df = 4, p < 0.001). The hartebeests were more active in feeding and moving in the morning and late afternoon; whereas they were more idle during the mid-day.

However, influence of the initial behaviour and period of a day on FID of hartebeest was not statistically significant.

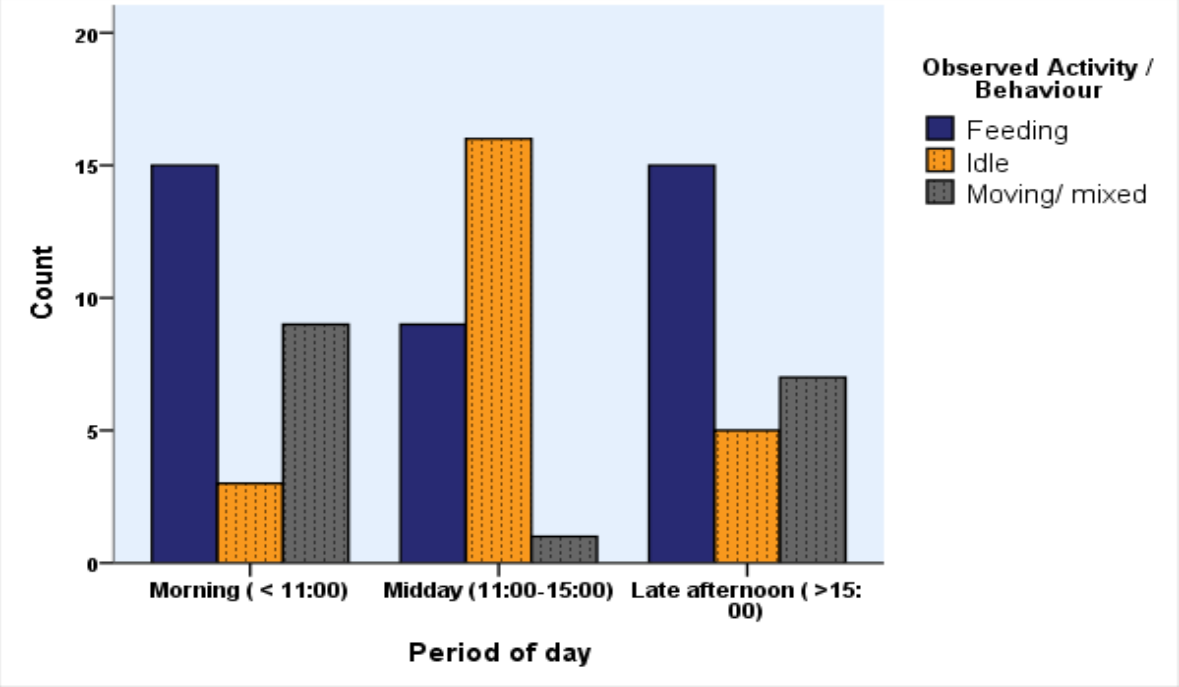

Figure 6: The recorded initial behaviour for hartebeests during the disturbance, clustered in to different period of a day

3.4 Socioeconomic Analyses

A substantial number of variables about local people socioeconomics and perceptions were surveyed and analysed in the study. 94.1% of local people were dependent on agriculture (crop cultivation and livestock rearing) and the rest come from other sectors. Mean household land size was 1.83 ha and mean total family size was 10.3. The percentage of children who were less than 10 years old was very high (42.6%). During the past ten years, the local population has grown dramatically. More than 94% of household respondents replied that they practiced no family planning and, it was similar to all the kebeles (x^2 = 0.9, df = 3, P > 0.05). The family planning of the respondents was affected by their education level (x^2 = 12.9, df = 2, P = 0.002).

Those who have better educational status, practiced more family planning. However, due to high level of illiteracy in the area (Appendix 1), the education role in suppressing general human population growth in the study area is minor. The culturally promoted polygamy marriage and religious related factors contributed to high fertility rate in the area. Fast human population increase was a top rated problem, with mean value of 2.7 out of 3 in the area compared to drought and presence of the sanctuary (Table 4).

Table 4: Descriptive statistics summery for some variables surveyed of the sampled respondents.

Variables	N	Mean	SD	Variance
Average family size	186	10.5	5.9	35.0
Children less than ten years old	186	4.4	2.7	7.6
Land size per HH (ha)	186	1.8	1.4	2.0
Private grazing land (ha)	186	0.2	.2	.1
Problem related to human population increase	186	2.7	.4	.2
Problem related to drought	186	2.1	.7	.5
Problem related to presence of the sanctuary	186	1.2	.5	.3
Valid N (list wise)	186			

Local migration (people and livestock) was a common practice among residents living nearby the sanctuary and people who lived far from the sanctuary. The patterns of migration, however, varied seasonally (x^2 = 558, df = 9, P < 0.001). During the summer, migration was done towards the sanctuary for pasture search by people who were living other places. The migrants stayed in their relative's homestead on a temporal basis, and they grazed their livestock in the sanctuary during the summer season. 33.9% of the sampled respondents received such kind of temporary migrants from other places to their homestead during the summer of 2014. However, these migrants moved back to their homesteads during the winter season. In addition, 14.5% of the respondents/ residents living nearby the sanctuary used to

move out with their livestock during the winter season for search of water, mainly to Lake Shalla, and they came back to their homesteads during the summer season. However, the majority of the residents (84.5%) reported that they stayed in their homestead nearby the sanctuary during winter season.

The residents have been reported that almost all of them used to move out to other place during the winter season in the past (Nishizaki 2004). However, this trend has dramatically decreased nowadays because of less availability of space during the winter season migration areas due to human population related decline in grazing land. During the summer season, all residents in the area (100%) plus the migrants (non-residents to the area) use to live nearby the sanctuary. The sanctuary is dominantly used as grazing land in the area (Fig. 7). More than 85% of the respondents, plus new migrants used to graze in the sanctuary during the summer season and, more than 67% of residents entered/crossed the sanctuary to collect firewood. The majority of respondents (80%) believed that their dependency on the sanctuary for resource access has increased since a few years ago, however, there was a statistically significant variation between kebeles (x^2 = 43.7, df = 6, P $\leq$ 0.001). The decline in livelihood of local people as a result of droughts and human population increase in the area were emphasised as the main reasons for the increase in the local peoples' dependency on the sanctuary.

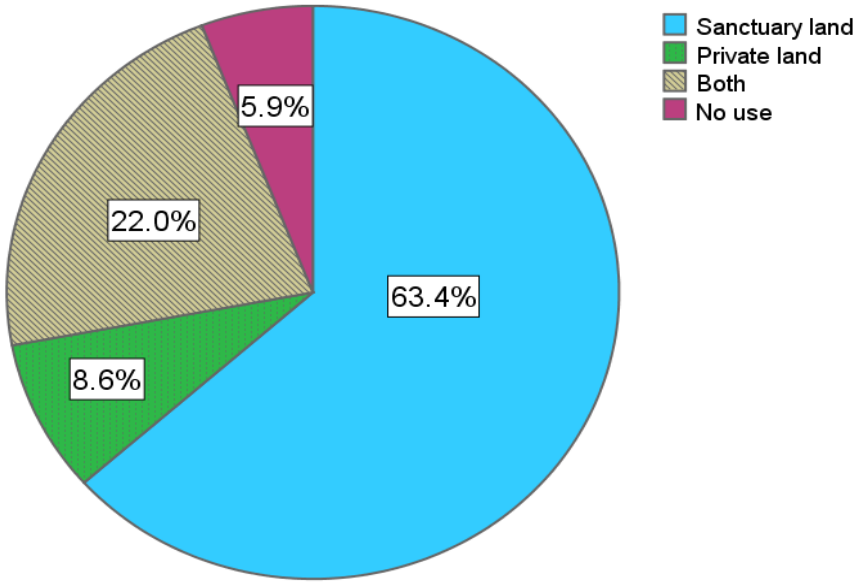

Figure 7: Proportion of different grazing land users in the study area.

There were a lot of changes identified during the field survey in terms of physical human settlements and human growth around the sanctuary. The larger Bilito State Farm adjacent to the sanctuary has been distributed to the local people and has become a permanent settlement. Except for the eastern border, which is a hilly landscape, the sanctuary is presently surrounded by agriculture and human settlements. A census was carried out to public infrastructures close to the sanctuary. There were 1005 resident huts, 1 mosque and 1 elementary school has been built at immediate boundary of the sanctuary. The current size of the sanctuary tracked by GPS was estimated to be 48.8km^2 (Fig. 2).

Human-wildlife conflicts were common and there was a highly statistically significant variation in terms of damage between kebeles (x^2 = 15.9, df = 3, P = 0.001, Fig. 8). Although hartebeest hunting was common in the past, 100% of the respondents reported as they never hunted/killed hartebeests over the last two decades (Appendix.1). A banned hunting practice by local elders a few decades ago and more awareness created by the sanctuary officials was brought a significant change. A number of questions were surveyed regarding perceptions of the local people toward the sanctuary and, most of them indicated a positive support to its presence. However, why they supported the sanctuary was associated to private benefits rather than the conservation of hartebeests (Table 5). Most of the respondents were happy to see more hartebeests population in the future, however, there was variation between kebeles (x^2 = 37, df = 3, P < 0.001).

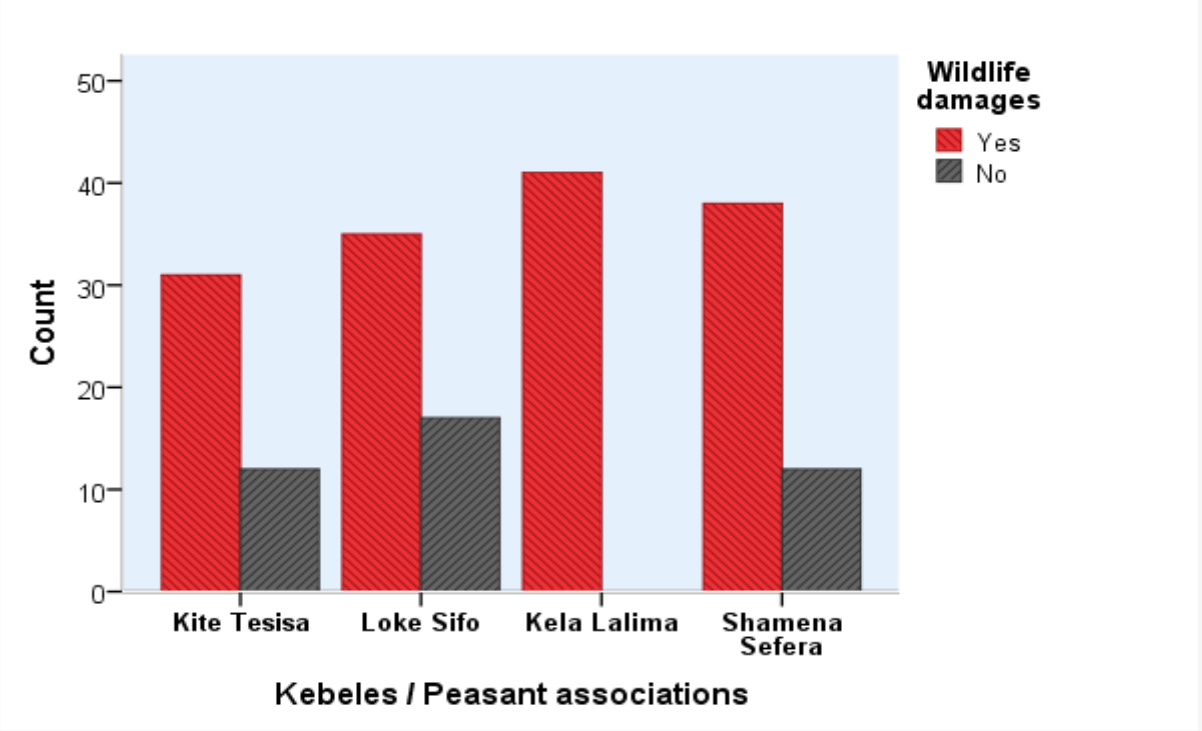

Figure 8: Frequency of wildlife damage per kebeles

Table 5: Respondents' willingness to allocate the sanctuary land to local people and the reason behind their perceptions.

Wish	Household response	Number of respondents	Commonly given reasons	Frequency	Percentage (%)
Allocating the sanctuary land to local people	Disagree	120 (64.5%)	Economic benefit (from grass cut, etc.)	106	35.5
			Livestock grazing place	102	34.1
			Hartebeests' place	17	5.9
	Agree	66 (35.5%)	Land shortage	59	19.7
			Sanctuary is useless	8	2.7
			Wildlife damage	7	2.3
Total	2	186 (100%)	6	299	100.0

4. DISCUSSIONS

4.1 Rainfall and Temperature Changes and, its Challenges to the Conservation

The effects of climate change, such as increasing temperature and change in precipitation are already affecting ecosystem, biodiversity and people (Hussein 2011). The rainfall based crop cultivation and grazing oriented livestock rearing make the livelihood in Senkele area predominantly dependent on the rainfall. In addition, the survival of the wildlife in the area depends on the availability of forage in their habitats. The spatial and temporal distribution of forage in the protected area is highly determined by rainfall (Redfern et al. 2005, Gereta 2010). Despite to the fact that a few summer months showed positive trends in the amount of rainfall and homogenous variations, as hypothesized, most of the important months' rainfall showed declining trends with a high seasonal variation. In general there is clear trend that the dry months are getting dryer and the wet seasons are limited but are getting wetter. The overall annual precipitation was indicated a declining trend, although, this trend was statistically non-significant. Also, as stated in Hulme et al. (2001), the East African rainfall distribution scenario will be sporadic and unpredictable; in which the increased precipitation will come with fewer large rainstorms, mostly during the already wet seasons. Moreover, it is expected that the dry season will be dryer and will receive less precipitation due to climate change effects. The observed trends in the Senkele aligned with the previously projected East African climate change scenario that dry seasons are getting dryer and wet seasons are becoming wetter.

In most of the large scale projected rainfall scenarios for Ethiopia, the precipitation amount between June and September were showed a decreasing trend over the past three decades (Seleshi and Zanke 2004, Cheung et al. 2008). In addition, there was less changes during the 'belg' rainy season. However, this seems less likely in the case of the local level in the study area, where the months between June and September have showed an increasing trend in precipitation. Although except for July month, the rest of the months were not statistically significant. Such variation at large and small scale levels of the precipitation trends may come from other factors which control rainfall distribution. The Ethiopian rainfall distribution at local levels are highly affected by topography (Seleshi and Zanke 2004). As a result the climate

change and topographic related factors might affect the observed precipitation trend variation in combination.

Change in temperature will affect the availability of moisture in the environment, there will be high evapotranspiration and, as a result, less water will be available in the vegetation. Such phenomena will have significant impacts on ungulate species (Rubenstein 1992), the hartebeest depend on precipitation from foraging (Messana 1993), and therefore will be more vulnerable to the change. The hartebeests' life history, including reproduction and ranging behaviour is sequential during the year (Messana 1993, Gebre and Yirga 2005). More than 78% of calving takes place from December to March, reaching its peak (89%) by the end of March. Fifty percent of mating occur from April to June and the gestation period ranges from April to February. For all these timely sequential activities, the importance of and availability of the quality and quantity of forage in the hartebeest habitat is a key. There are no water points for animals in the sanctuary. As a result, a change in the natural precipitation time and space would most probably affect the survival of the hartebeest in this area. Moreover, the change in temperature will have adverse impact on hartebeests, since temperature has crucial impact on the water cycle (Karabulut et al. 2008), consequently it affects environmental moisture.

The months from December to March showed both a declining trend and a high variation in precipitation over the past 30 years. In addition, over all mean annual temperature within the past 25 years indicated a significant increasing trend. This means that the long adapted and seasonal based life activity of the hartebeest would be under a constant stress. Successful calving and preparation for the next reproduction greatly depend on an individual's evolved physiological function. Therefore such changes in the physical environment most probably affect the physiology of the hartebeest and in the long run the sustainability of the ecosystem in the area.

The late dry season (Belg) comes with an important rainy season that contributes significantly to food and pasture production in Senkele as well as other places of the country (Nishizaki 2004, Seleshi and Zanke 2004). However the belg season, such as February and March months showed significant increasing and decreasing trends for temperature and precipitation respectively. In addition, these months are among the months that showed the highest temperature change. The overall change in mean annual temperature was $0.16C^0$over

the 25-year period. The months with highest and lowest temperature increase varied between 0.18 and $0.14C^0$ respectively. The overall temperature showed less change than the African projected mean temperature in Hulme et al. (2001), that was varies $0.2 – 0.5C^0$ per decade. This is may be because of steady increase in global mean temperature within the past fifteen years due to effects of the equatorial pacific surface cooling (Kosaka and Xie 2013).

More unpredictability of the rainfall start and as well as the more frequent occurrence of unexpected long drought periods in and around Senkele are affecting livelihood security of the local people as well as the hartebeest. The 85% of household respondents argued that they have experienced such a change over the last decades. The neighbouring districts, Shalla and Siraro are drought prone areas of the rift valley region and victim to the climate change related drought shocks. People in these zones have been sharing similar sociocultural elements as the people in Senkele. As a response to drought periods they have adapted a seasonal migration pattern (Godansa) to where pasture and water are available for their livestock throughout the year. The sanctuary area is a well-known destination for such kind of migrants. In the summer of 2014, more than 33% of the respondents received migrants to their homestead. This practice has been an old tradition in the area and was reported as it is declining due to change in social and physical environments. However, according to my observation the seasonal migration is increasing in the region and is becoming a means of survival rather than choice. The problem with all the new migrants is not only that it is scaling up the competition on the sanctuary resources, but the migrants are less aware of rules and regulations of the sanctuary. As a result they aggravate the human-wildlife conflict in the sanctuary.[1]

The climate change related drought shock is not only attracting new people to the area, but the local people' demand for resources from the sanctuary is also increasing. This is the second ranked problem affecting the livelihood of local people next to the rapid human population increase. The shortage of drinking water for people and their livestock has been an unsolved problem for a long time. The sanctuary office has been promised to solve the problem

[1] *While doing field survey, we met a person who was grazing his cattle in the middle of the sanctuary and we had discussion with him. He wasn't from the nearby area and walked a one-day distance with his cattle to reach the sanctuary area. He was a victim of drought shock in his area. He said, he has no idea about the sanctuary rules and we told him that he would be punished if scouts found him. However, he replied that 'it is better to be punished by them rather than my cattle die by hunger'.*

for the local people; however, the local people were blaming the office for not keeping what they have promised them. The office has argued that they have tried but did not succeed due to the shortage of ground water in the area. A serious consequence of these contemporary environmental droughts will most likely jeopardize the local people's perception towards the hartebeest conservation in the future. Moreover, the general perception of the local people towards the environmental protection would not harmonize with the ongoing environmental changes. As a solution to combat the climate change related droughts, the majority of respondents believed that praying was the only solution to deal with this problem. Ethiopia has a well-organized plan and a national policy for climate change adaptation and mitigation (Birhanu 2014). However, in Senkele this plan has a very weak fundament and is not yet addressed at least when it comes to changing the public perception on how to combat climate change.

4.2 Flight Initiation Distance and Field Observations

The adult hartebeest males are territorial and consist of a single or clustered territory. Non territorial males form groups which could range up to six individuals. These males spend most of their time together in grazing areas between territories or move away to less networked areas within the sanctuary. Female hartebeests groups move freely between resource available areas (Messana 1993). During the night time, females and sub-adult hartebeests prefer safer and relatively less covered areas and aggregate to form larger groups or a number of clusters that can observe each other. During the summer time most of the plain is covered by grass taller than half a meter. The fresh grass has high water content that affects the temperature during night (Messana 1993). As a result hartebeest have been observed to prefer to stay on roads inside the sanctuary during the night, not far away from the-headquarter. The reason why the hartebeest prefer to aggregate around the-headquarter during the night is not clearly understood. However, may be the human disturbance during the night could be a potential cause. During the summer night, livestock grazing inside the sanctuary and, shouting from the border of the sanctuary as a means of chasing away warthogs from crop raiding, is very common.

Early in the morning the hartebeest group starts dispersing and movement based grazing to different directions of the sanctuary, mainly to the larger area of the sanctuary plain. The

movement continues until they reach enough available resources. The time the hartebeest used to stay in one place depend on the behaviour of territorial males, group size, period of the day and human disturbance. For instance, some male hartebeests are very disturbing in their trial to make sexual harassment. In more than 21% among trials, during the disturbance experiment sexual harassment behaviour was observed. When female hartebeests flew to new territories with an adult male, in some cases they were subjected for such behaviour and had again to fly out to another place as a result. In addition, during of midday most of the hartebeests are idle and less active to graze and move, so they spent a long time in the same place.

Clusters of females, sub-adults and juveniles are mostly free to do regular activities as grazing, walking, sleeping etc. In the Senkele plain, at day time the territorial males are most vigilant and can observe more than other hartebeests any human movement from far distance. This is because most of time they stand and follow females' movements, other territorial activity or bachelor's and give vigilance services to hartebeests within the territory. Such conditions allow them to spot and follow any human approach and activities from a distance. However, even though they spot any movements before the rest of groups, they are usually the ones with the shortest FID and they are most resistant to leave the territory. Such behaviour is common in many territorial animals (Messana 1993, Hollén et al. 2011). This is to protect others group members or due to territory related costs. In disturbance related displacements, more than 16% of the fighting cases were recorded for male hartebeest in their first destination after disturbance. The figure both for fighting and sexual harassment may increase during the main mating season (April to June), also territoriality reaches its climax during this period (Messana 1993).

Territorial males are most of the time not busy by grazing and they are highly vigilant by turning their heads and bodies toward nearby females groups, thus they spend very little time grazing. Such sexual and territorial behaviour are strongly displayed when females are at an observable distance from them. However, these males are active in giving alarm to the rest of the group members when humans are approaching. Such communications are boosted up by other hartebeests and are frequently followed by dropping of faces and by urinating of some of the group members. As communication normally start in this way, most of the time females with calves start escaping when a human being approaches. Then the escaping followed most

of the time followed by sub-adults, other females and finally territorial male or bachelors. The direction they escape is towards the large open area within the sanctuary or to other nearby hartebeests. In this way they ensure they are in a safest place.

The level of disturbance to hartebeests by human approaches depends on time of a day, position in the habitat, group size, group composition and people category (e. g local's vs strangers). Hartebeests in the Senkele frequently interact with the local people because they enter the sanctuary for grazing, resource collection and use to pass through the sanctuary. The experiment was done to better understand how the local people affect the behaviour of the hartebeest. We hypothesized that the animals exposed to high contact with locals, will release a shorter FID than it will to strangers. By keeping all factors that affect FID constant, the hartebeests generally showed higher flight distance to strangers than to local people supporting this hypothesis.

Animals could easily learn and react to both positive and negative stimulants (Fernández-Juricic et al. 2005, Tarakini et al. 2014). The adaptation may come from the absence of an alternative place to escape from negative pressures or by incentives that positively could attract the animals. In populations or areas were hunting is practised animals showed higher FID (Setsaas et al. 2007). Since two decade back hunting practices were completely ceased in the sanctuary and might therefore have brought such an adaptation to the hartebeests. On another hand, the frequent contact the hartebeest has had with local people and the absence of alternative places to escape may have brought the adaptation change to the animals. The sanctuary area is small, the hartebeests are easily visible and detectable in the sanctuary plain with a presence of high local human population in the area. As a result the hartebeest may have been suppressed to stay close to human and take the risk of adapting to local people. However, by any means, habituation has indorsed the hartebeest to have different FID response toward the local people and strangers. The outcome is a good indicator as how much local people use to enter the sanctuary so that the hartebeest alter themselves to develop such worthy adaptations.

In the household survey, farmers were asked to compare past and present hartebeest scariness to local people approach. More than 96% of them assured that nowadays hartebeests were performing shorter flight distances to the local peoples approach. The reason was, that in the past they used to hunt/kill them as a protein source and as a revenge to the sanctuary office.

The hunting problem was well known to the hartebeests' population in the sanctuary (Lewis and Wilson 1979, Messana 1993, Gebre and Yirga 2005). However, meanwhile the hartebeest's in the area have been given a recognition as part of local people by local elders of Arsi Oromo and more awareness was created, then killing/ hunting hartebeests has been seen as a completely unethical practice nowadays in the area.

Another important point that needs to be discussed here is the potential impact of the overlap in time of when the local people use to enter the sanctuary and when the hartebeest actively use to move inside it. In main habitat the hartebeests use a larger range during the summer than during the winter season (Messana 1993, Gebre and Yirga 2005). They actively move and graze during the morning and late afternoon. Early morning and late afternoon during the summer season are the time when local people mostly use to enter the sanctuary. In such a clear temporal overlaps of hartebeest ranging behaviour and local people activity, the FID responded to the local people will have a significant impact on the hartebeest. Nowadays the hartebeest population is increasing to about 804 individuals (sanctuary office report). Despite the increase in numbers they are getting more vulnerable to integrated threats from humans and the changing environment.

4.3 Socioeconomic and Environmental Change Impacts

Demographic and social changes place more people in direct contact with wildlife (Distefano 2005). The rapid human population growth has been and would be an ongoing principal conservation challenge in Senkele area. More than 94% of livelihood income comes from agriculture, coupled with the presence of large numbers of livestock. There is a high level of illiteracy in the area, with an average family size that has reached 10.3, where more than 42% of the population is less than 10 years old. Sociocultural elements like polygamy marriage is contributing significantly to population fertility. The Ethiopian family planning has on average reached 27%. This figure grows to 50% in urban areas and drop to 23% in rural areas (EDHS-ICF 2012). However, in the Senkele area more than 94% of household respondents never tried any family planning and, their underlined reason was religion-related. In addition to this, a high level of illiteracy has significant stake in discouraging the use of birth control. Local migration,

the establishment of the new settlements and the allocation of a state farm nearby the sanctuary a few years back were among the important factors which have boosted the local population. Human population increase is a top rated problem by local people compared to climate change and the presence of the sanctuary. The increase in local human population and related natural resource degradation in the zone, increased the local people's dependency on the sanctuary. More than 80% of the residents believed that they are more dependent on resources from the sanctuary compared to the past. However, there was variation between people from different kebeles. People from Shamena kebele believed they relatively less dependent on the resources from the sanctuary. This is because of their lifestyle, which agroforestry is mixed with fewer livestock compared to the people from the other kebeles.

The larger state farm/ fallow land adjacent to the sanctuary, was a traditional hartebeest habitat before it was confiscated by the state farm in 1972 (Lewis and Wilson 1979). Later it has been mentioned as an important area serving as dry season ranging places for the hartebeest when crop was harvested or when it was under fallow land (Messana 1993, Gebre and Yirga 2005). However, a few years back the state farm was allocated to local people and is presently occupied by permanent settlements, and is no more serving as habitat for hartebeest. Moreover, Nishizaki (Nishizaki 2004) argued that almost all settlers nearby the sanctuary have homestead in other areas, and use the sanctuary area settlements only during the summer season and migrate back to their homesteads during the winter/dry season. The absence of local people during the winter season has allowed the hartebeest to freely move into new habitat/ the fallow land (Gebre and Yirga 2005). However, nowadays only 14.5% of the residents nearby the sanctuary use to migrate out to other areas during the dry season. The remaining 85.5% is no more leaving the settlement during the winter. The major cause for such change was fast human population increase in the areas that were previously used for winter season migration. As a result the hartebeest have less chance to move in-to adjacent farm lands during the winter season. Moreover, during the summer season in their main habitat (sanctuary), they are crowded by local people and new migrants that compete for the sanctuary resources.

The human-wildlife conflict has been common near the sanctuary for a long time. The close human settlements, and related crop growing, as well as the local people' demand for resources from the sanctuary has intensified this conflict over the last decades (Kumssa and

Afework 2013). The wildlife population in the sanctuary has been reported to decline, and some of the species has already gone extinct from the sanctuary. However, mammal species like the hartebeests, Warthogs (*Phacochoerus aethiopicus*), Oribi (*Ourebia ourebi*) and Jackals (*Canis aureus*) are commonly observed alongside of numerous bird species in the sanctuary. Spotted hyenas (*Crocuta crocuta*) are rare. Crop raiding has been reported as the dominant damage that locals experience from the wildlife and, there is variation among kebeles in receiving damages. Kela Lalima is the most affected among the adjacent kebeles. This is because they use less protection mechanisms such as night time on farm patrolling, fence etc. compared to the others. However, the overall damage by wildlife in the area has declined when compared to the past. This is most likely because of the declined wildlife populations in the sanctuary. The warthog is the major animal causing damage and is the most offended species by the local people. The dominant crops cultivated in the area are maize and potato, and the mature fresh maize is the favourable food by warthogs. Most of local peoples are happy to see more hartebeest in the sanctuary in the future. However, there is variation between kebeles; respondents from Shamena Sefera were less interested in further increasing of the hartebeest population. Wildlife caused damage, calming as less beneficiary from the sanctuary and less feeling toward the hartebeest ownership were among their reason to have such perception.

The number of huts built at the immediate border of the sanctuary was reported to be 229 in 2006 (Kumssa and Afework 2013). However, in the summer of 2014, there was 1005 huts with more public infrastructures such as a school and a mosque at immediate boundary to the sanctuary. Except for the eastern hilly chain, the sanctuary is bounded by immediate settlements and agricultural lands. The expansion of new settlements in the sanctuary has been considered as an unsolved problem. The socioeconomic and environmental change connected with the fast human population growth has been degrading the natural resources at an alarming rate in the zone. Most of the community grazing land in the district such as Tetesa and Dida Harre, are already occupied by permanent human settlements and is no more serving as public grazing zones. Only around 30% of households have their own grazing land in their homestead with insignificant size. The sanctuary is the only public grazing area which attracts thousands of livestock during the summer season. Grazing and firewood collection in the sanctuary is illegal, however, only a short distance from headquarter we can daily observe enormous cattle herds and humans crossing the sanctuary.

As a measurement to reduce this problem, the sanctuary officials patrol the protected areas and catch cattle found in the sanctuary and punish the owner by fining them. However, this approach seems to be little effective since the proportion of cattle owners fined is very low compared to the number of livestock which is found grazing in the sanctuary. The fine is also small and affordable, and therefore not high enough to keep the owners away from using this valuable land. In addition to this, most livestock owners adapt new grazing approaches and move in to the sanctuary during early morning or late afternoon, including night time grazing when there are almost no patrolling activities. Most farmers told that they love and have special respect for the hartebeest at similar level as to their cattle, however, generally they believe that there is nothing wrong if their cattle use the same graze as the hartebeest. They therefore consider the enforcements from the sanctuary officials to stop their livestock from grazing as a power exercise to limit their traditional resource access rights. Most of them agree in the future existence of the sanctuary, however, both those who agree and disagree do not do it because of the sustainable conservation of hartebeest. It is more of a private benefit-oriented perception which would easily be volatile with such rapidly changing socioeconomic and environmental conditions.

As a conservation incentive the sanctuary recently established in an officially organized way a measure to allow local people to harvest grass from the sanctuary for construction or to sell to generate profit from it. For this measure, the local people were thankful to the sanctuary and, in 2013 the revenue local people earned from such harvested grass was estimated to be 267,579.56 USD (sanctuary office report). The newly started approach is contributing to an appreciable role in suppressing illegal grass cutting, unprescribed fires and in securing livelihood of local people. Moreover, it increases positive perception of local people toward the sanctuary. However, according to the sanctuary official report, quitting fire from the sanctuary and preserving grass to be harvested by local people, is increasing tick manifestation in the sanctuary. This is may be because of the large numbers of livestock which use to graze in the sanctuary and, ticks are easily transferred from cattle to wildlife or vice versa. Fire may have contributed in suppressing the tick manifestation in the past, but nowadays due to the avoided fire management, tick populations may increase in the sanctuary.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

In Senkele are there is a clear climate change impacts. The hartebeest activity pattern, including ranging and reproduction cycles are timely sequential and well-adjusted to the ecosystem function. The lag or change in amount of rainfall and raise in temperature have potential impacts on forage quality and quantity for the hartebeest. Moreover, it will intensify human-wildlife conflict, insecure livelihood of people and affect the physiology of the animals.

Swayne's hartebeest has a special behaviour in their group formation, composition and ranging. The rapidly increasing human population in the area has come-up a lot of human disturbance in the sanctuary. Livestock grazing, firewood and other resource collection, night shouting across the border and using passage inside the sanctuary are all very common. People category, period of day, position in the habitat, group composition and group size are among potential factors that affected the hartebeests' flight responses. The FID model showed the animals used larger flight distances to strangers than to local people. However, it does not clearly indicate the exact sources of the adaptation behaviour. There are both positive and negative stimuli to hartebeests that could bring a potential adaptation toward the local people in the sanctuary. A few decades back hunting/killing was ceased and the frequent contact between the hartebeest and local people within a small area have possibility to develop such an adaptation. Adaptation has a tendency of suppressing and helping animals to deal with disturbance to some extent. Compared to the past, nowadays the hartebeests are less scared of the local people.

In the Senkele area, the fast human population growth has been and will be an ongoing principal conservation challenge. Socio-culturally supported polygamy marriage and, at the same time the discouraged family planning have granted high fertility rate in the area. Predominantly an agricultural based livelihood with the presence of large cattle populations, have aggravated the competition over natural resources in the zone. Many community grazing places and the larger state farm have already became permanent human settlements and ensured the sanctuary to be the only grazing site to attract thousands of livestock in the district during the summer seasons. Except a few parts, all most all boundaries of the sanctuary have shifted to agriculture and human settlements with dense huts and public infrastructures. Moreover, the

socioeconomic and environmental changes in the area have brought permanent settlement trends and are attracting more outsiders. The sanctuary is not free of human-wildlife conflict. The crop raids by animals and high resource demand from the sanctuary by locals' remain a tension to the hartebeest's conservation.

As conservation measurements, some fines and incentive based approaches have been established to enforce rules, improve perceptions and secure livelihoods of the local people. The fine approach is seen as not effective enough to teach or limit locals from entering the sanctuary. However, the recently implemented organized grass cut as an incentive seems holding up locals' positive perception. Following the management shifts in old practice such as using fire in the sanctuary may come up with other conservation challenges. Hunting/killing of hartebeests is completely ceased and, the awareness creation measurements done by integrating local elders has contributed significantly. An alarmingly increasing human population and, the climate change related impacts, will be the principal challengers in conservation of the only viable population of the endemic hartebeest in Senkele.

5.2 Recommendations

- The protection of this beautiful endemic hartebeest needs the effort of local and global communities. If not, the fate would be like many other species which already have become victims of anthropogenic activities.
- An integrated conservation approach needs to be the principal plan to deal with all current deep rooted problems. Awareness creation, capacity building, diversified research, clear rules and regulations should be implemented in and around the sanctuary.
- The schools, religion institutions, farmers training centres, veterinary and human health service areas should be used to teach and deliver messages about the conservation. For instance educating about family planning, it would be effective if district health office and/or religion centres are integrated, because family planning is considered as evil by locals'.
- Hartebeest conservation campaigns should involve children and youngsters in schools in the area.

- For climate change, mitigation and adaptation options such as tree planting, improving households saving capacity, educating and creating future alternative livelihood sources are important.
- When public service centres are developed, they should be avoided from the immediate boundary of the sanctuary since they can be a potential attraction for new people to migrate to the area.
- Legalized and clearly demarcated boundary map, known to local people and officials, should be obtained as soon as possible. Unless, space for hartebeests is not granted and diminishing will continue with such alarmingly increasing human population.
- The eastern hilly landscape, partly shared with the sanctuary, is relatively free of human settlements and less favourable to other land use. If the landscape could be included in to the sanctuary part, it will give more spaces for wildlife and, also will serve as a potential tourism attraction.
- Human interferences have potential impacts to hartebeests' behaviour. Morning and late afternoons, as well as summer and reproduction seasons, should have to be given special concern in limiting human entrance.
- Urgently water points needs to be built in the sanctuary.
- Warthog is a major human-wildlife conflict cause in the sanctuary and its population needs to be monitored.
- The incentives and right of accessing resource should be fairly distributed to local people. In addition to improving the livelihood of people, it should be used to teach them and address public decisions in the important issue of the sanctuary.

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7. APPENDICES

Appendix 1: Tables of socioeconomic variables analysis (frequency and percent).

No	Variables	Name / category/ measurements	Frequency	Percent (%)	Total	
					Frequency	Percent
1	Number of HH respondents per Kebeles / Peasant association	Kite Tesisa	43	23.1	186	100
		Loke Sifo	52	28.0		
		Kela Lelima	41	22.0		
		Shamena Sefera	50	26.9		
2	Sex of HH respondents	Male	149	79.0	186	100
		Female	39	21.0		
3	Age category of HH respondents	< 30	33	17.7	186	100
		30 - 50	113	60.8		
		>50	40	21.5		
4	Education level	None- educated	113	60.0	186	100
		Primary School	57	30.6		
		≥Secondary School	16	8.6		
5	Family planning use	Yes	10	5.4	186	100
		No	176	94.6		
6	Land lose scaring	Yes	37	19.9	186	100
		No	149	80.1		
7	Sanctuary grazing period	Summer	129	69.4	186	100
		Winter	13	7.0		
		Always	21	11.3		
		None	23	12.4		
8	Sanctuary accessing right	Very good	5	2.7	186	100
		Good	90	48.4		
		Limited	83	44.6		
		Highly restricted	8	4.3		
9	Firewood collection place	Own	60	32.3	186	100
		Sanctuary	83	44.6		
		Both	43	23.1		
10	Change in hartebeests' number	Increasing	163	87.6	186	100
		Decreasing	2	1.1		
		No change	9	4.8		
		No Idea	12	6.5		
11	Happy with hartebeests management	yes	157	84.4	186	100
		No	29	15.6		
13	Hartebeests scariness of local people compare to the past	Increasing	4	2.2	186	100
		Decreasing	179	96.2		
		No change	3	1.6		
14	Hartebeest hunting	Yes	0	0	186	100
		No	186	100		
15	Change in rainfall amount	Increasing	18	9.7	186	100
		Decreasing	159	85.5		

		No change	9	4.8		
16	Looking to sanctuary for resources	Increasing	150	80.7	186	100
		Decreasing	14	7.5		
		No change	22	11.8		
17	Mitigation should be taken to environmental management	Praying	145	78.0	186	100
		Environment protection measurements	6	3.2		
		Both	35	18.8		

Appendix 2: Summary of rainfall data statistics table.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
N	Valid	30	30	30	30	30	30	30	30	30	30	30	30	30
	Missing	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean		35.7	50.0	97.1	144.1	116.3	93.86	114.2	115.2	103.1	70.0	28.6	26.5	994.7
Std. Error of Mean		7.3	9.0	7.6	11.3	9.1	6.85	6.9	6.5	7.0	8.7	7.8	6.4	29.6
Median		19.1	34.9	98.4	139.1	112.1	88.60	106.7	109.3	99.3	74.7	12.2	10.7	962.1
Mode		.0	.0	9.0	55.0	37.2	30.10	70.0	58.9	40.5	.6	.0	.0	710.2
Std. Deviation		- 40.1	- 49.2	- 41.8	- 62.0	- 49.7	37.54	38.0	35.4	38.4	- 47.9	43.0	- 35.2	- 162.2
Coefficient of variation (%)		112.6	98.3	43.0	43.0	42.7	39.99	33.3	30.8	37.2	68.4	150.2	132.8	16.3
Variance		1610.5	2416.5	1744.9	3843.7	2466.3	1409.52	1446.2	1256.1	1474.5	2296.2	1848.2	1235.4	26303.3
Skewness		1.2	1.2	-.01	.6	.8	.30	1.1	.7	.6	.4	2.4	1.5	.2
S.Error of Skewness		.4	.4	.4	.4	.4	.43	.4	.4	.4	.4	.4	.4	.4
Kurtosis		1.1	.8	-.1	-.1	.6	-.56	1.0	.5	-.1	-.5	6.2	1.5	-1.0
S.Error of Kurtosis		.8	.8	.8	.8	.8	.83	.8	.8	.8	.8	.8	.8	.8
Range		150.4	188.1	181.2	242.1	211.4	137.30	147.7	150.9	151.7	180.1	181.4	122.9	565.3
Minimum		.0	.0	9.0	55.0	37.2	30.10	66.8	58.9	40.5	.6	.0	.0	710.2
Maximum		150.4	188.1	190.2	297.1	248.6	167.40	214.5	209.8	192.2	180.7	181.4	122.9	1275.5
Sum		1069.4	1500.1	2914.3	4323.0	3490.0	2815.9	3425.8	3456.3	3094.3	2100.5	858.6	793.7	29841.9
Percentile	25	3.7	8.5	67.4	89.6	78.1	65.93	83.7	91.2	79.2	30.8	.0	.0	859.1
	50	19.1	34.9	98.4	139.1	112.1	88.60	106.7	109.3	99.4	74.6	12.2	10.7	962.1
	75	72.5	79.0	131.1	183.8	141.1	115.65	135.0	130.9	130.0	107.6	44.6	42.6	1159.4

Appendix 3: Household sample surveyed questionnaires.

A. Questionnaire's Information

1. Questionnaire number: _____ 2. Date of interview: _____

3. Kebele/ PA: _____ 4. Code of respondent: _____

5. GPS coordinates of respondent house: _____, _____

B. Socioeconomic Questionnaires

1. Sex of HH: F/ M, Age: _____

2. Education level: a. Uneducated b. Primary (1-8) c. secondary school/ above

3. Household size: I. Total _____, II. ≤ 10 year _____, III. > 10 years _____

4. What is your total land size in hectares? _____, I. Cultivated ____, II. Grazing_____

5. Do you have livestock? Yes/ No. If yes, size _____

6. Do you cultivate crop? Yes/No. If yes, list dominant crops _____

7. What are lists of grazing land which you use for livestock?

a. Own land b. Sanctuary land c. Both d. No use at all

8. Do you practice seasonal local livestock migration (Godanssa) in your area? Yes/No

If yes,

I. Direction and season of the migration, _____

II. What are the causes to migrations? _____

9. At what time you use sanctuary land for grazing to your livestock?

a. Winter b. summer c. Always d. not use at all

10. Are you scared to lose your land by being near to the sanctuary? Yes/No

11. Do you agree if government officials are agree to allocate some of the sanctuary land to local people? Agree/Disagree why? _____

_____.

12. What are the sources of your livelihood income? _____.

13. How you evaluate the right of accessing resources from the sanctuary?

a. Very good b. good c. limited d. highly restricted

14. From where do your family use to collect firewood?

a. Own land b. Sanctuary c. Both

15. Compare and rank the following listed factors based on their adverse impact on your livelihood improvement (*High = 3, average = 2 & below average = 1*)?

1. Drought and rainfall problems _____

2. Human population increasing problems _____

3. Presence of the hartebeests and sanctuary _____

16. Do you think the hartebeest population is changing nowadays? Yes/No

If yes, is it increasing/ decreasing/ no-change/ no-idea

17. Compare to the past, how you evaluate hartebeests' scariness to the local people?

a. Increasing b. decreasing c. no-change

18. Have you been practised hunting hartebeests or other animals within the past few years?

Yes/No

19. Are you happy with current hartebeests' management system? Yes/No

20. Have you been got any damage/attack from wild animals to your crops/livestock/family members? Yes/No, if yes, is there compensation for damages? Yes/No

21. Comparing back to the past 10-20 years, what do you think about change in rainfall amount in your area? a. Increasing b. decreasing c. no-change

22. List the consequences you are experiencing due to change in human population and weather: _____

23. How you evaluate your dependency level on the sanctuary compare to the past?

a. Increasing b. decreasing c. no change

24. Do you think such changes attracting new/more people from another place to your area? Yes/No

25. What do you think would be possible solutions to alleviate climate change related problems? a. Praying b. reforestation/environmental protection c. Both

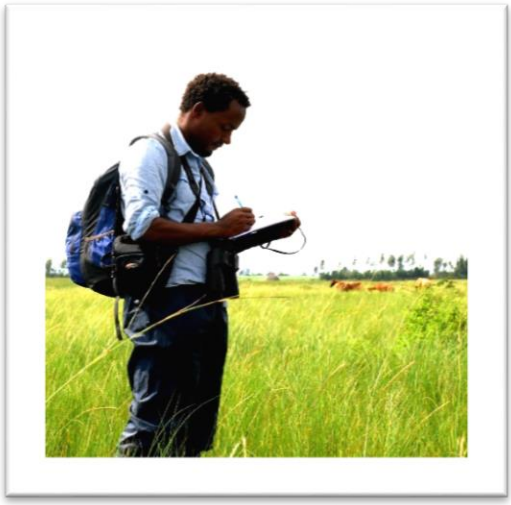
26. If you have more information or suggestions you would like to say: _____

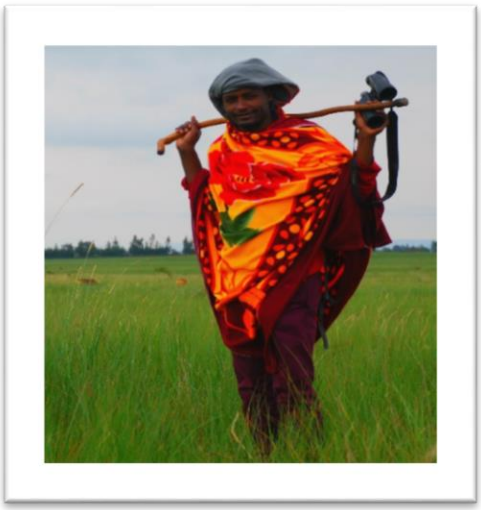
Thank you very much for your help!

Appendix 4: Flight data collection sheet.

No	Date	Time	GPS points		Group Size	Distance (meters)	Group description	Initial behavior			Mimicked disturbance		Disturbance outcome	
			Start	End				Feeding	Idle	Moving/ mixed	Local	New comers	Fighting	Sexual harassments
1														
2														
3														
4														
5														
…														

Appendix 5: Pictures from the fieldwork.





Pictures description orderly: (1st) on work with the strangers clothing style, (2nd & 5th) mimicked locals clothing style, (3rd) shepherds in the sanctuary, (4th) household interview.