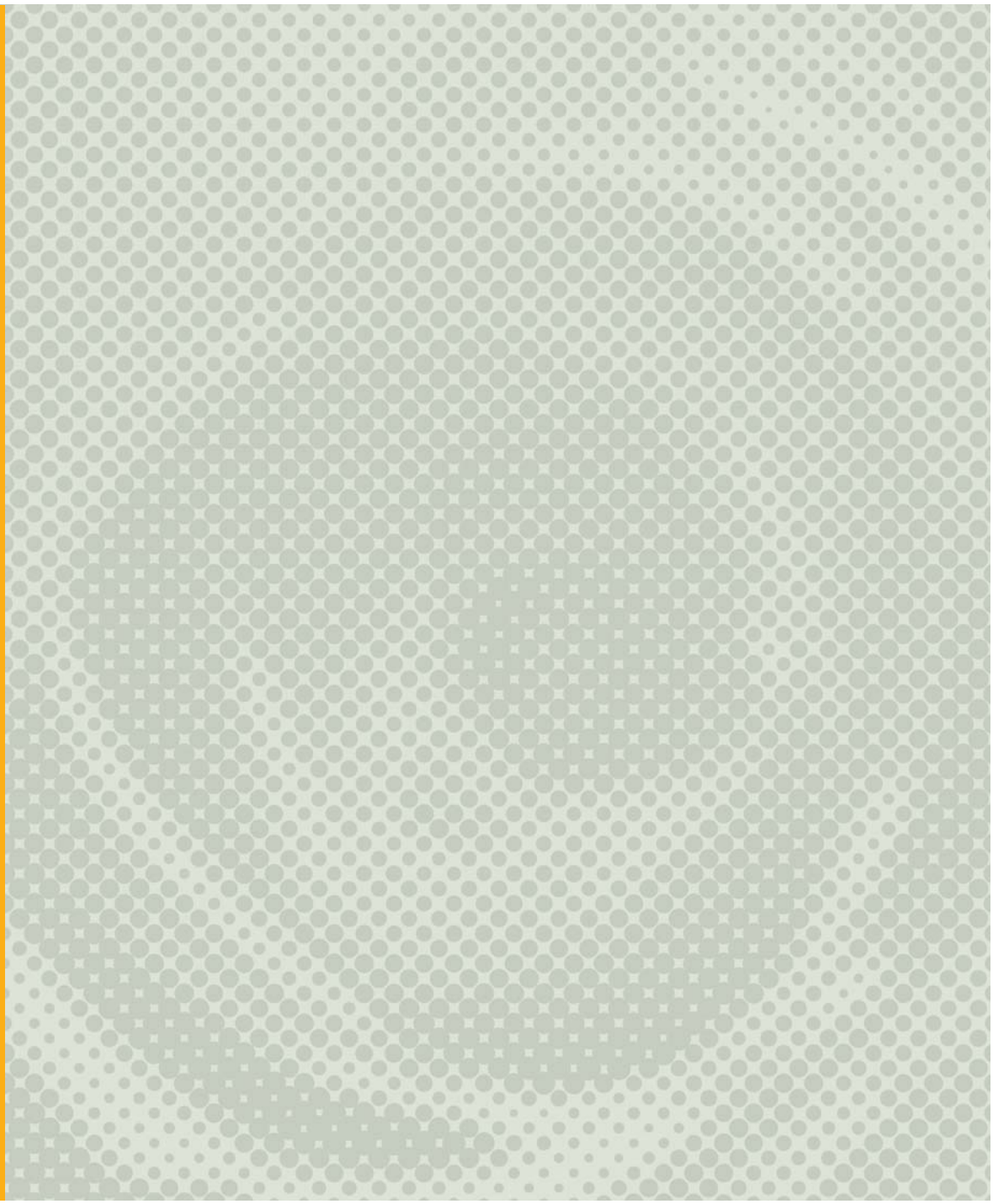
# Bushmeat trading and human demography, the effects on population structure of the puku antelope (Kobus vardonii) in the kilombero valley game controlled area (kgca), ulanga district, tanzania.

Tore Rødseth Ulvund

Norwegian University of Life Sciences
Department of nature management
Master Thesis 60 credits 2011



## 1. Title

Bushmeat trading and human demography, the effects on population structure of the Puku antelope (*Kobus vardonii*) in the Kilombero Valley Game Controlled Area (KGCA) in the Ulanga district, Tanzania.

## 2. Preface

The reason why this thesis was chosen, was my interest for the African ecosystems, and especially the ungulate populations, which I find very interesting in connection their population structure and biology in general. The possibilities to get an inside view into another culture with such diversity in respect to both tribes and their customs and traditions, also inspired me to choose this type of thesis. The interaction between people and wildlife is to be seen all over southern Tanzania, and the management this represents, is important to understand in all its diversity.

The institute of Nature management at the University of Life sciences in Norway, alongside the department of forest biology at the Sokoine University of Agriculture in Tanzania and their participation in the NUFU (Norwegian programme for Development, Research and Education) project is hereby given my sincere thanks for providing important economical support, especially in connection to our travel and stay in Tanzania.

The people providing help during the forming of this thesis, from writing the proposal, completing the filed work, to analysing the data collected, is Stein Ragnar Moe, Ole Gunnar Støen and Thor Larsen from the University of Life sciences which has contributed with both general and specific guidance during the whole period of completing the thesis. At the Sokoine University of Agriculture, head of department of forest biology, Prof. Pantaleo Munishi is given a special thanks, alongside many other invaluable people that contributed in their own important way.

## 3. Abstract

The background for this thesis is the NUFU project "integrating livelihoods and multiple biodiversity values in wetlands management in Tanzania" which is a research project where the assessment of biodiversity, among several other studies, was assessed during the fall of 2008. The Kilombero Valley houses about 75% of the remaining populations of Puku antelope (*Kobus vardoni*) in the world, and the populations are being hunted unsustainably (Corti, G. R. et al. 2002), alongside high populations of buffalo (*Syncerus caffer*) and elephant (*Loxondonta africana*), these are some of many charismatic and important species residing in the Valley, (Bonnington, C. et al. 2007).

The objectives of the study was to Find an overview of the legal harvest, thereby hunting quotas in the Ulanga district in the Kilombero Valley, Find the extent of illegal harvest in the villages neighbouring the two study areas and to study the population structure of puku antelope in two study areas in the actual annually inundated floodplain, inside and outside a hunting concessionary. This was looked at in relation to both density of humans in neighbouring villages, and data on bushmeat trade in the villages. This was not quantitative, but some assumptions could be made to analyze the tendencies found in the answers from the questionnaires.

The study site was situated in the Ulanga district in the Morogoro region, in the KGCA (Kilombero Game Controlled Area). The study area is a part of the Kilombero Valley Floodplain, located in the South-eastern part of Tanzania. One picked 20 more or less randomly chosen transects, 10 inside the hunting concessionary of Wild footprint Ltd., and 10 transects outside the hunting concessionary. Both study areas wore inside the KGCA boundaries. One drove and assessed all transects with an SUV three times, where all ungulates wore assessed. After the field work, puku antelope was picked as the studied species for the thesis because of the amount of data. One also made the assumption that one could on average see 400m out on each side of the vehicle, and that about as many puku that wore assessed, wore also not assesses, and all data was multiplied by 2.

The presence of a hunting concessionary inside the KGCA, seems to impact the populations of puku antelope in a positive way compared to areas of the KGCA that are not inside a hunting concessionary. Line transects wore used as a way of estimating the structure of puku antelope in

the two study areas, one inside a hunting concessionary run by Wild footprint Ltd which was located west of the village of Itete, the other further north but still inside the KGCA.
The results on population structure of puku antelope and numbers, showed a skewed sex ratio of adults inside the hunting concessionary showed 30 % males and 70 % females. In the southern study area this ratio was 48 % males and 52 %. This could suggest that trophy hunting does exist to some degree inside the hunting concessionary. The ratio of females and juveniles overall wore skewed towards females, in fact the number females was double that of juveniles. This could suggest some form of stress upon females, perhaps leading to lower birth ratios then in areas with lower stress in general.
The bushmeat data collected and analyzed suggests that bushmeat trading exists at a relatively high scale, and that the possible economic revenue is present if bushmeat could instead, first be sold as hunting quotas. The seemingly low estimates of bushmeat trading of puku, suggest a possible total economic loss (N=78 puku) of 46.800.00, - Tanzanian shillings (TSH).
The general assumption that the methodology used in this thesis could be different from earlier studies and that the density measures of puku could be different than in other studies, could be criticised and be subjected to scrutiny.

# 4. Introduction

## 4.1

Wetlands contribute in diverse ways to the livelihoods of millions of people in Africa, which relies on crucial wetland resources on a daily basis (Kangalawe & Liwenga 2005; McCartney & Van Koppen 2004; NUFU 2007; Thorsell et al. 1997). The lack of knowledge is one of the major constraints to manage African wetlands wisely by planners and natural resource managers (Hook 1988; Kangalawe & Liwenga 2005; McCartney & Van Koppen 2004). Wetlands cover about 6% of the worlds land surface (Hook et al., 1988), while in Tanzania about 10% of the land surface area consists of wetland, which is primarily utilized for producing products for human consumption such as crop production and livestock (Hinde et al. 2001b; NUFU 2007). A wetland ecosystem can support a wide diversity of species, and its functioning gives rise to over 10,000 species of fish, 4,000 amphibian species and a great abundance of waterfowl, thereby supporting important levels of global biological diversity (Bergkamp & Orlando 1999). There has been big differences between what government authority policies dictate and what actually occurs on the

local level, and because of this, the lack of well coordinated inter-sectoral approach to wetland management is evident (McCartney & Van Koppen 2004).

Some of Tanzania's most diverse wildlife populations reside in the Kilombero Valley, especially considering that it is located outside the protection of a Game Reserve or National Park (Bonnington, C. et al. 2007). A number of factors, including commercial forestry, have substantial impact on large mammal populations in the Kilombero Valley in Southern Tanzania (Bonnington, C. et al. 2007; Caro 1999a; Haule et al. 2002; Mysterud et al. 2007; Rannestad et al. 2006).

Many mammalian populations are strongly structured by skewed age and sex ratios. Because survival rates typically differ among age and sex classes (Gaillard et al. 1998), populations of equal size but differing structures will have different temporal dynamics (Coulson et al. 2001) and will respond differently to stochastic environmental variation (Cameron & Benton 2004; (Gaillard et al. 1998). Consequently, by perturbing population sex and age structure, selective harvesting affects population dynamics (Gaillard et al. 1998).

Ungulate populations are regulated mainly through density-dependent mortality outside the breeding season, with environmental stochasticity often combined with density dependence through a common effect on resources supply (Caughley and Gunn 1993, Sæther 1997) (Illius & O`Connor 2000). An increase in wild ungulate populations has been reported when livestock is removed, and this indicates the presence of competition between domestic and wild species (Hendricks et al. 2005; Rannestad et al. 2006).

The Kilombero Valley houses about 75% of the remaining populations of Puku antelope (*Kobus vardoni*) in the world, and the populations are being hunted unsustainably (Corti, G. R. et al. 2002), alongside high populations of buffalo (*Syncerus caffer*) and elephant (*Loxondonta africana*), these are some of many charismatic and important species residing in the Valley, (Bonnington, C. et al. 2007). The Puku formerly occurred widely in grasslands near permanent water within the savanna woodlands and floodplains of south-central Africa (Hoffman & Mallon 2008). It has been eliminated from large parts of its former range and reduced to fragmented, isolated populations, but some of these are still numerous (Hoffman & Mallon 2008). Large numbers now occur in only two countries, Tanzania and Zambia (Hoffman & Mallon 2008).

Demographic changes in many wild populations of ungulates has been linked to harvesting, for example skewed age structure and reduced life-expectancy (Langvatn & Loison 1999),

fluctuating population sizes (Myers *et al*. 1995; Solberg *et al*. 1999) and distorted sex ratios (Ginsberg & Milner-Gulland 1994; Saether, Solberg & Heim 2003) (Coulson et al. 2007)
Several studies suggest that population densities and population dynamics is being altered by exploitation of wildlife (Caro, 1999a; Fischer and Linsenmair, 2001; Milner-Gulland et al., 2001) (Holmern et al. 2007). Because many hunters target males, female biased sex ratios caused by demographic changes (Milner-Gulland et al., 2001; Fischer and Linsenmair, 2002), may affect wildlife population dynamics negatively (Ginsberg & Milnergulland 1994; Holmern et al. 2007).
Recent reviews have called attention to the potential selective effects of sport hunting on wild ungulates, in which large-horned or large-antlered males are selectively targeted (Coltman et al. 2003). Phenotype-based selective harvests, including trophy hunting, can have important implications for sustainable wildlife management if they target heritable traits (Coltman et al. 2003).
According to the National Bureau of Statistics, the average annual growth rate of people in the Ulanga district has been 2,4 % from 1988-2002 (National Bureau of Statistics 2006), and in this thesis, the number of people counted in each village during the 2002 national population census is being used since this is the last census completed in the Ulanga district (National Bureau of Statistics 2002). The next national population census in villages in the Ulanga district is planned in 2012 (National Bureau of Statistics 2002).
Very little seems to be known about which possible indirect and direct effects that people have on the puku populations I the Kilombero Valley Floodplain. Especially estimates of possible loss of revenue due to bushmeat hunting and trading in connection to the number of people living there, seems to be absent. In this thesis only some indirect effects of possible loss of economic revenue and simple estimations on this has been assessed in some of the neighbouring villages to the study areas used has been looked at.
Such studies are important because there is a need to assess and estimate the wildlife populations present in the Kilombero Valley Floodplain, and by doing this, getting an idea of what state the wildlife populations currently are in, especially in connection to the factor that could be the most significant indirect effect on the wildlife in the area, namely the indirect factors and direct factors linked to the number and density of people surrounding and in parts of the year, inhabiting the floodplain. Some of these factors like licensed hunting and bushmeat trading is especially discussed and assessed in this thesis. When one knows with relative certainty, the effects of all of

these factors, one can implement management schemes that preserve the wetlands biological integrity and functioning. According to (Hinde et al. 2001 and Caro, 1999), animals that persist and survive outside protected areas are perhaps under most immediate threat from human activity as these areas often contains important wildlife populations. This definitely applies to the possible situation in my research area, which is situated partly in a migration route for many animals from the Selous Game Reserve and down south west into the study areas inside the Kilombero Game Controlled Area (KGCA). A Game controlled area (GCA) is an area of land that was previously gazetted to prohibit all forms of hunting. The law however makes no restrictions on other forms of land use and local communities are allowed to permanently reside within a game controlled area (Baldus & Cauldwell 2004). In this area companies exercise extensive commercial hunting and the game is protected only to some degree by having the status as a game controlled area and by surviving under the partly protection of the hunting outfitters themselves. Human encroachment around, at the border line and inside the game controlled area, seemed evident. The villages surrounding the Puku antelope's ecosystem during the dry season may play an important role by then being able to go into the area an effect the puku population in a diversity of ways. The puku also has fragmented wet season habitats along the floodplains border zone, that is basically the miombo forests surrounding the floodplain, namely at higher elevations containing more diverse macro-vegetation.

The primary research topic of this thesis is to find the population structure of the Puku antelope in two specific areas of the Kilombero Valley Floodplain and possible effects on these populations in connection to the number of people residing in a number of neighbouring villages in the district of Ulanga. Specifically the effects of bushmeat trading and some assessments on the population structure itself.

**4.2 Objectives:**

1. Find an overview of the legal harvest, thereby hunting quotas in the Ulanga district in the Kilombero Valley, (Table 2).
2. Find the extent of illegal harvest in the villages neighbouring the two study areas, based on a questionnaire, see appendix.

3. Study the population structure of puku antelope in two study areas inside and outside a hunting concessionary in relation to both density of humans and data on bushmeat trade in the villages.

### 4.3 The study area

The study site was situated in the Ulanga district in the Morogoro region, in the KGCA (Kilombero Game Controlled Area) (Coordinates according to google earth, in the middle of our study area is 8°26`32.88”S, 36°24`29.82”E). The study area is a part of the Kilombero Valley Floodplain, located in the South-eastern part of Tanzania (Fig. 1).

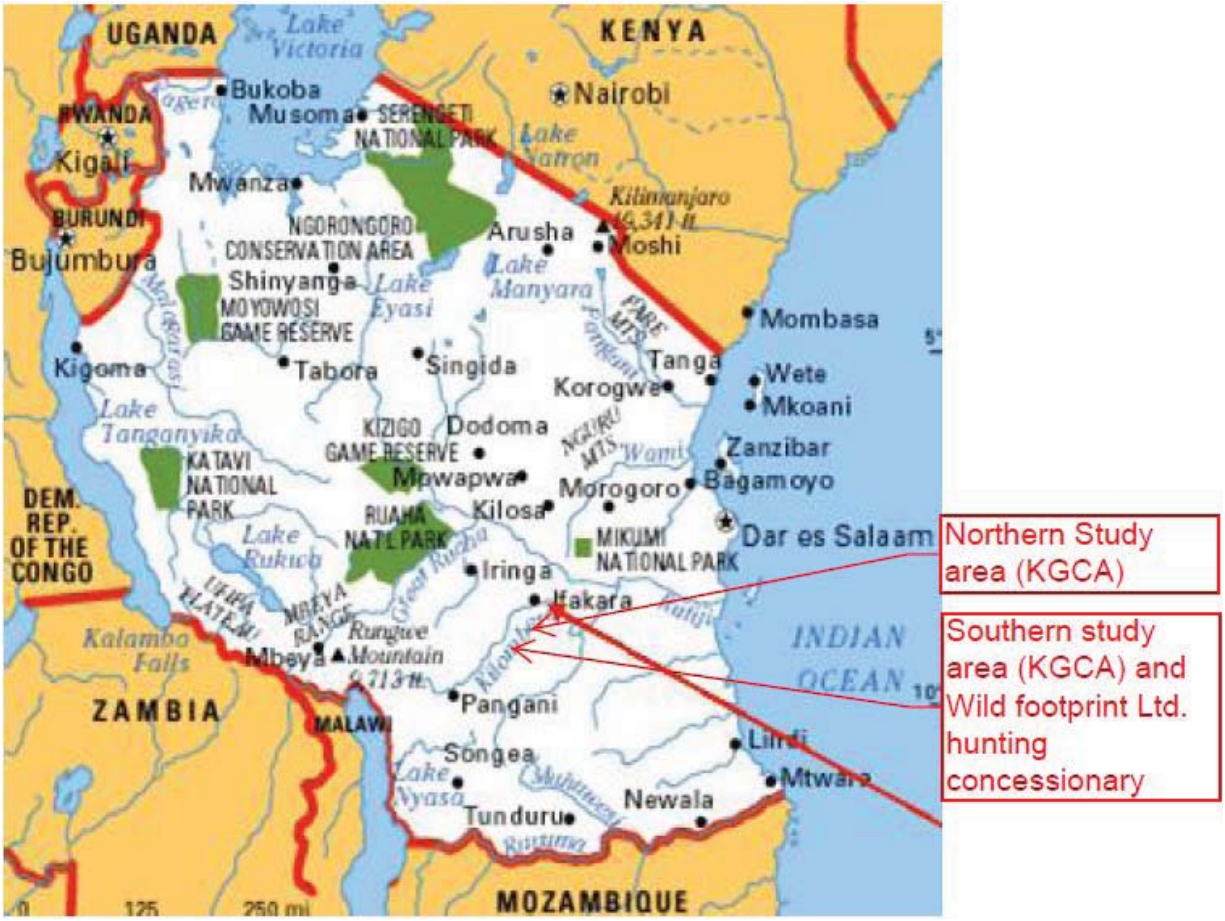



**Fig 1.** Showing the location of the two study areas (The two red arrows pin-points) in connection to the biggest city in the Kilombero Valley, this is Ifakara. The KGCA surrounds the two study areas on both sides of the Kilombero river from a northeast to a southwest gradient, its borders starting south of Ifakara, roughly stopping northeast of Pangani.

The two main survey areas were located at relatively heterogeneous parts of the Kilombero Valley floodplain when considering the big differences in actual vegetation cover. The one study area farthest south, containing 10 transects, was located near the village of Itete and situated within a hunting concessionary managed by the professional hunting outfitter, Wild Footprint. The other main study area farthest north, with the other 10 transects, had Nakafulu, Kichingani, Igumbiro and Lupiro as the closest villages. Both study areas was also wihin the boundaries of the Kilombero Game Controlled Area (KGCA). The closest neighbouring villages, also among those mentioned above, Itete, Lupiro, Nakafulu Igumbiro and Kichingani, wore also among the villages where one gathered data on bushmeat trading.

The Kilombero Valley consists of an area covering 6660 square kilometres (Hinde et al. 2001a). Temperatures are in the range of 22-41 degrees Celsius (Haule et al. 2002). Mean annual rainfall ranges from 1000-2000mm within the area (Haule et al. 2002). There are mainly two vegetation types, wooded grassland and miombo woodland (Haule et al. 2002). Multi-layered evergreen forest with high biological diversity is found within a smaller area (Haule et al. 2002). The study area includes sites where collecting firewood, cattle grazing and tourist hunting occurs on a regular basis (Haule et al. 2002). The study was carried out in September and the first half of October in the year 2008 during the dry season when the hunting lodges operates in some areas of the chosen study area.

According to the Department of Wildlife, some of the areas within the game controlled area are leased out to professional hunting companies by using the area for hunting purposes. This activity is being conducted throughout these specific areas of the KGCA roughly between July and November.

Annually, especially during the dry season and thereby the hunting season, the floodplains vegetation is deliberately burned to facilitate new sprouting and thereby creating new open feeding habitats for the grazing domestic animals. This was seen and experienced personally throughout the fieldwork periods and told to us on a number of occasions by our game scouts guiding us throughout this period. For the hunting outfitters, this burning seemed to make the hunt itself easier and probably more predictable when choosing an area to hunt. This was indeed pointed out to us by several sources, among them the local hunting outfitters boss, Mr. Ryan

Shallom, head of Wild footprint Ltd. The area is usually covered in dense, 2-3 metres high vegetation. According to Ryan Shallom, the burned patches makes this vegetation open up, and creates a more patched and possibly a more attractive grazing area also for the wild ungulates native to the area because of the high nutrition value in the sprouts appearing after a burning episode.

## 5. Methods

### 5.1 The Transects

In this study, only relative densities could be assessed because of tall brush and vegetation that made it impossible to defend an absolute density of especially puku antelope in a given area. This because the animals could be hidden from view in specific areas along most of the study areas (and transects) where one because of relatively short perpendicular distance from the transect line, should have found more animals behind for example tall grass. To find enough data, one had to more or less choose several pre-burned areas that had sprouted to some degree (Often around 5-10 cm tall sprouts), where one would expect to see more animals that indeed, had easy access to new grass sprouts. One assumed that these areas could be attractive feeding areas, and that the taxation, for obvious reasons, would be easier in these areas in the sense that the relative abundance of wildlife was assumed to be higher. After the first taxation period in the hunting concessionary managed by Wild footprint was completed, one ended up in, to some degree, more dense areas, but also more open areas with agricultural influences with scattered fields and dense vegetation alongside natural areas, burned and not burned.

When considering closely the vegetation overall in both areas overall, one made the assumption that roughly about 50 % tall natural vegetation with patched openings wore present, and 50 % burned areas where most of these, had sprouted and was thereby, attractive feeding area for the puku antelope.

In this thesis relatively simple calculation methods has been used to find the results in this study. One uses a set 400 m perpendicular distance from the line on each side of the line in connection to an individual or a defined group. Based on this, one can roughly assess the possible density of animals within this pre-set area. 400m was considered to be a distance that one could with relative certainty, manage to assess the puku correctly, since the range finder could operate up to this distance, though often after several attempts. By sitting about 2,5 meters up above ground, on

the roof of our four wheel drive vehicle, created a relatively good visual range by the help of binoculars and the experience of the game scouts, which assessed and concluded on all animals spotted.

Because of more or less pre-determined lines, and that the study areas wore indeed diverse in vegetation cover depending on if the area had been burned, had or did not have sprouts, or had tall natural grass taller than one could view over, one assumed that about 100 % of all animals present within this 400 meter perpendicular line, on both sides, had not been spotted. In this thesis a relative distance from the line that one could in most cases, was used. That was considered to be up to about 400m, and was concluded after actually testing the range finder and our visual skills out in the field. One found out that there was indeed about 50 % foreseeable area in view up to about 400m out (to where the functionality of the range finder device was considered to be), and roughly about 50 % unforeseeable area up to 400m out. This was finally concluded after the fieldwork, when one took into account the registrations of where one had noted down the mentioned vegetation categories and the relative frequency of these throughout the study of all areas.

Transects wore started at around 7.00 am and ended approx 5.00–6.00 pm. In the morning drive this was defined as the time that vehicle lights are not required for driving (Caro et al., 1999), or as soon as possible thereafter (Caro 1999b)). Some transects wore directed more or less from east to west, towards the Kilombero river, while others wore directed more from north to south, in the floodplain. 20 transects was completed three times, except one which was only driven two times because of several logistic issues.

One took into consideration the speed one should use to get the best assessments of the animals, about <10km/h (Caro et al., 1999). One used a GPS to get the exact location on the line already chosen and followed by the help of the GPS, and a rangefinder to measure the length from the line and thereby being able to record the STD (Starting Distance) (Holmern et al. 2007). As soon as an ungulate was sighted, the vehicle was stopped and a record was made of the exact number of individuals within the group (Caro 1999c). A group was defined as individuals being exactly 50 m or less from their nearest neighbouring Puku individual (Caro 1999c). During the study all ungulates spotted was assessed like the Puku, but as the study areas was completed, one found enough data on the puku antelope, and chose this relatively rear ungulate as the only species assessed closer in the thesis.

Habitat was categorized into different typical floodplain dry season environments, which was either burned or not burned. Within the categorization burned or not burned, either sprouting or not sprouting in the burned areas was noted down. The obvious problem of spotting animals in tall dry floodplain grass, made open burned areas obvious choices to establish transects, often with patched or surrounding tall dry grass. In other areas one did not find burned areas, and this was typical for our northern study area where five transects with Nakafulu as the closest neighbouring village, had this natural dry season vegetation cover in this part of the floodplain. The distinction between male, female and juveniles (calfs), was defined as all individuals estimated to be <1,5 years of age. All estimations of individuals being >1,5 years of age, was considered a grown up, either male or female.

**5.2 The hunting data**

During the study one took into account the available material on resident/local hunting, tourist hunting by safari hunting (Possibly trophy hunting), illegal poaching for pot or poaching for sale in local markets, quotas in general, and statistics on the quotas that has in fact been given and utilized during the last years. That means data on the years 2006 and 2007, the years before this study was conducted. Data on the local hunting done within hunting concessionaries by professional hunting companies was found at the Ulanga district game office in Mahenge, the local authority headquarters in the Ulanga district. Data on illegal hunting was obtained from the districts local authorities and the Game Department. A survey in some of the villages directly adjacent to our two main study areas, wore conducted to get a relatively good insight into the prices and availability of bushmeat at the local markets. Available data on the quotas was obtained from District Local Authorities (District Council Offices), Safari Operators from the Wildlife Division and the data gathered through our own question forms that were used in a number the nearest villages to our two study areas.

**5.3 Bushmeat data from neighbouring villages**

After one had conducted the practical fieldwork in all study areas, one could see which villages that could be suitable to use in a small scale study into a possible bushmeat trade from villages that in space was neighbouring villages to the study areas. 14 villages wore picked out based on relative location to our study areas, and also on the basis of being located along the floodplain on

the Ulanga district side. These villages wore Idunda, Igota, Igumbiro, Ikonguawa, Ilagua kati, Ilagua Mission, Itete, Kichingani, Kigualo, Lupiro, Mavimba, Milola, Minepa and Nakafulu. The villages that one also had on relatively trustworthy maps, wore used in the study to also look at the length to the study areas center, to find which ones was indeed the closest to the study areas: Igumbiro, Mavimba, Nakafulu and Kichingani and Lupiro by the northernmost study area and Itete and Lupiro (Lupiro could be considered to be in between, and was considered in both study areas) in the southernmost area. An example of the lengths that was calculated (Straight red lines) with the help of the mapsource transect data with a map-layer from google earth that included three of these villages, can be seen in figure two, under:

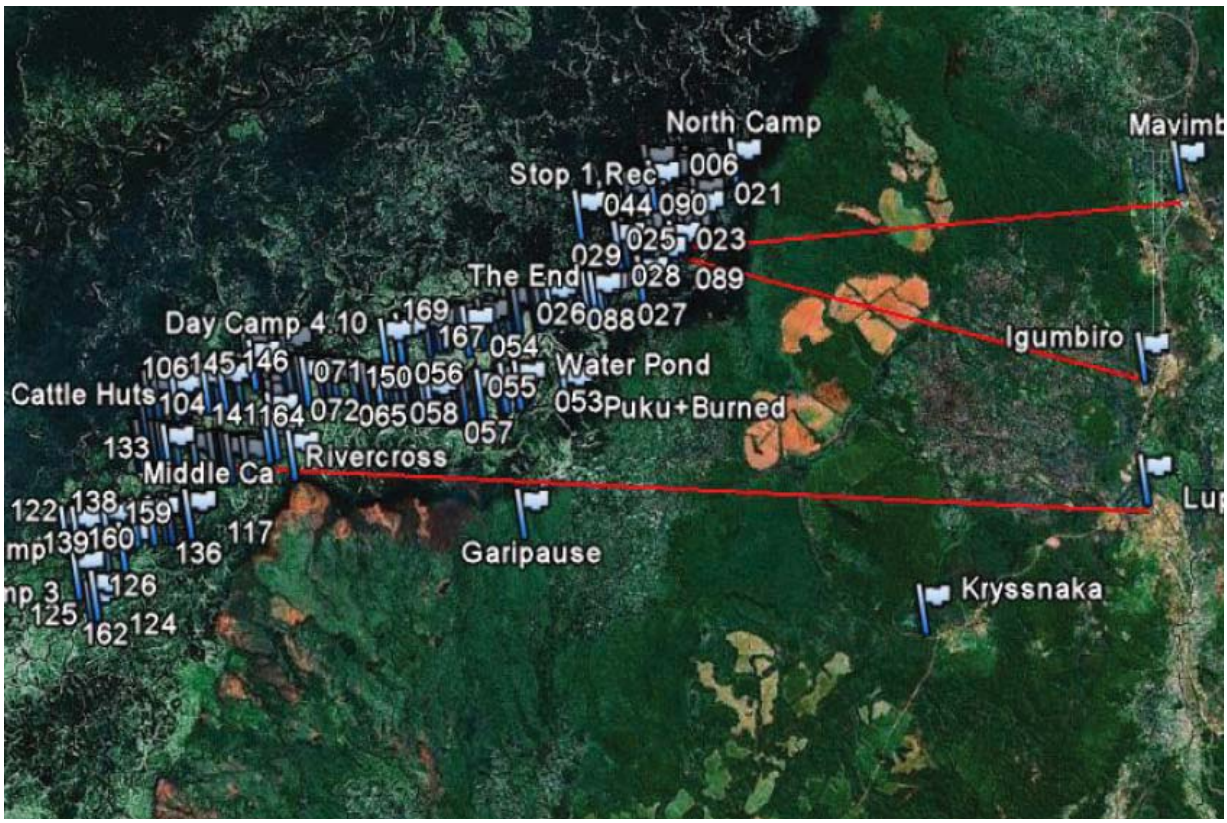



**Fig 2.** The example map with Mavimba, Lupiro and Igumbiro showing on the map with red lines, wore the straight lines in kilometres used in the calculation of length from the closest mapped villages. The map also shows roughly the distribution of agriculture seen as brown and red patches with scattered miombo woodland in between and alongside the border-line to the floodplain itself. Note that some of this agriculture is actually in the lowland, appearing in the darker areas to the west, hence in the actual floodplain. This map is from the northernmost study area where one conducted studies across 10 more or less randomly picked transects in the KGCA.

# 6. Results

## 6.1 Assessed Puku antelope

The total number of Puku antelope counted and assessed in this study, is 2841 individuals of puku antelope. They were counted along the same transects three times (with the exception of transect 20, which was driven two times. (not one individual was spotted during these two taxations on transect nr. 20 and because of time and logistic issues, the last run was not completed).

In all transects 1-20, an average total number of 947 (2841/3) puku antelope was counted.

In all transects referred to in this thesis as transects number 1-10, in the southernmost area with Itete as one of the closest villages, a number of 737 puku antelope were counted on average after three runs. Of these individuals, 239 (239*2=478) wore male, 328 (328*2=656) wore female, and 170 (170*2=340) wore juveniles. When one assumes that as many puku that was spotted within the assessed area, as outside it and on the other side out to maximum 400m perpendicular distance from the line, the total number could have been around 1474 puku antelope present within the 12 km2. Puku per square kilometre in the southernmost study area could roughly have been (1474/12) 122 puku per square km. The sex relationship between adults in this area was 42 % males and 58 % females.

In all transects referred to in this thesis as transects 11-20, in the northernmost area with Lupiro as one of the closest villages, a total average number of 210 puku was counted after three runs. Of these individuals, 48 (48*2=96) wore male, 113 (113*2=226) wore female and 49 (49*2=98) wore juveniles. When one assumes that as many puku that was spotted within the assessed area, as outside it and on the other side out to maximum 400m perpendicular distance from the line, the total number could have been around (96+226+98) 420 puku antelope. The sex relationship between adults in this area between adults was 30 % males and 70 % females.

Puku per square kilometre in the northernmost study area could roughly be (420/26) 16 puku per square km.

When looking at the overall sex distribution for all males and females considered <1,5 years of age, one found that this relationship seems to be skewed towards more females than males. It showed that the relationship between them, when looking at all transects, males n=287 (39%) and females n=441 (61 %).

A seemingly skewed relationship between females and juveniles was also found. Females n=441 (67 %) and juveniles n=219 (33 %). The skewed relationship is significantly towards more females, in fact, the number of females is double that of juveniles.

### 6.2 Data on hunting quotas

According to the data on hunted puku in the years 2006 and 2007 obtained from the district game officer, this showed a total revenue on the sale of puku antelope quotas to be 4975000,- TSH (Tanzanian shillings), or about 875,- US Dollar (See table 1, under).

| Year | Animal Species | No. Hunted | Revenue (US Dollar) | Reveenue (Tot. US Dollar) | T. Shilling |
|---|---|---|---|---|---|
| 2006 | Buffalo | 34 | 750 | 25500 | 25.500.000.00 |
| | Warthog | 3 | 400 | 1200 | 1.200.000.00 |
| | Hartebeest | 1 | 465 | 465 | 465.000.00 |
| | Puku | 5 | 275 | 1375 | 1.375.000.00 |
| | Zebra | 7 | 740 | 5180 | 5.180.000.00 |
| | Reedbuck | 4 | 365 | 1460 | 1.460.000.00 |
| | Waterbuck | 2 | 550 | 1100 | 1.100.000.00 |
| | Lion | 2 | 2500 | 5000 | 5.000.000.00 |
| | Leopard | 3 | 2500 | 7500 | 7.500.000.00 |
| | Hippopotamus | 2 | 1050 | 2100 | 2.100.000.00 |
| | Crocodile | 2 | 1050 | 2100 | 2.100.000.00 |
| | Baboon | 2 | 110 | 220 | 220.000.00 |
| | Common Duiker | 1 | 225 | 225 | 225.000.00 |
| | Civet Cat | 2 | 175 | 350 | 350.000.00 |
| | Hyena | 1 | 230 | 230 | 230.000.00 |
| | Impala | 1 | 300 | 300 | 300.000.00 |
| | **Total:** | **72** | | **54305** | **54.305.000.00** |
| | | | | | |
| 2007 | Baboon | 3 | 110 | 30 | 330.000.00 |
| | Leopard | 1 | 1200 | 1200 | 12.000.000.00 |
| | Puku | 6 | 600 | 3600 | 3.600.000.00 |
| | Warthog | 3 | 400 | 1200 | 1.200.000.00 |
| | Crocodile | 2 | 1500 | 3000 | 3.000.000.00 |
| | Buffalo | 16 | 1500 | 24000 | 24.000.000.00 |
| | Hartebeest | 2 | 600 | 12000 | 12.000.000.00 |
| | Hyena | 1 | 500 | 500 | 500.000.00 |
| | Hippopotamus | 1 | 2500 | 2500 | 2.500.000.00 |
| | Zebra | 3 | 1000 | 3000 | 3.000.000.00 |
| | Reedbuck | 2 | 400 | 800 | 800.000.00 |
| | Bushbuck | 1 | 500 | 500 | 500.000.00 |
| | Serval Cat | 1 | 300 | 300 | 300.000.00 |

| | | | | | |
|---|---|---|---|---|---|
| | Bushpig | 1 | 250 | 250 | 250.000.00 |
| | Elephant | 1 | 15000 | 15000 | 15.000.000.00 |
| | Red Duiker | 1 | 220 | 220 | 220.000.00 |
| | Impala | 1 | 500 | 500 | 500.000.00 |
| | Wildebeest | 1 | 500 | 500 | 500.000.00 |
| | **Total** | **47** | | **80200** | **80.200.000.00** |

**Table 1.** The data on quotas and species hunted was acquired from the Ulanga district game office in Mahenge.

This adds up to an average revenue per year of about 437, - USD. The number of puku on the quota was five in 2007 and six individuals in 2007 and 2008 respectively.
The average weight of puku is for female (63 kg) and male puku (79 kg) (Kingdon 2004). The possible amount of meat per individual, without bone skin and intestines, will be roughly half of that weight, for female (31,5 kg.) and male (37,5 kg.), and this then is a possible estimate of the number of kilos that could be sold in local markets according to how often the local salesman estimated bushmeat to come in. Note that the questionnaires were based on the price for sold meat per kilo, and that therefore the possible average weight is then relevant. If one assumes that the average weight of the estimated 78 puku is ((37,5+31,5)/2) 34,5 kg, the amount of kilos sold is then (78*34,5) 2691 kilos per year. The average prize is 1750 TSH, -, thereby the total net revenue for local salesman all together in the Ulanga district, could be (2691*1750) 4 709.250 TSH, - per year. This is slightly over 10 % of the value estimated if these animals wore sold on the yearly hunting quota (See bottom estimate in this chapter for estimated revenue loss for the game district office in possibly sold quotas: 46. 800.000 TSH, -).
An important point is that no quantitative information was gathered because this was impossible for us to get data on. The person that conducted the questionnaires thought that it would seem suspicious if he asked specific questions like the number of each species and how often through the year one could expect the different species. He posed as a possible buyer of bushmeat, and one concluded that the buyer does not need data on the number of different species that comes through the local markets to buy bushmeat, that would deter the salesman from giving any data. The questionnaires results suggested that puku, in most villages, could roughly come in every month or more often, since other species also was told to be sold in these markets (see example layout of the questionnaire in the appendix). Another factor that made the assumption on frequency seem probable was made because puku was overwhelmingly the most abundant

species in our study areas overall compared to other animals assessed, especially buffalo, warthog and zebra which were in all questionnaires present as bushmeat species being sold in local markets. This could suggest that the estimates of 12 puku sold in illegal markets is relatively low when considering only eight (Which also are considered with the number of people in chapter **6.3**) of the villages subjected to the bushmeat questionnaires, and that the minimum estimate of bushmeat found, is feasible. This suggests a possible net economic revenue loss of 7 200 000, - TSH per year in possible lost quotas and hence possible sold quotas in only this limited area in and around these eight villages.

To show a possible difference in revenue to the community from quotas compared to prices per kilo one must look at the local prices for puku meat, which is between 1500-1999,- TSH, according to local the local merchants. That means that the revenue per illegally hunted and sold puku could be on average 51750, - TSH (1500,- TSH*34,5kg). That means a possible net loss, given that the puku had been hunted on a legal quota, (Quota sale income per puku in the year 2007: 600000, - TSH) of 548250, - TSH,-.

If one adds together the estimated number of roughy78 puku sold for bushmeat sold in local markets, the total economic revenue loss could be (78*600000, - TSH) 46.800.000, - TSH.

The possible total annual bushmeat trading of puku antelope alone, could constitute a possible loss in economic revenue to the district of about >30 %, when considering that according to the districts official revenue in 2007, the total revenue of all species was 80.200.000, - TSH.

### 6.3 Human population

The population count conducted in 2002 by the national bureau of statistics, show that the four neighbouring villages to the northern study (see fig. 1) has 2276 (Igumbiro), 4358 (Lupiro urban and rural), 2621 (Mavimba) and 1209 (Nakafulu). By adding together the data on people residing in the villages, the population is 10464 people.

In the southernmost area the four neighbouring villages to the northern study has 7084 people (Itete village and Itete rural ward), 4358 (Lupiro urban and rural), 4513 (Iragua) and 3271 (Mtimbira) is the four closest villages to this study area.

According to the national bureau of statistics, the growth rate of 2,4 % estimated up to the year 2002, if it has been close to the same growth rate up to the year of 2008, the total number of people residing in the villages in the year 2008, will be about 12064 in the southernmost study

villages and 22164 people in the northernmost villages respectively. All together, 34228 people were estimated to live in the eight neighbouring villages to the study areas in the year 2008. This was used to find and show possible anthropogenic stress that could be present also in other areas along the Kilombero Valley floodplain, when one for example considered the total amount of people residing in the Ulanga district. According to the national bureau of statistics, the number of people residing in the Ulanga district in 2002 was 193260 people. With an estimated low growthrate of at least the same as in the period from 1988-2002 which was 2,4 %, in the year 2008, this will mean roughly 22814 people. By simply considering that 34228 people in 8 villages seems to cause at least 12 puku to be hunted and sold in local markets, the amount of puku possibly sold through bushmeat overall in Ulanga, could be 6,5 (650 %) times higher all together in the Ulanga district. That means a possible total bushmeat sold in local markets in the Ulanga district alone, could be (6, 5*12) roughly 78 puku antelope in the year 2008.

**6.4 Assessed area**

The total area covered at the southernmost study area (Assuming that one could measure up to 400m perpendicular distance from the line), is an area of (15,2 km*0,8=12,16) 12 square kilometres. The average number of puku spotted per square km. is then (210 puku/12= 17,5) 17,5 puku per square kilometres.

The total area covered at the northernmost study area (Assuming that one could measure and spot puku up to 400m perpendicular distance from the line), is an area of (32,1 km*0,8=25,68) 26 square kilometres. All together this constitutes that one has covered of 38 square km.

## 7. Discussion

The results of this study could suggest that the number of people residing in the 8 neighbouring villages to our two study areas in themselves, does not seem to explain the differences in the number of puku antelope in the two study areas. The fact that both areas are situated in the KGCA, and that the southernmost study area, seems to possibly explain more of the denser and markedly bigger population assessed in the southernmost study area, suggests that the hunting concessionary run by Wild footprint Ltd, possibly plays an important role in explaining the difference in population and the number of puku. The studies in the Wild footprint hunting concessionary show that the densities in this area is much higher than in the other study area, it could be about 7 times higher considering the data in this thesis, which could suggest that the presence of the hunting outfitter and their activities thoughout especially the hunting season, indeed has a positive effect on preventing several negatively associated disturbances, among these, bushmeat hunting and trading, which was discussed closer in this thesis.

The number of people residing in neighbouring villages to the study areas in the Kilombero Valley could and probably still have profound direct and indirect effects on the density and structure of the Puku antelope in other ways besides bushmeat trading. The presence of more large villages further from the closer assessed villages, with cities like Ifakara further north as the most important, and a higher number of people living in the northern parts of the Ulanga district in itself, suggests that this could have an effect along a north-south gradient down through the floodplain.

During the dry season, puku are relatively easy to approach, when densely aggregated on floodplains, and are consequently very vulnerable to illegal hunting (Hoffman & Mallon 2008). Unsustainable hunting and especially heavy poaching appear to have extirpated Puku across their range (Hoffman & Mallon 2008). This could suggest that the behaviour experienced during our fieldwork, supports the behaviour also seen and described by Hoffman and Mallon (2008).

When considering the estimate of the bushmeat that was collected from 14 of the neighbouring villages adjacent to the two main study areas and narrowing this down to the four closest to the northern study area in which wore Lupiro, Mavimba, Igumbiro and Kichingani, one found indications that suggest a widespread bushmeat trade in these local village markets. For example in Lupiro, the markets salesman said that five species of bushmeat came in on a regular basis, these wore  Puku antelope, buffalo, Hippo (*Hippopotamus amphibious*), warthog (*phacochoerus*

*africanus*) ( and “other bushpigs”). According to the local salesman, the meat from all these species cost between 1500-1999 TSH per kilo, and bushmeat was said to come in every day to this village. Still, the salesman pointed out in the end of the questionnaire, that he did not sell bushmeat, and that he did not know where people could purchase bushmeat. How to interpret this statement is uncertain and is a possible error that should be subjected to criticism and thereby scrutiny. The same results was seen and roughly documented in the answers given in the other villages most adjacent to the study areas, for example for example the other three villages most adjacent in the north, Mavimba, Igumbiro and Kichingani. The only difference was that the bushmeat came in on slightly longer intervals, that are every 1-2 weeks instead of every week. The rough estimate of about 78 puku antelope sold as bushmeat in the Ulanga district in 2008 based on the results from the questionnaires, could suggest that the total bushmeat trade in this district is indeed significant and could have a negative effect on the population structure, and hence on the yearly hunting quotas estimated and sold by the district game office.

When considering the data on bushmeat found in these villages, and comparing the possible amount of revenue that is indirectly lost because of possibly lower census counts of animals (if this is indeed the basis for the estimated and given quotas each year by the district game office), one estimated how often puku came in to these villages collectively, this is based on all eight villages. One found that a puku antelope could come in to the villages on average, every fifth day, maybe more often after considering a seemingly higher frequency of spotted species in the floodplain in the northern study area, indeed was puku antelope when at the same time, comparing this to the frequency of sightings of the other species mentioned by the local salesman as being sold as bushmeat. One sighted markedly more puku overall in along all transects compared to other ungulates.

To better support the estimate, one also considered the study by Haule (2002), which indicated that the second most common species pupils said they had eaten as their latest meat meal in general, was puku antelope. Only topped by buffalo, which was the most frequent animal consumed in a meat meal (Haule et al. 2002). Note that this study was conducted in five randomly picked villages in the Kilombero district. Through several personal communications with the district game officer Mr. John Makotta, it was suggested that the highest densities of puku indeed was to be found in the Ulanga district, and thereby on that side of the river and the valley. If this was the case, one should think that the questionnaire studies conducted in 14

villages in the Ulanga district in connection to our study, and the rough estimates found on the possible amount of puku being sold in local markets, are indeed low, and relatively conservative. This because one assumed that puku came in to the villages at roughly the same frequency as the other animals that was mentioned by the local salesman. This because the questions did not give specific answers to how often each species indeed came in, and more importantly, how often puku came in compared to all other species.

If one assumes that the bushmeat trade estimates found in the results are not to high, that for example one puku comes in on average every 14 days to each of the four studied villages neighbouring the northern study area, which the results indicated (Lupiro, Kichingani, Igumbiro and Mavimba), one still found a relatively high estimate on the possible number of puku actually being hunted for the bushmeat trade in these four villages. If two puku indeed comes in every week to the four villages combined, assuming that the animal is split up between these villages, this could suggest as many as 78 puku per year is being sold as bushmeat in these four villages alone. Important assumptions is that when one considers puku, one assumes that the whole animal, or at least close to the whole animal that goes through the local markets in the process, are consisting of not just smaller pieces of the hole animal. Other weaknesses and criticism that should be subjected to scrutiny, could be that the persons interviewed simply did not tell the truth, and/or that they could have given more precise answers and estimations on for example how often a puku antelope comes in compared to the other most common bushmeat species, if the questions and the general approach has been different.

When one considers the findings of the quota for puku in 2007, which was 6 individuals (Not specified to gender/sex) and the revenue was 3600000, - TSH, one puku costs 600000, - TSH to hunt for a professional outfitter, one found the possible loss of revenue for the wildlife division in hunting quotas. Note that this is given that all puku sold for bushmeat, was sold to a local hunting concessionary. The net loss that could be roughly (600000,-*78) 46.800.000, - TSH-, suggests that there is a significant amount of money to be made, if one focuses more resources on preventive anti poaching measures, and thereby in the future being able to raise the sold hunting quotas because of naturally higher populations of puku. This possible economic loss constitutes more then half of the whole income revenue in 2007 from selling quotas, which was 80.200.000,- TSH.

The clear difference in density of puku in general between the hunting concessionary in the KGCA and the other study area, with 122 puku per km2 in the hunting concessionary and 16 puku per km2 respectively, is a relatively big difference. This could suggest that roughly 7 times denser populations do reside inside the hunting concessionary during the dry season in the KGCA. This could suggest that the puku antelope indeed receives a form of protection from the activities that is undertaken throughout the hunting season inside the concessionaries boundaries. The densities of puku estimated in a former GCA Zambia, from the year 1994, (Today the Kasanka national park) showed a density ranging from 1-126 puku per km2 (Goldspink et al. 1998). The mean density of puku in the actual floodplain areas ranged from about 30-126, with the highest densities in the central areas, and especially alongside the Luwombwa river. This suggests that the levels estimated in the year of 1998 could have been roughly as big as in the parts of the best areas in the KGCA studied in 2008, where one found densities inside the hunting concessionary of 122 puku per km2 by using the method in this thesis. Note that the best area inside the hunting concessionary and thereby the KGCA, was called "The Serengeti" by the game scouts Edward Mlaponi, Chris Nchimbi and Mr. Ryan Shallom head of Wild footprint Ltd., simply because these wore the areas, according to them, that had the densest populations of puku antelope in the KGCA. The protection currently offered to large wild mammals in the KGCA comes in the form of hunting concessionaire, especially at the hunting lodge, near the village of Itete (Bonnington, C. et al. 2007). The duration of the hunting season is 6 months, and for the remainder of the year little or no patrolling is carried out to control for livestock in the area (Bonnington, C. et al. 2007). According to our game scout Mr. Edward Mlaponi, the presence of vehicles in the field inside the hunting concessionary, was enough to deter locals from bringing in domestic cattle, conduct fishing or just travel trough the area. According to an official from district game office in Mahenge, people in the field inside the hunting concessionary, are deterred because of incidents where locals have been beaten up by the hunting company's staff, often for just being in the area during the hunting season. This suggests that the reputation of hunting companies in the area, could be divided among the locals, and possible bad to some.

The skewed structure of the female – juvenile numbers, especially in the study area outside the hunting concessionary, suggests that the puku antelope could suffer from some form of stress due to human disturbances like general encroachment and that this is stronger outside the hunting concessionary. This could be due to increased agricultural land use, several forms of poaching,

for example by either poaching for pot, possibly subsistence hunting, or organized poaching for sale in local village markets. Note that our practical fieldwork also showed that other possible indirect anthropogenic effects, for example disturbances by domestic livestock and its encroachment on puku habitat, which is also supported by published a number of published studies. The presence of unregulated human encroachment and subsequent activities (e.g. habitat conversion, illegal off-takes and livestock husbandry) are thought to adversely impact puku in the Kilombero Valley negatively (Bonnington et al. 2010).

The lack of good enough definitions before the study concerning how one in fact assessed and separated a juvenile from an adult, must be mentioned and could be a source of uncertainty if for example more of the juveniles that was spotted was in fact an adult, or vice versa. Luckily the general view in retrospect from the game scouts and after revising published studies, is that the behaviour of males to form bachelor herds when they are immature, yet grown ups, >1,5 years, suggests that the possible mistakes in the estimation of juveniles, that is all animals less then <1,5 years of age, seems to be relatively small when considering the group. The group registration of this behaviour with the formation of bachelor herds was conclusive when estimating males and when separating them from juveniles and females, and with very few exceptions, the other males that were not defined to be in a group, wore single roaming males.

Another possible weakness of this study is that the transects, due to holes in the ground, impenetrable high grass, small rivers, muddy areas and other physical constraints, made our transects only partly randomly picked.

The lack of a relatively high number of independent yet similar studies with the same methodology of the same areas in the Kilombero Valley Floodplain inside the KGCA (Especially in the district of Ulanga, which is seemingly most studied), seems evident. The first ground based study on Tanzanian puku was conducted in 1998 (Corti, G. et al. 2002). This suggests and supports the notion that similar studies in the same areas are lacking to some degree. Corti and Fanning 2002 does not however give an exact density per km2, which could have been used to compare a similar study outside of Itete, with our study.

The lack of studies focusing on also on the possible gradient towards the Kilombero river, also could suggest the need for more studies.

The most recent and similar study puku antelope to this one has been conducted in the Rukwa game reserve near Lake Rukwa in Tanzania, where the findings wore collected by using zig-zag

line transects, which according to the author, would increase the certainty of the estimated densities (Chuwa et al. 2009). These notions still gives rise to the suggestion of more follow up studies with similar line transect methods, perhaps zig-zag transects, with GPS coordinates in the same areas, which indeed could provide good estimates on the actual density in and outside the hunting concessionary in the KGCA and thereby possible changes in time and specifically in space. This study shows alongside other studies mentioned, could also suggest that another way to get an updated complete view of the population structure, is to complete new aerial survey, according to for example Rogers (1986). GPS-collars on puku antelopes could also give closer whereabouts of specific target individuals in space and time. The main view is to (Bonnington et. al 2010) recommend implementation of a large scale conservation programme to quantify how puku use habitat in space and time and to highlight possible strongholds within the Kilombero Valley for the species. One could then use data collected by especially Rogers (1984) as a comparison. Rodgers (1984) alongside Bonnington (2010) also supported a proposal to upgrade the status of the central part of the KGCA to conserve puku in the Kilombero Valley, which according to the mentioned studies and others studies, seems to have by far the most dense and biggest puku populations in Africa.

**Acknowledgements**

The Sokoine University of Agriculture in Morogoro, Tanzania and the NUFU project which is a collaboration with the University of Life Sciences in Norway. The district authorities in Ulanga for providing the necessary permits to conduct the practical field work, and also for helping out with the logistics on our venture, and experienced personnel in the field. Special thanks to Mr. Samora, the overall logistics manager, Mr. Ezekiel from Sokoine, Prof. Pantaleo Munishi, head of the dep. of forest biology at the University. Mr. Edward Mlaponi, our invaluable game scout and translator and also Mr. John Makotta, the district game officer, for their essential help in all important matters that helped us complete our studies in the Kilombero Valley. Also sincere thanks to game scout Chris Nchimbi which did an invaluable job clearing our path on foot in the floodplain throughout our field work.

**Appendix (Point 1-2)**

**1. Terminology** (according to Baldus 2004)

**Concession** - An area of land that the Wildlife Division leases together with a hunting quota to companies authorized to guide foreign hunting clients on a hunting safari, frequently referred to as a Block.

**Game controlled area (GCA)** - An area of land that was previously gazetted to prohibit all forms of hunting. The law however makes no restrictions on other forms of landuse and local communities are allowed to permanently reside within a game controlled area.

**Game reserve** - An area of land gazetted as game reserve and under the full jurisdiction of the Wildlife Division. No human habitation is permitted within a game reserve. Game reserves are utilised for various forms of tourism, which includes tourist hunting.

**Government revenue** - Used in this document to reflect the income accrued by the Wildlife Division from hunting. Does not necessarily reflect income accrued by the Government through various forms of taxation, for Ulanga district, see fig 3).

**Hunting outfitter** - A person / company responsible for offering a hunting safari to a hunting client. The outfitter provides a camp, 4x4 vehicle, employs a professional hunter, trackers and camp attendants to serve the needs of hunting clients and is responsible for general organisation.

**Trophy fees** - Fees paid for the right to hunt a specific animal. Government trophy fees are according to the schedule of trophy fees. (to see official trophy fees for the Ulanga district, see fig 3).

**Wildlife Division** - A Department of the Ministry of Natural Resources and Tourism in Tanzania.

**2. Questionairre**

## Questions for the local markets salesman: (Start off broad to set the scene, if the salesman says that he does not sell, move on to the next one instead of using unnecessary time on one!)

1. **Do you know of any place around to get bushmeat?**

□ yes □ no

If yes, which species do can I choose from?

□Puku □Buffalo □Zebra □Hippo □Warthog

□Hartebeest □Reedbuck □Elephant □other:……

2. **How much does one kg of meat cost?**

| Species \ Price | 100-499 tsh | 0-999 | 1000-1499 | 1500-1999 | 2000-2499 | More |
|---|---|---|---|---|---|---|
| Puku | | | | | | |
| Buffalo | | | | | | |
| Zebra | | | | | | |
| Hippo | | | | | | |
| Warthog | | | | | | |
| Hartebeest | | | | | | |
| Reedbuck | | | | | | |
| Elephant | | | | | | |
| Other: | | | | | | |

3. **How often do you receive bushmeat?**

□Every day □Every 3-4 day □Once a week

□Every 2. week □Once a month □Infrequent

**4. Do you order it, or does it come in coincidently?**

□ order □ coincidently

**-** If coincidently, which species come in most frequently, and about how frequent does the different species come in?

| Species \ Freq. | Every day | Every 3-4 day | Once a week | Every 2. week | Once a month | Infre-quent |
|---|---|---|---|---|---|---|
| Puku | | | | | | |
| Buffalo | | | | | | |
| Zebra | | | | | | |
| Hippo | | | | | | |
| Warthog | | | | | | |
| Hartebeest | | | | | | |
| Reedbuck | | | | | | |
| Elephant | | | | | | |
| Other: | | | | | | |

**5. Is there a market for selling bushmeat in this area?**

□Yes □No

**6. What market has the best selection and amount of bushmeat in this area?**

**…**……..

7. **Does any of the neighbouring villages have bushmeat for sale?**

□Yes □No

8. **Will you consider it hard to get bushmeat here in the district?**

□Yes □No

## References


Baldus, R. D. & Cauldwell, A. E. (2004). Tourist hunting and its role in development of wildlife management areas in Tanzania. Dar es Salaam. 146 pp.

Bergkamp, C. & Orlando, B. (1999). *Wetlands and Climate Change*. Exploring collaboration between the Convention on Wetlands (Ramsar, Iran 1971) and the UN Framework Convention on Climate Change, p. 22: IUCN.

Bonnington, C., Weaver, D. & Fanning, E. (2007). Livestock and large wild mammals in the Kilombero Valley, in southern Tanzania. *African Journal Of Ecology*, 45: 6.

Bonnington, C., goodwin, J. L., Grainger, M., Owen, N. & Steer, M. D. (2010). Evidence for local declines in Tanzania`s ouku antelope (*Kobus Vardoni* Livingstone 1857) populatiom between 1999 and 2003. *African journal of ecology*: 4. 48 (4): 1139-1142

Caro, T. M. (1999a). Abundance and distribution of mammals in Katavi National Park, Tanzania. *African Journal of Ecology*, 37 (3): 305-313.

Caro, T. M. (1999b). Behaviour and demography of African mammals subject to exploitation. *Biological Conservation*, 91 (1): 91-97.

Caro, T. M. (1999c). Densities of mammals in partially protected areas: the Katavi ecosystem of western Tanzania. *Journal of Applied Ecology*, 36 (2): 205-217.

Chuwa, M., Kiffner, C. & Waltert, W. (2009). An assessment of the puku (*Kobus vardonii* Livingstone 1857) population at lake Rukwa, Tanzania. *African journal of ecology*, 47 (4): 5. 47 (4): 688-692.

Coltman, D. W., O'Donoghue, P., Jorgenson, J. T., Hogg, J. T., Strobeck, C. & Festa-Bianchet, M. (2003). Undesirable evolutionary consequences of trophy hunting. *Nature*, 426 (6967): 655-658.

Corti, G., Fanning, E., Gordon, S., Hinde, R. J. & Jenkins, R. K. B. (2002). Observations on the puku antelope (Kobus vardoni Livingstone, 1857) in the Kilombero Valley, Tanzania. *African Journal of Ecology*, 40 (2): 197-200.

Corti, G. R., Fanning, E., Jenkins, R. K. B. & Roettcher, K. (2002). Management implications of antelope habitat use in the Kilombero Valley, Tanzania. *Oryx*, 36 (2): 161-169.

Coulson, T., Milner-Gulland, E. J. & Proaktor, G. (2007). Evolutionary responses to harvesting in ungulates. *Journal of Animal Ecology* (76): 10.

Gaillard, J. M., Bianchet, M. F. & Yoccoz, N. G. (1998). Population dynamics of large herbivores: variable recruitment with constant adult survival. 13 (2): 6, 58-63.

Ginsberg, J. R. & Milnergulland, E. J. (1994). Sex-Biased Harvesting and Population-Dynamics in Ungulates - Implications for Conservation and Sustainable Use. *Conservation Biology*, 8 (1): 157-166.

Goldspink, C. R., Holland, R. K., Stjernstedt, R. & Sweet, G. (1998). A note on the distribution and abundance of puku, *Kobus vardoni* livingstone, in Kasanka national park, Zambia. *African Journal of Ecology*, 36: 11.

Haule, K. S., Johnsen, F. H. & Maganga, S. L. S. (2002). Striving for sustainable wildlife management: the case of Kilombero Game Controlled Area, Tanzania. *Journal of Environmental Management*, 66 (1): 31-42.

Hendricks, T., Mayaka, T. B., Prins, H. H. T. & Wesseler, J. (2005). Improving the benefits of wildlife harvesting in Northern Cameroon: a co-management perspective. *Ecological Economics*, 54 (1): 67-80.

Hinde, R. J., Corti, G. R., Fanning, E. & Jenkins, R. K. B. (2001a). Large mammals in miombo woodland, evergreen forest and a young teak (Tectona grandis) plantation in the Kilombero Valley, Tanzania. *African Journal of Ecology*, 39: 318-321.

Hinde, R. J., Corti, G. R., Fanning, E. & Jenkins, R. K. B. (2001b). Large mammals in miombo woodland, evergreen forest and a young teak (Tectona grandis) plantation in the Kilombero Valley, Tanzania. *African Journal of Ecology*, 39 (3): 318-321.

Hoffman, M. & Mallon, D. P. (2008). *The IUCN red list of threatened species*. In IUCN (ed.): IUCN. http://www.iucnredlist.org/ . 29.11.2011

Holmern, T., Mwakalebe, G., Roskaft, E., Setsaas, T. H. & Stokke, S. (2007). How does human exploitation affect impala populations in protected and partially protected areas? - A case study from the Serengeti Ecosystem, Tanzania. *Biological Conservation*, 136 (4): 563-570.

Hook, D. D. (1988). *The Ecology And Management Of Wetlands*. 1 ed., vol. 1. Portland: Timber Press. 582 pp.

Illius, A. W. & O`Connor, T. G. (2000). Resource heterogeneity and ungulate population dynamics. *Oikos*, 12 (89) 2: 283-294.

Kangalawe, R. Y. M. & Liwenga, E. T. (2005). Livelihoods in the wetlands of Kilombero Valley in Tanzania: Opportunities and challenges to integrated water resource management *Physics and Chemistry of the Earth*, 30 (11-16); 968-975.

Kingdon, J. (2004). *The Kingdon pocket guide to African Mammals*. London: A and C Black Publishers Ltd. 269 pp.

McCartney, M. P. & Van Koppen, B. (2004). Sustainable Development and Management of Wetlands. *FAO – NETHERLANDS PARTNERSHIP PROGRAMME*. Rome: UN. 49 pp.

Mysterud, A., Barton, K. A., Jedrzejewska, B., Krasinski, Z. A., Niedziałkowska, M., Kamler, J. F., Yoccoz, N. G. & Stenseth, N. C. (2007). Population ecology and conservation of endangered megafauna: the case of European bison in Białowiez'a Primeval Forest, Poland. *Animal Conservation* (10): 11. 10 (1): 77-78.

National Bureau of Statistics, M. o. p. (2002). *Village statistics, table 1, Morogoro*: The United Republic of Tanzania. Available at: http://www.nbs.go.tz/index.php . 28.11.2011.

National Bureau of Statistics, M. o. p. (2006). Tanzania census. In Tanzania, T. U. R. o. (ed.). Dar er Salaam. 211 pp.

Nasjonalt utvalg for utviklingsrelatert forskning og utdanning (NUFU). (2007). Integrating Livelihoods and Multiple Biodiversity Values in Wetlands Management in Tanzania.

Rannestad, O. T., Danielsen, T., Moe, S. R. & Stokke, S. (2006). Adjacent pastoral areas support higher densities of wild ungulates during the wet season than the Lake Mburo National Park in Uganda. *Journal of Tropical Ecology*, 22: 9. 22: 675-683

Thorsell, J., Levy, R. F. & Sigaty, T. (1997). A GLOBAL OVERVIEW OF WETLAND AND MARINE PROTECTED AREAS ON THE WORLD HERITAGE LIST. Gland: The World Conservation Monitoring Centre. 47 pp.