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Village based hunter behavior in the Eastern Democratic Republic of Congo

M.Sc. thesis

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Declaration

This thesis report is the result of my own work. Sources used derived from previous work are indicated as such.

Abstract

A multi methodology approach was used to study hunter behavior of gun hunters and trappers in six different villages of the buffer zone of the Lomami national park in Central-Eastern DRC. A total of 100 semi-structured interviews and 60 hunter follows were conducted throughout four months of study. Variation between the sites was found in monthly incomes of hunters, hunting techniques and hunting success. Hunting success was most strongly related to the quality of the gun used by the hunter. Hunting success increases with increasing distance from the village, which confirms predictions from foraging theory. Pursuit behavior did not correspond to the optimal diet model, as pursuit rates were not correlated with the size and market value of the animal. The price of a shotgun shell was found the most relevant factor for selectivity among gun hunters. Both trappers and gun hunters show habitat preference, choosing old growth habitats over others. Encounter rates with wildlife were simultaneously higher for such habitats, indicating that hunters spread over the landscape according to the concept of ideal free distribution.

Key words: hunter behavior, bushmeat-hunting, gun hunting, foraging theory, social-ecological systems, Cemocratic Republic of Congo

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1. Problem statement

Bushmeat hunting comprises one of the main sources of income for forest-dwelling people and their communities in the Democratic Republic of Congo (DRC) (van Vliet and Nasi, 2008, Nasi et al., 2011; Fa and Brown, 2009; Harrison, 2011). Bushmeat is all meat drawn from sources other than domesticated animals, including wild mammals, birds and reptiles (Coad, 2008). Excessive commercial bushmeat hunting, where bushmeat is hunted with the purpose of selling it, has resulted in population decreases of wildlife resources including protected species, local extinctions of species and especially larger bodied species, and defaunation of large forest tracts all over the Congo basin (Coad, 2008; Kumpel, 2006; Fa and Brown, 2009; Ghazoul and Sheil, 2010), therefore jeopardizing forest integrity (Coad et al., 2013; Ghazoul and Sheil, 2010). As a consequence, unsustainable hunting practices eventually lead to decreased harvest of wildlife resources and deprivation of income opportunities for rural forest-dwelling communities in DRC. These developments are further exacerbated by population growth, migration and improved accessibility to formerly isolated forest areas. Commercial bushmeat-hunting can further be seen as a source of conflict both between local communities, as well as between communities and intruders, including city-based hunter gangs employed by powerful merchants, who challenge local institutional set-ups that unofficially govern village based hunting (Lukuru Foundation, personal conversation). Village based hunting refers to the activity of hunting exercised by village inhabitants. Hunting is the chase or search for wild animals with the purpose of catching or killing them (appendix 1 for definitions).

The Tshuapa-Lomami-Lualaba landscape (TL2-landscape) situated in the provinces of Maniema, Tshuapa and Tshopo in the central-eastern DRC is highly affected by bushmeat-hunting pressures. The newly established Lomami national park is expected to ensure conservation of one of the last big forest blocks of DRC and its biodiversity. The TL2 landscape is characterized by a variety of different habitat types. In general a forest productivity gradient stretches from north to south, with relatively high productivity ecosystems in the north and low productivity systems in the south. The southern third of the landscape is furthermore characterized by patchily distributed savannah habitats, resulting in distinctive local gradients in terms of habitat types. As a result biodiversity and local communities in the TL2- landscape are nested in a heterogeneous landscape. The TL2- landscape is home to a range of species endemic to DRC that are classified endangered (IUCN, 2016), including the Okapi (*Okapi johnstoni*) and the Bonobo (*Pan paniscus*). Bonobo populations have suffered severe fragmentation within the TL2-landscape in the past, due to unregulated hunting. Such trends have been decelerated throughout the past 10 years as a result of better information capacity building on protected species at the village level, as well as improved law enforcement measures, including the control of bushmeat markets and main bushmeat trade routes, by the TL project in collaboration with state agencies.

A range of different ethnic groups live in the buffer zone of the Lomami national park. These local communities interact with their environment through hunting, hence, the harvest and exploitation of wildlife resources. Little is known about local hunting systems and hunter behaviour, that is the interactions of wildlife and local village based hunters around protected areas in DRC, including the Lomami national park. Hunter behaviour is characterized by prey choice, hunting effort and success, hunting techniques and habitat patch selection and spatial use through preferences, as a consequence of hunter decision-making (Kumpel, 2006; Coad, 2008). Improving the understanding of such systems is relevant in the landscape conservation context, as the hunter is the link between ecosystems and the wider bushmeat market, and thus an entry point for the action and management of the bushmeat trade (Kumpel, 2006). Optimal foraging theory predicts hunter behavior and decision-making (Kumpel, 2006; Coad, 2007). Studying hunting behavior in the TL2 landscape challenges such models in this regional context. Furthermore, the study of hunter behavior provides information on the levels of depletion of wildlife around the village. Hunter behavior refers to habitat and spatial use of the hunted territory by the hunters, trapping and hunting techniques and tactics employed, as well as prey choice (Kumpel, 2006; Coad, 2007)). Furthermore, there are no empiric insights into the way such hunting systems- and hunter behavior respectively- are vested in a heterogeneous landscape, and whether and how these hunting systems differ according to environmental features of the landscape, as well as hunting success among the hunter populations. Studies addressing hunter behavior and the characteristics of hunting systems conducted in other countries of the Congo basin, including Gabon, Equatorial Guinea and the Republic of the Congo have provided valuable findings on hunting systems, hunting success, the effect of seasonality on hunter behavior and socio-economic factors that influence local hunter behavior and the hunting systems, respectively (Coad, 2008; Foerster et a., 2012; Coad et al., 2013). However, few studies address spatial use and habitat choice by hunters (Kumpel, 2006; Coad 2008; Fa and Brown, 2012). In the TL2 landscape little is known on the characteristics of local hunting systems, including the spatial use of the landscape and habitat preference by village based hunters, hunter behavior, off-take rates and hunting success.

Successful conservation interventions and law enforcement measures depend on a thorough understanding of the drivers that threaten wildlife populations and the habitat these populations depend upon. It is desired by the TL2 project and their partners to work towards comprehensive and integrative conservation strategies that are based on a thorough and holistic understanding of the social ecological interactions through village based hunting in the TL2 landscape. This is expected to result in more effective protection of species and their habitat on the landscape level, as well as to better address the needs of local forest dwelling communities. An improved understanding of village based hunter behavior and local hunting systems is essential for effectively working towards sustainable local bushmeat hunting systems, on an informed and scientific basis and using a more social-ecological approach to conservation on the landscape level. Additionally, the findings of this study can indicate the levels of wildlife resources depletion in the areas of the buffer zone that are subject to this study. Controlled and regulated hunting in the buffer zone is likely to have the capacity to decrease hunting pressure on the national park area. In the long-run, biodiversity conservation is only viewed to be deliver successful and sustainable results if local hunting systems are regulated under a legal framework including exclusive wildlife exploitation rights for local communities, taking traditional forms of wildlife resource governance and use into account.

2. Research objective, research questions and research hypothesis

2.1. Research objective and research questions

The general objective of this comparative study is to provide a better understanding of village based hunter behavior and local hunting systems operational in the TL2 landscape, on a scientific basis. Furthermore this study is aimed to explore whether and how local hunting systems differ in terms of hunter behavior, hunting success and spatial features and habitat use by the hunters between the hunter populations that are considered for this study. Foraging theory in the context of bushmeat hunting is further discussed against the backdrop of empirical findings of this study. The framing research question is the following: What are the characteristics of village-based hunting systems and village based hunter behavior and how do they differ in a heterogeneous, forest dominated landscape in the Democratic Republic of Congo? For analytical purposes, more specifically, the following three research questions are addressed by the methodological approach explained in the subsequent chapter.

1. How do hunting systems differ in terms of hunter behavior and hunting success
2. Does hunting success increase with increasing distance to the village?
3. Do village based hunters show preference for certain habitat types and environmental conditions in a heterogeneous landscape, and does preference differ between the sites?

2.2. Research hypothesis

<u>Null hypothesis:</u>

Q1: There is no difference between the hunter populations in terms of hunting behavior and hunting success

Q2: CPUE does not increase with increasing distance to the village

Q3: Hunters in all villages use the village surroundings homogeneously for hunting and do not show habitat preference.

Alternative hypothesis:

Q1: Local village based hunting behavior differs between villages and their hunter populations, because wildlife abundances and habitat composition of the hunted areas differ between the sites.

Q2: CPUE increases with increasing distance to the village because wildlife populations are more abundant in areas that have experiences less hunting pressure in the past.

Q3: Hunters visit certain forest and habitat types more than less attractive sites because of varying levels of wildlife abundance

3. Theoretical framework

The theories and concepts elaborated upon in this chapter constitute the basis for the understanding the dynamics related to village based hunting behavior and hunting systems in the TL2-landscape. The theoretical framework identifies the interface that comprises the connecting point - illustrated in chapter below - for this research and the research questions, which are presented subsequently presented in chapter the **Error! Reference source not found.**.

3.1. Social-ecological systems

Conservation strategies have been subject to significant paradigm shifts in the past (Palomo et al., 2014; Minteer and Miller, 2011; Berkes 2004; Sayer et al., 2013). While protected areas have partially achieved positive conservation outcomes, general global trends including deforestation, biodiversity loss and habitat fragmentation continue (Palomo et al., 2014). It has increasingly been acknowledged by those concerned with forest and nature conservation that more integrative conservation strategies, building on interdisciplinary analysis of ecosystems that takes social factors into account are required to fully understand the dynamics within landscapes and to better cope with the multitude of challenges conservation of nature is confronted with (Berkes, 2004; Berkes, 2007; Palomo et al., 2014). Concepts and frameworks for conservation on the landscape level have adopted human beings and their communities as components that interact with, and contribute to the dynamics of a landscape (Berkes, 2004; Palomo et al., 2014). Social ecological frameworks have been suggested as a means to mitigate limitations that concern current protected area models (Palomo et al., 2014).A social-ecological framework suggests the integration of ecological and social aspects into comprehensive conservation strategies, in order to achieve landscape conservation goals effectively, and to prevent conflict between livelihood and conservation goals; based on an understanding of the landscape as complex systems where social and biophysical components interact with nature and natural resources, thus shaping the dynamics of the environment (Bengtsson et al., 2003; Bohnet and Smith, 2007; Ostrom, 2009; Palomo et al., 2014). In an SES ecosystems and social systems are interdependent and are integrated with reciprocal feedback (Folke et al., 2010). Many of the problems in the conservation and use of natural resources originate from the lack of recognition that ecosystems and social systems are thoroughly interlinked (Folke et al., 2010).The analysis of ecological systems is required to be complemented by the review of social processes to allow for pondered conservation decision-making (Palomo et al., 2014). The concept of SES is used for this study to understand hunting systems as being dynamic and adaptive systems, vested in the TL2 landscape as the larger SES. The local hunting system is defined through the interactions of the four major components of the SES (Figure 1), the TL2 ecosystems and habitats (RS), prey species and their abundance in the landscape (RU), village based hunters as resource users and their hunting behavior (U) and village based institutions that provide guidance for hunting activities (GS).

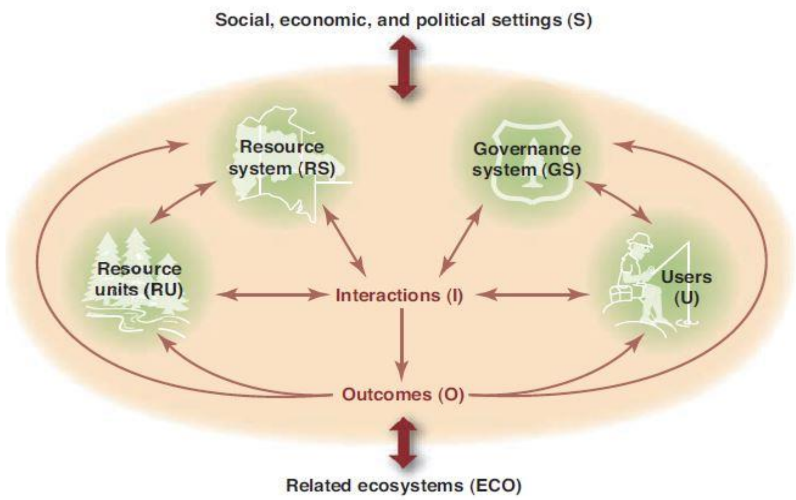

Figure 1: Conceptual model showing links and interactions between the major components in a SES.

3.2. Social-ecological resilience

Various terms and definitions have been shaped throughout the academic debate around SES and "resilience thinking", the applicability of terms and the use of related concepts. Resilience can as a term be applied at various levels and in various contexts (Folke et al., 2010; Scheffer et al., 2015). Social-ecological resilience is one of the major concepts for the understanding and management of SES, and it has been applied in various contexts and fields of research including climate change (Scheffer et al., 2015) and community-based conservation (Berkes, 2006). Social-ecological resilience addresses the dynamics and developments of complex social-ecological systems, where people and nature are interdependent and linked through feedback loops, that eventually determine the characteristics and dynamics of the system (Folke et al., 2010) Resilience thus can be defined as "The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity" (Folke et al., 2010). It therefore is the tendency of a SES subject to change with the purpose of remaining in a stability domain, yet remaining within critical thresholds (Folke et al., 2010). The concept of social-ecological resilience is used for this study to understand both hunters and wildlife as components of the hunting system, and the larger SES, adaptive to change. Hunters may adapt their gun-hunting strategies and trapping behavior according to changes in wildlife abundance around their villages, in order to successfully hunt. Apart from this, hunter behavior and decision-making may be adapted to activity patterns of hunted species. Hunters may furthermore adapt their behavior to external measures, such as law enforcement.

3.3. Source and sink dynamics

The concept of source-sink dynamics is linked to the meta-population theory (Groom et al., 2006). Meta-population theory has been relevant in conservation decision-making and contributed to landscape approach concepts (Sayer et al., 2013). It is linked to prey availability and abundance in a heterogeneous landscape, and thus, patch selection and habitat preference by hunters (see Optimal foraging theory). The theory states that in a meta-population system, subpopulations of a species that occupy patches of similar quality are linked by dispersal and immigration and outmigration. There are occupied and unoccupied patches, and subpopulations can go locally extinct, while patches can be re-colonized. Source-sink dynamics differs from that concept in such a way that it accounts for heterogeneous landscapes where patches are of varying quality (Groom et al., 2006). The concept is grounded on the idea that there are patches of good quality and those of bad quality that highly affect the dynamics of a metapopulation in the sense that patches of good quality are characterized by populations that have higher reproductive success than mortality rates, whereas this is the opposite in bad quality patches. Accordingly, good quality patches or habitat serve as sources, with outmigration to less suitable patches, whereas bad quality habitat or patches function as sinks in a metapopulation system (Novaro et al., 2000; Groom et al., 2006). The concept has in the past been used in the context of the sustainability of human hunting in landscapes dominated by tropical forests (Peres, 2006). It is important to consider that excessive hunting pressure can result in the turn-over of patches that naturally function as sources into sinks (Novaro et al., 2000; Peres, 2006). How the source- sink concept is addressed in this study, and what variables related to source sink dynamics were measured are explained in the general methodology section.

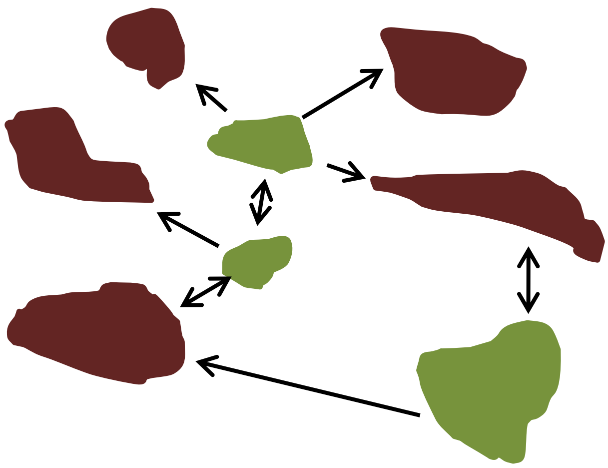

Figure 2: illustration of source-sink dynamics in a metapopulation system. High quality patches (green) function as sources with outmigration to patches of poorer quality (red)

3.4. Optimal foraging theory

Optimal foraging theory has been proved an important concept to be taken into account in the study and management of hunting (Dwyer, 1985; Winterhalder and Lu, 1997; Koster and Venegas, 2012), including bushmeat hunting in Central Africa (Kumpel, 2006; Coad, 2010). Its concepts have been useful to predict the behavior of human hunters in a landscape (Coad, 2010; Koster and Venegas, 2012). Three concepts are relevant for this study, as these are used to explain the spatial pattern of hunting activities where hunters are vested in a heterogeneous landscape, and prey choice.

The first concept is the optimal diet model and is related to prey choice. The optimal prey choice model ranks prey according to their profitability, and predicts that more profitable species are taken more often by hunters, than less profitable species (Alvard, 1995; Kumpel, 2006). This concept has been studied majorly in the context of hunting methods that usually are characterized by selectivity, including gun hunting in Peru (ALvard, 1993; Alvard 1995)

The second relevant concept is Ideal Free Distribution which suggests that foragers –hunters- are distributed over a landscape in such a way that patches and geographical locations with the highest amounts of available food are occupied the most (Groom et al., 2006; Kumpel 2006). It is linked to hunter behavior in such a way that hunters show habitat and patch preference, according to habitat quality and wildlife abundance. Patches with the highest amount of available prey resources will have the most hunters. The assumptions of the model as frequently reported from literature are freedom of movement, ideal knowledge on patches and patch occupation by prey (Kumpel, 2006; Coad, 2010; Koster and Venegas, 2012), as well as hunting skill .

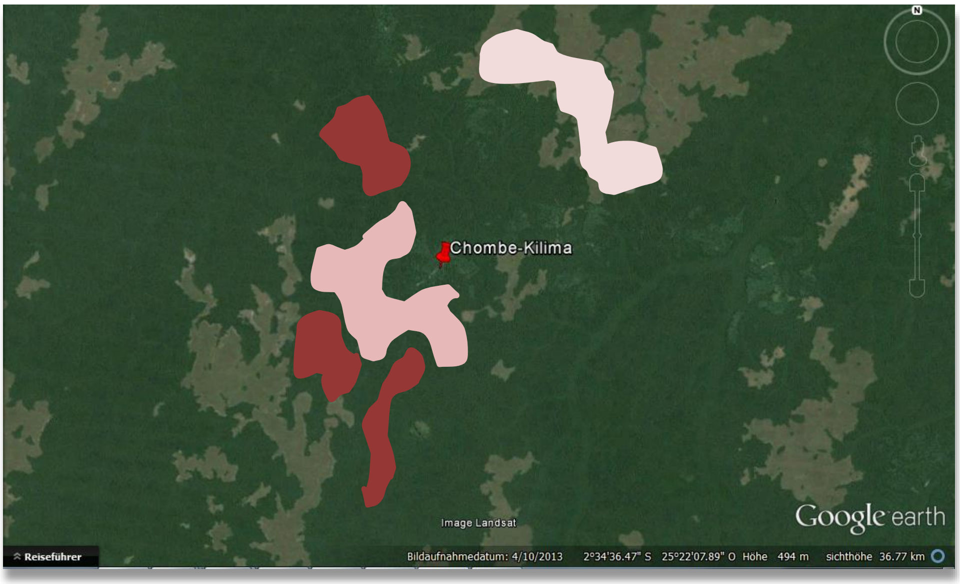

Figure 3: Illustration of Ideal Free Distribution. Patches in the landscape are occupied by hunters heterogeneously, according to the availability of food resources (dark red, high levels of occupancy; light red, low levels of occupancy).

Central place foraging is a concept that traditionally concerns animals that hunt from a fixed location (Sutherland, 1996; Coad, 2008; Levi et al., 2011). It is linked to hunter´s effort and hunting success. In the case of a village based hunter the central place refers to the village, or a hunting camp from which the hunter departs for the search of animals (Kumpel, 2006). The model predicts that the forager will maximize its calorific returns, and thus will increasingly go after larger bodied prey with increasing distances from the central place, to balance increased travel costs (Orians and Pearson, 1979; Sutherland 1996; Kumpel, 2006; Levi et al., 2011). In a village context this implies that the further hunters travel from the central place, for example due to depletion of prey resources in the nearer surroundings of the village, hunters will preferably hunt for larger bodied species in order to account for increased travel costs. The way the three concepts of foraging theory is addressed by this study, the variables measured for quantification and which analysis was conducted in order to do so are explained in the general methodology section.

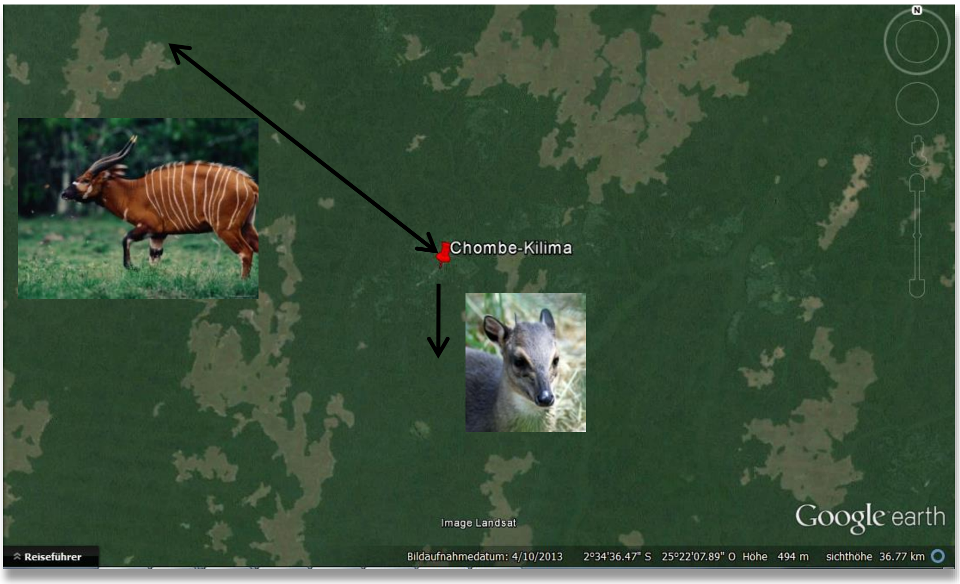

Figure 4: Illustration of central place foraging, where hunters hunt for larger-bodied prey species the further they go from the central place, in this case a village.

3.5. Village based hunting in the TL2-landscape in the context of theory

The general framework for this study is defined by the interlinkages of these concepts in the TL2-landscape where this study is conducted, shown in Figure 5.

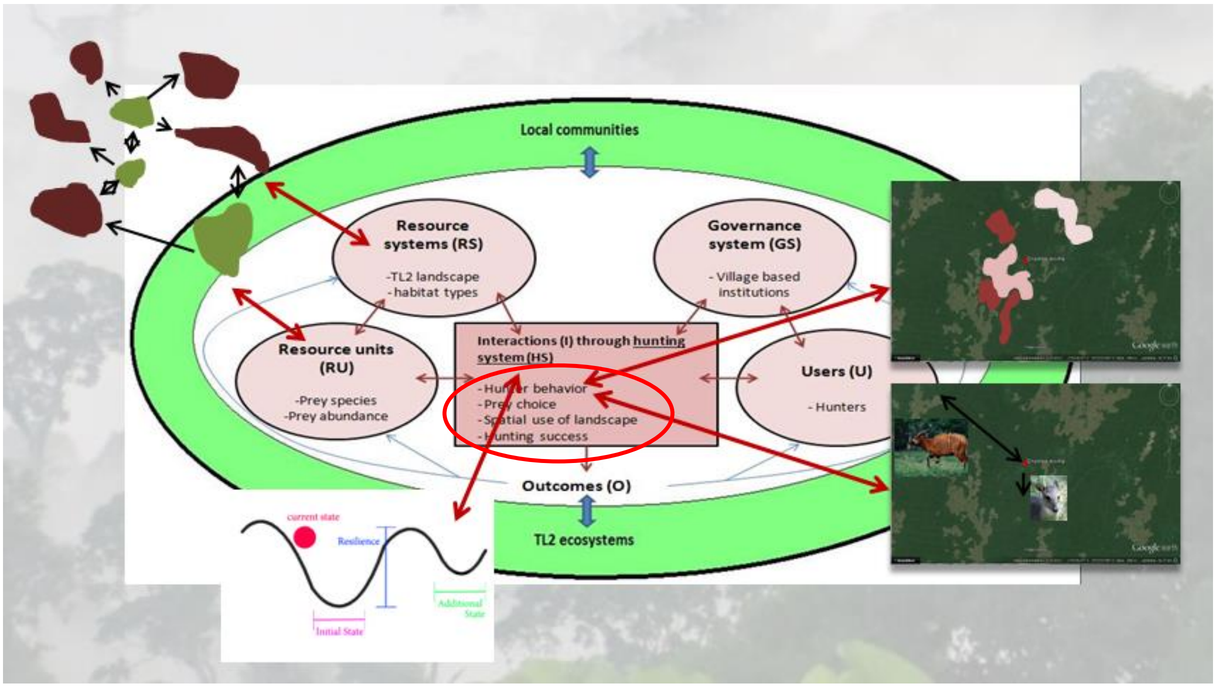

Figure 5: General framework for the proposed study; linking the wider SES to hunting systems and to concepts that predict hunter behaviour

The social-ecological framework constitutes the general framework for this study. The TL2-landscape is understood as a heterogeneous forest dominated landscape where human society and wildlife resources interact through village based hunting. Hunters, as the social component, interact with wildlife -the ecological component- through hunting systems in the wider SES TL2-landscape. Their actions give feedback to one another, and both components are adaptive to change, hunters for example through changes in hunting behaviour. The concepts of foraging theory predict hunter behavior in these hunting systems. The dynamic interactions through the hunting system which are characterized by hunter behavior are viewed to produce all kinds of outcomes such as localized prey population declines, local extinctions and population recoveries, altered patch selection by prey species, modified species composition and ultimately modified habitat quality, which likewise give feedback to the hunters and affect their hunting behaviour. The dynamics of RS and RU are further influenced by source-sink dynamics, determining metapopulation dynamics, as well as the linked feedback from the hunting system. This for example can be the depletion of wildlife resources locally, or local extinction of a particular species. The abundance of wildlife thus may vary between the hunting territories of the villages, and within the hunting territory, for example between habitat types or between distances to the village, with implications for the effort a hunter needs to invest to successfully hunt. Accordingly, such configurations can have implications for the characteristics of the hunting system and can for example influence hunter behavior, indicating that the characteristics of a hunting system are dynamic over time.

The characteristics of hunter behaviour that determine the interactions between local communities and nature through hunting can furthermore be subject to external influences, such as markets, policies or the activity of intruders into the hunted landscape (Kumpel, 2006; Milner-Gulland et al., 2011; Coad et al., 2013). However, the incorporation of these factors is beyond the scope of this study.

The transformability and adaptability of the hunting system, for example through changes in hunter behavior, is related to social-ecological resilience. In the hunter context in the TL2 landscape this suggests that hunters who exploit wildlife resources in the surroundings of their villages, which are vested in heterogeneous landscapes, adapt their hunter behavior to changes in the ecosystems, for example in terms of dynamics in wildlife abundance, in order to maintain the ability to successfully hunt for prey species. Changes in hunter behavior simultaneously modify the hunting system and again give feedback to wildlife and their abundance. This understanding of local hunting systems as resilient and thus dynamic systems supports the assumption, that local hunting systems and village based hunter behavior are different between hunter populations.

The study addresses the characteristics of the hunting system, by focusing on hunter behavior, where spatial use of the landscape and prey choice are part of hunter behavior, and hunting success.

4. Study locations

All study sites are situated inside the buffer-zone of the Lomami national park. The buffer zone extends into the provinces of Maniema, Tshopo and Kasai-Oriental. The landscape is dominated by tropical forests, including riverine forest habitats, tropical lowland forests. In the south of the landscape savanna mosaics are extensive.

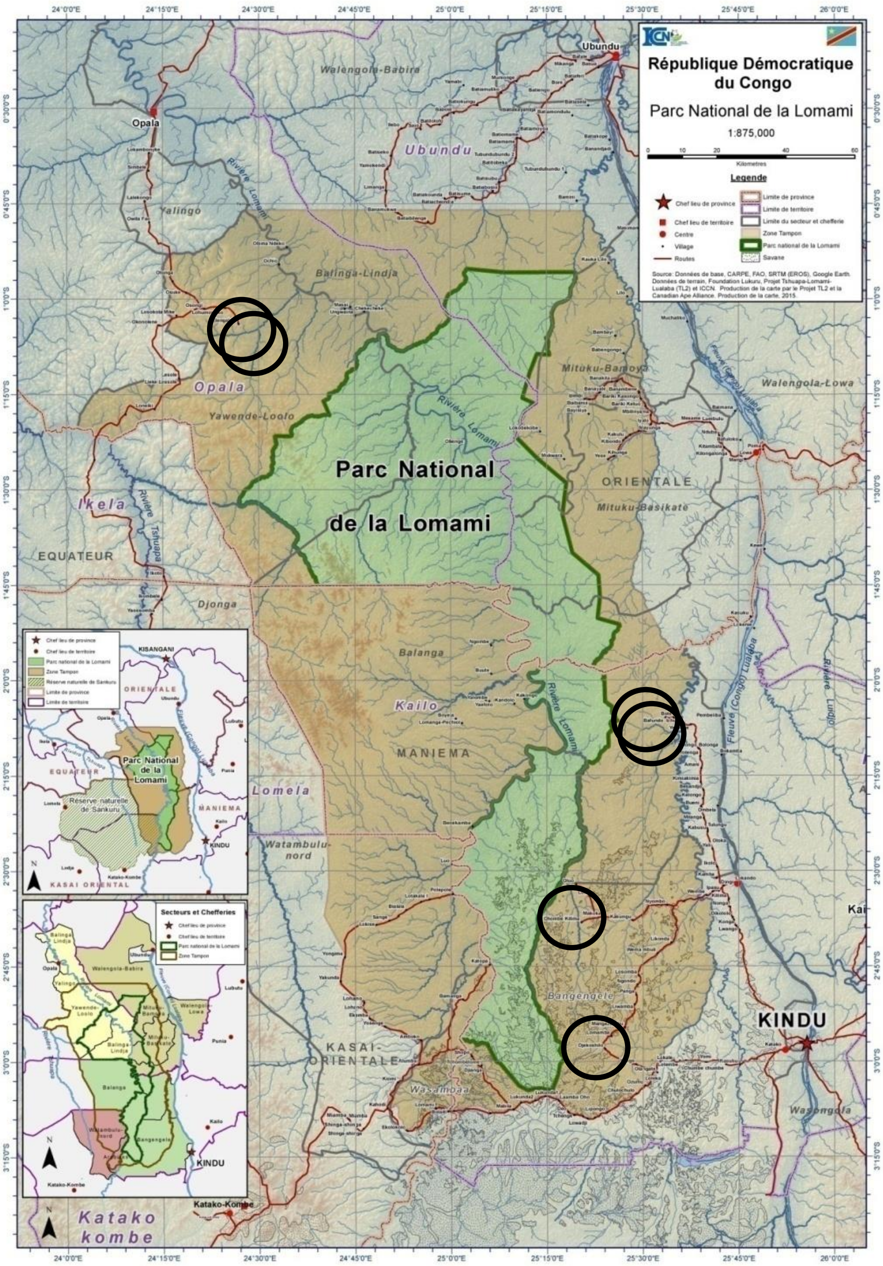

Figure 6: This map illustrates the core of the TL2-landscape, with the Lomami national park coloured green, as well as its bufferzone (beige). Study locations are indicated by black circles.

Data on village based hunting systems and hunter behavior was collected in six different villages, sampling hunter populations in adjacency to the national park area. These hunter populations comprise the groups that were compared to one another with respect to the research questions. All of the sampled villages are situated at the end of forest dirt tracks that connect the sectors and their populations to urban centers, including Kindu and Kisangani. These paths can usually be travelled by motorcycles, however, access may be restricted during the dry season. Two of the villages are situated in the Bangengele[1] territory, situated in the South-Eastern part of the TL2-landscape (1), in Maniema province. Another two of the villages considered for this study are situated in the Balanga[2] sector, bordering the Bangengele sector to the north[3] (appendix 3). While the village of Bafundo has a population of autochthone Balanga, the village of Likandjo in the vicinity of Bafundo has a population majorly comprised by immigrants from the Kasai[4] provinces. The village of Elengalale is located in the territory of Opala in adjacency to the North-Western boundaries of the Lomami national park (2) in Tshopo province. The dominant ethnic Bantu group settling in that area are the Bambole. The sixth study location is Lonolo, a pygmy settlement nearby Elengalale, comprised by one extended family. Exclusively village based hunters, who permanently inhabit these village were sampled for this study.

4.1. Criteria for study site selection

Several criteria were relevant for the choice of the study locations and the hunter populations that were sampled throughout this study. The criteria for study site selection are linked to the implications derived from the theories and concepts that are used for this study. One of the criteria for sample site selection was the composition of the landscape in terms of habitat types the villages and their hunter populations are embedded in. Landscape and habitat heterogeneity as a factor for site selection is linked to foraging theory as well as the concept of source sink dynamics. Source sink dynamics suggest that wildlife populations, and accordingly, their abundance, are distributed heterogeneously in a heterogenic landscape. Foraging theory implies that hunters search for prey in areas that are rich in the abundance of food resources, in this case wildlife and prey species. This suggests that hunters use a heterogenic landscape according to varying levels of prey availability and abundance, displaying habitat and site preference. The concept of social-ecological resilience implies differences in hunting behavior between all sites. This is because hunting systems and hunter behavior are considered dynamic, where hunters adapt their hunting and trapping behavior according to changes in terms of the state variables that characterize the hunting system, such as the abundance of prey species.

The study sites with their hunter populations in the Bangengele territory are vested in a more pronounced heterogeneous landscape, with extensive savanna-forest mosaics. On the other hand, the sampling locations within the the Balanga and Bambole villages are nested in a more homogeneous

[1] The Bangengele are an ethnic Bantu group that traditionally has engaged in slash and burn agriculture, the collection of non-timber forest products (NTFPs), fishing and subsistence hunting.

[2]

[3] See in appendices map illustrating the territories and administrative units into which the TL2 landscape is vested

[4]

forest landscape. The village of Elengalale, he northernmost site is situated in an exclusively forest dominated landscape, with presumably more homogeneity in terms of habitat characteristics, given the fact that savanna mosaics as well as forests adjacent to savannas are absent from the area. Accordingly, hunting activities are expected to be more homogeneously distributed over the landscape surrounding the village, if wildlife abundances are homogeneously distributed in homogeneous landscapes that are comprised by similar habitat types. The variability in terms of habitat composition of the village surroundings is important for testing the hypothesis´ that are linked to research question 3. A number of socioeconomic factors were furthermore relevant for sample site selection. All villages considered for this study are similar in terms of population size, and all populations engage in similar activities for their livelihoods, including slash and burn agriculture, collection of NTFPs, fishing and bushmeat hunting, of which the latter is the only activity generating a monetary income.

Distance to the national park border as well as distance to nearby urban centers and bushmeat markets is another criterion taken into account for the selection of the sample sites, as the populations in the selected villages are known to depend on bushmeat hunting as the exclusive source of monetary income.

Additionally, logistic and practical reasons were influential for the selection of the sample locations as well. All of the villages were targeted by community outreach efforts carried out by the TL2-project, and Djekoshilo, Chombe-Kilima and Bafundo host TL2 camps for field operations inside the Lomami national park.

4.2. Ethnicity and the villages

Numerous ethnic groups settle in the TL2 landscape. These groups can be divided into indigenous Pygmies and Bantu tribes, who have settled within the landscape more recently in history. Nowadays, the majority of villages are Bantu villages, and the majority of people are Bantu. The Bangengele sector in the South of the landscape is dominated by ethnic Mungengele. is part of Maniema province, situated in vicinity to the provincial capital of Kindu. Sectors are administrative units, as part of the territories of the provinces. Each sector has a sector chief, who is the linking element between the sector populations (which are usually relatively homogeneous for each sector, comprised by a certain ethnic group) and higher political levels. While being the same spatial entity, many of the sampled villages in fact were two villages, with different names, and different chiefs. This was applicable for Djekoshilo, which in fact consisted of the villages of Djou and Shilo, Chombe Kilima and Oleke, as well as Elengalale and Lelende. However, these villages were similar in population composition, in terms of ethnicity, as well as having used the same hunting territory with identical user rights for a long period of time. In Djekoshilo, there were different hunting territories for the two populations, however, the establishment of the national park seems to have challenged spatial separation in hunting activities, as much of the area of one of the two hunting territories lies within the park´s boundaries. Djekoshilo, the southernmost village that was sampled for this study is characterized by a homogeneous population consisting of ethnic Mungengele, and almost all hunters that were surveyed were born in the village. Chombe-Kilima, the second village in the Bangengele sector is characterized by a largely homogeneous population of ethnic Mungengele, with few exceptions including a hunter from Equateur, who moved to the area for better hunting opportunities. The vast majority of the population of Chombe-Kilima was born inside the village, while some of the hunters inhabiting the village were born outside of the village, but are ethnic Mungengele. The Balanga sector borders the Bangengele sector to the north. Both sectors have experienced inmigration from other provinces of the DRC throughout the last 1-2 decades, as civil war and unrest has destabilized vast parts of the country. Most significantly, ethnic Mutetela groups now form considerable populations in the Bangengele and Balanga sectors. These populations rather recently inmigrated from the former Kasai provinces in Central DRC. The village of Likandjo in the Balanga sector has an especially pronounced population of Mutetela people, and many keep arriving to this date. Migration and influx of people who search for "empty space" for their livelihoods, including the hunting of bushmeat for commercial purposes is most likely to represent one of the bigger challenges for the future management of the TL2- landscape. Likandjo and Bafundo represent the same spatial entity. However, both populations are delineated by ethnicity and recent history, and the ethnic Mulanga from Bafundo are autochthone, whereas inmigrated Mutetela, Dzonga and Mungengele are allochthone. In fact, Likandjo as such can be divided according to ethnic groups as well, as both Mutetela and Dzonga populations have their own chiefs, and this is reflected by the spatial arrangement of the two communities within that village. For this study, almost exclusively ethnic Mutetela participated in the sampling activities for Likandjo. Intra-village has been reported an issue in Likandjo, as the Dzonga and Mutetela have clashed in disputes in the recent past, with some levels of violence. Pygmy groups settle in vicinity of some Bantu dwellings and villages in the Balanga sector (to the West of the Lomami river) and the territory of Opala. There is no census on the pygmy populations living in the western Balanga sector, as well as for the groups in the territory of Opala. However, there are up to 10 pygmy settlements in the sector of Yawende-Loolo[5] in Opala territory, some of these settlements may only contain one extended family (personal speech, "grouepement" chief of Yawende) while others feature numerous pygmy families

4.3. Collaboration with village authorities and hunters

Prerequisite for the feasibility of this study was collaboration and cooperation with the village authorities and the hunters in each of the villages chosen for this study. Bushmeat hunting and the bushmeat trade are a sensitive issue in the DRC (Yamagiwa, 2003). The TL2-landscape is no exception.

[5] Elengalale is situated in Yawende-Loolo

This is because many, if not most of the village based hunters in the sampled villages qualify as poachers, as a range of protected species are usually hunted, and numerous hunters encroach the Lomami national park frequently (personal speech). Local communities are characterized by open distrust and occasionally even hostility towards external agencies, including NGOs and state agencies. It would not be fair to generalize on this matter towards those individuals who are generally welcoming, and distrust and hostility are not evenly present in all the villages that were subject to this study. Oftentimes distrust is related to the general view, that external players and initiatives are considered aggressors against their customary authority to deal with their communal issues and the use of their customary lands, including hunting. The villages were visited by the researcher and one assistant, and a meeting with village authorities arranged after arrival[6]. This process was facilitated by Congolese field staff in Chombe Kilima, Bafundo and Djekoshilo, where the Lukuru Foundation has field camps to their missions in the national park. The village authorities then were informed about the purpose of the visit and the research, including the research objective according to FPIC[7] principles. Authorization for collaboration with individual hunters and the right to move within the communities´ customary lands, including the forest and hunting grounds by village authorities was obtained by paying authorization fees[8]. The amount was negotiated and involved small amounts of money and small gifts, including salt and sardines, as well as alcohol. The levels of authority and power village chiefs had on their population differed between the villages. In some settings hunters had a separate chief who was responsible for issues concerning hunting, or authority was not really clear. In all settings, after having settled an agreement with the village authorities, more participatory meetings that involved the hunters took place. The purpose of the study was explained to the hunters, and the hunters had the opportunity to ask questions to the research team regarding the implications of the proposed research. Concerns were usually linked to law enforcement, for example gun confiscation and the hunt of protected species, or access to the national park, the security of the researchers during hunter follows in the forest as well as possible rewards hunters would receive for collaboration. In all villages, the research team started with interview sessions where the collaborative hunters were interviewed individually and subsequently were asked for further cooperation with the hunter follows. An attempt was made to motivate as many hunters as possible for the hunter follows in order to collect data on as many hunter individuals as possible. However, many hunters did not show any interest in having a researcher accompany them, as they, besides the factors mentioned above, did not regard the rewards offered by the research team as motivating enough. Thus, the data collected is rather

[6] The village chief of Djekoshilo was met in Kindu before starting field activities in Djekoshilo.
[7] Free prior informed consent
[8] This applies for external hunters too (f.e. from Kindu or other villages), who come in order to hunt on the villages customary lands. A fee for the "right to access" is negotiated with the village chief, usually payed in bushmeat from that hunt afterwards.

skewed towards those individuals who showed interest in participating in this study. Willingness to cooperate and the amount of hunters usually multiplied throughout the time spans of our stays in the villages, as hunters increasingly gained trust in the activities carried out by the researchers. Before each hunter follow, normally one day in advance, the hunter who was to be followed was instructed about the follow to avoid misunderstandings and flawed data, as a researcher´s presence may have an influence on the individual behavior of the hunter. The research team usually stayed in the villages for between 14 and 21 days. This is a considerably short time to gain the hunters´ trust. However, in all settings more courageous hunters volunteered first, and distrust usually decreased among hunters as soon as they saw that the company of a researcher during a hunting trip is not a risk. In Likandjo and Bafundo, inter-village tensions and conflict played a role for the implementation of research activities as well. Bafundo chiefs in the beginning were not in favor of the idea that the researchers collaborate with allochthone Muetetela hunters from Likandjo. The reason for this is that the chiefs and hunters from Bafundo were anxious regarding the possibility that allochthone Mutetela hunters would benefit more from our presence in terms of rewards, than autochthone Mulanga, while moving on customary Mulanga hunting territory.

5. General methodology

The data collection for this study was carried out throughout the months of October (2016) – February (2017). In all villages that were sampled for their hunter populations a timespan between 14 to 21 days was spent. A total of 909 km of hunter follows were conducted[9], as well as a total of 100 interviews with hunters throughout this time span. These months fall into the rainy season in Kindu and dry season in the territory of Opala, and the hunting season in Maniema province[10].

5.1. Hunter follows

Hunter follows were conducted with hunters in each of the study locations, comprising a methodology that allows for collection of spatial, temporal and quantitative data of human activity (Broeseth and Pedersen, 2000; Kumpel, 2006; Coad, 2008). In a hunter follow a hunter is accompanied during a hunting trip and information is recorded. Hunter follows have proved to be a useful method to assess territory use of hunters, capture rates and other characteristics of hunting behavior in previous studies (Broeseth and Pedersen, 2000; Coad, 2008).

The general objective of this methodology component is to gain a complete picture of hunter behavior through the collection of spatial and quantitative data on hunter behavior, hunting success as well as habitat and landscape use by the hunters. Both gun hunters and trap hunters were followed in all

[9]

[10] Hunting is permitted in the buffer-zone throughout 6 months of the year

sampling sites. Track logs for each hunting trip were recorded to measure the distances covered by the hunter, alongside waypoints for each observation. All data points from the hunter follows were recorded using a GPS and a log book where data was entered according to each recorded waypoint in datasheets. Before each hunting trip the age of the hunter, years of hunting experience, start time, number of persons involved in the hunting trip and date were recorded. The track logs of the hunting trip, snare sites, trapped animals, animal encounters and hunting camp sites were were registered for trap follows. Animals were identified using a The Kingdon´s field-guide to African mammals, and their head-body length was recorded in centimeters, and shot or trapped animals were photographed. The hunters´ position was recorded in time intervals of 10 minutes. Tracks and waypoints were recorded using a UTM format. Tracks were closed after the hunting trip was terminated. For every trap group the number of traps and the age of the traps (that is the number of days the traps have been operational in the forest), as well as the trap type were recorded. For each trapping location environmental features including stream adjacency, slope, hill top or valley will be recorded. Stream adjacency applied if the trap group was located within a distance of 50 meters to a stream that is wider than 3 meters. The extent of trapping groups is defined according to these environmental characteristics. The habitat where the particular trapping site is located in was classified according to the habitat classification scheme presented in the subsequent sub-chapter below. For gun hunter follows, the moment of an animal encounter were recorded, taking the geographic position, the species name and whether or whether not the animal was pursued. In the case of an animal pursuit the outcome was recorded. Additionally, the habitat where the animal encounter occurred was recorded according to the habitat classification scheme mentioned previously. Notes were taken on each data point for further information on the circumstances of the event. Hunter follows were generally classified into three categories: village-based hunter follows, where the departs from the village and returns to the village after the hunting trip for animal handling (1), camp-based hunter follows, where the hunter departed from a hunting camp and returned to the hunting camp for animal handling activities (2) and transit follows, where the hunter either departs from the village to arrive at a camp or vice versa (3). The general variables measured to address the research questions and related theories are displayed in Table 6, and a more detailed table showing the variable measured and calculated is shown in the appendix.

5.1.1. Calculating catch per unit effort (CPUE)

Hunting success was measured using catch per unit effort (CPUE). CPUE can be measured in various ways (Kumpel, 2006). The data generated from the hunter follows allowed for the application of different measure techniques for CPUE. For this study CPUE was measured by number of killed animals over the distances covered by the hunter for each hunting trip, as well as number of killed animals over time invested in the hunting trip. This approach was suggested as the weight of total biomass of the catch was not measured, due to logistical constraints to .

5.1.2. Recording wildlife encounters

Prior to the follows the hunters were instructed to indicate all encounters with wildlife and hunted species. Encounters involved both direct encounters with wildlife, that is, animals that were either heard or seen directly by the hunter, as well as indirect encounters with wildlife, including recent animal traces and the smell of an animal. Hereby exclusively traces that were not older than a day were taken into account. The recording depended on the judgement of the hunter. All encounters with mammal species were recorded, except for squirrels (*Sciuridae*) and other rodents, as well as Galagos (*Galagidae*) that were frequently spotted during night hunts. However, for the few occasions that a squirrel was pursued with the purpose of killing it, this was recorded as well. As for birds encounters with Guinea fowls (*Numidiae*) and the Congolese peacock (*A.congensis*) were systematically recorded. For the rare occasion of a hunter pursuing a hornbill, birds of prey or the Great Blue Turaco this was recorded as well. Among reptiles encounters with large snakes (that qualified as a prey species) and the Dwarf crocodile (*Osteolaemus tetraspis)* were recorded. For all encounters the number of animals was recorded. For the occasion of encounters with primates that were dwelling in groups, or traces of the red river hog for instance, the number of individuals was estimated by the hunter when it was not possible to count. The animals were identified with the help of the hunters and a Kingdon´s field guide to African mammals.

5.1.3. Forest and habitat classification for hunter follows

Forest and habitat classification was used to provide a description of the habitat type of the hunting sites visited by hunters during hunter follows. For each waypoint of an observation as recorded using a GPS the habitat type was recorded. Forests can be classified differently, according to the underlying approach. For example, forests can be classified according to plant communities dominant in the ecosystem, climatic conditions, edaphic factors or anthropogenic influences, using distinctive methods such as inventory designs or remote sensing. Due to the lack of detailed habitat maps and forest inventory data on the study site or high resolution maps displaying forest types, the approach to forest classification adopted from similar studies was used (Coad, 2007; van Vliet and Nasi, 2008). Therefore, a general classification of forest and habitat types based on factors that are relatively easy to identify in the field is considered useful for this study. Forest and habitat types are classified into six categories, shown in Table 1: 1) Plantations and garden mosaics, 2) young secondary forest, 3) old secondary forest, 4) old growth forest, 5) open savanna and 6) forests in the buffer of savannas. Types 5 and 6 are complementary to previously used classification schemes. During the hunter follows, the forest type where the hunter sets up snares or hunts with the gun will be assessed on the basis of forest characteristics inside a 100 m radius of the specific hunting site.

Forest classification			Description
Detailed	1	Plantations and gardens	Plantations, fields and gardens in the village surroundings.
	2	Young secondary	Regenerating young secondary forest, recently cleared. Young, spindly, thicket trees. Very dense understorey with abundant liana (species). Open canopy.
	3	Old secondary	Trees with larger diameter than observed for (2). Dense understorey but less thick and easier to walk than (2).More closed canopy, less gaps in the canopy.
	4	Old-growth forest	Numerous large and thick trees. Closed canopy and little light reaching the understorey. Bare understorey vegetation, easy to walk.
	5	Open savanna	Open savanna lands, with dominance of grasses (*Poaceae*), no trees.
	6	Savanna adjacent forests (<300 m to savanna border)	Forests adjacent to savannas. Usually with thick vegetation in the understorey, many trees with small diameter, relatively small tree heights. Low productivity systems.

Table 1: Forest and habitat classification scheme used for hunter follows

5.1.4. Sample size: hunter follows

Three major factors influenced sample size in terms of hunter follows throughout this study: time, number of hunters in the villages (as well as their presence in the villages throughout out the stay) and willingness-to-cooperate both by hunters and village authorities. Due to limited available time for fieldwork a number of ten hunter follows per sample site and hunter population, a total of 60 hunter follows were conducted in 6 different villages, with 705 km of gun hunter follows and 204 km of trapper follows. Hunters and trappers were identified with assistance of the village authorities. The hunters participating in this study for hunter follows were volunteers, and purposively selected from the hunters in each village. Usually, hunters were interviewed first and then asked to participate in hunter follows. Hunters who participated in the study were given small material rewards or money[11]after the hunting trip. Rewards, apart from money, included socks, baseball-caps, little bags filled with salt, and sardines. Rewards were suggested by project staff, as a measure to encourage hunters to participate in the study. The gifts were considered small enough to avoid an effect of the rewards on the hunting activity and the behavior of the hunter. In Djekoshilo, a total of 3 different hunters were followed. In Chombe-Kilima 4 different gun hunters were followed, in Bafundo 2 and 1 in Likandjo. In Elengalale 4 different gun hunters were followed. All of the hunters who participated were between 19 and 45 years old. Most of the hunters in all of the villages showed interest in participating in the study after initial meetings to achieve free prior informed consent. However, due to distrust and rewards that were considered

Village	n Follows
Bafundo	8
Chombe Kilima	8
Djekoshilo	7
Elengalale	16
Likandjo	5
Total	44

Table 3: Sample size of gun hunter follows per village

Village	n Follows
Bafundo	2
Chombe Kilima	3
Djekoshilo	7
Elengalale	1
Likandjo	3
Total	16

Table 2: Sample size of trap hunter follows per village

[11] In general the research team anticipated to avoid handing out money as rewards for willingness to cooperate by the hunters. However, in three of the villages collaboration with hunters could only be ensured through the provision of money as a reward for participation in hunter follows. The amounts given varied, with a maximum of three US Dollars for a hunting trip. To ensure authenticity of hunter behavior, the amount given was less than the smallest primate species is worth as of market value in the village (C.ascanius: 3-5 US Dollar).

5.1.5. Assumptions for gun hunter follows

Previous case studies on hunter behaviour have identified age of the hunter as a strong predictor for hunting success (Coad, 2008). Age in these studies is related to hunter skills and the hunters´ ability to cover large distances, and to visit patches that have relatively high abundance of prey situated further away from the village. Because hunters were not sampled based on their age, I assume that gun hunters who were sampled for this study have similar hunting skills, including the ability to cover large distances and visit patches where wildlife is presumably relatively abundant, the ability to detect wildlife[12], the ability to approach wildlife without being detected and to acquire a good shooting position, and to have equal skills in shooting precision. In this sense, the hunters who are sampled in this study can be seen as representative for the total village population of hunters.

5.2. Semi structured interviews

5.2.1. Introduction of the questionnaire

The second major research method that has been applied throughout data collection for this study was the use of semi-structured interviews. Village based hunters were interviewed to gain information on hunter behavior and the hunting system in place. Furthermore, the semi-structured interviews delivered information on variables such as preferred hunting techniques, preferred habitat and hunting success, as well as prey choice (appendix 7). The questionnaire was structured into sections according to the research questions. Each section was organized from more general to more specific questions.

The first section contains general questions related to the hunter, including the hunter´s name, age, village and the number of children the hunter has, as well as the date at which the interview is conducted.

The second section entails questions regarding the personal motivation of the hunter to go hunting, and the way hunting is organized. Therefore questions are asked related to the frequency of hunting trips, the purpose (subsistence and cash-income generation), seasonality as a factor for hunting frequency, and how hunting is governed on the village level.

Section 3 inquired on the hunting techniques used and on species that are hunted. This section entails questions related to the use of hunting techniques (snare hunting, gun hunting, hunting with dogs), preferred prey species, hunting of protected species and more specific questions on gun hunting and snare hunting.

[12] Especially primates, that are often detected by hearing them

Section 4 of the questionnaire asks about the spatial use of the hunting territory and habitat types used for hunting. The questions ask about distances to hunting sites from the village, hunting success in relation to distance from village, the use of habitat types, preferred environmental conditions for the set-up of snares, the way the hunter classifies habitat/forest types and whether certain areas within the hunting territory are set aside as refuges for wildlife to recover.

Section 5 inquired about how the hunting system corresponds to neighboring communities and the national park. Questions are asked on whether the village based hunting territory overlaps with the hunting territory of neighboring communities, awareness of the location of the national park and the use of the national park as a hunting ground.

5.2.2. Sample size: Semi structured interviews

The interviews were conducted in each of the 5 villages. Prior to this study, a number of 20 interviews were planned to be conducted, based on the assumption that each of the studied villages has a number of around 20 hunters[13]. Sample size is based on the following formula (Israel, 1992) for calculating sample size, estimating the total hunter population per village to be around 20 and using a 95% confidence level:

$$n = N/1+N*(0.05)^2$$

Where n is sample size and N is the total hunter population in the sample location.

Apart from the size of the total hunter population in each of the villages samples, the amount of hunters that was interviewed depended on willingness-to-cooperate among the hunters. Hunters were identified with the support of the village chief and/or other village authorities, such as hunter chiefs. In some occasions, TL2 field staff was assisting in connecting to the hunters.

Village	**N interviews**
Bafundo	13
Chombe-Kilima	22
Djekoshilo	20
Elengalale	21
Likandjo	21

[13] The assumptions are grounded on estimations from project staff

Lonolo	3
Total	**100**

Table 4: Number of interviews conducted per village

13 semi-structured interviews were conducted in Bafundo. In Chombe-Kilima a total of 22 hunters were interviewed, 20 in Djekoshilo, 21 in Elengalale and 21 in Likandjo. In Lonolo all 3 hunters were interviewed. While in Bafundo and Lonolo the number of interviews conducted was limited by the number of hunters in the village, time and willingness-to-cooperate were the limiting factors for the amount of conducted interviews in Elengalale, Likandjo, Djekoshilo and Chombe-Kilima. All of the interviewed hunters participated with the hunter follows. The number of hunters was underestimated in most of the villages (appendix). In Lonolo, 100% of the hunters living in the village were interrogated, 76% in Bafundo, 56% in Djekoshilo, 51% in Chombe Kilima, 40% in Likandjo and 25 % in Elengalale.

5.3. Satellite imagery and maps

Satellite imagery was used as a third component of the methodology to address the research questions of this study. The use of satellite imagery is linked to the data points collected during the hunter follows. The spatial analysis for research question 2 and 3 was conducted incorporating satellite imagery and thematic maps (Table 5). The map material was provided by the Lukuru Foundation.

Type material, content	Format	Cell size
Landsat 2010, land use	Raster	60 X 60 m
DRC land use	Raster	1000 X 1000 m
Administration	Shapefiles, polygons	
Hydrology TL2 landscape	Raster	100 X 100 m
Hydrology TL2 landscape	Shapefiles; lines	
Savanna extent	Shapefiles, polygons	
DRC vegetation	Raster	300 X 300 m
Settlements	Shapefiles, point files	
Bonobo range	Shapefiles, polygons	
Patrol coverage maps	PDF	

Table 5: Map material used for spatial analysis

5.4. Participatory mapping and village profiling

Participatory mapping is a method to collect information on natural resources and territory use by local communities (Newing, 2010). Local informants and researchers work together to map the geographical area where the local community uses natural resources or has customary claims to the land. Participatory mapping was used for this study to map and identify the approximate extents of customary hunting territories of the villages. The method was implemented according to principles for carrying out participatory mapping (Newing, 2010). Participatory mapping was conducted in Djekoshilo, Bafundo and Elengalale. In Participatory mapping was not conducted in Chombe Kilima, due to limited collaboration of the hunter chief, and not conducted in Likandjo, out of respect towards the hunter community of Bafundo, who consider the forests surrounding Likandjo/Bafundo their customary land. In the first place, throughout the initial free prior informed consent meetings with the village authorities and hunters, the audience was informed about the method and its purpose. In all villages, both authorities and hunters participated in creating the maps. In Djekoshilo a total of 3 persons was involved, in Bafundo 4 people were involved, and in Elengalale 15 people were involved. In all participatory mapping workshops the village chiefs participated. A base map was created by the researcher before starting the mapping process, with basic orientation features of the landscape, including the location of the village and large rivers. Subsequently, the informants mapped all major rivers and greater habitat types, such as savannas and the boundaries of their customary hunting territory, as well as the situation of other villages. Simultaneously, informants provided information on the levels of wildlife abundance of certain areas of their territory. More sensitive features and sites of the territories were not asked to have them included in the map, including an unauthorized diamond mine in the hunting territory of Elengalale. Ground truthing, where the features drawn in the map are checked upon in the terrain, was indirectly and in a limited way conducted through tracking the hunters. However, in none of the villages the entire hunting territory was visited throughout the time of study.

Village profiling was used to collect demographic information on each of the villages. The number of households, household inhabitants and occupation of the adult men were recorded. Therefore, the number of gun hunters and trappers could be determined. The profiling was conducted together with at least one village authority. Village profiling was important to verify sample size.

5.5. Data sources and measured variables

The study is explorative and comparative. A multiple methodology approach with triangulation was used to address the research questions. Data derived from five methods were taken into account in this study to gain insights into village based hunter behavior and the local hunting systems in place and whether and how hunter behavior differ from one hunter population to the other: 1) hunter follows, 2) semi-structured interviews with hunters 3) satellite imagery, 4) participatory mapping as well as village profiling 5) (see below table). All methods are interlinked and partly complementary, as well as partly triangular. This is because the methods partly inquire on the same questions, with a different underlying approach. Triangulation was used to check upon identical or similar variables by using different approaches. While the semi-structured interviews yielded quantitative and qualitative data on general hunter behavior by addressing questions around preferred environmental conditions for hunting site selection by hunters, hunting techniques employed and hunting success, hunter follows allow for the collection of quantitative and spatial data on hunting success and spatial use of the hunted landscape. Method 1 and 3 are interlinked in the sense that the spatial data points derived from hunter follows are combined with satellite imagery on land use-, forest cover, topographical and hydrological maps for analysis purposes, using ArcGIS. Each of the research questions is linked to the theoretical framework. The measurable variables seen in the below table were selected to address foraging theory, source-sink dynamics theory and social-ecological systems concept.

Type of data collection method	**Group variable**	**Theories addressed**
1) Hunter follow	- Geographic locations of hunting (EFF) - Wildlife encounters (ENC) - Pursuit behavior (PB) - Habitat and spatial use (SU) - Hunting success in CPUE (HS) - Distances covered (EFF) - Catch composition (P) - Head-body length of species	Foraging theory: optimal diet model, central place foraging and ideal free distribution Source-sink dynamics
2) Semi-structured interviews	- Habitat and spatial use (SU) - Hunting technique (HT) - Hunting success (HS) - Motivation for hunting (SE) - Socioeconomic factors (SE) - Village based institutions around hunting (SE)	Foraging theory: central place foraging, ideal free distribution;
3) Satellite imagery	- Spatial use (SU) - Landscape features	Ideal free distribution
4) Village profiling	- Village demographics	Sociodemographics

5) Participatory hunting territory mapping	- Hunting territory extent (SU)	Ideal free distribution

Table 6: Table illustrating the links between methods, theories and the variables measured

The above table illustrates what kind of variables were measured using the different methodologies. A detailed overview on the variables measured throughout this study can be found in the appendix 2 (hunter follows) and appendix 2 (semi structured interviews).

6. Data analysis

During the hunting trips the data points were recorded using a GPS where the geographical position was taken for each observation, as well as a logbook where the data was entered according to the waypoint number. The logbooks were prepared with the data sheet formats prior to departing on the hunting trips. After the fieldwork the data was transferred from the logbook into Excel and then uploaded into SPSS software. The geographical data was handled using ExpertGPS software to transfer the data to ArcGIS for analysis purposes. Each hunter was assigned a code, as was the village, the number of follows and type of follow. The code was used to correspond data and information between field log books and the data analysis applications. Thus, each waypoint and tracklog recorded throughout the study could easily be associated with time and location of the follow.

The following three types of analysis were carried out to answer the research questions: 1) statistical analysis of quantitative data collected throughout the hunter follows and interviews, 2) interpretation of qualitative data and 3) spatial analysis and interpretation of patterns in the data points collected during hunter follows using ArcGIS. All quantitative data was analyzed using Microsoft Excel and SPSS software. Graphs were created using both SPSS software and Microsoft Excel. ArcGIS was used for spatial analysis of the spatial data gained from hunter follows where the data is analyzed in the context of maps that feature land-use, forest cover, topography and hydrology of the TL2-landscape. All maps and visualizations of hunting trips were created using ArcGIS for Desktop.

6.1. Statistical analysis

The main purpose of this study was to explore whether hunter behaviour and the local hunting systems in place differ between the sampled hunter populations. The hunter populations in the different villages comprise the groups that were tested for group differences. Correlation analysis was conducted on several variables, including encounter rates (as a proxy for wildlife abundance), CPUE, age of the hunter, number of shotgun shells carried during the follow, km covered and gun type to discover relationships that may indicate explanation for hunting success. Furthermore, correlation analysis was used to address foraging theory, where HBL of shot and encountered animals[14] was correlated with distance of the encounter from the village as a central place (appendix 4). The optimal diet concept was addressed by correlation analysis between HBL and pursuit rates, both for the two main prey groups, cephalophes and primates, as well as other prey groups. Correlational analysis furthermore was used to support the assumption that hunters have similar hunting skills, including the ability to detect wildlife, and thus are representative for their populations and comparable across the villages. In the first place, this involves equal skills in detecting wildlife[15] and equal skills in approaching wildlife without being spotted by an animal before attaining a good shooting position. The validity of assumptions is discussed in the discussion section.

6.1.1. Research question 1

Research question 1 is addressing the characteristics of hunting systems and hunter behaviour in the studied villages. Furthermore, foraging theory is addressed. CPUE is compared between the villages, and villages nested in a forest dominated landscape are expected to have higher levels of wildlife abundance than villages where open water logged low productivity savannas dominate the landscape. For group difference analysis in hunter behaviour between the hunter populations, interpretation of data visualizations from hunter follow and interview data, for example in the form of graphs were used to explore patterns in the data. Subsequently, SPSS was used to test for statistically significant differences between the hunter populations in terms of hunting success, using CPUE as a measure. Data points for hunting success were the CPUE measures for each follow. Assumptions for conducting parametric group comparison tests could not be met as the CPUE data was not normally distributed. Sample size differed between the studied populations and the data showed negative skews, with relatively many 0 values, and relatively few values ranging between >0 – 1,3. The data then was transformed, using log10 transformation in SPSS. However, the transformations did not achieve normality of the data for the CPUE data. Subsequently, non-parametric Kruskal-Wallis test was applied to test for group differences in CPUE between the studied hunter populations. Besides hunting success, encounter rates with wildlife and pursuit rates of wildlife, species and species groups were tested for group differences using SPSS. Animal encounter rates were calculated dividing all direct encounters with wildlife (animals that were detected by the hunter through hearing them or seeing them) over distances covered by the hunter for the hunting trip. Encounter rates were furthermore calculated for all indirect encounters with animals that is animals that were detected by either a sign (f.e. a recent

[14] For encountered animals, maximum head- and body length of a species was used

[15] This is especially important for primates. Detecting primates, even though primate individuals or groups may be situated far from the hunter, is important for hunting success. Primates usually comprise a large share of the returns from hunting trips.

trace or recent foraging remains) or their smell by the hunter. As observed with CPUE data, the data yielded for encounter rates did not match assumptions for the application of parametric statistical tests to test for group differences. The data was log10 – transformed. However, normally distributed data was not obtained. Accordingly, a non-parametric Kruskal Wallis test for group comparison was applied to test for differences between the studied hunter populations. Majorly quantitative, but also qualitative data from the semi-structured interviews was used to investigate diversity in hunting techniques, night hunting, trapper behavior, species availability. Quantitative and qualitative data was used to analyse hunting territory governance and territorial conflicts between villages.

6.1.2. Research question 2

Research question 2 is directly addressing foraging theory. The theory of central place foraging, where the forager departs from a central place to search for food, trying to maximize calorific returns is in the focus of analysis. For this analysis, as it is more generally addressing foraging theory in the context of hunters in the TL2 landscape, all hunter follows from all the villages were taken into account as data points. In order to test for whether hunting success increases with increasing distance from the village, the landscape surrounding the villages was divided into four zones for the purpose of this study (see appendix 2). The zones represent the groups that are used for group comparison tests on hunting success, to allow for analysis on hunting success with respect to distance to the village. This analysis is addressing foraging theory, and more specifically central place foraging. Hunter follow track logs were handled in ArcGIS to calculate the distances covered by hunters in each of the zones per follow. Hereby the village in each of the cases is the center of three circles that define the extent of the zones. Two classifications of distance zones were used to address research question 2. In the first classification scheme, zone 1 ranges from 0-4 km distance to the village, zone 2 from 4-10 km, zone 3 from 10-16 and zone 4 comprising all tracklogs and data points from hunter follows that were recorded at a distance of >16 km from the village. In the second classification, zone 1 ranges from 0-4 km distance from the village, zone 2 from 4-8 km, zone 3 from 8 – 12 and zone 4 from > 12 km from the village. The classification scheme for distance classes was related to certain features of the landscape surrounding the villages. Usually, zone 1 (0-4 km from the village) is characterized by mixed cropland and secondary regrowth vegetation due to slash- and burn agriculture around the villages. Zone 2 is usually comprised by mixed secondary and old growth forests, whereas zones 3 and 4 are more dominated by vegetation formations that are not, or to a small extent, subject to human management or interventions. Habitat and hunter behaviour related variables are subject to the statistical anylsis of research question 3. For each of the zones CPUE was calculated for each of the hunting trips. Next to CPUE, animal encounter rates, animal pursuit rates and kills/pursuit rates were calculated for each of the zones. In SPSS, these rates were tested for group differences, using either parametric tests (ANOVA) or non- parametric Kruskal Wallis tests, for when assumptions for parametric tests could not be met. Furthermore correlation analysis was conducted to test the relationship between head- and body length of encountered species and distance to the villages.

6.1.3. Research question 3

Research question 3 is linked to foraging theory. The concept of ideal free distribution, where the forager selects patches for food-search according to the availability of food resources is addressed by this research question. Furthermore, but more indirectly, source sink dynamics, where more productive habitats and patches have higher abundances than lower quality patches, is addressed. To conduct spatial analysis for habitat types on hunting success, encounter rates and pursuit rates, all distances covered in either of the 5 different habitat classes were calculated for each follow using ArcGIS and Microsoft Excel. Subsequently, CPUE and animal encounter rates, alongside pursuit rates and kills/pursuit rates were calculated for each follow and each zones. Animal encounter rates are linked to source-sink dynamics theory, although abundance of wildlife is most likely to be a function of ecosystem productivity and the history of hunting and hunting pressures across the landscape. All rates were tested for group differences using SPSS. Non parametric Kruskal-Wallis test for group differences was applied, as the data did not match assumptions for the application of a parametric test for group differences. Apart from spatial analysis ArcGIS, the data obtained from the semi-structured interviews was taken into account and interpreted as well as visualized in graphs, where hunters scored a habitat matrix, according to their preferences.

6.2. The village of Lonolo, and the Likandjo-Bafundo case

Lonolo comprises a small pygmy village nearby Elengalale, situated on a clearing with small crop plantations. The village is inhabited by one extended family. Three men and one youngster engage in trap and bow hunting. One hunter follow was conducted with Lonolo hunters, and interviews were carried out with the the three eldest men. The low amount of conducted hunter follows disqualifies Lonolo for group comparison tests with the other sampled villages. As all hunters were surveyed for the interviews, the data gained from interviews is representative for the entire population of hunters in Lonolo and thus considered for analysis of interview data. The village of Likandjo and Bafundo, although being the same spatial entity, were treated separately for data analysis. This is because both villages display strong differences in terms of size, ethnicity and recent history, as explained previously in the study location section.

7. Results

7.1. Results of research question 1: How do hunting systems differ in terms of hunter behavior and hunting success?

In this section more general features of the hunting systems and more general differences and similarities of hunter behavior between the studied sites are elaborated. Hereby the focus is on the hunting techniques, the extent of hunting territories, prey choice by the hunters and differences in monetary incomes from hunting across the villages. This section subsequently focuses on differences between the two largest groups of hunters – gun hunters and trap hunters – across the studied sites. The variables compared include CPUE and encounter rates with wildlife, and certain aspects regarding the equipment these hunters use, as well as strategies these hunters apply. The results section focusses on gun hunters and trappers.

7.1.1. Motivation for hunting and types of hunting,

The main purpose for hunting in all of the Bantu villages were either exclusively revenue or both revenue and subsistence (**Error! Reference source not found.**). However, monetary income can be onsidered the main motivation for hunting among the hunter populations of the Bantu villages, as hunting represents the sole source of monetary income. The highest share of exclusive commercial hunters was observed for Likandjo. In the Mungengele villages of Djekoshilo and Chombe Kilima exclusively commercial hunters comprise around 60 % of all hunters. Hunters usually consume animal body parts of low market value. The hunters in the surveyed villages practice different types of hunting. Hunters can be classified as gun hunters, snare hunters (trappers), mixed gun and snare hunters, dog hunters bow hunters and mixed bow, - trap and/ or gun hunters. The villages differ in terms of the hunting practiced in each one of them. Gun hunting and snare hunting are the dominant types of hunting in the villages of the Bangengele sector (Chombe Kilima and Djekoshilo). Close to 40 % of all hunters that were interrogated for this study are exclusive gun hunters in the village of Chombe Kilima, while in Djekoshilo around 30 % of hunters are mixed snare and gun hunters (compared to 10 % in Chombe Kilima) (Figure 9). For those hunters who practice both gun hunting and snare hunting are usually those who do not possess a gun personally, but who occasionally borrow guns, and this behavior is more common in Djekoshilo than in other villages (appendix 3). In Bafundo, snare hunters (70 – 80 %) dominate clearly over gun hunters (Figure 10). Likandjo shows a pattern similar to Bafundo in terms of hunter type composition. Elengalale features gun hunters, mixed gun and snare hunters, snare hunters, bow hunters and mixed bow and snare hunters. Alongside "aller-retour" hunting, staying in a camp in the forest for several days is common among both snare hunters and gun hunters. Thereby the hunter faces logistical constraints, as it involves costs that need to be covered in advance, including nutrition and hunting equipment. The average amount of the number of days a hunter spends in the forest differs between the villages. While the hunters of Chombe Kilima spend between 3 and 4 days averagely in the forest, Elengalale hunters stay longer than 12 days (appendix 3). For longer hunting trips hunters depart with a group.

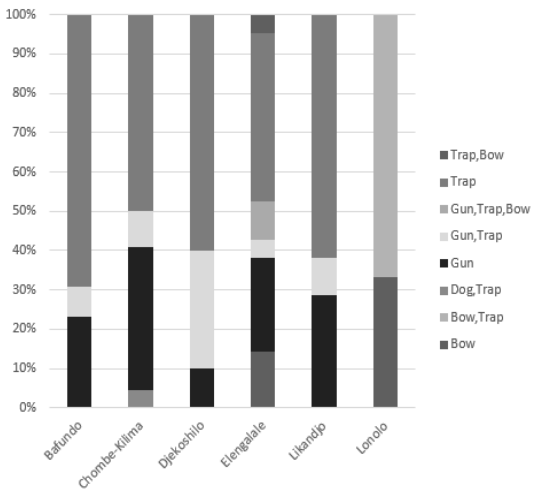

Figure 9: Share of hunting types in the hunter populations

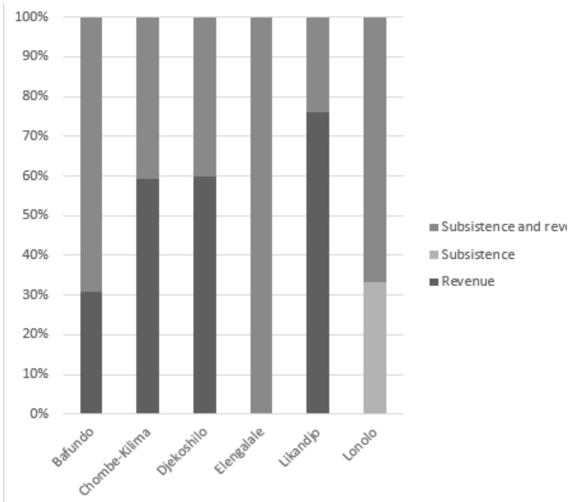

Figure 7: Relative purpose of hunting across the villages

7.1.2. Hunting territories

The below map (Figure 11) shows the approximate extent of customary hunting territories of the villages of Djekoshilo, Bafundo and Elengalale[16]. The areas indicated in the map are estimated hunting territory extents, based on participatory mapping with village authorities and hunters. The forests and hunting grounds where hunters go for gun-hunting or trapping are named according to the names of the rivers. Elengalale comprises the most extensive hunting territory with approximately 3450 km^2, followed by Bafundo with approximately 2000 km^2. The hunting territory of Djekoshilo comprises an area of around 1000 km^2. These are vast areas. Delimitation with other villages seems to be strict in closer distances to the villages, whereas large shares of the territories further away from the villages seem to overlap with other villages hunting territories, and often overlap with territories of other villages (appendix 3). However, much of the extent of customary hunting territories has become national park with no authorization for hunting activities. All villages lost large areas, but especially Djekoshilo and Chombe Kilima only have small forest areas left in the buffer-zone of the park where hunting is authorized through half of the year. Those forests are perceived by the hunters to have low wildlife densities. Chombe Kilima and Bafundo hunters report conflicts over hunting territory with other populations (appendix 3). Bafundo hunters, ethnic Mulanga, consider the migrants, majorly

[16]No participatory mapping was conducted in Chombe-Kilima, due to little interest in participation from the hunters side.

ethnic Mutetela and Dzonga, in Likandjo intruders. Chombe Kilima indicate conflict with neighboring villages over their customary territory. Hunters in Elengalale perceive low levels of conflict, but there are intruders who are ethnic Dzonga, coming from the west bank of the Tshuap river, west of Elengalale

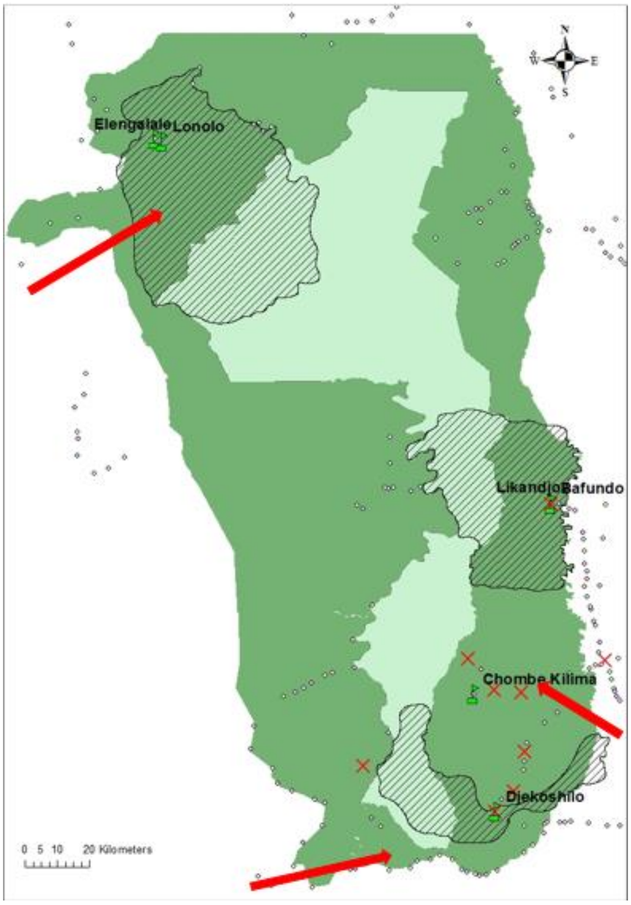

Figure 11: Approximate extent of customary hunting territories of Djekoshilo (south), Bafundo (middle) and Elengalale (north). Red arrows indicate generalized origin of intruders. Red crosses mark villages with who the studied villages have frequent conflict.

7.1.3. Hunted species and species availability

A wide range of species are found within the TL2-landscape, and basically all larger bodied species are subject to hunting and poaching (see appendix 3 for bushmeat prices).

Animal group	Common name	Scientific name
Ungulates	Weyn´s duiker	*Cephalophus weynsi*
	Blue duiker	*Philantomba monticola*
	Bay duiker	*Cephalophus dorsalis*
	Black-fronted duiker	*Cephalophus nigrifons*
	Yellow-backed duiker	*Cephalophus silvicultor*

	Water chevrotain	*Hyemoschus aquaticus*
	Sitatunga	*Tragelaphus spekii*
	Bongo	*Tragelaphus eurycerus*
Large mammals	African forest buffalo	*Syncerus caffer nanus*
	Red river hog	*Potamocherus porcus*
	African forest elephant	*Loxodonta cyclotis*
Primates	Black crested mangabey	*Lophocebus aterrimus*
	Red-tailed monkey	*Cercopithecus ascanius*
	Wolf´s mona monkey	*Cercopithecus wolfi*
	De Brazza´s monkey	*Cercopithecus neglectus*
	Angola colobus monkey	*Colobus angolensis*
	Dryas monkey	*Cercopithecus dryas*
	Blue monkey	*Cercopithecus mitis*
	Lesula monkey	*Cercoptihecus lomamiensis*
	Tshuapa red colobus	*Procolobus tholloni*
	Potto	*Perodicticus potto*
	Bonobo	*Pan paniscus*
Civet cats	African civet cat	*Civetticus civetta*
	Servaline genett	*Genetta servalina*
	Central African linsang	*Poiana richardsoni*
	African plam civet	*Nandinia binotata*
Pangolins and Porcupines	Long-tailed pangolin	*Uromanis tetradactyla*
	African White-bellied Pangolin	*Phataginus tricuspis*
	African bursh-tailed porcupine	*Atherurus africanus*

Felids	African golden cat Leopard	*Profelis aurata* *Panthera pardus*
Reptiles	Dward crocodile Python	*Osteolaemus tetraspis* *Pythonidae spp.*
Birds	Congo peafowl Guinea fowl	*Afropavo congensis* *Numidiae*

Table 7: List of species that were directly or indirectly encountered throughout the gun hunter- and trapper follows.

The above table (Table 7) displays all species that were encountered during the hunter follows. All of the species listed are potential prey species. Primates and cephalophes, alongside the red river hog (*P.porcus*) accounted for the majority of animal encounters in all villages and comprise the most important prey groups (see appendix 3). Among primates (appendix 3), Red-tailed monkeys (*C.ascanius*) and Wolf´s mona monkeys (*C.wolfi*) accounted for >80% of primate encounters in Chombe Kilima, and around 90% of primate encounters around Djekoshilo. Bonobos (*P.paniscus*) were exclusively found around Bafundo/Likandjo. While Red-tailed monkeys and Wolf´s mona monkeys are relatively abundant in the hunting territories of the other villages as well, species such as the Blue monkey (*C.mitis*) and the Black mangabey (*L.aterrimus*) were furthermore relatively frequently encountered. Taking both direct and indirect encounters into account, this indicates that biodiversity and species abundance are not uniform across the landscape. Encounter rates with wildlife and species availability in relation to distance to the village are presented in the chapters Wildlife encounter rates, pursuit behaviour and CPUE, and7.2.

7.1.4. Incomes of hunters

There is variation in terms of incomes of the hunters, both between the villages, as well as between the types of hunters (Figure 13). Gun hunters in each of the villages have a higher monetary monthly income through hunting than trap hunters. Hunters who practice both types of hunting were intermediate between the two groups. In Chombe Kilima, gun hunters, with more than 400000 FC[17] in a month have a times and significantly higher monthly income as compared to gun hunters in Bafundo (P = 0,027), and Elengalale (P = 0,007), both with around 100000 FC monthly (Figure 12). Likandjo and Djekoshilo gun hunters have intermediate incomes, with around 350000 FC. Trap hunters in Chombe Kilima, with around 200000 FC, earned on average statistically significantly more than trap hunters in Elengalale, who earn less than 100000 FC (P = 0,020) (appendix 3). Trappers from from

[17] Exchange rate with US Dollar in Kindu and Kisangani during the ime of the study was: 1150 FC = 1 US Dollar

Djekoshilo (around 150000 FC) earn 50 % more than Bafundo and Likandjo trappers (both around 100000 FC).

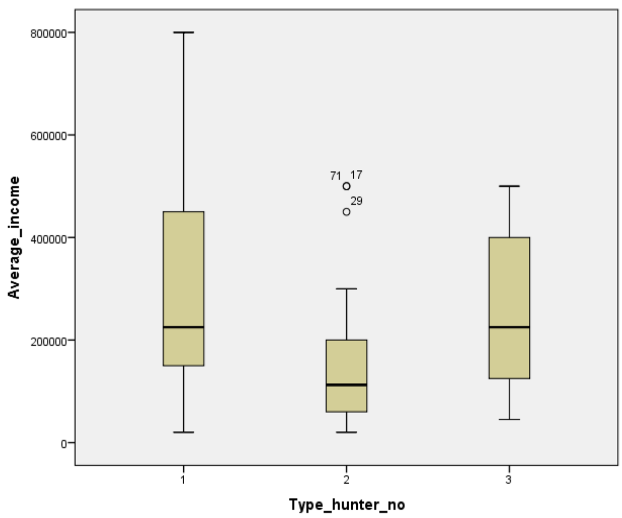

Figure 13: Boxplot showing the differences in average incomes between gun hunters (1), trappers (2) and hunters who practice both types of hunting (3)

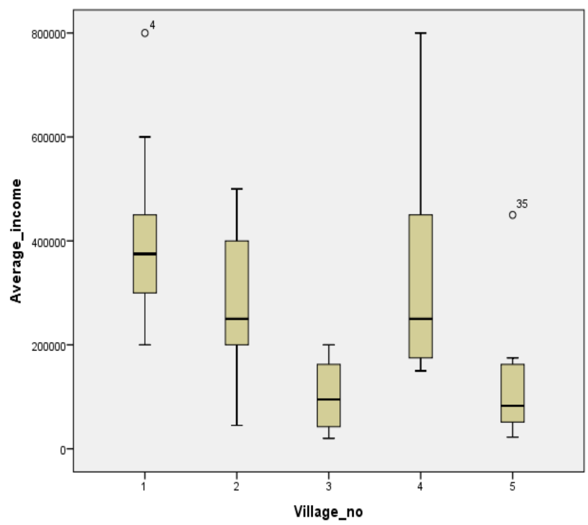

Figure 12: Boxplot showing the differences in median monthly incomes of gun hunters in the villages of Chombe Kilima (1), Djekoshilo (2), Bafundo (3), Likandjo (4) and Elengalale (5).

7.1.5. Gun hunter behavior

This section focuses more explicitly on gun hunters and differences in hunter behavior between gun hunters of the studied sites. Gun hunting is a widespread hunting method within the TL2- landscape. Gun hunters were present in all of the sampled villages, except for the pygmy village of Lonolo, but are usually out-numbered by trappers in all of the villages (appendix 3). These hunters can target wildlife that is usually out of reach for trappers[18], such as primates. Gun hunting requires higher investments than trap hunting, but returns are higher, which is also reflected by higher incomes (Figure 13). Gun hunters hunt solitary or in groups. For longer hunting trips gun hunters are usually accompanied by kin, friends or other people from the village who are "contracted" for this period of time. While the gun holder does all or most of the hunting, and covers all prior expenses, including basic nutrition[19] his companions assist with the hunting, take care of the camps, do the cooking and much of the animal smoking, and carry prey. They are rewarded dependent on their contributions and the catch, and they are paid with bushmeat. During hunting trips other than go- and return trips, gun hunters in Chombe Kilima stay an average of 5 days in the forest, compared to 10 days Elengalale hunters spend (appendix

[18] Some primates may be caught with traps, including Bonobos (*Pan paniscus*) and the Lesula monkey (*Cercopithecus lomamiensis*), that do descent from trees for foraging and moving around the forests. Some hunters do also trap monkeys. This was reported for Mutetela hunters in Likandjo (however, not empirically verified), as well as hunters in Elengalale, who set up traps in the lower canopy at the edges of secondary regrowth to trap for the Red-tailed monkey (*Cercopithecus ascanius*).
[19] Rice, fufu (a cassava flat cake), salt, palmoil

3). Djekoshilo-, Bafundo- and Likandjo hunters are intermediate. Go- and return trips, where the hunter returns to the village without staying in a camp in the forest, may be conducted by the gun hunter on his own, but hunters hunting in the night are usually accompanied by kin or friends, due to higher risks. Such hunting trips are especially widespread among gun hunters in Chombe Kilima and ELengalale (appendix 3) .Go- and return hunting in Chombe Kilima is strongly associated with night hunting (see sub-chapter Night hunting). In Djekoshilo none of the gun hunters conducts go- and return hunting trips, while Likandjo and Bafundo, where night hunting is widespread as well, display moderate values (50 % of gun hunters conduct go- and return hunting trips.

The types of guns hunters used differed between the sites. While Bangengele and Balanga hunters exclusively hunt with original shotguns, with an average market price of 600 US Dollar the most expensive guns, the Mutetela from Likandjo use city- manufactured guns[20], which are less expensive (averagely 118 US), but also less powerful. Gun hunters in Elengalale use either city-manufactured guns[21] or guns that are manufactured on the village level. These guns are partly made out of bicycle parts and have lower power and precision than the other two gun types, and are less expensive (averagely 32 US Dollar). While hunters in Bafundo, Chombe Kilima, Likandjo and Djekoshilo carried averagely between 8 and 17 shotgun shells per follow, Elengalale hunters carried less than 3 on average. Shotgun shell scarcity in Elengalale is common. All gun hunters in Elengalale and Djekoshilo practice selective hunting according to them. In Chombe Kilima more than half of the hunters hunts selectively, in Bafundo less than half, and none of the gun hunters in Likandjo hunts selectively[22] (appendix 3).

The detection ability of primates further away from the hunter, through their vocalizations and movements in the canopies did not significantly differ between the sites (appendix 3), suggesting that hunters have similar skills in terms of detecting wildlife.

7.1.5.1. Wildlife encounter rates, pursuit behaviour and CPUE

Catch per unit effort is the central analytical element to compare hunter success between the sites. A Kruskal-Wallis test on catch per unit effort of all gun hunter follows, comparing the different villages, showed that there is a statistically significant difference between the village of Djekoshilo (3) and Elengalale (4) (p= 0,006), where catch per unit effort is higher in Djekoshilo than in Elengalale (Figure 14). Elengalale has a CPUE value of < 0,01. This means that on average hunters walked more than 100 km without killing an animal in Elengalale. Likandjo, Bafundo and Chombe Kilima have moderate CPUE values. Encounter rates between the villages, where direct encounters with wildlife were taken into

[20] Among the Mutetela, guns usually originate from Kindu
[21] Originating from Kisangani
[22] Hunters from Likandjo state, that they „kill any animal that presents itself in front of the hunter in the forest“

account did not show any statistically significant differences (p = > 0,05). However, direct encounter rates with wildlife were relatively high in Elengalale in Tshopo province (>0,6 direct encounters/km), and similarly lower for Chombe Kilima, Djekoshilo, Bafundo and Likandjo in Maniema province (< 0,5 encounters/km) (Figure 15). Primate encounter rates were significantly higher in the surroundings of Elengalale than in Chombe Kilima (P=0,001) (appendix 3). This means that Elengalale simultaneously comprised the highest encounter rates with wildlife, as well as the lowest CPUE values.

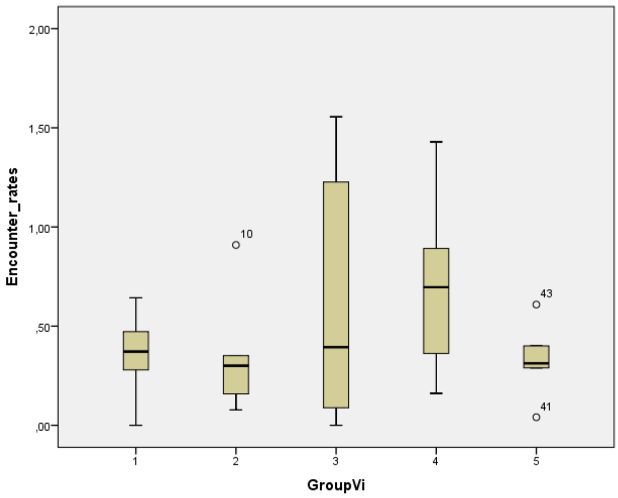

Figure 15: Direct encounter rates with all wildlife in Bafundo (1), Chombe Kilima (2), Djekoshilo (3), Elengalale (4) and Likandjo.

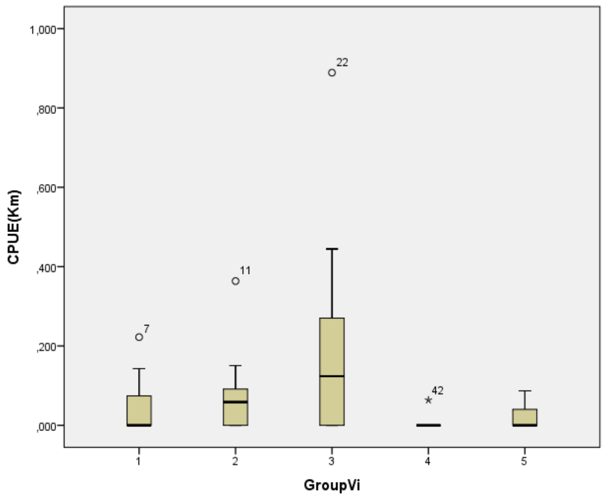

Figure 14: Catch per unit effort in Bafundo (1), Chombe Kilima (2), Djekoshilo (3), Elengalale (4) and Likandjo.

Primates and cephalophes accounted for almost 90 % of the off-take of gun hunters (appendix 3) across the villages. Cephalophes were always pursued[23] following a direct encounter. Primate pursuit rates were similar across the villages as well, with a median around 0,6 in Chombe Kilima, Djekoshilo, Bafundo and Elengalale, and insignificantly higher in Likandjo (appendix 3). Primates were mostly encountered through their vocalizations or their noise in the canopies (appendix 3), and frequently not pursuit when they were either very far away, or when primates were alert before the hunter could assume a shooting position. Cephalophes were significantly more pursued in the occasion of an encounter than primates (p=0,000), and all directly encountered cephalophes were pursued, except for one Bay duiker in Elengalale vanishing quickly. Other mammals than cephalophes and primates account for a large share of species encountered in the night (appendix 3) mostly ground-dwelling species were pursued, whereas arboreal species such as *N.binotata* and *P.potto* were not (appendix 3). The pattern is equal across the villages.

In the case of a direct encounters with duikers, close to 60% of the occasions resulted in the killing of the encountered animal, whereas less than 20% of the direct encounters with primates resulted in the

[23] There was one exception for a duiker encountered in Elengalale, that vanished rapidly after the encounter

killing of the animal (appendix 3). The chance that prey escaped even though it was hit by the gunshot was higher for duikers (appendix 3).

7.1.5.2. Follow types: village-based, camp-based and transit

The results show that encounter rates with wildlife are significantly higher throughout camp-based follows as compared to transit follows (p=0,00) and village-based follows (p=0,04). Simultaneously, CPUE is significantly higher for camp-based follows compared to transit follows (p=0,006), and higher, though not statistically significant, when compared to villages based follows. Pursuit rates of species of one of the major prey groups – primates- did not significantly differ between the follow types (appendix 3).

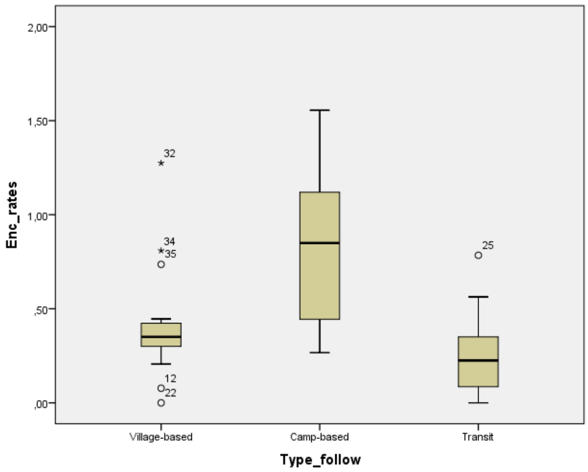

Figure 17: Direct encounter rates with wildlife per type follow

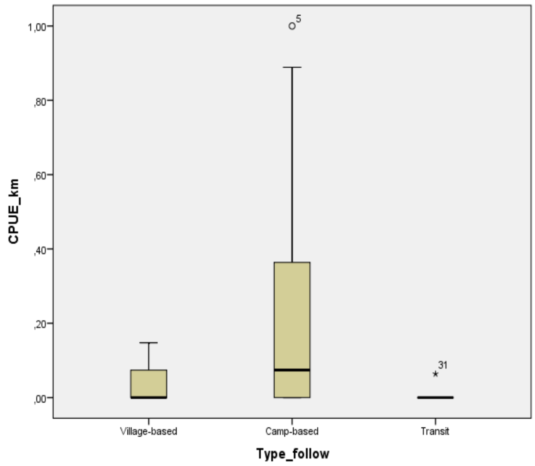

Figure 16: CPUE per type follow

7.1.5.3. Night hunting

Night hunting is a method applied by gun hunters to hunt nocturnal prey species. Night hunting differs across the villages of the TL2- landscape and is widespread in Chombe Kilima and Likandjo, where equally 100 % of the gun hunters use this method. It is relatively widespread in Djekoshilo, where a majority (>60 %) of gun hunters practices night hunting, and present in Bafundo. There is no night hunting in Elengalale.

During a night hunt the hunter is equipped with a head-lamp, alongside extra sets of batteries and his gun. The tactics applied vary compared to gun hunting conducted throughout the day, where usually primate species are targeted and comprise the by far largest share of encountered potential prey species (appendix 3). During the night hunt, the hunter follows hunter trails in the forest, scanning the understorey of the forest for the reflective eyes of duikers or porcupines. Orientation is a challenge to night hunters, and usually known hunter trails are followed.

Encounters with duikers were more frequent during the night, then during the day (appendix 3). Night hunting is a method to hunt for duikers. Many duikers have a relatively high market value (appendix 3). Other mammals that are frequently directly encountered in the night are *P.potto* and civet cats, usually through vocalization. However, these majorly arboreal species are only pursued opportunistically, if the animal is encountered at short distance that allows for a shot (appendix 3) . Torches until recent were not widespread, but this has changed in the mid-2000s, when Chinese manufactured and low-priced torches became available on the markets in urban centers like Kindu or Kisangani. Equipment for night hunting, such as torches and batteries are sold in some of the villages, like in Likandjo. Prices vary according to the model, but can be purchased on the village level for about 3 US Dollar. .

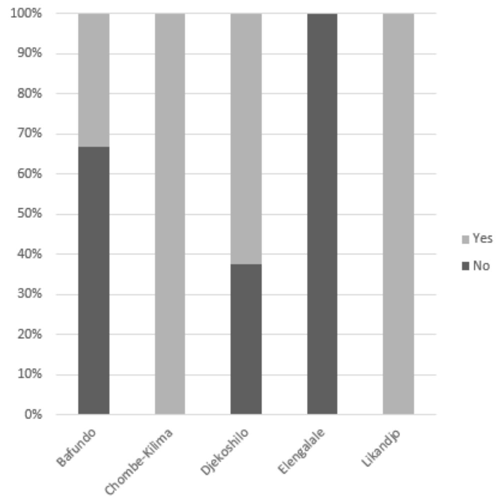

Figure 18: Share of gun hunters who practice night hunting with a head lamp across the villages

7.1.5.4. *Correlates in gun hunter success*

Among the variables measured (appendix 2), the type of gun used by the hunter seems to be the best predictor for hunting success. Gun hunters using an original brand shotgun had significantly higher CPUE values, and returns from their hunting trips, than hunters who use either guns that are manufactured in the city (P=0,01) or village (P=0,041). Likewise, kills per shot taken ratios are significantly higher for original shotguns as compared to the two other gun-types (appendix 3). Likewise, hunters in Djekoshilo, Chombe Kilima and Bafundo have significantly higher ratios than hunters in Elengalale (appendix 4). Hunters using original shotguns earn more on a monthly basis than hunters who use city-manufactured guns. Hunters using guns that are produced on the village level earn less than the latter two (ANOVA analysis for group differences yielded p=0,055) (appendix 3). There is no correlation between encounter rates and hunting success (CPUE) for hunters using a city-manufactured gun or a village-manufactured gun (Pearson correlation coefficient = -0,101) (appendix 4). Encounter rates are strongly correlated with CPUE for hunters of Djekoshilo, Chombe Kilima and

Bafundo who use original shotguns (Pearson correlation= 0,693) (appendix 4). These correlates underpin the relevance of the quality of the gun for hunting success, and correspond to average gun hunter incomes, either using original brand shotguns, city-manufactured guns and village-manufactured guns. Apart from encounter rates, age and experience of the hunter, pursuit rates and success ratios for the shots taken did not correlate significantly with CPUE (appendix 4). The maximum prices paid on the village level for cephalophe-, primate- and antelope species, as well as the red river hog are strongly positively correlated with maximum head- and body length of these species of the major prey groups (appendix 4). However, there is no significant correlation between the individual pursuit rate for each of the species and the market price of that species, nor HBL and pursuit rates (appendix 4). For when other mammals apart from the major prey groups are taken into account, there is a weak correlation between HBL and pursuit rates (appendix 4).

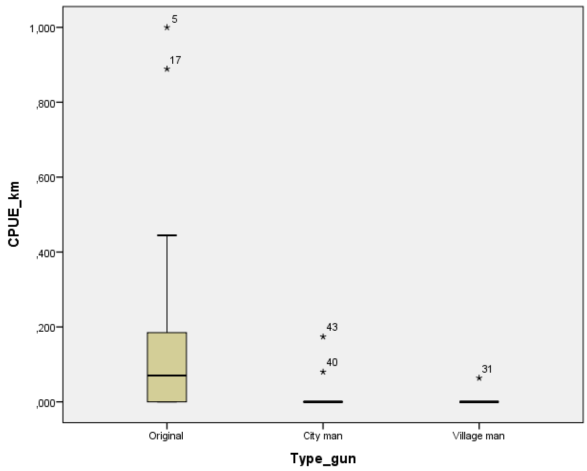

Figure 19: CPUE according to the type of gun used by the hunter.

7.1.6. Trapper behaviour

Trap hunting is the most widespread hunting method within the TL2-landscape. Youngsters with little financial means usually start exploiting wildlife through trapping, or bow hunting in Elengalale. While all hunters younger than 25 interrogated in Djekoshilo and Likandjo and more than 70% in Elengalale were trappers, a strong share of younger hunters hunted with guns in Bafundo and Chombe Kilima (appendix 3).

There are generally two types of snares used to trap for wildlife: rope snares and cable snares. Rope snares are less expensive than cable snares, and seem to be less effective and less powerful. Trappers choose where to set up snares almost exclusively according to animal tracks and paths in the forest, and there is no difference between the trappers from the studied villages (Figure 21). A minor number of trappers indicated, that trapping is more successful along small streams for example, or on top of hills. However, trappers usually do not prefer any specific environmental conditions for the set-up of their snares (Figure 20). While smaller species such as porcupines and smaller duikers are trapped for using rope snares, larger ungulates such as yellow-backed duikers or the Sitatunga, as well as red river hogs are trapped for using cable snares. Trappers have reported to hunt less throughout the hunting closure[24]. Seasonality seems to have a strong impact on trapping (appendix 3, appendix 3). Trappers state that wildlife circulates less in the forest during the dry season, and that wildlife is more concentrated along streams and where else water can be found. Trappers decide on where to set up snares according on recently used animal tracks and paths, thus, where they promise themselves a high chance for catching an animal. Trappers in all villages state that it is relatively difficult during the dry season to identify recently used animal paths in the forest as animal tracks are relatively hard to see on the dry soil and organic matter of the forest ground. Furthermore, trappers state that it is more difficult to install the traps during the dry season, as the soil is blowy, and thus less appropriate to keep hold of the branches that are inflected for snare installation. Selectivity among trappers is especially pronounced in Djekoshilo, where half of the trappers stated to apply selective trapping methods. In Djekoshilo, especially strong snare set-ups with cables and 2 snares in a row are set-up to prey for Sitatunga antelopes. Around 30 % of trappers in Bafundo, Likandjo and Elengalale claim to hunt selectively, compared to 10 % in Chombe Kilima (appendix 3).

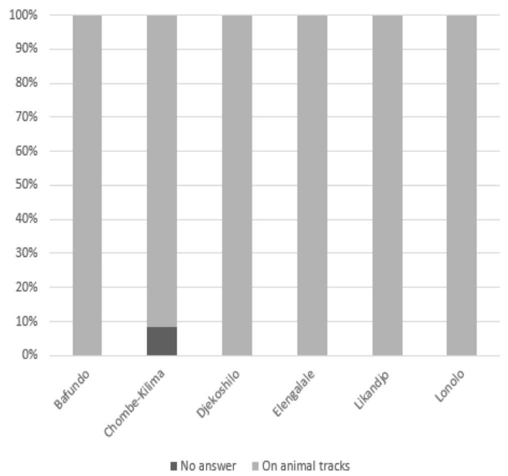

Figure 21: Factors for snare site selection

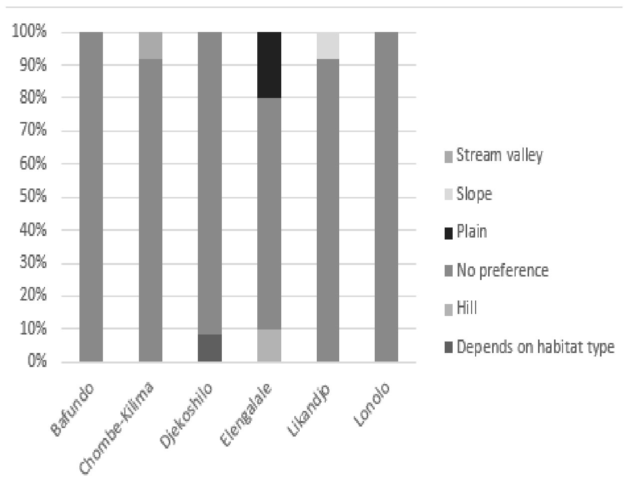

Figure 20: Environmental conditions and snare site selection

T

Chombe-Kilima (2). In Bafundo, Likandjo and Elengalale not a single animal was found trapped during the trapper follows.

[24] A period of time when all hunting is prohibited, according to provincial law

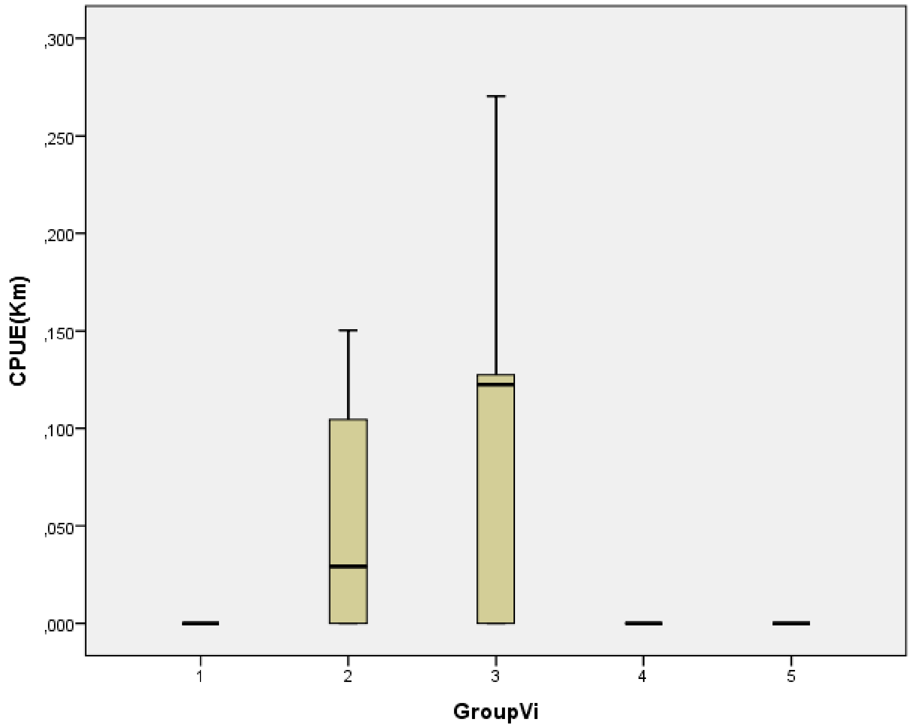

Figure 22: Boxplot displaying median CPUE for Bafundo (1), Chombe Kilima (2), Djekoshilo (3), ELengalale (4) and Likandjo (5)

7.1.6.2. *The use of snares*

Generally, trappers use either cable snares or rope snares for trap hunting, or both. Cable snares are more expensive, but are more suitable and more powerful to trap for larger bodied species. The use of cable snares was not equally popular across the villages (Figure 24). More than 90 % of the surveyed trappers in Djekoshilo hunt with cable snares, followed by > 80 % of trappers from Chombe Kilima. In Elengalale and Bafundo less than 50 % of the trappers hunt with cable snares, and Likandjo is intermediate with a slightly above 70 % of trappers, who install cable snares to trap animals. While trappers in Bafundo, Djekoshilo, Likandjo and Elengalale averagly have around 100 snares (both rope and cable snares) installed in the forest, the amount of snares in the forest per hunter is higher in Chombe Kilima, with an average of around 150 snares per trapper (P = <0,05) (Figure 23).

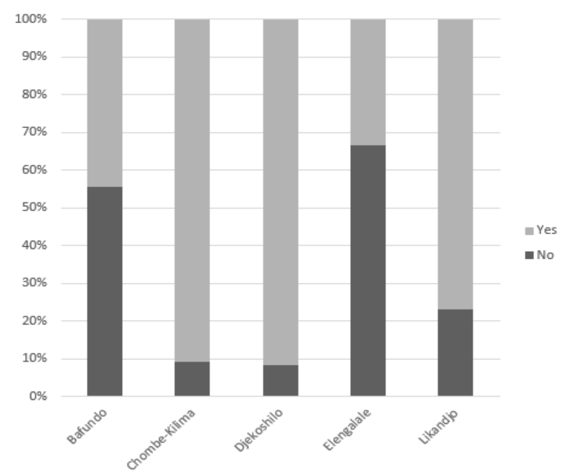

Figure 24: Proportion of trappers in each village that utilizes cable snares for trapping activites.

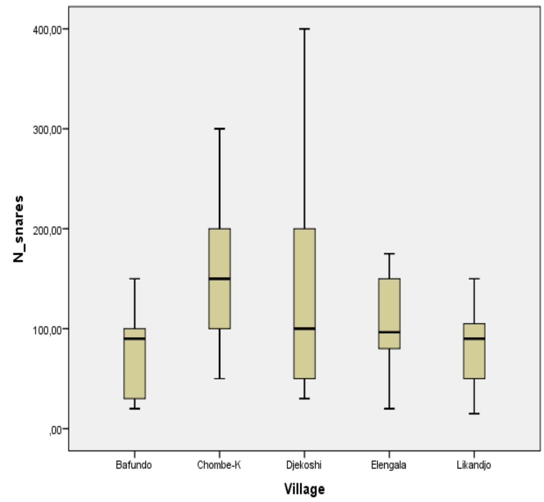

Figure 23: Average number of snares that trappers have installed in the forest.

Trappers do prefer to install snares further away from the village. The amount of snares installed in the forest per km covered by the trapper on a hunting trip increased almost lineally from zone 1 to zone 3 (Figure 26). However, a Kruskal Wallis test for group differences did not yield any significant results. The amount of cable snares per km covered by the trapper in zones 1 and 2 did significantly increase for zone 2 (P = 0,036) (Figure 25).

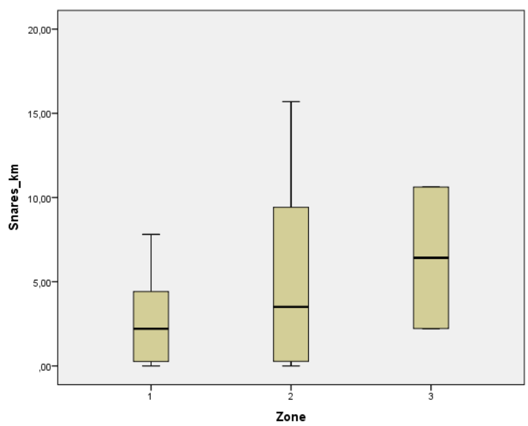

Figure 26: Medians of n snares for km covered in different zones

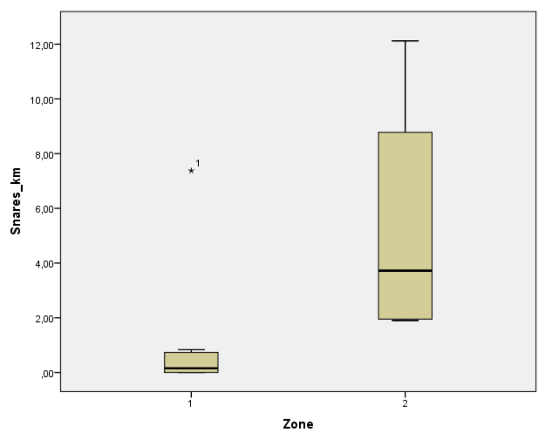

Figure 25: Average of n cable snares for km covered in different zones

7.2. Results of research 2: Does hunting success increase with increasing distance to the village?

In this section the results are displayed that relate to the research question, whether or whether not hunting success increases with increasing distance to the village, the village being the central place from where hunters depart. Hereby the distance classes represent the groups, and all gun hunter and trap hunter follows were taken into account for the analysis. This research question addresses foraging theory, with a special focus on central place foraging. Prior to investigating CPUE values, group comparison analysis was conducted on encounter rates for each of the distance classes. As described in the general methods section, two different schemes with different distance classes for the zones were used to test for the hypothesis of RQ2. The results indicate (**Error! Reference source not found.**) hat encounter rates for zone 1 (0-4 km) are relatively low across the villages, while encounter rates for the zones 2 (4-8 km) and 3 (8 -12 km) are higher and relatively similar. Direct encounter rates were significantly higher in zone 4 as compared to zone 1 (P = 0,001). This pattern is similar across the villages. This corresponds to the hunters´s perceptions, where a minority of gun hunters and trappers state that wildlife abundance does not increase in more distant areas form the villages.

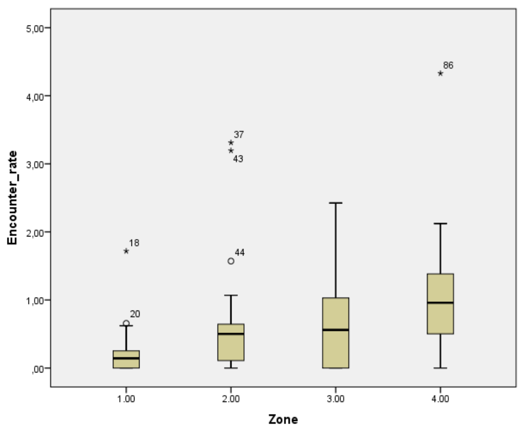

Figure 27: Boxplot showing differences in encounter rates across the zones, according to classification scheme 2

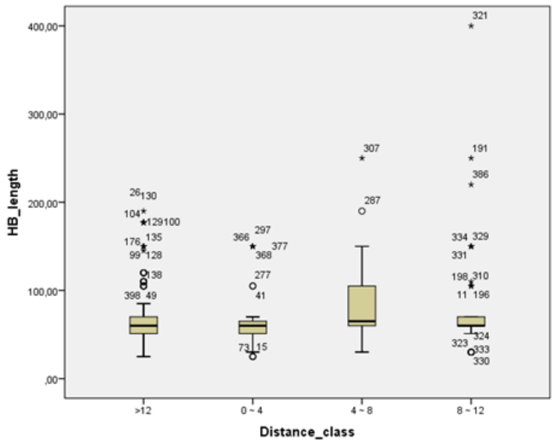

Figure 28 Maximum head-body length of animals encountered with respect to distance to the village. All types of encounters were taken into account.

Head and body length was significantly higher for animals found between 4 and 8 km from the village as compared to animals found within the first 4 km from the village (**Error! Reference source not ound.**), where both direct and indirect encounters were taken into account. The graph indicates that animals were found in zones 3-4 as are larger compared to animals found in zone 1. However, there was no correlation between the distance of an animal encounter from the village and the maximum head-body length of the animal encountered (Pearson Correlation coefficient = --0,028).

While primates and small duiker species, such as *P.monticola* account for the majority of animals shot with a body-length of around 50 cm, larger duikers comprise the top values. There was no significant difference (P= <0,05) detected in terms of median animal body sizes between the villages (appendix 5). However, in Elengalale more larger bodied species, including the African forest elephant and the forest buffalo, were found during the follows than compared to Djekoshilo, Chombe-Kilima, Bafundo and Likandjo.

Some species seem to be generally more abundant around the villages and found at distances <5 km from the village, including Blue duikers (*P.monticola*), Weyn´s duikers (*C.weynsi*) and red river hogs (Figure 30), as well as several primate species (**Error! Reference source not found.**), including the Red-ailed monkey, The Blue monkey and the Lesula monkey (*C.lomamiensis*) around Elengalale. The hunters´ perception corresponds to encounters with wildlife during the follows. Bonobos encounters took place relatively far from the village. Tshuapa red colobus monkeys around Elengalale were rather found in further distances from the village[25]. Apart from that, wildlife encountered at distance of <5 km from the village were the bushy-crested porcupine (*A.africanus*), the black fronted duiker (*C.nigrifons*) and guinea fowls (Figure 30). Larger antelopes, including the Bongo antelope (*T.eurycerus*) and the Sitatunga (*T.spekii*), as well as other larger-bodied species such as larger duikers, the African forest buffalo (*S.c.nanus*) and the African forest elephant (*L.cyclotis*) were exclusively found further away from the villages. Generally larger antelopes were encountered significantly further away from the village than the other prey groups (appendix 3).Traces of Sitatunga accounted for around 50% of the encounters with larger-bodied species in the savanna dominated hunting territory of Djekoshilo (appendix 3).

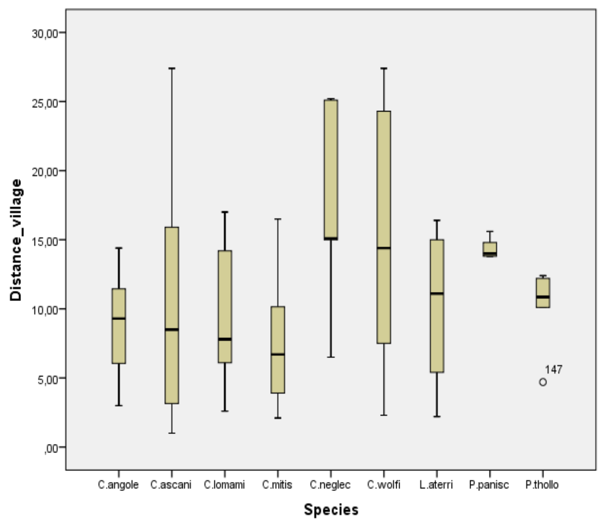

Figure 29: Boxplot showing the median distances for at which distances primate species were encountered.

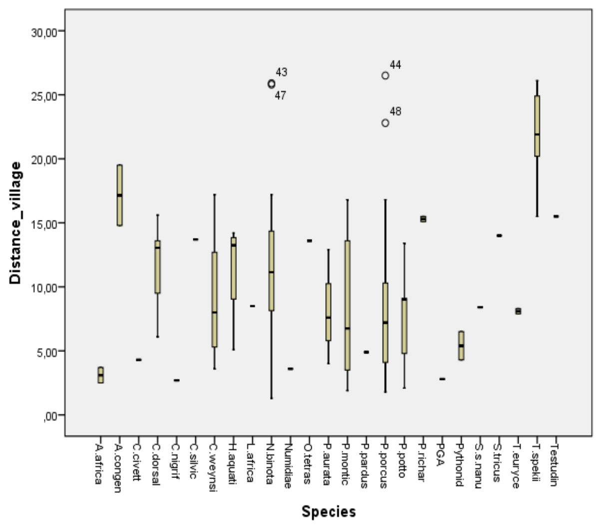

Figure 30: boxplot showing the median distances for at which distances other hunted mammals were encountered.

Catch per unit effort did increase across the villages for when the hunters were hunting further away from the village (Figure 31). A Kruskal Wallis test revealed that CPUE was significantly higher for gun hunter follows in zone 4 as compared to zone 1 (P = 0,022). Statistically, CPUE was not significantly higher in zones 2 and 3 as compared to zone 1, as well as zone 4 as compared to zones 2 and 3 (P = >0,05). Hunter decision-making in terms of wildlife pursuits was not significantly different between the zones (P= >0,05) (appendix 5). However, animals were slightly more inclined to be followed by hunters in zones 1 and 4, as compared to zones 2 and 3. 50% of the times a primate or a group of primate was encountered in zone 4 the hunter fired a shot, compared to around 30% in the three other zones (appendix 5).

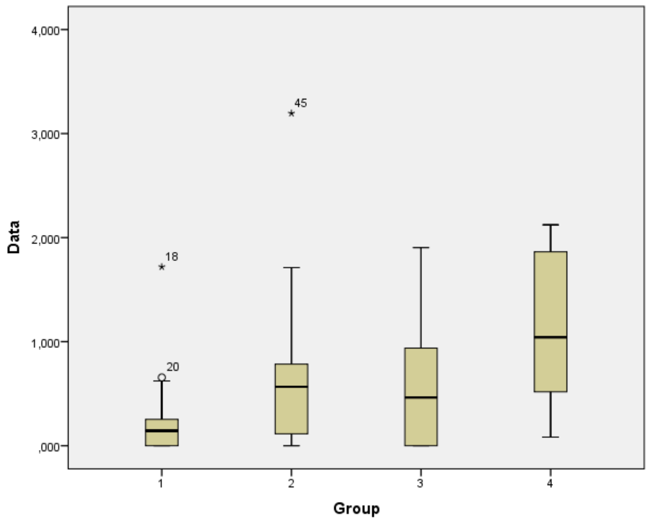

Figure 31: Comparison of CPUE for gun hunter follows per zone

The results for the trapper follows indicate that, as was observed for gun hunter follows, CPUE increases with increasing distance to the villages. However, the differences in terms of CPUE between the three different zones were statistically not significant (P = > 0,05) (appendix 5).

7.3. Results of research question 3: Do village based hunters show preference for certain habitat types and environmental conditions in a heterogeneous landscape, and does preference differ between the sites?

This research question addresses habitat preference by hunters and is linked to foraging theory and source sink dynamics. The results show that hunters do show preference for certain habitats, and across all villages both gun hunters and trappers favor old growth forest (OGF) for hunting activities (Figure 32, Figure 33). Gun hunters in Chombe Kilima show 30% preference for hunting on savannas (S), predominantly during the night. Hereby gun hunters count in savanna adjacent forests[26]. Gun hunters show a relatively stronger preference for riverine habitats as compared to gun hunters, however, this does not apply for Djekoshilo and Elengalale. Although having a lot more savanna habitat available within the customary hunting territory (appendix 6). Djekoshilo hunters do not show a pronounced preference for this type of habitat, and to reach desired hunting ground, gun hunters needed to cover large distances over less favored savanna habitat (appendix 6). Generally, Cropland-secondary habitats (MSC) and secondary regrowth (SFS) are not favored by gun hunters nor trappers. Elengalale gun hunters show 20% preference for secondary regrowth forests, usually found in the nearer surroundings of the village. Pursuit rates did not differ significantly between the habitat types, however, were lowest for MSC (appendix 6).

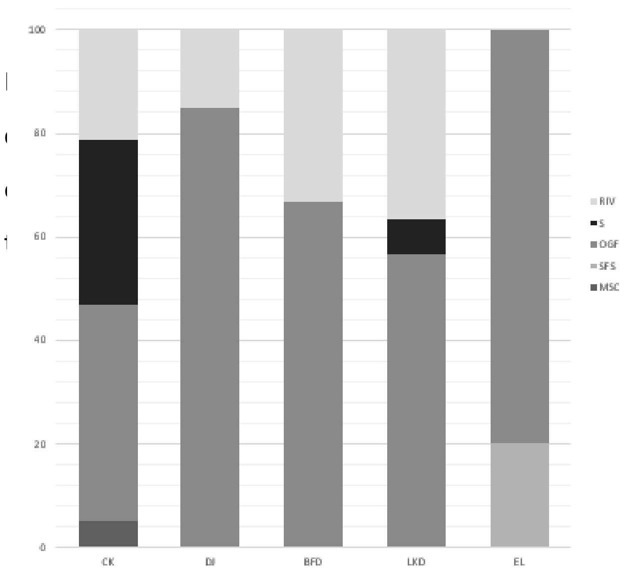

Figure 32: Habitat preference by gun hunters

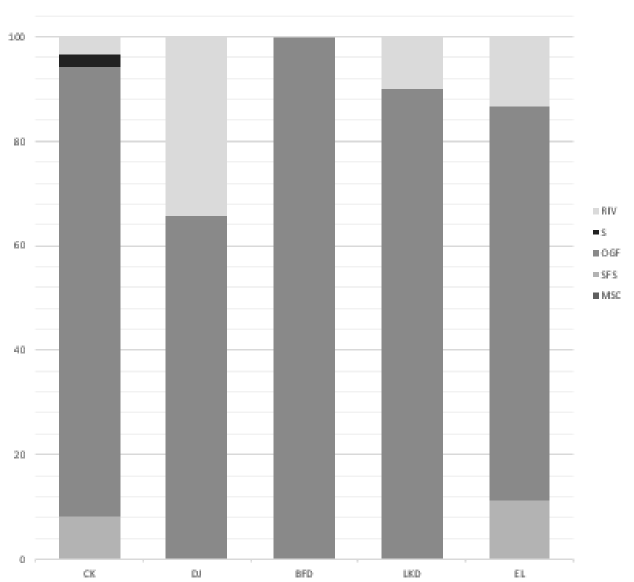

Figure 33: Habitat preference by trappers

[26] Revealed by qualitative information

In order to further explore why hunters do have preferences for different habitat types, encounter rates were calculated for the habitat types and tested for group differences. Furthermore median body size of animals that were encountered in the different habitats were tested for differences according to the habitat groups. A Kruskal Wallis test revealed that encounter rates (Figure 35) are significantly higher in old-growth forests (3) as compared to cropland-secondary regrowth vegetation (1) (P = 0,000), and higher as compared to savannas (4) and riverine habitats (2). The same applies for savanna adjacent forests (5) as compared to cropland-secondary regrowth vegetation (1) (P = 0,049). A Kruskal-Wallis test for differences in terms of CPUE in the different habitat type groups was conducted and did not detect any significant differences. The same applied for a Kruskal Wallis test applied to those follows where gun hunters hunted with original brand shotguns, and CPUE was highest for old-growth forest habitats, however, statistically not significant (p=> 0,05).

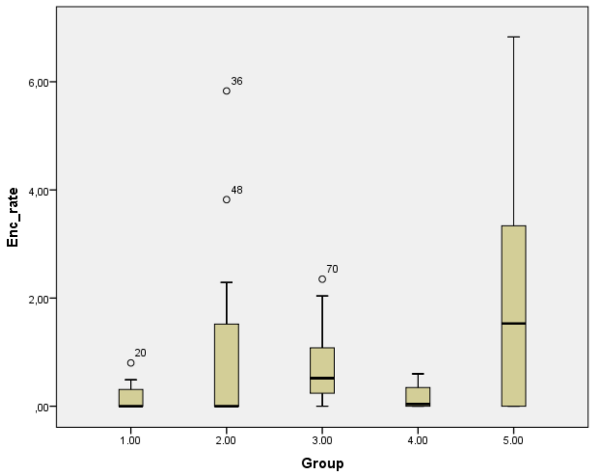

Figure 35: boxplot showing the differences in encounter rate between the different habitat types

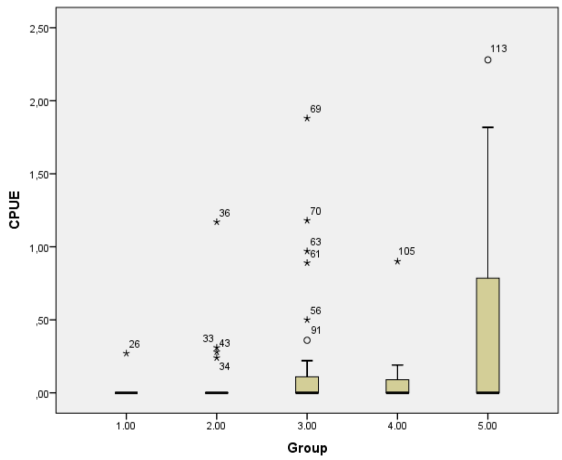

Figure 34: boxplot showing differences in CPUE per habitat.

Median maximum head- and body length of species that were directly or indirectly detected while the hunter was in open savanna habitat is significantly higher than in cropland-secondary mosaics (P= 0,019), savanna adjacent forests (P=0,02) and secondary forests with small trees (0,001)(Figure 36). Animals found in old growth forest habitats were significantly larger than animals found in secondary regrowth forests (P=0,036). The graph shows that in old growth forests encounters with larger bodied species, including elephants (head- and body length of 400 cm) and larger antelopes were observed, while such encounters were absent or rare in cropland mosaics and secondary regrowth forests.

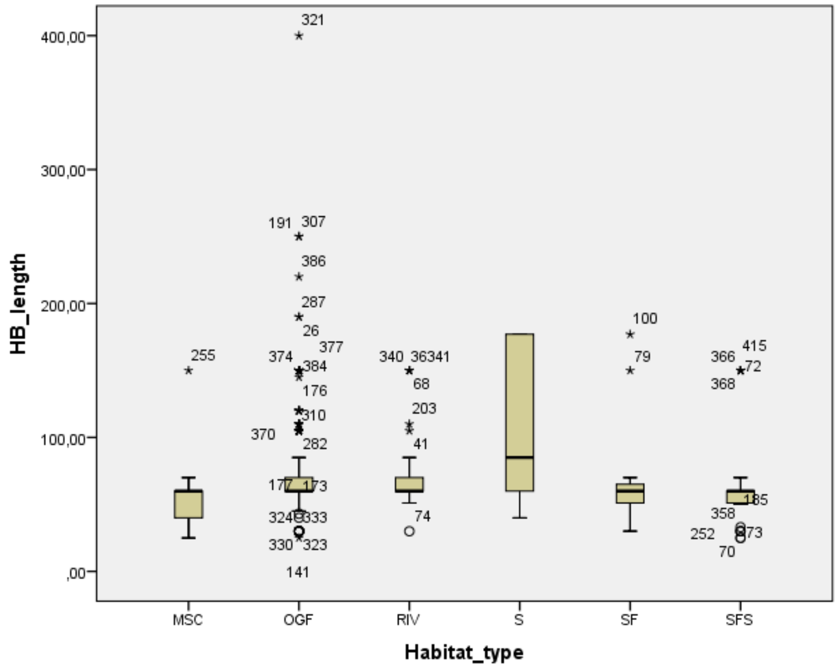

Figure 36: Median head- and body length of species encountered in different habitat types

8. Discussion

8.1. Hunter behavior: hunting technique, prey choice and hunting success

Bushmeat hunting in the TL2 landscape is the only relevant source of monetary income among the inhabitants of the studied villages, and all hunters across the villages hunt with the purpose to sell their catch, or part of their catch. Different hunting techniques are used in the different villages. Gun hunters and trappers are found in all villages, and trap hunting is more widespread than gun hunting. Gun hunting, especially with more expensive shotguns seems to be more widespread in villages where hunters have higher incomes, especially in Chombe Kilima. Cable snare hunting is more common among trappers in Djekoshilo and Chombe Kilima, as compared to Elengalale in the north, and especially pronounced in Djekoshilo. Trappers in Djekoshilo use cables snares to more selectively prey for larger antelopes, such as *T.spekii,* as has been observed for trappers in Gabon (Coad, 2007). The hunting areas around Djekoshilo and Chombe Kilima seem to be under higher exploitation by trappers than in the other villages, as trappers install significantly more snares in the forest as compared to all the other villages, where the amount of snares per trapper are similar. Primates and small antelopes comprise the largest animal groups in prey of gun hunters, and hunters seem to adapt their tactics according to the activity of these groups. Antelopes are more likely to be targeted in the night, where hunters use head lamps to scan the vegetation for the reflective eyes of duikers and other prey, while primates are hunted throughout the day (usually in the morning, afternoon and early evening).

Gun hunters are more selective than trappers, who apply a more passive hunting method to catch any animal of a certain size, which corresponds to previous findings on hunter behavior (Kumpel, 2006; Coad, 2008). However, the results on prey choice among gun hunters only weakly resembles optimal foraging theory and the optimal diet model. The protection status of an animal does have an effect on prey choice. Bonobos are taken by some hunters in the Likandjo and Bafundo hunting territory, but are not sold in the village, due to fear of law enforcement measures. There were no taboos regarding the hunt of species on the village level, as was found for hunters in Peru (Alvard, 1993) and there is no strong correlation between HBL or market value of the species, and pursuit rates. Pursuit rates among primate species, cephalophes and larger antelopes are not correlated with HBL and market value of the species. Pursuit rates were significantly higher for cephalophes than for primates. This is linked to the fact that most encounters with primates occurred through their vocalizations or movement in the trees, and many of them far away, while cephalophes were majorly encountered through seeing them within a rather small radius around the hunter. Arboreal and nocturnal species[27] have relatively low pursuit rates, but are targeted occasionally when the opportunity is there. Oftentimes these species were encountered through their vocalizations in the canopy further away, and the hunter did not show interest in searching for them, which is difficult in the night. Selectivity among gun hunters is also evident when shots are not taken on smaller bodied primates, even though a good shooting position is assumed by the hunter, to minimize opportunity costs. For such decisions the price of the shotgun shell seems to be relevant, as was observed among gun hunters in Peru (Alvard,1993), and seems to be the major factor for selectivity among gun hunters in the TL2-landscape. Hunters are attack limited through limited amounts of shotgun shells the hunter carries, and with lower amount of shotgun shells, the risk to fail a shot seems to play a role in hunter decision-making. In Elengalale, where hunters carried small amounts of shotgun shells, shots were only taken when an excellent shooting position was obtained. Due to lower quality and power of the guns, hunters seemed to be required to get closer to the animals, to have a chance for hunting success. This is especially a challenge throughout the dry season, when leafs are dry and the hunters make more noise when approaching an animal. The sex of the animal and the type of prey did not seem to play a role in hunters´ decision making within the TL2 landscape. There was no clear relationship between the number of shotgun shells the hunter carried and primate pursuit rates. In Elengalale, where hunters went hunting with small numbers of shells, these hunters invested similar efforts in pursuing primates, with lower returns, as compared to the other villages. Shotgun shell scarcity was discussed in previous studies as a limiting factor (van Vliet and Nasi, 2008), and scarcity was common among gun hunters in Elengalale. Primate pursuit rates

[27] Such as the potto, the African plam civet and civet cats

were similar across the villages, and highest in Likandjo, where almost all hunters hunt for almost exclusively commercial purposes.

The hunt for larger antelopes and buffalos is difficult as it requires powerful guns, and thus can be considered a factor influencing prey selectivity among gun hunters, but this relationship requires further investigation. While original shotguns are used among the hunters from Djekoshilo, Chombe Kilima and Bafundo, city-manufactured guns are common among the hunters in Likandjo and among hunters in Elengalale, and village-manufactured guns are found among in Elengalale. Hunters using a original brand shotgun had significantly higher CPUE values, and kills per shot taken than hunters who were using the latter gun types.

There is a stronger relationship between the gun type used by the hunter and CPUE, as compared to encounter rates with wildlife, or age and experience of the hunter, which was found a relevant predictor for individual hunting success among trappers in Gabon (Coad, 2008) and hunter effort in Equatorial Guinea (Kumpel, 2006). Better success for original shotgun hunters is likely to be linked to a better range of the gun, better shooting power and faster recharge. CPUE and monetary incomes of gun hunters were significantly higher in Chombe Kilima than in Elengalale, where unsophisticated guns are common, and generally gun hunters using original shotguns earn more than gun hunters using city-manufactured guns (moderate incomes) and hunters using villages-manufactured guns (low incomes), which corresponds to observed CPUE values. Encounter rates with wildlife were higher in Elengalale, and significantly higher for primates as compared to Chombe Kilima. Their relative abundance, and their presence around the village may be understood as a consequence of the limited ability of hunters in Elengalale to exploit these wildlife resources, due to the above mentioned factors. Higher incomes of trappers in Chombe Kilima correspond to higher amounts of snares individual trappers bring out in the forest, and the use of cable snares. Relatively high incomes among trappers in Djekoshilo may be related to the abundant use of cable snares and trapping for larger antelopes, including the Sitatunga.

The type of follow seems to have an effect on hunter decision-making and behavior. Primate pursuit rates are lower, although not significant, during transit follows as compared to village-based follows and camp-based follows. Oftentimes hunters walk rather fast to either get to their camps, or return to the village from a camp, and carry heavy loads. They also seem to rather quickly want to get to the camps or back to the village, and before nightfall, and they seem to promise themselves high chances for hunting success when departing from the camps.

The null hypothesis for research question 1 – There is no difference between the hunter populations in terms of hunting behavior and hunting success – is rejected. Significant differences were detected for CPUE, hunter incomes and the use of snares by trappers. Furthermore variation across the sites is evident regarding hunting techniques applied by the hunter populations, including night hunting and the type of guns used for hunting, as well as prey availability and abundance. Hunter decision-making in terms of pursuit behavior is similar across the sites

8.2. Hunting success in relation to distance to the village

Both encounter rates and hunting success (CPUE) did increase with increasing distance to the village. This general trend was observed for all villages. These results correspond to predictions of central place foraging models, that suggest that prey and especially larger bodied prey species are depleted around the villages and more likely to be found with increasing distance from the village and findings on previous studies investigating on central place foraging in the hunting context (Alvard, 1993; Levi et al., 2011). For this analysis habitat quality was not taken into account. Likewise, encounter rates and CPUE during camp-based follows are significantly compared to village based and transit follows. Relatively low encounter rates during transit follows may be explained through hunters usually using more frequented principal hunter trails that connect villages to hunting camps and hunting grounds, and hunters tend to conduct less listening-points to detect primates. There was no significant relationship between HBL of encountered and shot species and distance from the village, which contradicts foraging theory, although encounters with larger bodied species, such as wild pigs, larger antelopes, buffalos and elephants (1 encounter) were more frequent further from the village. This corresponds to findings on hunter behavior in Gabon on the depletion of larger bodied species populations under hunting pressure near village surroundings over time (van Vliet and Nasi, 2008). The high amount of primate groups encountered in distant areas from the village is likely to be a strong factor influencing median body size of encountered animals in each of the distance classes. Although not statistically significant, direct encounter rates with wildlife in zone 1 were higher in Elengalale as compared to Likandjo-Bafundo, Chombe Kilima and Djekoshilo, where village surroundings seem to be more depleted. This may be related to the observation, that hunters with poor quality guns have more difficulty in targeting primates. Pursuit rates for wildlife after direct encounters were slightly higher in zone 4 as compared to zone 1, and pursuit rates were slightly higher in zone 1 as compared to the zones 2 and 3. For primates, one of the main prey groups, this pattern applied as well. However, distance does not significantly seem to influence hunters´ decision making in pursuit behavior on primates, contradicting foraging theory, which predicts that hunters prey for rather larger bodied species the further they go from a central place. Hereby the commercial nature of hunting can be considered influential, and the price of a shotgun shell as a major factor for hunter decision-making in pursuit behavior. For the occasion of a primate pursuit, in almost 50% of the occasions of a primate encounter in zone 4 a shot was taken, compared to around 30% in the other zones. This suggests, that hunters are more likely to risk a shot the further they are from the village. Hunters hunting further away may have the feeling to get more animals in less time, as compared to hunting in patches closer to the village, and this may encourage them to take higher risks. Furthermore, throughout village based follows, hunters did not enjoy to come back to the village without any catch, as they could be sure to be made fun of by fellow villagers. Trappers install more snares per km covered further away from the village, and this is especially evident for the use of cable snares, where between-zone comparisons were significant. Cable snares are more appropriate traps to prey for larger bodied species. This trapper behavior is in line with predictions of central place foraging. The use of rope snares in village surroundings may correspond to Kumpel´s findings (2006), where trappers set up snares on animal paths of smaller bodied species as a security measure. Furthermore, older trappers seem to concentrate their trapping activities closer to the village, as was observed in Gabon (Coad, 2008).

The null hypothesis for research question 2 - CPUE does not increase with increasing distance to the village- is rejected. Hunting success did increase with increasing distance to the village, and across the sites. CPUE effort was significantly higher in areas >12 km distance from the village than in nearer village surroundings (0-4 km). Simultaneously, encounter rates with wildlife increased with increasing distance to the village.

8.3. Habitat preference and patch selection

Few studies have addressed patch and habitat preference by hunters (van Vliet and Nasi, 2008; Coad, 2007; Noss, 1995), especially regarding gun hunters. Coad (2007) found that trappers tend to set up their snares along rivers or creeks. Both gun hunters and trappers show patch preference across the landscape, in terms of and in all villages, both trappers and hunters prefer old growth forests for hunting activities, which corresponds to the results of similar studies (van Vliet and Nasi, 2008). Trappers, especially in Djekoshilo, do also favor riverine habitat. This may be linked to the fact that snares are difficult to install on more dry soils, and the dry season is more pronounced in the southern part of the landscape. Generally, hunting seems to be easier during the rainy season, as approaching wildlife by gun hunters is facilitated by moist leafs that produce less noise when pursuing wildlife. Trappers have less difficulty finding recent animal traces and the installation of snares is facilitated by moist soils, and generally perceive wildlife to be more abundant in water-logged area. This behavior has previusoly been observed among trappers in Gabon (van Vliet and Nasi, 2008) Easiness to access snare sites for more riverine habitat has not been found a factor for decision-making, as suspected by Coad (2007). Trappers do not hunt on open savanna, but gun hunters occasionally do. Hunting on the savanna is more popular in Chombe Kilima than in Djekoshilo. Encounter rates with wildlife, as a proxy for abundance, were higher for habitat types that are simultaneously preferred by hunters, as old growth forests had the highest encounter rates. Such forests are usually found further away from the village, while cropland-secondary regrowth habitats are found in proximity of the villages. The latter habitat type is dominant in zone 1 of distance classification, while the other habitat types are usually found further away. These results correspond to the concept of ideal free distribution which predicts, that hunters visit patches with higher abundances of prey more than other patches. It is likely that central place foraging, alongside environmental factors at least partly explain variation in animal encounter rates across the different habitat types. This suggests that certain areas and patches that comprise the habitats preferred by hunters are more under exploitation pressure than others. Around Djekoshilo and Chombe Kilima, where large areas of the hunting territory are occupied by savanna grasslands, wildlife exploitation pressure both by gun hunters, and especially trappers who do not trap on the savanna at all, is likely to be concentrated on relatively small patches. Especially in Djekoshilo, gun hunters travel far to visit desirable habitat and to arrive there, a lot of least preferred savanna habitat is crossed. The fact that go- and return hunting is unpopular among gun hunters in Djekoshilo is likely to be linked to this.

Furthermore, it was observed that species encountered in old-growth forest habitats are larger than those found in cropland- secondary regrowth vegetation formations, and on open savannas as compared to the other habitat types except for old growth forests. Primates were only occasionally encountered on savannas when walking close to the forest edge, while larger species such as *P.porcus and T.spekii* were relatively frequently indirectly encountered on savannas, when they left traces from foraging activities in the night. Direct encounters were rare, which may partly explain the gun hunters low interest in hunting on the savannas, corresponding to ideal free distribution. In Djekoshilo, hunters travel far over low productivity open savannas to hunt in small forest and riverine patches situated west of Djekoshilo, but still display the highest CPUE values. Pursuit rates did not significantly differ between habitat types, but were relatively low for cropland-secondary habitats. Shooting attempts in savanna adjacent forests in the Djekoshilo hunting territory were proportionally more successful as compared to other habitat types. This may be facilitated through forest structure, as canopies in such forests are relatively low and open, and primates are likely easier to target. This may partly explain hunting success among Djekoshilo hunters, but requires further investigation.

Customary hunting territories are significantly larger in the studied sites than observed in other settings in central Africa (Kumpel, 2006; Coad, 2008; van Vliet and Nasi, 2008). However, how much of these territories is frequently used, and how much of the area overlaps with other hunter communities has not been quantified. A significant share of these territories nowadays is situated in the national park and hunting activities are prohibited by national law. However, poaching is widespread, presumably especially among gun hunters, as snare hunters or snare sites are more easy to detect and control by law enforcement measures. The hunting territory of each of the villages seems to be open access for all men who engage in hunting activities, as long as these men are “children of the village”, allowing for free patch selection. This would correspond to foraging theory, as hunters can freely choose patches in the landscape, based on their own experiences, preferences and physical abilities to reach those patches. There is evidence that gun hunters compete with trap hunters, and the nature of competition has implications for patch selection by gun hunters. Gun hunters prefer to choose patches for hunting where trapping densities, and thus noise, are relatively low. Presumably, such patches are more available inside the national park area or generally further away from the village, as trappers in recent years have suffered strong costs due to the loss of snares through law enforcement measures and nowadays conduct less trapping in that area. Especially for settings where night hunting is uncommon, gun hunters may preferably travel further in order to avoid trapper´s noise. Such information provides evidence on factors, including the legal framework and law enforcement that may interfere with foraging theory models. Such patterns provide an interesting perspective on hunter behavior and hunting dynamics for protected area and buffer zone settings, especially where hunter communities still hold a customary claim on areas that may legally exclude hunters (protected areas), but require further quantification and investigation.

The null hypothesis of research question 3 -Hunters in all villages use the village surroundings homogeneously for hunting and do not show habitat preference- is rejected. Generally both trappers and gun hunters show preference for old-growth forest habitats. Preference seems to be in line with wildlife encounter rates for the habitat types.

8.4. Discussion of assumptions and limitations

Different studies on hunter behavior suggest that the age of the hunter is a good predictor for hunting success, as was observed for trappers (Kumpel, 2006; Coad, 2007). In this study, where age was significantly correlated with experience, there was no clear relationship found between the age and experience of the hunter (in years) and hunting success throughout gun hunter follows. If the income is taken as an indicator of general hunting success and hunting ability of an individual hunter, there were no statistically significant differences detected for three different age groups of hunters (<25 years old = group 1, 25-45 years old = group 2, > 45 years old = group 3). Despite this, exclusively hunters from the second age group (one exception being one hunter from Bafundo, with an age of 19 years) were considered for hunter follows to ensure similar physical capacities, and linked to this, skills, among the hunters. Some animal species are more likely to be detected from a given distance between the hunter and the animal, than other species. For example, while primates (above all those who have loud calls) are rather easy to detect from far, and 90% of all encounters with primates were due to hearing them, duikers are not. Weather is stated by the hunters as a highly influential factor for the likelihood to detect wildlife. Oftentimes hunters detect groups of primates through the sound of moving tree branches, when these groups move in the canopy. Wind was often stated as having negative implications, as it complicates to detect primates on the basis of moving tree branches. Primates also tend to remain less agile after heavy rains and throughout midday, when the sun is at its peak. It was assumed for this study that hunters have similar abilities in detecting and approaching wildlife without being spotted by the animals. Therefore, pursuit time as a proxy for the distance at which primates were detected by the hunter was subjected group comparison analysis. There was no significant difference found for between individual comparison and between village comparison (P= >0,05), which justifies the assumption on similar hunter skills. Furthermore, hunting success and encounter rates were not correlated with age or experience of the hunter, excluding a possible age or experience factor influential for hunter skill as a factor that may comprise a bias in terms of hunters who participated throughout the follows. Thus, the data obtained from the follows is likely to be representative for the population. The hunters participating in gun hunter follows were not randomly selected. Although the sample is skewed towards more courageous hunters, this is not expected to have an effect on the results obtained.

No significant differences were detected between CPUE of trapper follows between the sites, although considerable effect size was given. This outcome is linked to a small sample size, and unequal sample sizes between the village groups. The amount of hunters in each of the villages was underestimated before the start of this study. Only in Lonolo minimum sample size (Israel, 1992; Field, 2009) for the number of interviews to gain representative information from the samples population was achieved, and virtually achieved in Bafundo. In Elengalale the number of conducted interviews comprises one third of desirable sample size. Nonetheless, the variables used for this thesis is considered representative. Generally between-individual variation was perceived low in the villages, and answers relatively uniform. Between-individual variation was relatively low in terms of incomes in each of the villages. Certain socioeconomic factors, such as the number of children, age or experience were not significantly correlated with income, as a proxy for hunting success. Night hunting was entirely absent in Elengalale, and common among all gun hunters in Chombe Kilima. The number of interviews carried out in each of the villages was limited by available time and willingness-to-cooperate by the hunters.

Language barriers were overcome with the help of the research assistants. The semi-structured interviews were carried out by the research assistants in the regional languages. Communication in French was furthermore possible with the largest share of collaborators throughout this study. The basic vocabulary for the hunter follows was known by the researcher, including the names of species.

The sensitivity of the “bushmeat- issue” certainly had an effect on the results of this study, especially regarding the questionnaire. Questions addressing poaching, including the hunting inside the protected area and the hunting of protected species were usually not answered correctly by the hunters. Such data was not included in the analysis. A total of 6 hunter follows were carried out on the national park territory. The hunters accepting the researcher to accompany them on poaching trips reflects the high levels of trust many of the collaborating hunters built within little time. Other illegal activities witnessed throughout the hunter follows, included the hunting of protected species, such as the Golden cat or the Tshuapa red colobus monkey among others, as well as cable snaring.

9. Conclusions

The results of this study provide two significant general contributions on a quantitative and qualitative basis: a baseline study on hunter behavior and variation of hunting behavior across the TL2-landscape, and thus a better understanding of social-ecological systems and hunting subsystems, as well as results that further challenge foraging theory in the bushmeat hunting context. The hunter follow method is a useful means to study hunter behavior in a heterogeneous landscape, and to collect data on all kinds of variables relevant for addressing foraging theory. Hunter follow methods applied over a longer period of time, to increase sample size and to cover both rainy and dry season would allow for more thorough analysis of spatio-temporal patterns in hunter behavior, and the dynamics of the buffer-zone as social-ecological system from a hunter perspective. Sample size for gun hunter follows enabled village comparisons in hunter behavior. Both participatory mapping and semi-structured were useful tools to engage the hunter communities in this study. Although sample size was small, semi-structured interviews provided relevant information on hunter behavior, including species availability, hunting techniques, spatial use of the landscape, incomes and costs of hunting and seasonality effects among others. Village profiling was useful to validate sample size and to get an overview on village demographics. The theoretical framework was useful to gain a better understanding of factors and dynamics that influence hunter behavior, including the understanding of the buffer-zone as wider social-ecological system, with hunting systems as sub-systems. Foraging theory and its concepts helped to identify relevant measurable variables to address theory and the research questions and to form the hunter follow methodology, as well as to structure the questionnaire.

Both gun hunting and trapping are widespread hunting techniques across the sites. The type of guns that are used differ and gun hunters with original brand shotguns have significantly more hunting success than hunters using lower quality guns, and a much a higher kills/shot taken-ratio. For original brand shotgun hunters, CPUE is strongly correlated with wildlife encounter rates. This relationship is not significant between gun hunters using other types of guns, underpinning range and shooting power as relevant factors for hunting success. Gun hunters earn more than trappers. Incomes for gun hunters and trappers are higher in Djekoshilo, Chombe Kilima and Likandjo as compared to Elengalale and Bafundo.

Predictions of foraging theory were only partly confirmed by the results of this study. Wildlife pursuit behavior by gun hunters does not significantly correspond to the optimal diet model of optimal foraging theory. Pursuit rates of species do not correlate strongly with HBL and market value of species. Pursuit rates for major prey groups did not differ between the sites, indicating no differences in hunter decision making with respect to animal pursuit behavior across the sites. Limiting factors for prey choice include the distance and time at which a species is encountered, as arboreal species usually are not pursued in the dark of the night, protection status of the animal in the case of the Bonobo, and most likely body size of the animal. Very large species, including forest buffalos and Bongo antelopes are difficult to hunt with weak guns, and hunters from Djekoshilo, Chombe Kilima and Bafundo seem to have an advantage over Likandjo and Elengalale gun hunters. However, this has not been quantified. Above all, the price of a shotgun shell seems to be decisive for prey choice and selectivity among gun hunters. Only very small species and juvenile primates are usually not taken, as returns to not compensate for opportunity costs. Species are targeted regardless of sex and age. Primates and cephalophes comprise the two most important prey groups, accounting for most direct wildlife encounters and off-take. Primates are hunted during the day, while night hunting is an effective method to target cephalophes.

Seasonality, according to the hunters has an effect on hunting, as wildlife is perceived to circulate more throughout the rainy season, and approaching wildlife is easier as wet leafs make less noise, and animal traces are better visible for trappers, for whom recent animal traces are the main criterion for trapping site selection. Furthermore, traps are easier to set-up on moist soils.

CPUE did significantly increase with increasing distance to the villages, which is in line with foraging theory and the concept of central place foraging as well as previous empirical studies addressing this topic, and is linked to higher animal encounter rates, that gradually increase over distance from the village, indicating depletion of wildlife resources around the village. Larger bodied species were also more frequently encountered further away from the villages, and usually absent in nearer village surroundings, as predicted by central place foraging. Encounters with several species suggest that certain species, including the Blue duiker, the Weyn´s duiker, Red-tailed monkeys and Red river hogs show more resilience towards hunting pressure than other species. Pursuit behavior over distance did not significantly change, however, primates were averagely more often pursued in further areas from the village, which may be related to differing hunter behavior in terms of village-based follows, camp-based follows and transit follows. During camp based follows, which are usually conducted relatively far away from the villages, hunters seem to more thoroughly attempt to detect wildlife species, especially primates, and are furthermore more inclined to attempt a shot. Trapping densities increased with increasing distance to the village, especially in terms of cable snares that are used to

Both trappers and gun hunters showed preference for old growth forest habitats. In these habitats, encounter rates with wildlife were higher, which is likely to be a consequence of habitat quality, and the fact that these forests are usually found further away from the village. This suggests that hunter behavior in terms of patch selection corresponds to predictions of the ideal free distribution concept. To what extent source-sink dynamics contribute to wildlife abundance in different patches could not be quantified, as wildlife abundance in the hunting territory is a function of ecosystem and patch quality and hunting pressure and impact. It is likely that most of the buffer zone is a sink, while the national park, although facing hunting pressure, may be rather characterized as a source. Trappers showed some preference for riverine habitat. Gun hunters in Chombe Kilima occasionally hunt on the savannas, especially with a headlamp in the night.

The national park may have a role influential for the dispersion of gun hunters and trappers over the landscape and their patch-selection behaviour. Trappers experienced significant losses of snares in recent years, and seem to be more concentrated in the bufferzone. Gun hunters on the other hand, often disturbed by increasing numbers and noise of trappers, seem more likely to take risks and hunt inside the national park.

10. Recommendations

This study has delivered insights and dynamics between hunters and wildlife majorly in the bufferzone, from a hunters´perspective. The encounter rates with wildlife recorded for all villages indicate that species abundance increases with increasing distance from the village. A more standardized method, such as camera-trapping, to estimate species densities, especially of cephalophes, would be a means of triangulation to further investigate the bufferzone. The ecological data could then be analyzed against be backdrop of implications from this study.

Social systems and inter-village were only superficially addressed by this study. The results show that conflict is an issue in some of the studied sites. Further study and insights into conflict and the history of village relations, as well as the quality of conflict should be taken into account when working towards a framework of community based natural resource management in the buffer zone, including the demarcation of community lands.

The depletion of customary hunting law, including concession-type hunting, could be a useful study subject. Depletion may be linked to inmigration, population growth and excessive hunting pressure, especially through increased numbers of trappers. The customary hunting law and related principles may comprise promising connecting points for efforts directed at regulated hunting and community concessions in the buffer zone.

Patch selection by gun hunters and trappers, taking into account the implications of protected areas may further challenge foraging theory in the context of bushmeat hunting in Central Africa. Whether, and to what extent, gun hunters seek to change patches that are more frequented by trappers, and whether they are more likely to take risks and enter protected areas through this, has yet to be explored.

Hunters did collaborate in the hunter follow methodology within little time of building certain levels of trust. Participatory monitoring of hunting behavior and spatio temporal-dynamics of hunting could be a means to engage communities and their hunters in further collaboration with external partners, including the Lukuru Foundation and state agencies.

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Appendices

1. Appendix 1

1.1. Table of definitions

Term	Definition
Bushmeat	Meat derived from non-domesticated animals that are hunted for food, including mammals, reptiles and birds.
Hunting	The chase or search for wild animals with the purpose of catching or killing them.

Village based hunting	The activity of hunting exercised by village inhabitants. There is no differentiation in terms of the later use of caught animals.
Hunting system	The interactions of wildlife and hunters. The hunting system is characterized by hunter behavior, including prey choice and spatial use of the hunted territory, and hunting success.
Hunter behaviour	Prey choice, hunting success, hunting technique and tactics employed, as well as spatial use of the landscape by the hunter as a consequence of hunter decision-making.
Social-ecological systems	Systems where ecosystems and social systems are interdependent and integrated with reciprocal feedback.
Social-ecological resilience	The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to change in order to maintain the same identity.
Specified resilience	The resilience of some particular part of a system, related to a particular control variable, to one or more identified kinds of shocks.
Patch	Smaller interactive spatial components of a wider hetergogeneous landscape or ecosystem, where patches comprise mosaics. Patches are demarcated by similar environmental conditions, composition and structure.

2. Appendix 2: Methods

2.1. Zonation of village surroundings

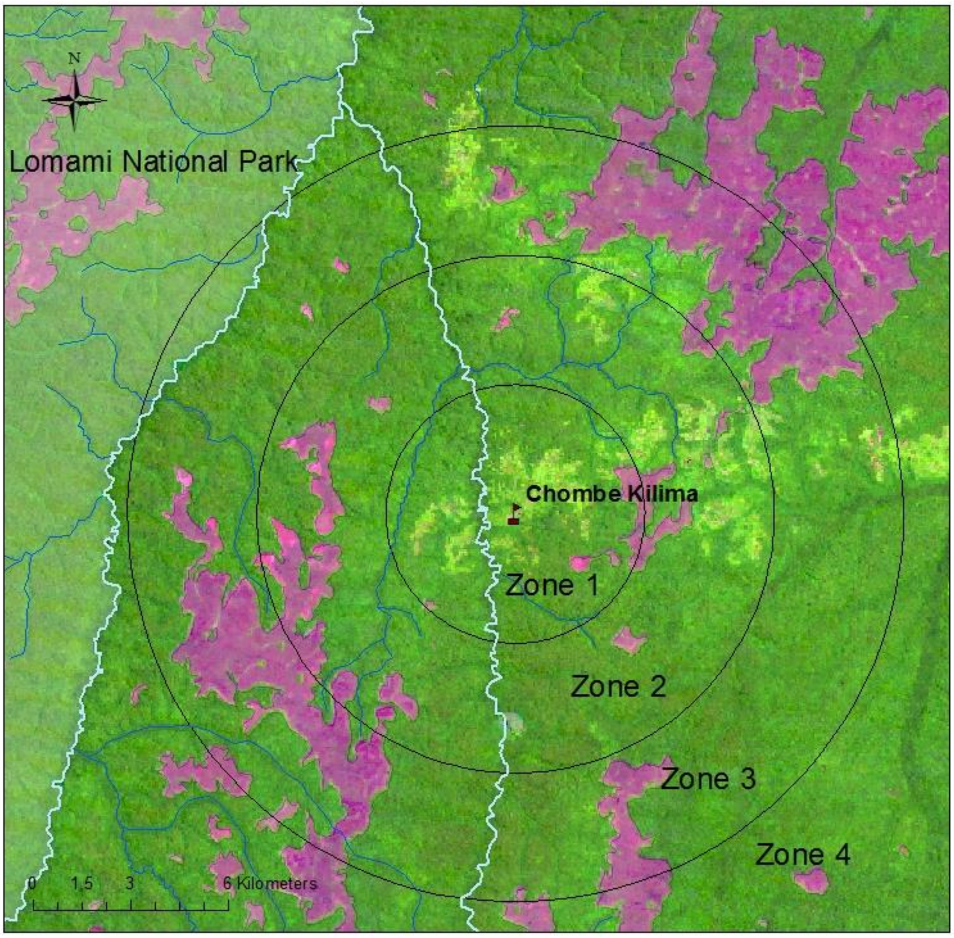

Figure 37 Scheme according to which distances were classified into 4 classes or zones. A classification scheme was used for this study to address research question 2. Zone 1 ranges from 0-4 km radius from the village, zone 2 from 4 to 8 km radius from the village, zone 3 from 8-12 km radius from the village and zone 4 is anything further from the village then a 12 km radius

2.2. Instruments used for data collection

Method	Instrument(s)	Data
Hunter follows	GPS, log book, data sheets, camera	Spatial data, quantitative data
Semi-structured interviews	Questionnaires	Quantitative and qualitative data
Satellite imagery	ArcGIS	Maps, shapefiles
Participatory mapping	Drawing maps	Maps on the extent of hunting territories

Village profiling	Data sheets	Demographic data of village populations

Figure 38: overview on the instruments used for implementing the three research methods

2.3. Number of hunters and sample size

Village	N interviews	N gun hunters	N trappers	% gun hunters inquired	% trappers inquired	% of entire population	Minimum sample size
Bafundo	13	4	13	100	69,23	76,47	16,30695
Chombe-Kilima	22	11	32	90,91	37,5	51,16	38,82619
Djekoshilo	20	13	23	61,54	52,17	55,56	33,02752
Elengalale	21	36	37	16,67[28]	32,43	24,66	61,73362
Likandjo	21	14	39	57,14	33,33	39,62	46,79912
Lonolo	3		3		100	100	2,977667
Total	**100**						

Table 8: Table displaying the numner of hunters in the villages, sample size, percentage of hunters interrogated and minimum required sample size to achieve representative information

2.4. List of methods

	Type of method
1	Hunter follows
2	Semi-structured interviews
3	Satellite imagery
4	Particpatory mapping
5	Village profiling

Figure 39: The five sources of data used for this study

2.5. List of variables measured for hunter follows

Method	General variable	Variable	Values
Hunter follows			
Gun hunter follows_measured during the follow			
		Type follow	1= village-based, 2=camp-based, 3=transit

[28] Many of the hunters who answered the question for occupation with hunter likely hunt with the bow

	SE	Age of the hunter	In years
	SE	Experience of the hunter	In years
	SE	Number of hunters involved in the hunting	Count
	SE	Number of porters	Count
	EFF	Total kilometers	Count
	EFF	N cartridges	Count
	ENC	Encounter	1= seen, 2=heard, 3=sign, 4=smellt
	ENC	Geographic position of the encounter	GPS location
	ENC/SU	Distance of encounter to the village	Measured in km
	P	Species name	Name of species
	P	Number of animals encountered	Count of animals ecountered/encounter
	PB/HS	Outcome for each encounter	1= shot kill, 2= no shot, 3=shot fail, 4=shot hit animal escape
	P	Length of shot animal	In centimeters
	SU	Habitat type	1=mixed secondary/cropland, 2=secondary small trees, 3= old growht forest, 4=riverine forest, 5=savanna, 6=savanna forest
		Notes	Additional information on the observation
	PB	Minutes of pursuit	Count of minutes a hunter pursued one animal
Gun hunter follows_calculated after follow	EFF	Total minutes	Sum of minutes
	ENC	Total direct wildlife encounters	Sum of direct wildlife encounters
	ENC	Total indirect wildlife encounters	Sum of indirect wildlife encounters
	ENC	Direct encounter	Direct encounters/km

		rates for wildlife	
	ENC	Indirect encounter rates for wildlife	Indirect encounters/km
	ENC	Total primate encounters	Sum of primate encounters
	ENC	Primate encounter rates	N primate encounters/km
	PB	Primate pursuits	Sum of primate pursuits
	PB	Primate pursuit rates	primate pursuits/primate encounter
	ENC	Total antelope encounters	Sum of antelope encounters
	ENC	Antelope encounter rates	N antelope encounters/km
	PB	Antelope pursuits	Sum of antelope pursuits
	PB	Antelope pursuit rates	Antelope pursuits/antelope encounter
	HS	N shot hit escape	Sum outcome=shot hit animal escape
	HS	N shot fail	Sum outcome=shot fail
	HS/EFF	Total n shots fired	Count of shots fired
	HS	Total n animals killed	Sum of animals killed by the hunter
	HS	Catch per unit effort in km	N animals killed/km
	HS	Catch per unit effort in hours	N animals killed/hours
Trapper follows_measured during the follow	SE	Type follow	1= village-based, 2=camp-based, 3=transit
	SE	Age of the hunter	In years
	SE	Experience of the hunter	In years
	SE	Number of hunters	Count

		involved in the hunting	
	SE	Number of porters	Count
	EFF	Total kilometers	Count
	EFF	N snares total	Count of all snares installed in the forest
	EFF/ENC	Sign	Animal encounters, snares, cable snares, hunting camps, animals in snare, animal escaped from snare
	P	Species	Name of species
	SU	Geographic position of the sign	GPS location
	ENC/SU	Distance of sign to the village	Measured in km
	P	Number	Count of animals or snares ecountered/encounter
	EFF	Age	Number of days snares are installed in the forest
	P	Length of caught animal	In centimeters
	SU	Habitat type	1=mixed secondary/cropland, 2=secondary small trees, 3= old growht forest, 4=riverine forest, 5=savanna, 6=savanna forest
	SU	Conditions	1=slope, 2=plain, 3=creek valley, 4=hill top
		Notes	Additional information on the observation
Trapper follows_calculated after follow	EFF	Total minutes	Sum of minutes, duration of follow
	ENC	Total direct wildlife encounters	Sum of direct wildlife encounters
	ENC	Total indirect wildlife encounters	Sum of indirect wildlife encounters
	ENC	Direct encounter rates for wildlife	Direct encounters/km
	ENC	Indirect encounter rates for wildlife	Indirect encounters/km
	HS	Number of animals escaped from snare	Sum of animals escaped from snare

	HS	Number of animals rotted in snare	Sum of animals rotted in snare
	HS	Number of animals killed	Sum of animals killed
	HS	Catch per unit effort in km	N animals killed/km
	HS	Catch per unit effort in hours	N animals killed/hours

Table 9 Table displaying the distinctive variables measured and calculated from hunter follows

2.6. List of variables measured for semi-structured interviews

Method	**General variable**	**Variable**	**Values**
Semi-structured interviews	HT	Type hun ter	The type of hunting the hunter practices
	SE	Age of the hunter	Quantitative, self explanatory
	SE	Number of children	Quantitative, self explanatory
	SE	Place of birth	Name of the village where hunter was born
	SE	Ethnicity	Name of ethnic group
	SE	Hunting experience in years	Quantitative, self explanatory
	EFF	Number of times hunting in a month	Quantitative, average of number of times hunter goes on a hunting trip
	EFF	Number of days hunter spends outside of village	Quantitative, average of number of days hunter spends outside the village during a hunting trip
	HT	"Aller-retour" hunting	Binary, Yes/No
	EFF	Variation in hunting activity throuhgout the year	Binary, Yes/No
	EFF/SE	Reason for if he hunts less	Explanation of reasons Codes: Hunting closure; Dry season + agriculture;

	HS	Season effect on hunting	Binary Yes/No; Qualitative Codes: Rains facilitate wildlife circulation; difficulty to install traps in dry season; The leafs make less noise in the rainy season; Easiness to detect animal traces in rainy season
	SE	Solitary hunting or group hunting	Binary, Yes/No
	SE	Number of people in a hunting group	Quantitative; Self explanatory
	SE	Hunting restrictions by village based institutions	Binary; Yes/No ; Qualitative Codes: Not son of the village
	P	Selectivity in prey choice	Binary; Yes/No
	P	Prey choice	Quantitative; Species easiest to hunt
	P	Awareness of protected species	Binary; Yes/No
	P	Hunting of protected species	Binary; Yes/No
	HT	Type of hunting	Hunting technique employed by the hunter
	SE	Gun ownership	Self explanatory
	SE	Origin of gun	Location where gun was purchased
	SE	Price of the gun	Quantitative, Self explanatory
	SE	Origin of shotgun shells	Location where shotgun shells were purchased
	SE	Price of shotgun shells	Self explanatory
	P	Prey choice for gun hunters	Species easiest to hunt
	HT	Night hunting	Binary; Yes/No
	HT	Application of animal calls	Yes/No

	EFF	Number of snares in the forest	Quantitative; Number of snares the hunter usually has installed in the forest
	SU	Snare site selection	Quantitative; Factors influencing trapper decision making
	EFF	Frequency of snare investigation	Quantitative; Frequency in number of days
	SE	Price of simple rope snares	Self explanatory
	SE	Price of cable snares	Self explanatory
	HT	Use of cable snares for trapping	Binary; Yes/No
	EFF	Distance of hunting locations from village	Quantitative; Measured in hours of walking from the village
	P	Animal abdundance and distance	Binary; Yes/No whether animal abundance increases with increasing distance from the village
	P	Decrease of animal abundance	Binary, Yes/No; qualitative Codes: Increased number of hunters after the war; Inmigration; Increased number of trappers
	SU	Habitat preference	Habitat preference scored in a matrix
	SU	Preference in micro conditions for trap set-up	1=slope, 2=plain, 3=creek valley, 4=hill top, 5=no preference
	SU	Forest classification	Classification hunter uses
	SE	Taboos	Binary, Yes/No, Taboos for hunting in certain areas in customary hunting territory
	SE	Inter village relations	Binary, Yes/No whether village based hunters share hunting territory with other hunter communities; location of communities
	SE	Inter village conflict and origin of intruders	Binary, Yes/No; qualitative Codes: Disrespect of territory borders; No hunting fees paid by external hunters;
	SE	Monthly income	Quantitative,Self explanatory

Table 10: Table displaying the variables measured, as well as coding of qualitative information from semi-structured interviews

3. Appendix 3: Research question 1

3.1. Hunting types and age

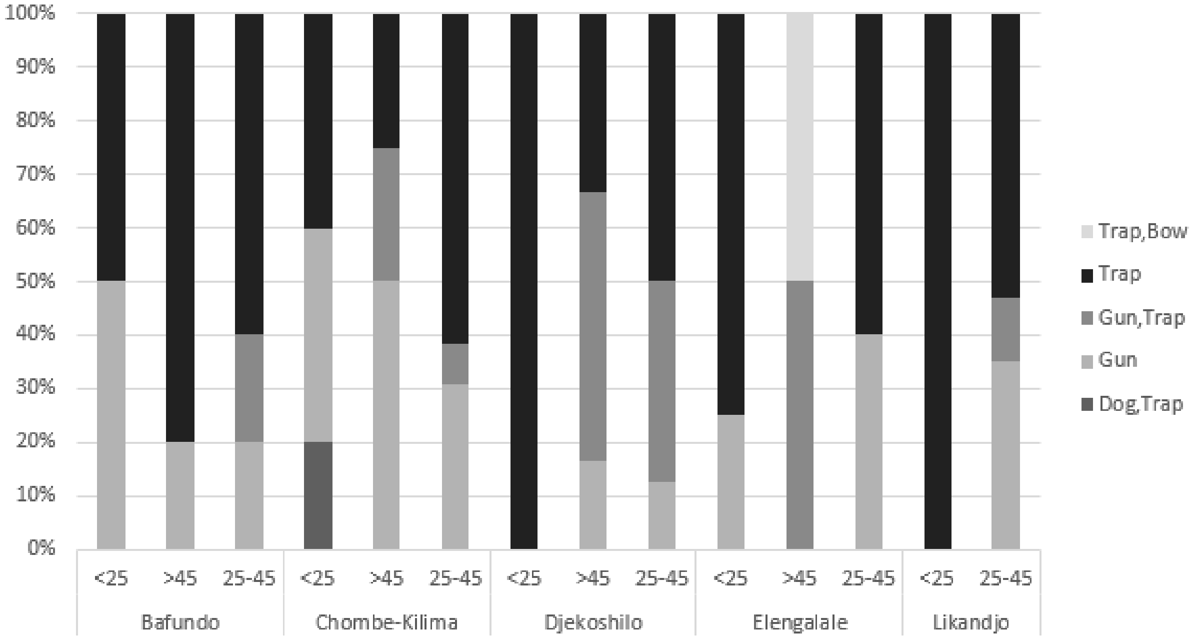

Figure 40: Graph showing the percentage of hunters using different hunting techniques for each of the sites

3.2. Go- and return hunting

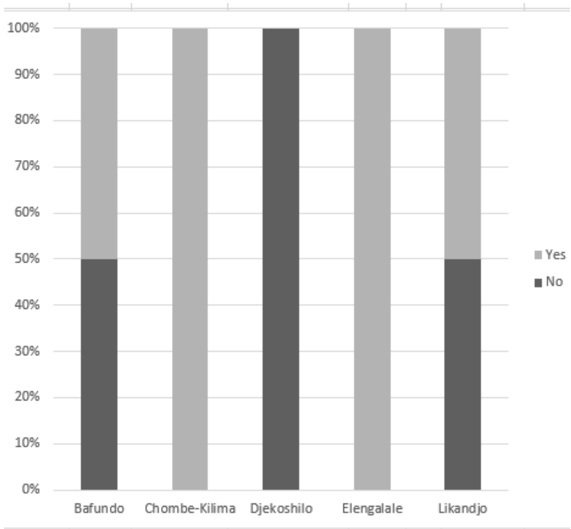

Figure 41: Share of gun hunters who frequently conduct go- and return hunting trips

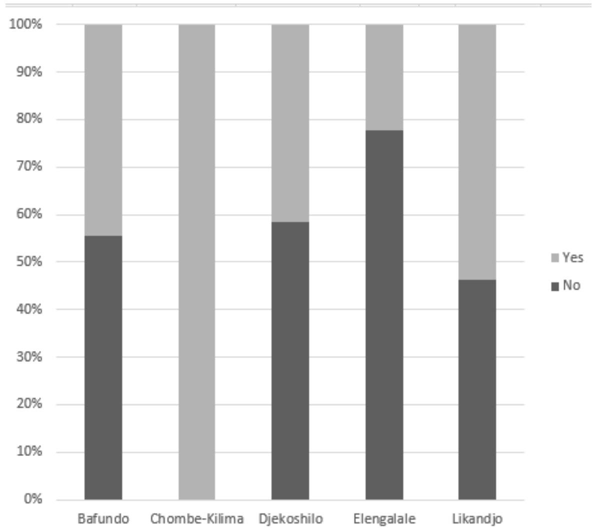

Figure 42: Share of trappers who frewuently conduct go- and return trips from the village

3.3. Seasonality

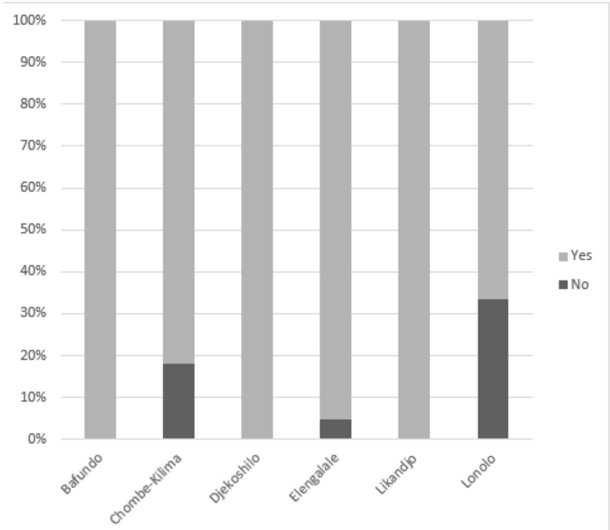

Figure 43: Perception of hunters on the question, whether seasonality has an effect on hunting

3.4. Selective hunting

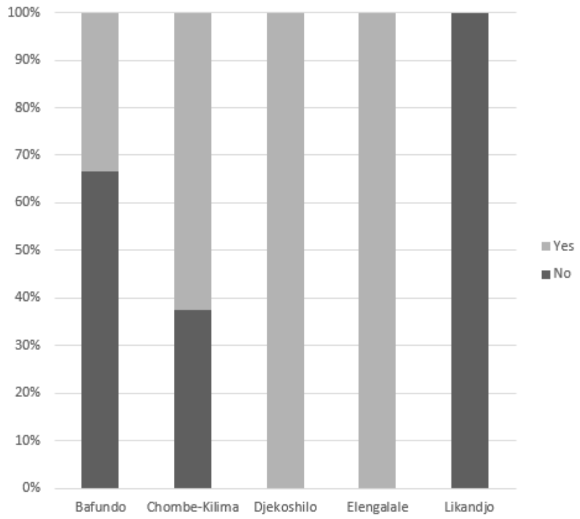

Figure 44: Share of gun hunters in each of the villages who practice selective hunting

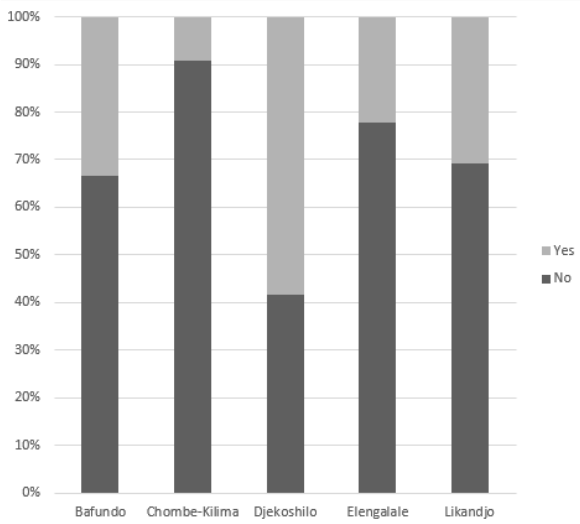

Figure 45: Share of trappers who hunt selectively in each of the villages

3.5. Proportion of encounters with wildlife groups

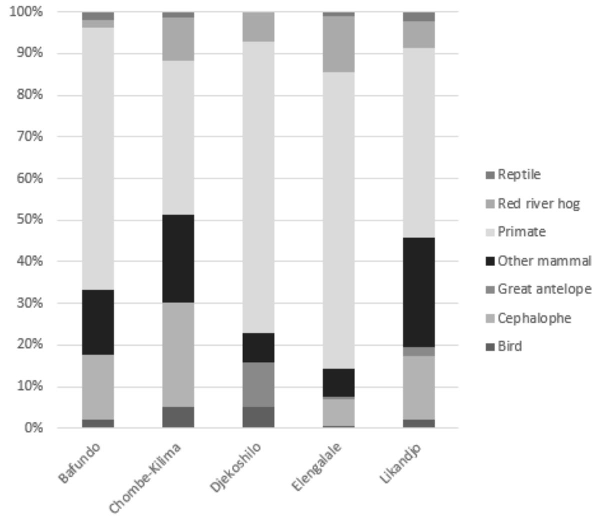

Figure 46: Proportion of animal groups as a percentage of all encounters in the different villages

3.6. Proportion of encounters with primates

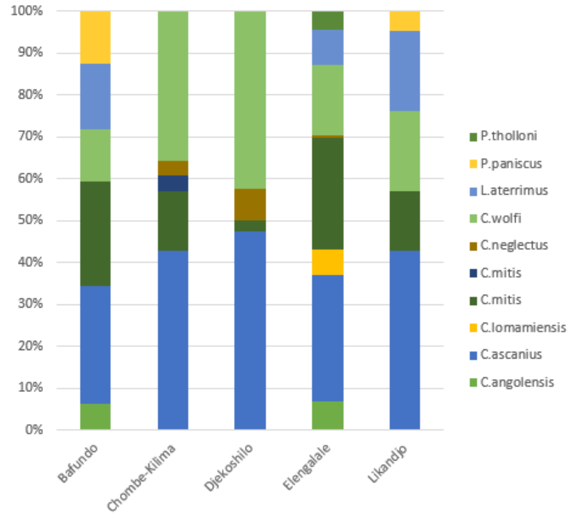

Figure 47: Proportion of primate species encountered as a share of total primate encounters across the villages

3.7. Proportion of encounters with cephalophes, antelopes and red river hogs

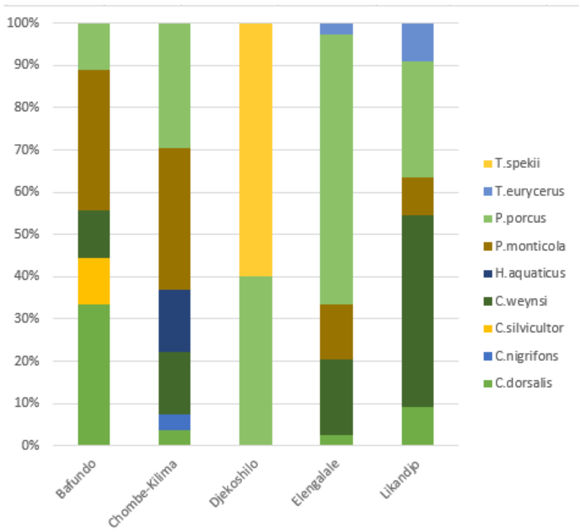

Figure 48: Proportion of cephalophe, antelope- and pig species as a share of total encounters

3.8. Median distances for encounters with prey groups

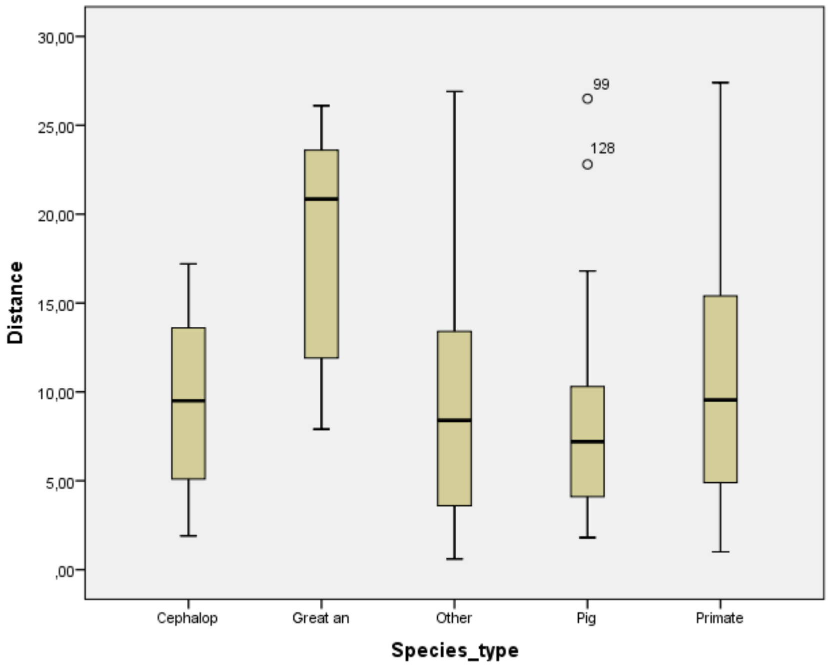

Figure 49: Median distances at which prey groups were encountered, calculated taking all encounters from all villages into account

3.9. Encounter rates with duikers over a day

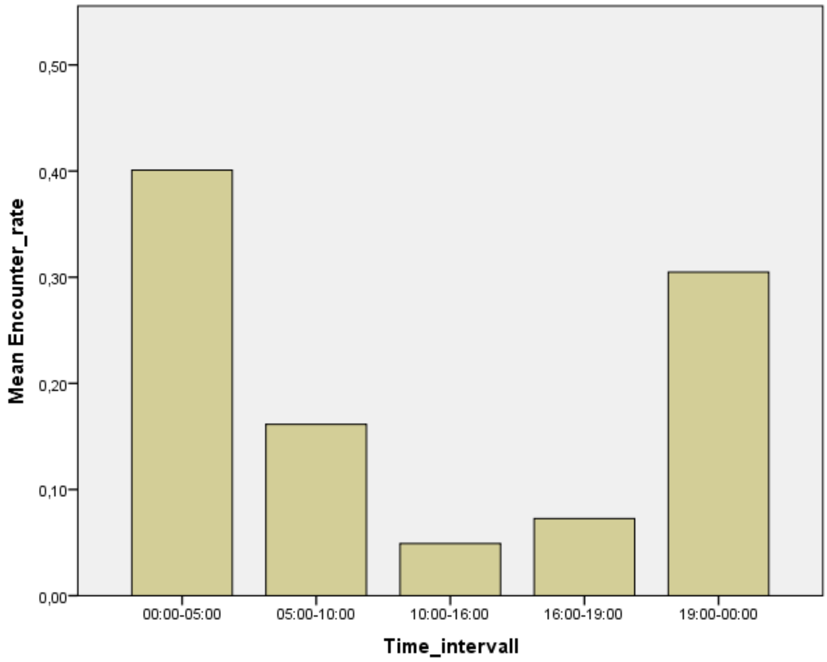

Figure 50: Mean encounter rates with duikers throughout the day. Encounter rates were higher during the night, as well as dusk and dawn.

3.10. Proportion of encounters with prey groups over time

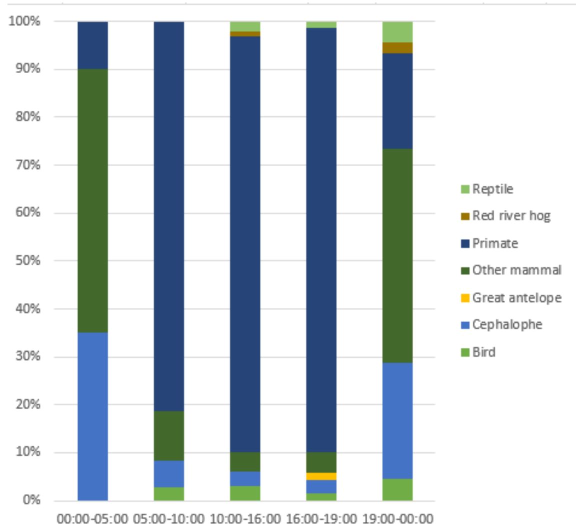

Figure 51: Proportion of encounters with prey groups over time intervals of a day, taking into account all hunter follows

3.11. Pursuits of primate species

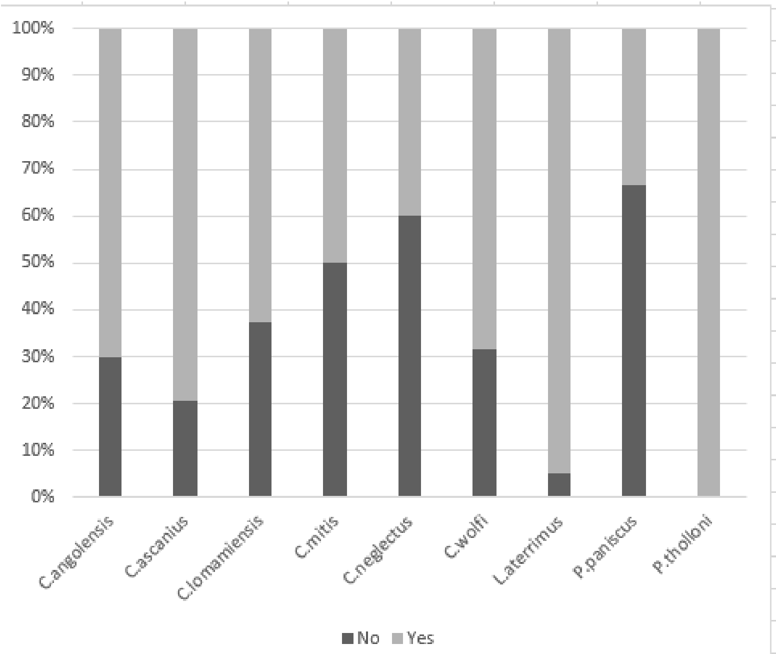

Figure 52: Percentage of pursuits per direct encounter with primate species

3.12. Pursuit rates of other mammals

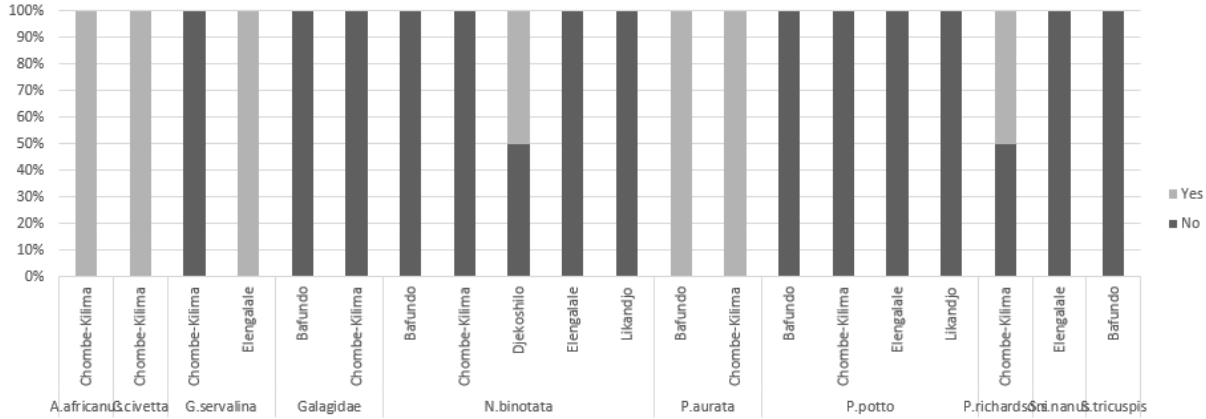

Figure 53: Percentage of pursuits per direct encounter for other mammals

3.13. Pursuit rates of cephalophes, antelopes and primates

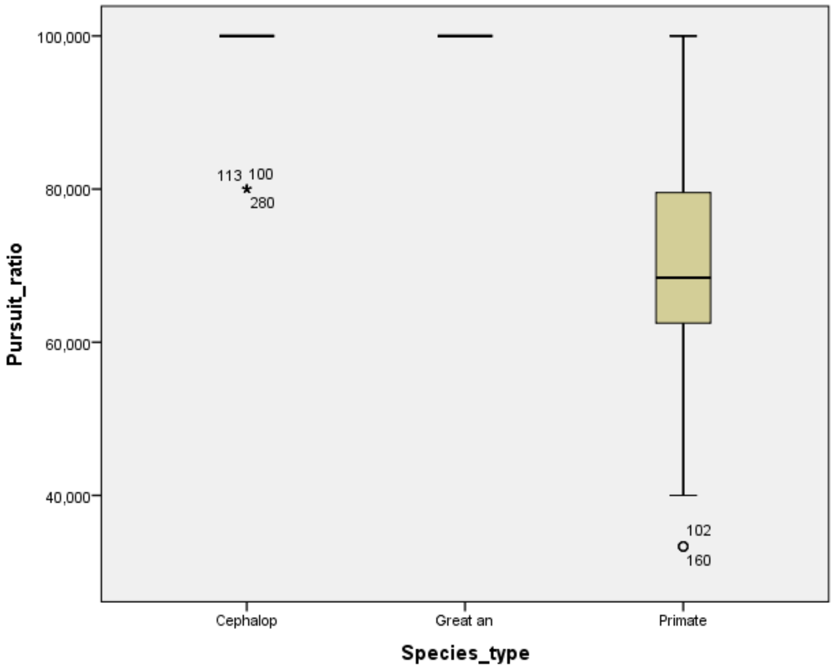

Figure 54: Comparison of pursuit rates for cephalophes, large antelopes and primates

3.14. Encounter types with wildlife

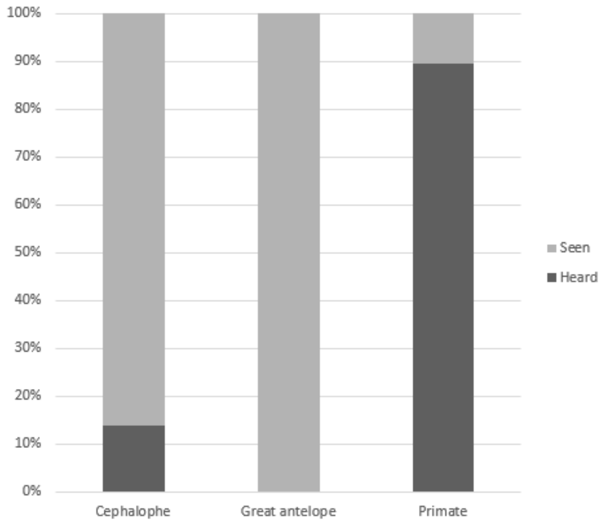

Figure 55: Type of encounter as a share of total direct encounters with cephalophes, great antelopes and primates

3.15. Primate encounter rates

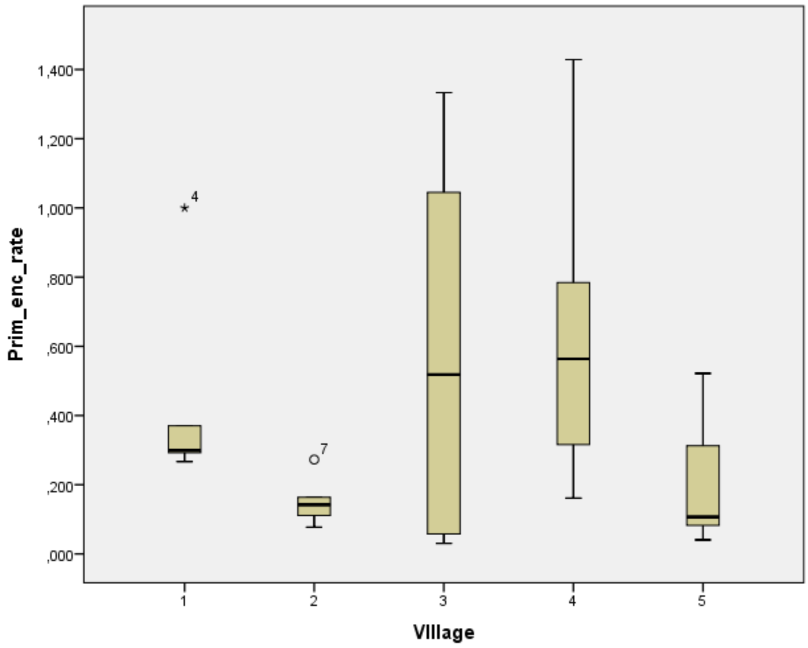

Figure 56: Primate encounter rates in Bafundo (1), Chombe Kilima (2), Djekoshilo (3), Elengalale (4) and Likandjo (5)

3.16. Outcome ratios for cephalophes and primates

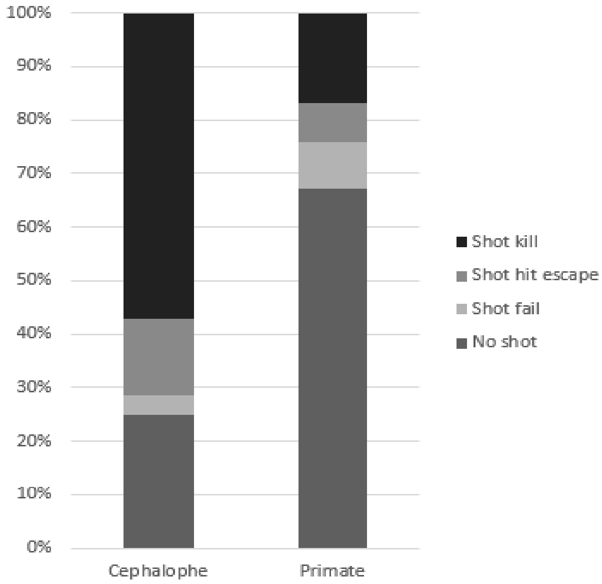

Figure 57: Graph illustrating the share of different outcomes for direct encounters with duikers and primates

3.17. Catch composition

Prey group	Count of kills
Bird	2
Cephalophe	16
Other mammal	2
Primate	29
Reptile	2

Table 11: Table displaying the number of species from different prey groups shot during gun hunter follows

3.18. Maximum head- and body length of cephalophes, antelopes, primates and red river hogs

Species	Max of HBL
C.angolensis	70
C.ascanius	60
C.dorsalis	110
C.lomamiensis	65
C.mitis	60
C.neglectus	64
C.nigrifons	105
C.silvicultor	145
C.weynsi	110
C.wolfi	51
H.aquaticus	85
L.aterrimus	65
P.monticola	70
P.paniscus	120
P.porcus	150
P.tholloni	65
T.eurycerus	250
T.spekii	177

Table 12: Table displaying the maximum head- and body length of cephalope-, large antelope- and primate species

3.19. Pursuit rates of primates after direct encounters across the villages

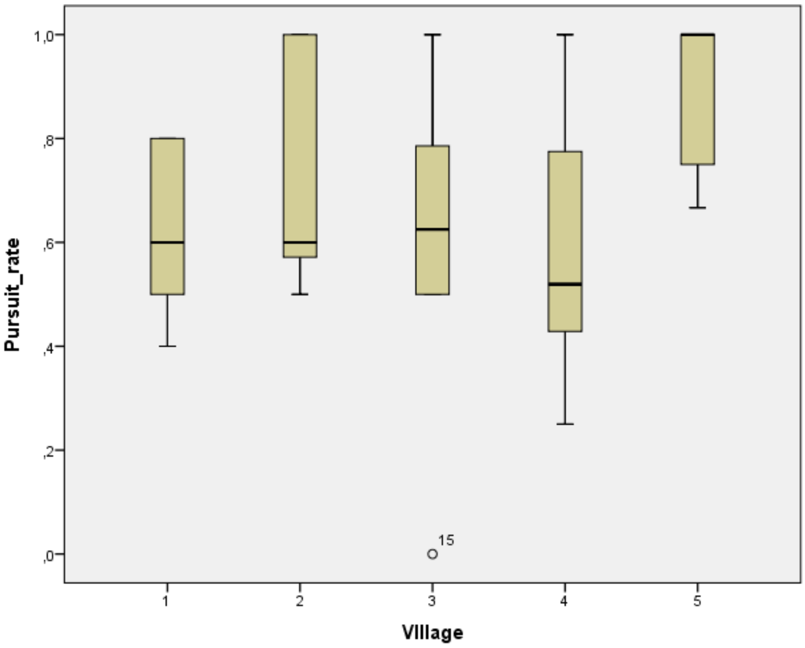

Figure 58Primate pursuit rates in Bafundo (1), Chombe Kilima (2), Djekoshilo (3), Elengalale (4) and Likandjo (5)

3.20. Primate pursuit rates for type follows

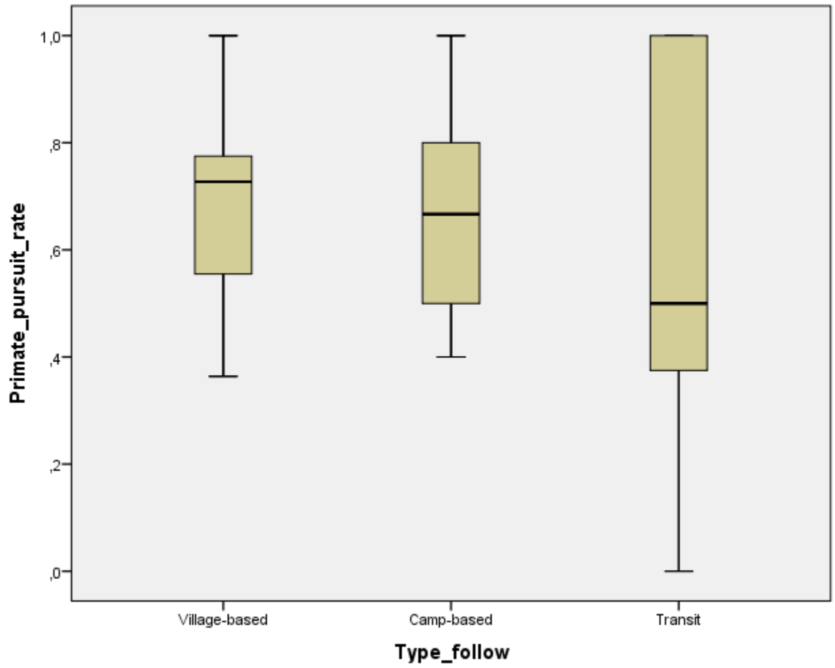

Figure 59: Comparison of primate pursuit rates for village-based-, camp-based- and transit gun hunter follows

3.21. Primate detection ability by hunters

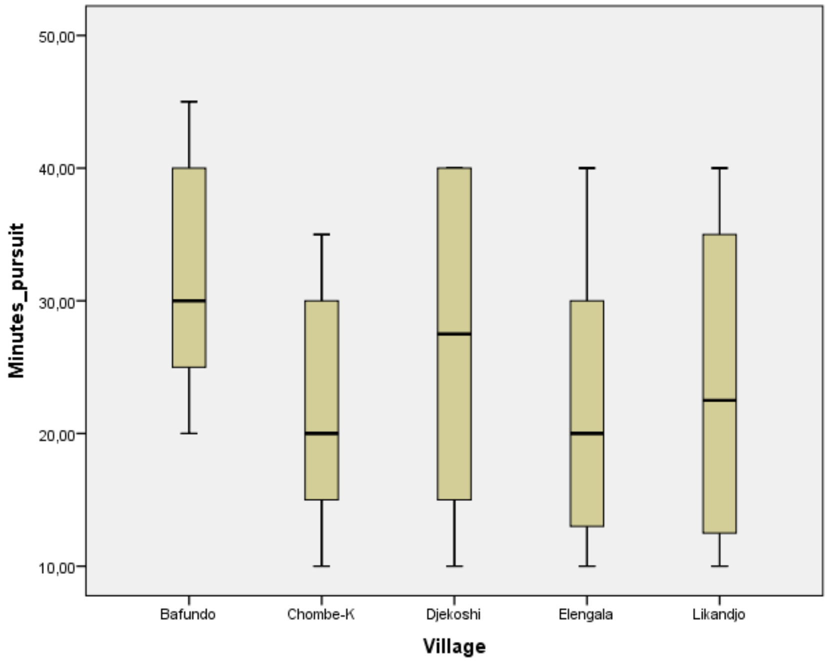

Figure 60: Median pursuit time in minutes as a proxy for detection range of primates. There were no significant differences between the villages

3.22. Bushmeat prices for species on the village- and town level

Scientific name	Chombe-Kilima	Likandjo/ Bafundo	Elengalale	Kindu	Kisangani
Cephalophus weynsi	25000	20000	15000	35000	30000
Philantomba monticola	5000	4000	3000	7000	10000

Cephalophus dorsalis	30000	25000	18000	40000	40000
Cephalophus nigrifons	22000	18000	15000	30000	40000
Cephalophus silvicultor	60000	50000	45000	100000	150000
Hemeuscus aquaticus	15000	15000	8500	30000	15000
Tragelaphus spekii	60000	100000	250000	100000	-
Tragelaphus eurycerus	-	150000	250000	-	-
Syncerus caffer nanus	80000	70000	300000	120000	-
Potamocherus porcus	80000	50000	45000	12000	60000
Okapia johnstoni	-	-	-	-	200000
Genetta servalina	5000	5000	-	7000	-
Poiana richardsoni	5000	5000	-	-	-
Nandinia binotata	5000	5000	-	-	-
Civetticus civetta	-	10000	-	-	-
Anomalures sp.	10000	-	-	15000	-
Uromanis tetradactyla, Phataginus tricuspis	-	5000	-	35000	-
Smutsia gigantean	35000	40000	-		50000
Atherurus africanus	5000	5000	3000	10000	10000
Orycteropus afer	-	-	45000	-	-
Crycetomys	-	-	1500	-	3000
Lophocebus aterrimus	10000	8000	10000	15000	18000
Cercopithecus ascanius	5000	6000	3000	8000	12000
Cercopithecus wolfi		7000	3000	-	12000
Cercopithecus neglectus		7000	5000	-	15000
Colobus angolensis		10000	10000	-	22000
Cercopithecus dryas	-	-	-	-	-
Cercopithecus mitis		7000	7000	-	20000
Cercopithecus lomamiensis	-	-	10000		-
Procolobus tholloni	-	-	10000	-	22000
Perodicticus potto	-	-	2500	-	-
Profelis aurata	-	7000		-	-
Panthera pardus	-	-	-	-	80000
Osteolaemus tetraspis	-	5000	-	-	-

Table 13: table displaying bushmeat prices on the level of different villages as well as Kindu and Kisangani.

3.23. Gun ownership of gun hunters across the villages

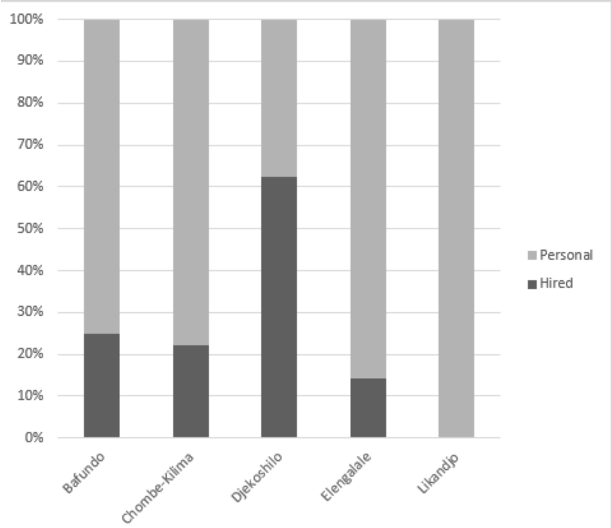

Figure 61: Gun hunters and gun use. Share of gun hunters who borrow the gun asking fellow hunters in the village

3.24. Average incomes of gun hunters respective to type gun used

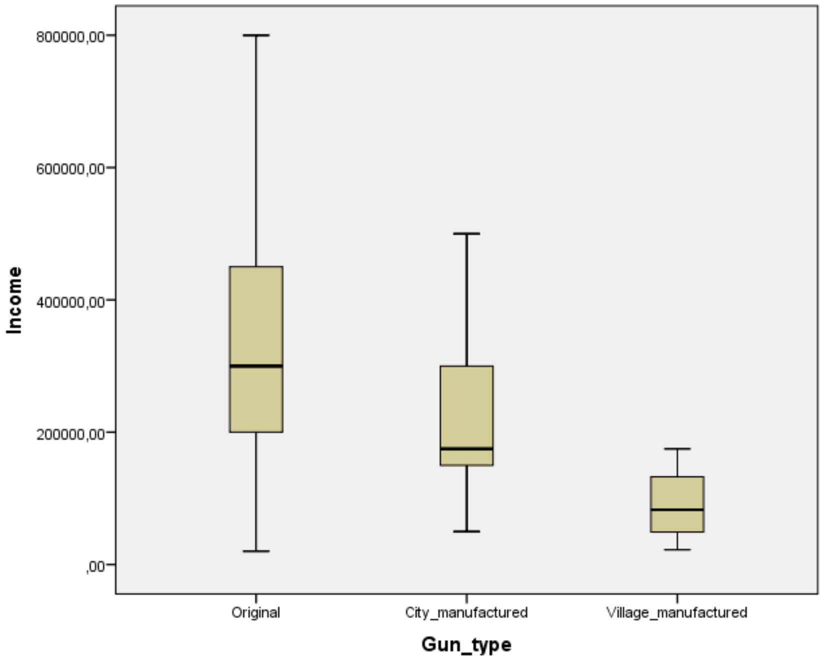

Figure 62: Average monthly incomes of gun hunters hunting with original shotguns, city-manufactured guns and village-manufactured guns

3.25. Income of trappers

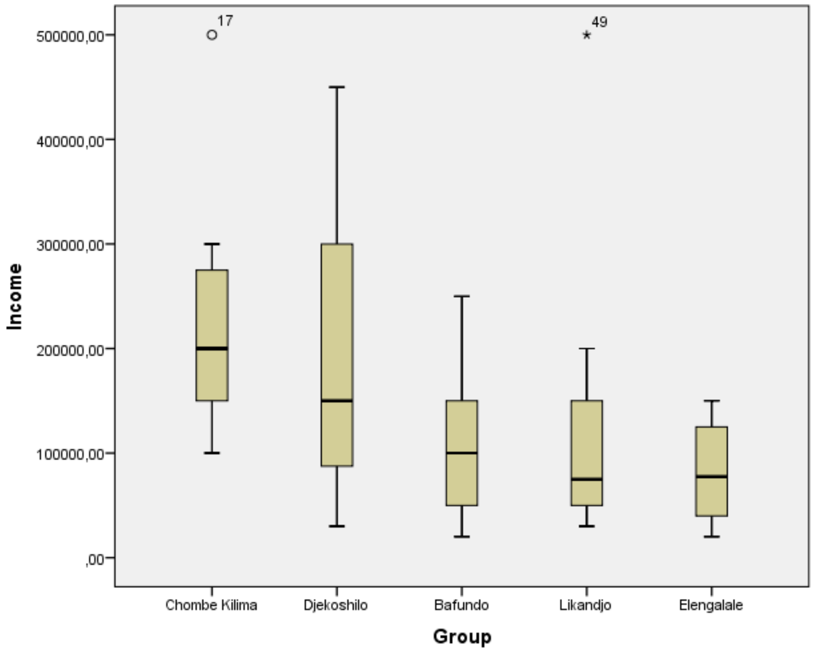

Figure 63: Median incomes of trappers in the sampled villages

3.26. Duration of hunting trips

Village	Average number of days
Bafundo	8,333333333
Chombe-Kilima	5
Djekoshilo	7
Elengalale	9,5
Likandjo	5,833333333

Table 14: Number of days gun hunters averagely spend in the forest per hunting trip

Village	Average number of days
Bafundo	4,055555556
Chombe-Kilima	2,416666667
Djekoshilo	1,916666667
Elengalale	12
Likandjo	7,038461538

Table 15: Number of days trappers averagely spend in the forest during a hunting trip

3.27. Seasonality effect and hunting

Type hunter		No	Yes	% Yes
Bow		1	3	75,00
Bow,Trap			2	100,00
Dog,Trap			1	100,00
Gun		1	23	95,83
Gun,Trap		1	11	91,67
Gun,Trap,Bow			2	100,00
Trap		3	51	94,44

Trap,Bow			1	100,00

Table 16: Table displaying the percentage of hunters using different hunting techniques perceiving tat season has an effect on hunting

3.28. Hunting territory governance

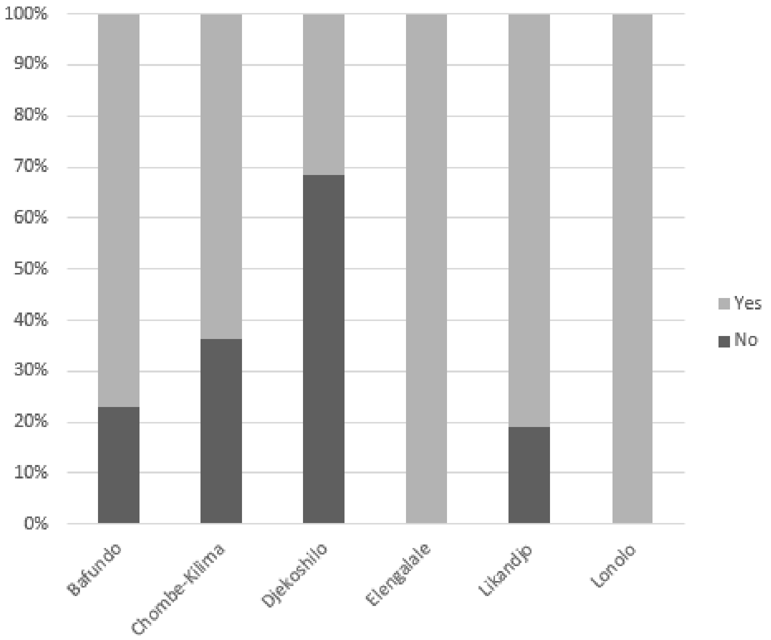

Figure 64: Percentage of hunters stating that their hunting territory overlaps with the hunting territory of other villages

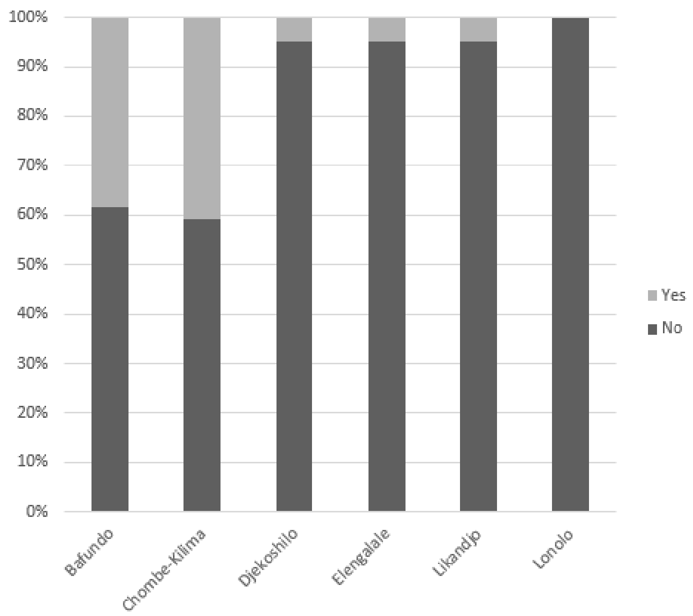

Figure 65: Share of hunters per village who indicate that there is conflict over hunting territory with other communities and their hunters.

3.29. Administrative units and sectors of the TL2-landscape

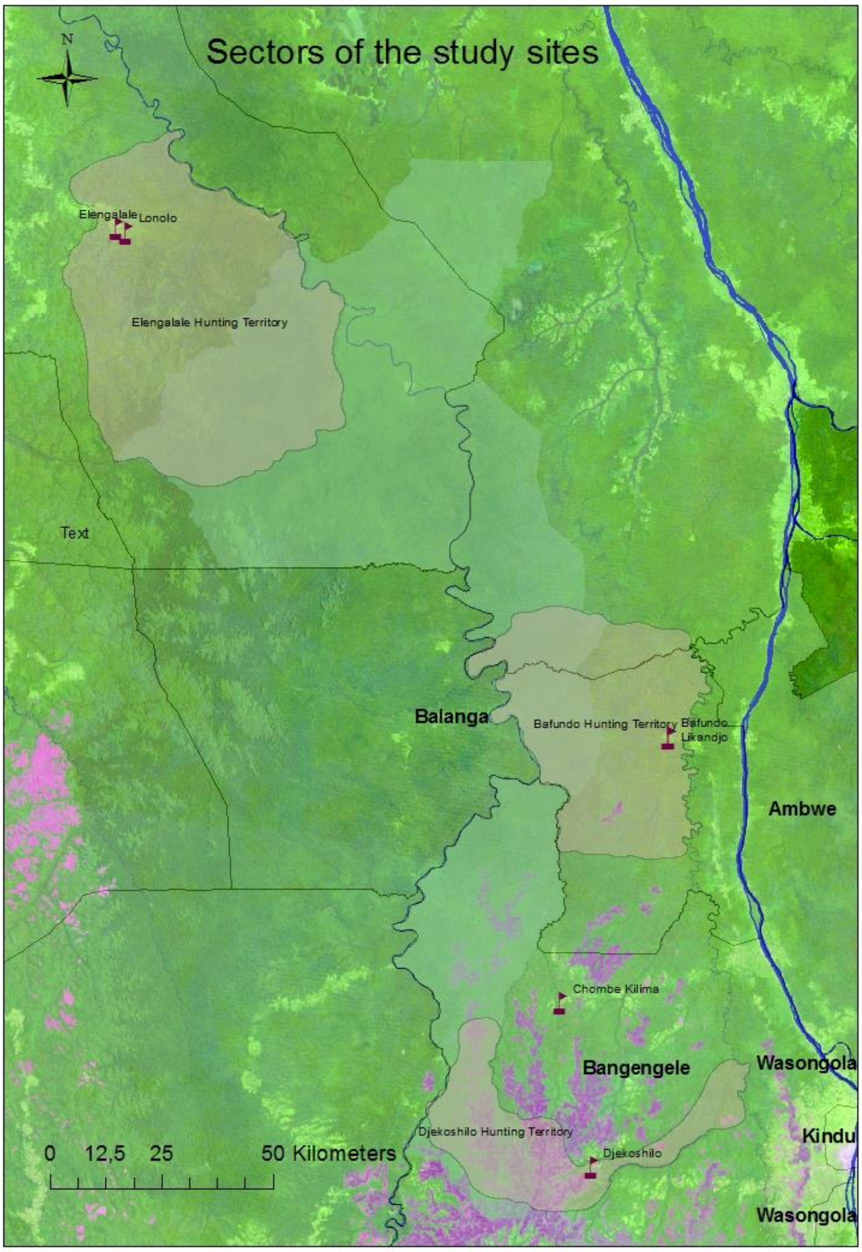

Figure 66: map displaying different administrative units, as well as national park boundaries and the extent of hunting territories

3.30. Cost-benefit analysis of a hunting trip conducted in Bafundo

A hunting trip conducted with two Bafundo hunters from the serves as an example. The "patron" (owner of the gun + organizer of the trip) was accompanied by one of his nephews (who hunted during the night), his wife and his youngest son. Three nights were spent in a camp situated roughly 15 km west of Bafundo, close to the park border. 2 days were transit (most encountered animals were followed whatsoever), and 2 days full hunting in the surroundings of the camp (furthest point from camp was about 6 km).

Costs: C				
Designation	**Unit**	**Price unit**	**Quantity**	**Sum**
Fufu	gobelet	200	15	3000
Palmoil	petite boutaille	800	1	800
Salt	gobelet (tomato can)	500	2	1000
Tomate	boite	500	2	1000
Battery	pair	300	10	3000
Alumette	petite box	50	2	100
Cartridge	Cartridge	1200	9	10800
Total				**19700**

Benefits: B				
Species	**Price**	**Note**	**Quantity**	**Sum**
P.monticola	5000		1	5000
C.dorsalis	30000		1	30000
C.silvicultor	40000	small	1	40000
L.aterrimus	10000		1	10000
C.ascanius	5000		1	5000
C.wolfi	3000	small	1	3000
P.aurata	10000		1	10000
Total				**103000**

Costs include all purchases made for that trip. The number of cartridges refers to the number of cartridges used throughout the trip (he was carrying a total of 21). Costs for weapon (his gun has a value of 600 $US) and torch are not included.

Benefits include all animals shot throughout the duration of the trip. Prices (on the village level) for average-, small size-, and large-size specimen for each species were recorded, interviewing 3 hunters in the village.

Resulting in: B – C = **83300 FC** net. Revenue

3.31. Bow- and dog hunting

Bow and arrow hunting was commonly practiced among hunters from Yawende-Loolo (Elengalale) and among few hunters from the Balanga sector (Bafundo). Bow and arrow hunting is absent from the Bangengele sector in the south of the TL2- landscape Hunters use poisoned arrows to hunt for primates. Bow and arrow hunting is especially common among the pygmies, as they do not use guns. In Elengalale, youngsters were frequently seen around the villages with their bows and arrows, hunting for squirrels. Some of the older gun hunters in Elengalale were occasionally bringing their bows and arrows as back-ups on the hunting trips, especially when a low number of cartridges for shotguns was available. This was the case for 7 out of 16 gun hunter follows in Elengalale. Hunting tactics for bow- and arrow hunters seem to be similar to those applied by gun hunters. Hunters walk the forest, stopping in irregular time-lags to detect primate noises to then decide whether they pursuit encountered primate groups or not. No hunter follows were conducted, where the hunter was eclusively using a bow and arrows to hunt, and there is no empirical data on hunting success. The one hunter follow conducted with Lonolo hunters (pygmies) was not taken into account for group comparisons. Dog hunters exist in the communities within the TL2-landscape as well. A dog hunter was present in Chombe Kilima, another one was encountered during a Djekoshilo hunter follow (where it was not clear whether the hunter himself was a inhabitant of the village of Djekoshilo) and at least one dog hunter was known to be present on Elengalale. In Elengalale, dog hunting is a method to hunt the Lesula monkey, that has a mixed arboreal and terrestrial lifestyle (personal speech). Dog hunters follow their dogs in the forest and run after them as soon as they have winded an animal. Sometimes this hunting method is combined with the use of a net, that is set up in the forest to chase f.e. duikers with the dogs towards the net. Throughout the time of the study, no follows with dog hunters were conducted. Dog hunters in both Chombe Kilima and Elengalale were doubtful on whether the researchers conducting the follows were able to deal with the pace of the hunt.

3.32. Gun hunter/Trapper ratio

Village	Gun hunter/Trapper ratio
Bafundo	0,307692
Chombe-Kilima	0,34375
Djekoshilo	0,565217
Elengalale	0,972973
Likandjo	0,358974
Lonolo	0

Table 17: Table displaying the gun hunter/trapper ratios in all sampled villages

4. Appendix 4: Correlates in hunting success

4.1. Correlations for gun hunter follows

Correlations

		Age	Experience	CPUE_km	n_Shots_fired	Encounter_rate_direct	Pursuit_rate_primates	Pursuit_rate_antelope	Torch	Gun_type
Age	Pearson Correlation	1	,696**	,051	-,003	,075	-,683*	,006	-,242	,061
	Sig. (2-tailed)		,000	,743	,987	,629	,043	,985	,114	,693
	N	44	44	44	44	44	9	12	44	44
Experience	Pearson Correlation	,696**	1	,134	,317*	-,090	-,477	,349	,105	-,424**
	Sig. (2-tailed)	,000		,386	,036	,562	,194	,266	,498	,004
	N	44	44	44	44	44	9	12	44	44
CPUE_km	Pearson Correlation	,051	,134	1	,441**	,519**	,156	,198	,171	-,373*
	Sig. (2-tailed)	,743	,386		,003	,000	,689	,536	,268	,013
	N	44	44	44	44	44	9	12	44	44
n_Shots_fired	Pearson Correlation	-,003	,317*	,441**	1	,273	,378	,150	,514**	-,375*
	Sig. (2-tailed)	,987	,036	,003		,073	,316	,643	,000	,012
	N	44	44	44	44	44	9	12	44	44
Encounter_rate_direct	Pearson Correlation	,075	-,090	,519**	,273	1	,308	-,042	-,052	,241
	Sig. (2-tailed)	,629	,562	,000	,073		,420	,896	,738	,115
	N	44	44	44	44	44	9	12	44	44
Pursuit_rate_primates	Pearson Correlation	-,683*	-,477	,156	,378	,308	1	.c	,177	,287
	Sig. (2-tailed)	,043	,194	,689	,316	,420			,649	,454
	N	9	9	9	9	9	9	2	9	9
Pursuit_rate_antelope	Pearson Correlation	,006	,349	,198	,150	-,042	.c	1	,314	-,629*
	Sig. (2-tailed)	,985	,266	,536	,643	,896			,320	,029
	N	12	12	12	12	12	2	12	12	12
Torch	Pearson Correlation	-,242	,105	,171	,514**	-,052	,177	,314	1	-,287
	Sig. (2-tailed)	,114	,498	,268	,000	,738	,649	,320		,059
	N	44	44	44	44	44	9	12	44	44
Gun_type	Pearson Correlation	,061	-,424**	-,373*	-,375*	,241	,287	-,629*	-,287	1
	Sig. (2-tailed)	,693	,004	,013	,012	,115	,454	,029	,059	
	N	44	44	44	44	44	9	12	44	44

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c. Cannot be computed because at least one of the variables is constant.

Table 18: table displaying relationships between variables measured and calculated for gun hunter follows

4.2. Correlates between encounter rates with wildlife and CPUE for original-brand shotgun hunters

		CPUE_km	Enc_rate
CPUE_km	Korrelation nach Pearson	1	,897**
	Signifikanz (2-seitig)		,000
	N	23	23
Enc_rate	Korrelation nach Pearson	,897**	1
	Signifikanz (2-seitig)	,000	
	N	23	23

**. Die Korrelation ist auf dem Niveau von 0,01 (2-seitig) signifikant.

Table 19: Output of correlation analysis on CPUE and encounter rates for hunter who hunt with original brand shotguns

4.3. Correlates between encounter rates with wildlife and CPUE for hunters using city- or village manufactured shotguns

		Enc_rate	CPUE_km
Enc_rate	Korrelation nach Pearson	1	-,101
	Signifikanz (2-seitig)		,665
	N	21	21
CPUE_km	Korrelation nach Pearson	-,101	1
	Signifikanz (2-seitig)	,665	
	N	21	21

Table 20: Output of correlation analysis testing the relationship between direct encounter rates and CPUE for hunter using city- or village manufactured shorguns

4.4. Correlates between primate and cephalophe pursuit rates, HBL and market value of species

		Price_max	HBL_max	Pursuit_ratio
Price_max	Korrelation nach Pearson	1	,966**	,069
	Signifikanz (2-seitig)		,000	,801
	N	17	17	16
HBL_max	Korrelation nach Pearson	,966**	1	,146
	Signifikanz (2-seitig)	,000		,577
	N	17	18	17
Pursuit_ratio	Korrelation nach Pearson	,069	,146	1
	Signifikanz (2-seitig)	,801	,577	
	N	16	17	17

**. Die Korrelation ist auf dem Niveau von 0,01 (2-seitig) signifikant.

Table 21: Output of correlation analysis on village based market value of cephalophe and primate species, maximum head- and body length, and pursuit ratio by the hunter

4.5. Correlates between pursuit rates, HBL and market value of species

		HBL	Pursuit_rate	Price
HBL	Korrelation nach Pearson	1	,244**	,942**
	Signifikanz (2-seitig)		,000	,000
	N	328	321	276
Pursuit_rate	Korrelation nach Pearson	,244**	1	-,036
	Signifikanz (2-seitig)	,000		,552
	N	321	323	276
Price	Korrelation nach Pearson	,942**	-,036	1
	Signifikanz (2-seitig)	,000	,552	
	N	276	276	276

Table 22: Output of correlation analysis between head- and body length of species, pursuit rates and village-based prices

4.6. Pursuit rates and HBL

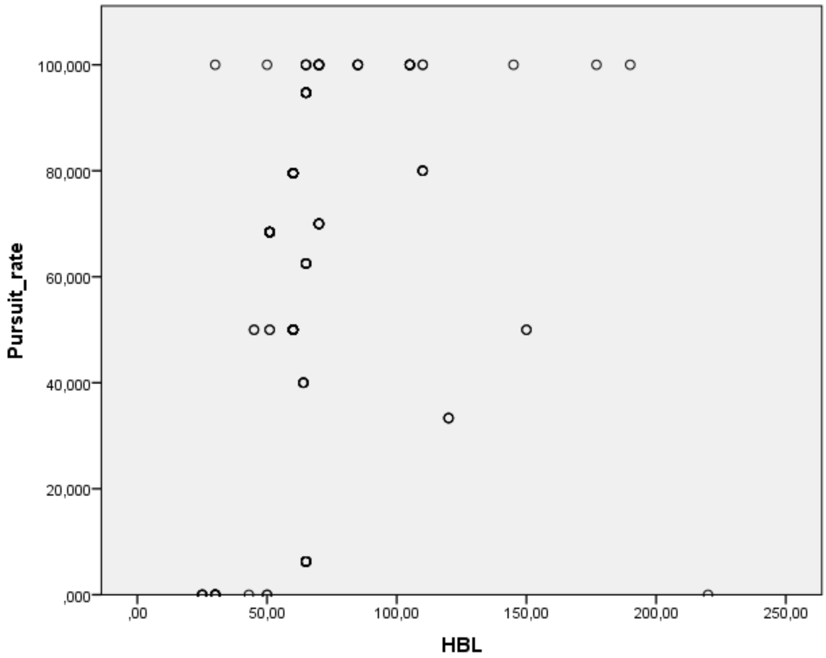

Figure 67: Scatterplot displaying the relationship between species head- and body length and pursuit rates

4.7. Relationships between experience-CPUE-encounter rates

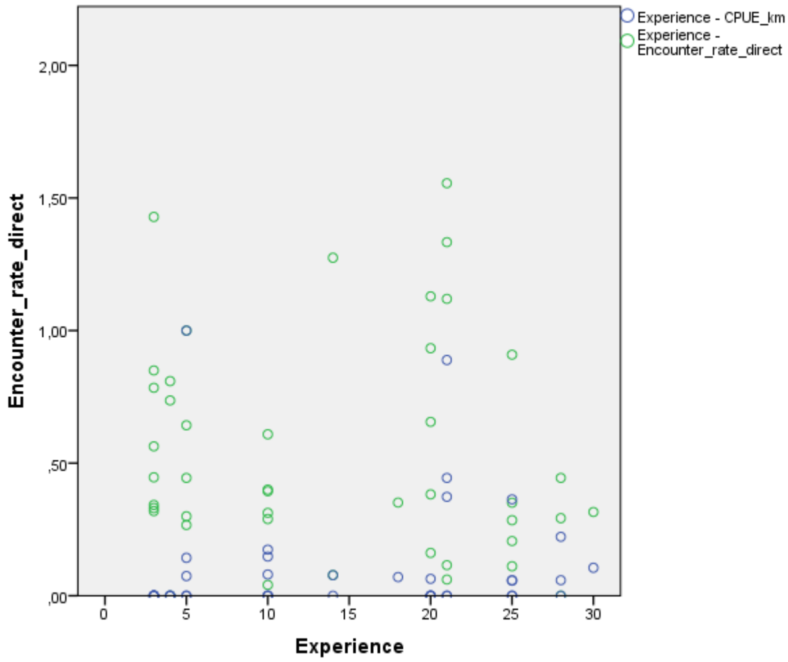

Figure 68: Scatterplot displaying the relationship between experience of the hunter (years) and direct encounter rates with wildlife

4.8. Kills per shot taken by hunters across the villages

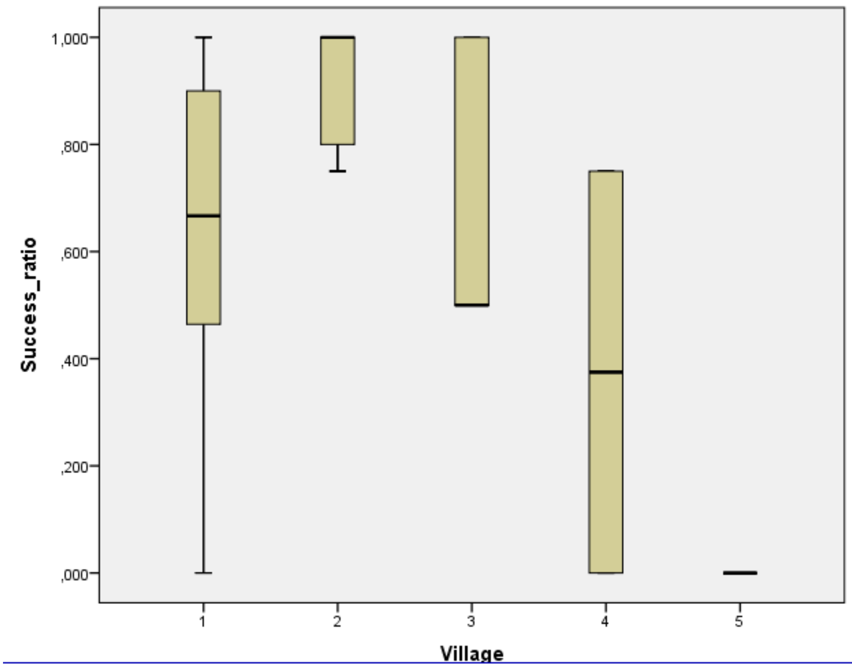

Figure 69: median for the ratio of kills/shot taken for hunters in the Chombe Kilima (1), Djekoshilo (2), Bafundo (3), Likandjo (4) and Elengalale (5)

4.9. Success ratio for different gun types

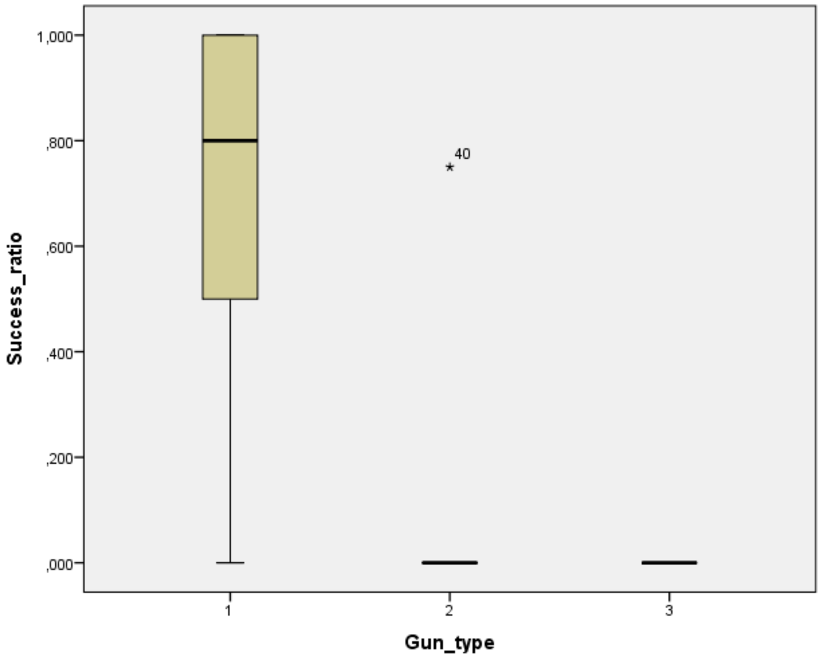

Figure 70: Kills/shot taken for hunters using original brand shotguns (1), city-manufactured guns (2) and village-manufactured guns (3)

5. Appendix 5: Research question 2

5.1. Encounter rates with wildlife according to the different distance zones

Zone	Encounter rate
1	0,248497358
2	0,696569301
3	0,715045244
4	1,053474819

Table 24: Encounter rates for the different zones according to classification 2 of distance

Zone	Encounter rate
1	0,248497358
2	0,759416250
3	0,673404190
4	1,103495990

Table 23: Encounter rates for the different zones according to classification 1 of distance classes

5.2. Median head- and body length of encountered species across villages

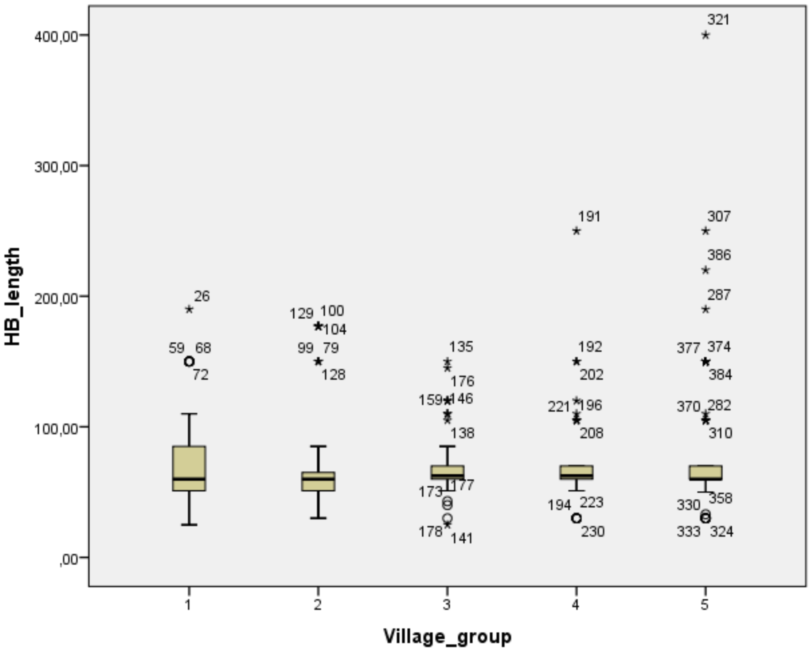

Figure 71: Median head- and body length of encountered species in the different sample sites. There was no statidtically significant difference detected.

5.3. Median distances for where prey groups were encountered from the village

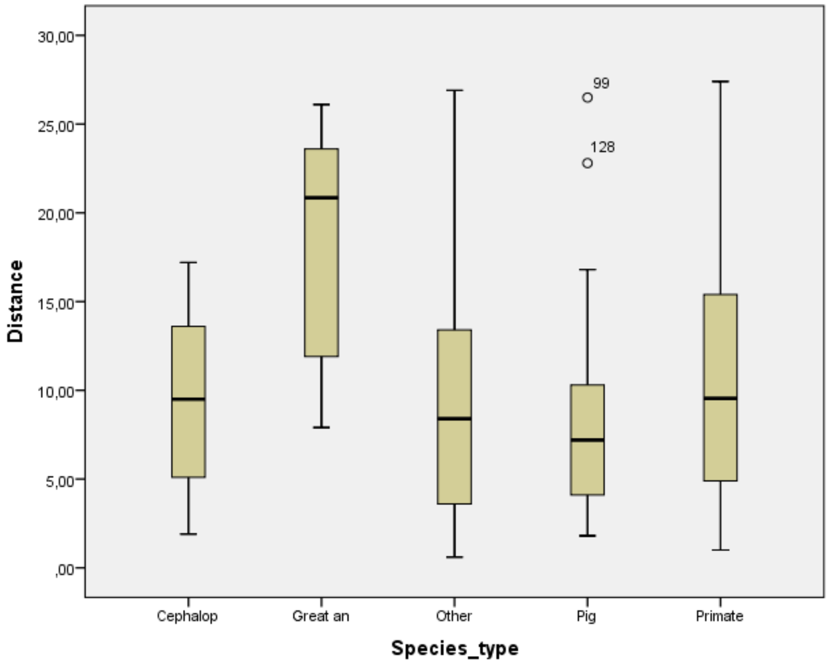

Figure 72: Median distances from the village for encounters with the largest prey groups: Duikers (Cephalophes), great antelopes, pigs and primates.

5.4. Encounter rates with wildlife in different zones across the villages

	Encounter rates			
	Z1	Z2	Z3	Z4
BFD	0,000	0,000	0,361	0,727
CK	0,195	0,411	0,216	1,372
DJ	0,026	0,202	0	1,112
EL	0,451	1,218	1,160	2,734
LKD	0,161	0,316	0,710	0,554

Table 25: Table displaying the encounter rates with wildlife across all distance zones for all villages

5.5. Encounter rates of wildlife in zone 1 for the villages

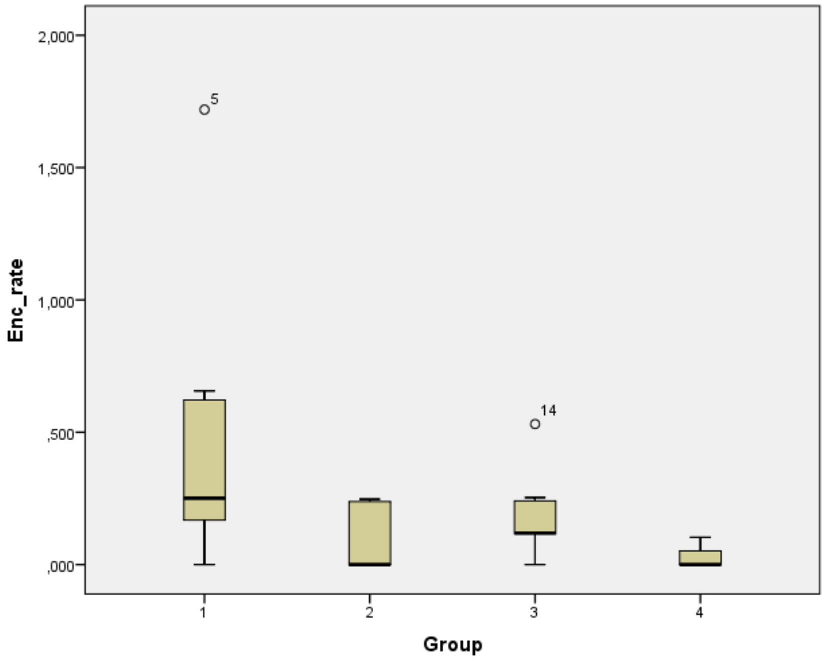

Figure 73: Encounter rates with wildlife in zone 1 for each of the villages. 1 = Elengalale, 2= Likandjo and Bafundo, 3 = CHombe Kilima and 4 = Djekoshilo. Likandjo and Bafundo were grouped for this analysis to increase sample size

5.6. CPUE of trapper follows in different zones

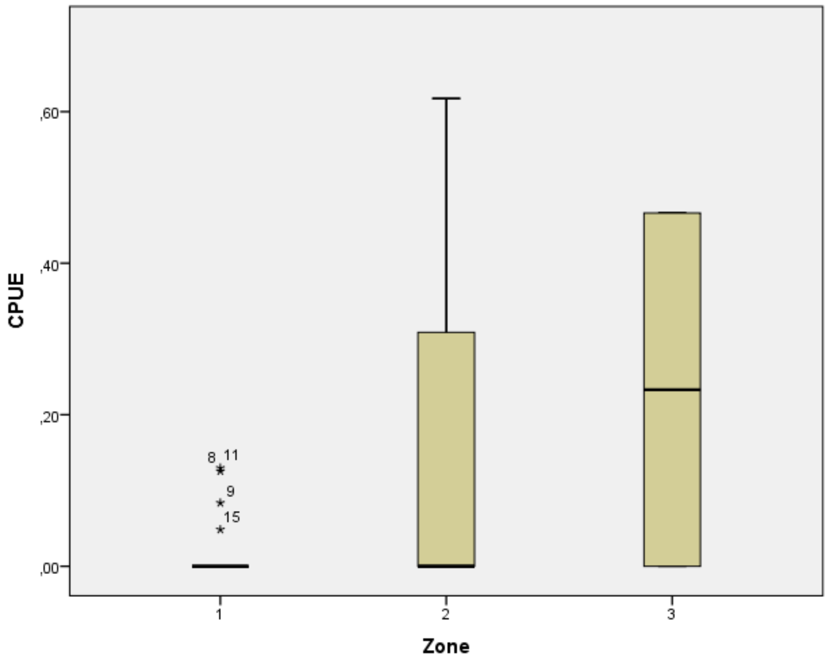

Figure 74 Boxplot showing the median CPUE per zone for trapper follows. The results indicate that CPUE is higher for zone 3 (8-12 km from the village) as compared to zones 1 (0-4 km) and 2 (4-8 km).

5.7. Pursuit rates of wildlife in the four different zones

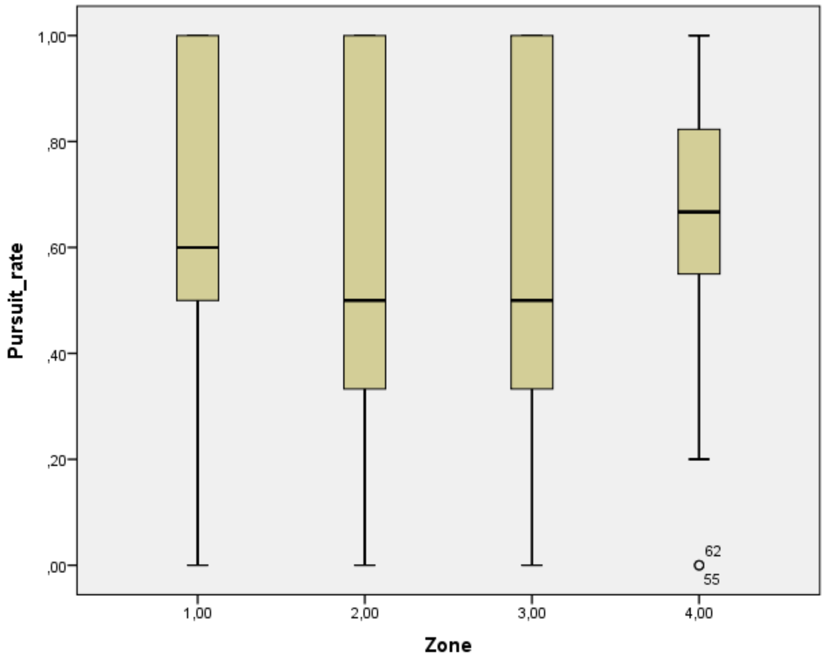

Figure 75: Pursuit rates for direct wildlife encounters in the four different zones according to classification scheme

5.8. Outcomes of pursuits for distance classes

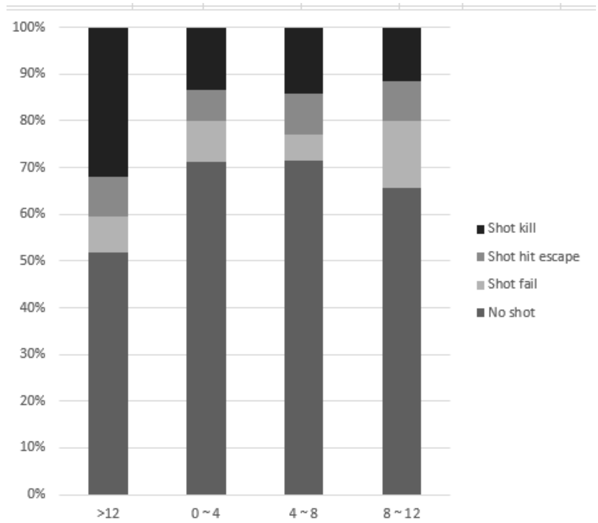

Figure 76: Percentage of outcomes as a share of all outcomes for primate pursuits in different distance zones

6. Appendix 6: Research question 3

6.1. Pursuit rates by gun hunters in different habitat types

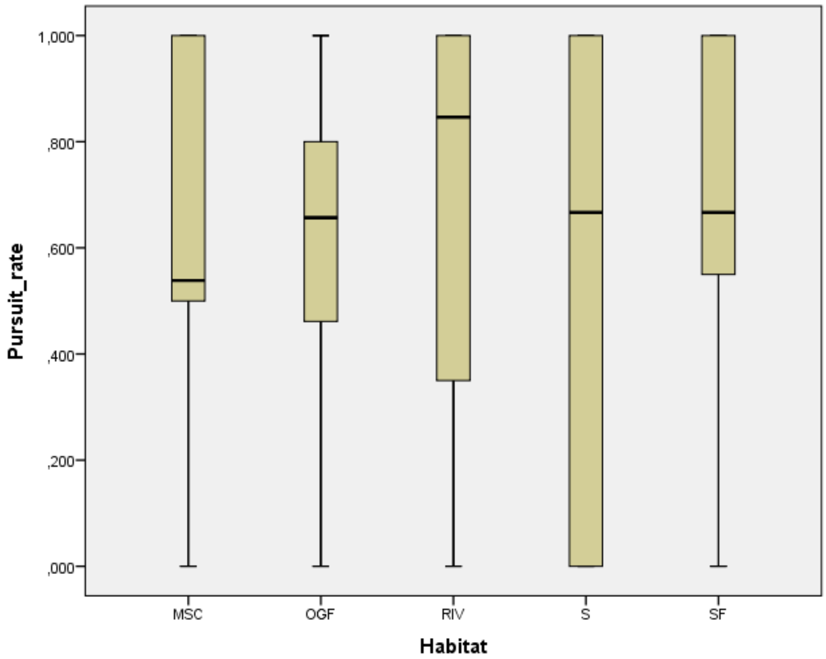

Figure 77: Figure illustrating pursuit rates for direct encounters in different types of habitat

6.2. Kilometers covered in different habitat types during gun hunter follows

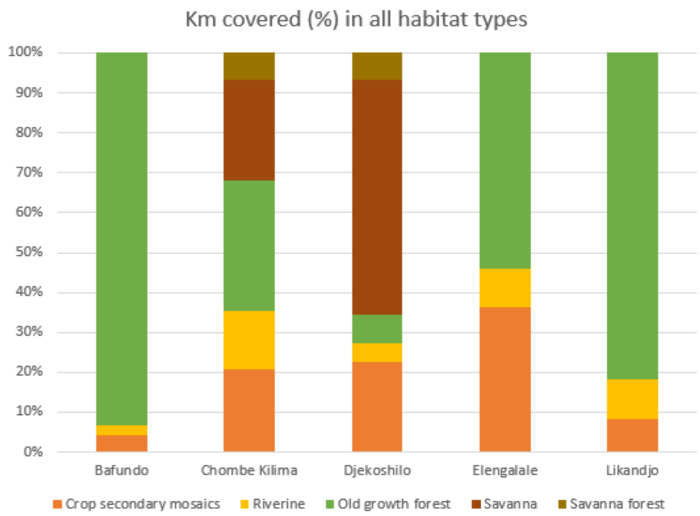

Figure 78: The share of km walked by the gun hunters in the different habitat types of all km covered during the follows

6.3. Village surroundings on landsat imagery with buffered river-, riverine and savanna habitats

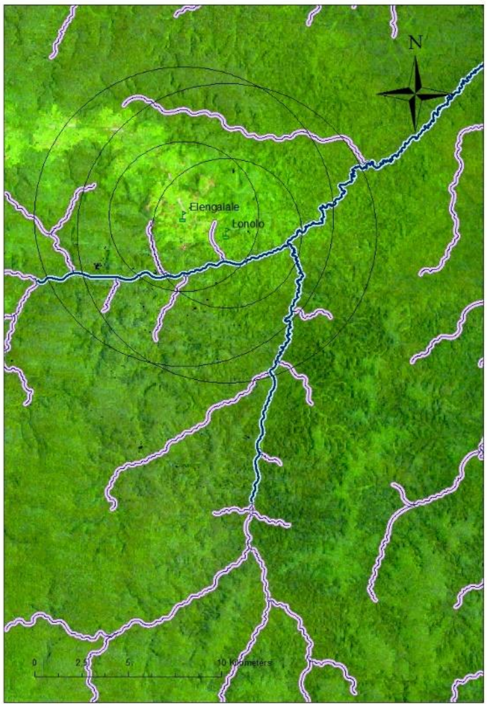

Figure 79: Surroundings of Elengalale as seen on Landsat imagery, with cropland- forest mosaics, old-growth forests and rivers and riverine habitat

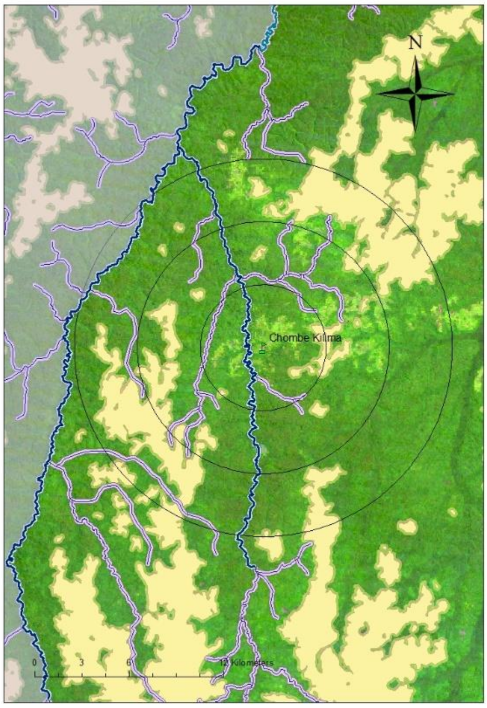

Figure 80: Surroundings of Chombe Kilima as seen on Landsat imagery, with savannas (beige), forests, cropland- forest mosaics, rivers and riverine habitats. Shadowed areas in the west is national park territory

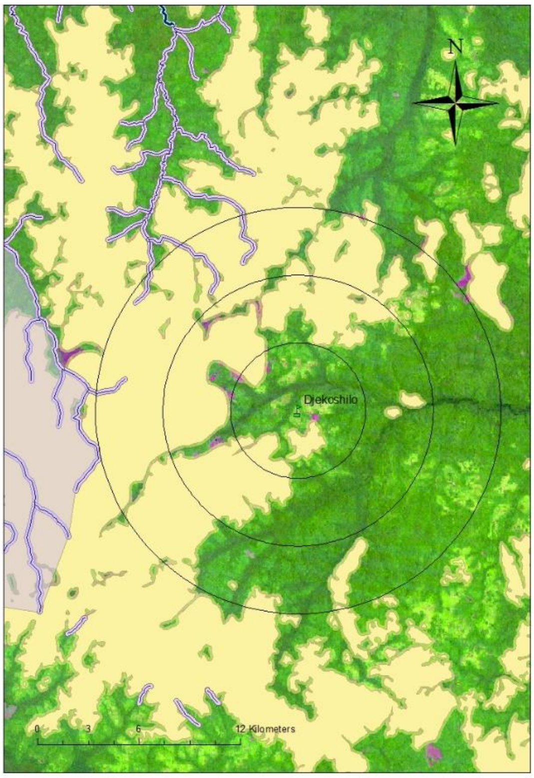

Figure 81: Village surroundings of Djekoshilo, with savanna (yellow), cropland- and forest mosaics, old growth forests and rivers and riverine habitats. Shaded area west of Djekoshilo is national park territory.

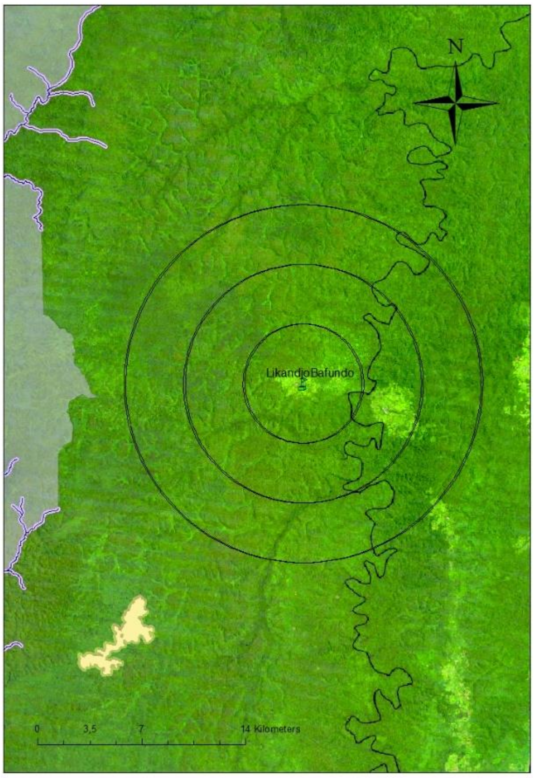

Figure 82: Village surroundings of Bafundo and Likandjo, with savanna (yellow), cropland- and forest mosaics, and rivers and riverine habitats. East of the villags is the Kasuku river.The shaded area in the west is national park territory

7. Appendix 7 : questionnaire

7.1. Explanation of the questions

There are two main types of questions:

- Closed format questions
- Open format questions

Closed format questions are multiple choice questions and are restricted to between two to five answer options in this questionnaire. The choices in the proposed questionnaire include Yes/No questions, implying that either the one or the other is true. These questions are often followed by why questions in order to gain more specific information. Most of the questions in the proposed questionnaire are open format questions. This allows for collection of quantitative data and statistical analysis as required for this conclusive study.

Open format questions offer the respondents to elaborate their opinion on the question freely. Open format questions are viewed to get true, insightful and even unexpected answers and provide diverse qualitative data. Open ended questions are located in the proposed questionnaire in situations where a lot of variation in terms of responses is expected, as for example in the case of section two, question 6, or section four, question 7.

7.2. Questionnaire

Interviewing person: (Statement and introduction to the questionnaire ; confidentiality of responses ; Purpose of the questionnaire)

Interviewing person: (Statement on the first section)

Section 1: General information/ attributes respondent

1. Hunter´s name: Date:

2. Hunter´s age:

3. Number of children:

   Village:

4. Place of birth:
   - ☐ Inside village
   - ☐ Outside village

   If outside village, where?

5. Ethnicity:

(Interviewing person: Statement on section 2)

Section 2: hunter behavior: motivation, frequencies, time, organization; RQs: 1

1. How long have you been hunting?

2. How frequently do you go hunting? (Times per month)

3. Do you hunt for subsistence or for cash income? What is your motivation to go hunting?
   - ☐ Subsistence
   - ☐ Cash income
   - ☐ Both

4. Are there periods during the year when you do not hunt, or hunt less?
   - ☐ Yes
   - ☐ No

   If yes, why?

   And when ?

5. Is season an important factor?
   - ☐ Yes
   - ☐ No

   If yes, why?

6. With who do you go hunting?
   i. Alone
   ii. Not alone

   If in groups, how many people do you usually go with?

7. How do you organize your hunt with fellow villagers and the village chief? Are there restrictions? (do you have to ask for permission)

(Interviewing person: Statement on section 3)

Section 3: hunter behavior: prey choice, hunting technique; RQs: 1

1. Do you hunt species selectively?

☐ Yes
☐ No

2. What animal(s) is/are easiest to hunt?

3. Are you aware of protected species?
   ☐ Yes
   ☐ No

   If yes, why?

4. Do you hunt protected species?
   ☐ Yes
   ☐ No

   (If yes, why?)

5. What hunting technique(s) do you employ? (Check all that apply)
   ☐ Snare hunting
   ☐ Gun hunting
   ☐ Trap hunting
   ☐ With dogs
   ☐ Bow

6. If gun hunting:
   a) Where is the gun from? How much did you pay?
   b) Where do you get the cartridges from? How much per cartridge?
   c) Species easiest to shoot?
   d) Do you hunt with a torch in the night?
      ☐ Yes
      ☐ No

   If yes, why?

   e) Do you use calls to attract animals?
      ☐ Yes
      ☐ No

   Which animals?

7. If snare hunting:

a) How many snares do you bring to a hunting trip?
b) How do you choose where to set up the snares?
c) At what time of the day do you set the snares?
   - ☐ Morning
   - ☐ Midday
   - ☐ Afternoon
   - ☐ Night
d) When do you check on them?
   - ☐ Morning
   - ☐ Midday
   - ☐ Afternoon
   - ☐ Night

e) After how many days do you check your snares?

e) How much does a snare line cost?
f) Do you hunt with cable snares?

(Interviewing person: statement on section 4)

Section 4: Hunter behavior: hunting success, spatial use of hunting territory; RQs: 1,2,3

1. How far from the villages do you usually go to hunt?
   - ☐ <2 h
   - ☐ Between 2 and 5 h
   - ☐ Between 5 and 10 h
   - ☐ >10 h

2. Does hunting success increase with increasing distance to the village?
   - ☐ Yes
   - ☐ No
3. Is this the case for all hunted species?
   - ☐ Yes
   - ☐ No

   Which ones not?

4. Has hunting success decreased within the last years (after the war?, reference for time span)
   - ☐ Yes
   - ☐ No

If yes, why?

5. Preferred habitat, frequency of hunting trips, wildlife abundance, “easiness” to hunt

	Preferred habitat type	Frequency of hunting trips	Wildlife abundance	Easiness to hunt
Mixed secondary-cropland				
Secondary forest small trees				
Old growth forest-tall trees				
Savanna				
Riverine forest				
	100	100	100	100

6. What conditions do you prefer to set-up snares?
   - ☐ On top of a hill
   - ☐ In a stream valley
   - ☐ At a slope
   - ☐ Depends on habitat type
   - ☐ No preference
   - ☐ Other

   If preferences, why?

7. Between how many types of habitat do you distinguish, and how do you define them?
8. Do you go hunting inside the protected area?
   - ☐ Yes
   - ☐ No

(Interviewing person: statement on section 5)

Section 5: Hunter behavior: institutions,

1. Are there areas within the hunting territory of the village that are not subject to hunting?
   - ☐ Yes
   - ☐ No

   If yes, why?

2. Do you share hunting sites with neighboring villages?

☐ Yes
☐ No

3. Are you aware of the exact location of the national park boundary?
   ☐ Yes
   ☐ No

4. Do you have problems/ conflicts with outsiders hunting in your customary territory?
   ☐ Yes
   ☐ No

   If yes, where do these people come from?

   And what is the conflict?

5. How much money do you earn per month? (average)

(Interviewing person: Thank you very much for taking your time etc.)

7.3 Guidelines for the interview survey

Informed consent
The interviews will only be conducted if the respondent´s informed consent to participate in this study is obtained. The respondent will receive information on what type of study he or she is about to participate, and in which way the gathered information will be used. The respondent will be ensured that any information provided will be treated in confidence.

Neutrality
It is very important that the person asking the interview questions maintains a neutral point of view to mitigate the risk to influence the respondent in terms of the answers provided. The respondent should not be given the impression that he or she provided a “good/right” answer or a “bad/wrong” answer. Neutral questions should be used for clarification, for example in case an answer has not been understood in the first moment. Questions, as well as answer options where applicable should be repeated in case the respondent does not seem to understand the question, or where the respondent shows insecurity.

Privacy
The interviews should be hold with the respondent individually. A third person or more persons present may have an effect on the quality of the answers provided. All questions should exclusively be answered by the respondent himself/herself.

7.4 How to fill in the questionnaire

The answers were recorded directly to the questionnaire. The questions were to be asked in the regioanl language (Swahili or Lingala) and written down in either English or French. In case interviews were carried out by a research assistant, answers were written down in French. For the possibility that translating the answer during the interview, the translations can alternatively be done after the interviews on the same day. The boxes should be checked according to the answer of the respondent. In the case of questions that ask for further information and explanation the answers are filled in the space provided. Additional information and statements by the respondent that do not seem to appear relevant for the questions should be noted as well. Almost all interviews were carried out by the research assistants. This was considered the best option, as hunters and trappers cooperating for interviews usually felt more comfortable with a Congolese interviewer.

8. Appendix 8: Images

Picture 1: A blue duiker shot during a night hunt in Bafundo

Picture 2: A golden cat shot during a night hunt

Picture 3: Black mangabey shot during the day

Picture 4: Red tailed monkey shot during the day

Picture 5: A blue duiker attached to a tree to protect the prey from other animals during a night hunt in Likandjo

Picture 6: Hunting camp near Likandjo

Picture 7: A gun hunter crossing a small river with his catch