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Socio-Ecological Impacts of Land Grabbing for Nature Conservation on a Pastoral Community

A HANPP-based Case Study in Ololosokwan Village, Northern Tanzania*

von

Lara Esther Bartels

** Masterarbeit verfasst am Institut für Soziale Ökologie (IFF-Wien), Studium der Sozial- und Humanökologie. Diese Arbeit wurde von a.o. Univ.-Prof. Dr. Karlheinz Erb betreut.*

“Olayaoni ake le memirayu oo Enkop”

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Abbreviations

(A)HANPP	Human Appropriation of (Aboveground) Net Primary Production
(A)NPP	(Aboveground) Net Primary Production
$ANPP_0$	ANPP of the potential vegetation
$ANPP_{act}$	ANPP of the actual vegetation
$ANPP_{lc}$	chances in ANPP through human induced land use change
$ANPP_h$	ANPP harvested and destroyed by human
$ANPP_t$	ANPP remaining in the system after harvest
CBD	Convention on Biological Diversity
DM	dry matter
FAO	Food and Agricultural Organization
GCA	Game Controlled Area
GIS	Geo Information System
GPP	Gross Primary Production
OM	organic matter
LPJ	Lund-Potsdam-Jena Model
MODIS	Moderate Resolution Imaging Spectroradiometer
NCA	Ngorongoro Conservation Area
NCEP/NCAR	National Centers for Environmental Prediction/ National Center for Atmospheric Research
NDC	Ngorongoro District Council
NLUPC	National Land Use Planning Commission
NP	National Park
PsnNET	net photosynthesis
TNRF	Tanzania Natural Resource Forum
UCRT	Ujamaa Community Resource Team
UNEP	United Nations Environmental Programme

Abstract

The Tanzanian government intends to redraw the boundaries of the Loliondo Game Controlled Area (GCA). This wildlife-protected area is located in northern Tanzania and is adjacent to the eastern boarder of the Serengeti National Park. The implementation of the proposed boundaries of this GCA would result in massive land losses for several villages located in the area. This thesis aims to analyze the socio-ecological impacts of the establishment of the new Loliondo GCA on the pastoral community Ololosokwan, which would lose more than half of its village area due to the new GCA. For this purpose, the socio-ecological indicator "Human Appropriation of Net Primary Production" (HANPP) is applied. This indicator allows the analysis of land use by measuring the appropriation of Net Primary Production (NPP) through harvest and land conversion by humans. Therefore, a scenario approach was chosen in order to quantify the aboveground HANPP (i.e. aHANPP) of Ololosokwan at the status quo i.e. before the implementation of the new GCA boundaries and hypothetically and based on *ceteris paribus* assumptions on the reduced village area. In addition, an assessment of the maximal exploitability of the pastures of Ololosokwan was carried out. The approach in this thesis considered the inter- and intra-annual dynamics of biomass productivity in order to account for specific constraints of the land use system in Ololosokwan. An analysis of qualitative interviews was also conducted in order to give insights into consequences of the establishment of the new Loliondo GCA on the investigated village which cannot be obtained through the HANPP indicator. The database for this thesis was collected over the course of three months of fieldwork in Tanzania and in particular Ololosokwan during 2012.

The aHANPP analysis showed that the inhabitants of Ololosokwan currently appropriate 34% of the potentially available biomass within their village. Biomass is mainly appropriated by grazing livestock. The aHANPP would hypothetically grow to 59% if the new GCA is established. During a year with less productivity, due to unfavorable climatic conditions, the aHANPP would slightly increase. The assessment of the maximal exploitability of the pastures of Ololosokwan showed that there is already no significant potential to further increase their exploitation at present. In addition, it was shown that traditional range management methods such as seasonal mobility have started to erode. Since the inhabitants of Ololosokwan mainly appropriate biomass through pastoralism, this indicates that the aHANPP of the village cannot be increased considerably within the predominant land use system. However, if the new Loliondo GCA is established it is not at all feasible to maintain the current land use practice, even if the reduced pastures are exploited to a maximum. In fact, should the new boundaries be implemented, it was estimated that the currently kept livestock herd would reduce, already within a good year, by 26% to 45% with the higher figure being more likely. These estimates could not account for the fact that the implementation of the new GCA would result in the complete loss of the dry season grazing area of the village, which actually used to sustain the livestock during this season. In any case, the estimated livestock loss alone would already cause such a decline of the animal per capita ratio, that pastoralism could no longer play a dominant part of the livelihood strategy of Ololosokwan anymore.

It has been shown that the current land use system of Ololosokwan is already under pressure. Thus, it is likely that the system will face a tipping point in the future. However, this will be exacerbated if Ololosokwan would loss more than half of its village area. If the new Loliondo GCA is implemented ad hoc, as has been attempted in the past, the Maasai of Ololosokwan will not have the chance to develop and implement adaptive strategies for their current land use and livelihood strategy. This thesis suggests the further examination of the idea of implementing a community-based tourism approach instead of a GCA alongside the eastern boarder of the Serengeti. This could be a first step in combining nature conservation and local communities' livelihood instead of separating them.

Zusammenfassung

Die Loliondo Game Controlled Area (GCA) ist ein Wildschutzgebiet im Norden Tansanias und schließt direkt an die östlichen Grenzen des Serengeti Nationalparks an. Die tansanische Regierung beabsichtigt, die Grenzen dieser GCA neu auszuweisen, wodurch Dörfer in diesem Gebiet von einem massiven Landverlust betroffen wären. Die vorliegende Arbeit analysiert die sozial-ökologischen Auswirkungen der Einrichtung der neuen Loliondo GCA auf das pastorale Dorf Ololosokwan, das mehr als die Hälfte seiner Dorffläche an die GCA verlieren würde. Aufbauend auf einer dreimonatigen Feldforschung in Tansania und insbesondere in Ololosokwan wird für diese Analyse der sozial-ökologische Indikator „Human Appropriation of Net Primary Production" (HANPP) genutzt. Der HANPP-Indikator ermöglicht eine Analyse der Landnutzung, indem die menschliche Aneignung von Netto Primär Produktion (NPP) durch Ernte und Landnutzungsveränderung quantifiziert wird. Ein Szenario-Ansatz wurde gewählt, um die oberirdische HANPP (aHANPP) von Ololosokwan sowohl im Satus quo d.h. vor der Implementierung der neuen GCA als auch hypothetisch auf der verkleinerten Dorffläche, basierend auf *ceteris paribus* Annahmen, zu berechnen. Ferner wurde die maximale Ausnutzbarkeit der natürlichen Weiden von Ololosokwan berechnet. Der Ansatz dieser Arbeit erfasst dabei auch die inter- und intra-annuellen Dynamiken in der Biomasseproduktivität, um spezifische Restriktionen für das Landnutzungssystem des untersuchten Dorfes berücksichtigen zu können. Anhand qualitativer Interviews werden Konsequenzen der Neuausweisung der GCA für das Dorf aufgezeigt, die mit dem HANPP-Indikator nicht erfasst werden können.

Die aHANPP-Analyse zeigt, dass sich die Bevölkerung von Ololosokwan zurzeit 34% der potentiell verfügbaren Biomasse aneignet, was hauptsächlich durch Beweidung geschieht. Die aHANPP würde hypothetisch auf 59% ansteigen, wenn die neuen Grenzen der GCA tatsächlich eingerichtet würden. Während eines Jahres, in dem eine klimatisch bedingte geringe Produktivität vorherrscht, würde die aHANPP des Dorfes leicht steigen. Die Berechnung der maximalen Ausnutzbarkeit der natürlichen Weiden des Dorfes zeigt, dass bereits gegenwärtig der Grad der Ausnutzung nicht signifikant gesteigert werden kann. Zudem erodiert das traditionelle Weidemanagement, das sich unter anderem durch die saisonale Mobilität zwischen zwei Wiedegebieten auszeichnet. Da Pastoralismus die aHANPP von Ololosokwan dominiert, zeigt dies, dass die Aneignung von Biomasse mit dem derzeit praktizierten Landnutzungssystem nicht signifikant gesteigert werden kann. Sollte jedoch die neue GCA eingerichtet werden, ist die Aufrechterhaltung des jetzigen Landnutzungssystems unmöglich, auch unter maximaler Ausnutzung der Weiden. Der derzeitige Viehbestand würde sich bereits in einem guten Jahr um 26% bis zu 45% reduzieren, wobei das obere Ende der Bandbreite realistischer ist. In beiden Abschätzungen konnte nicht berücksichtigt werden, dass das gesamte Trockenweidegebiet des Dorfes an die neue GCA fallen würde, das das Vieh normalerweise während der Trockenzeit ernährt. Allerdings zeigt bereits die berechnete Reduktion des Viehs, dass Pastoralismus nicht länger die dominante Lebensgrundlage in Ololosokwan sein kann, sollte die GCA eingerichtet werden, da das Vieh pro Kopf-Verhältnis zu stark sinken würde.

Die Arbeit zeigt, dass das Landnutzungssystem bereits zum gegenwärtigen Zeitpunkt unter Druck steht. Es ist daher wahrscheinlich, dass in absehbarer Zeit dieses System an einen Wendepunkt gelangen wird. Diese Entwicklung würde durch die Ausweisung der neuen Grenzen der Loliondo GCA massiv verschärft werden. Zudem würde eine ad hoc-Etablierung dieser Grenzen, wie es bereits versucht wurde, den Maasai die Möglichkeit nehmen, alternative Strategien für ihr Landnutzungssystem und damit auch für ihre Lebensgrundlage zu entwickeln und zu implementieren. Die vorliegende Arbeit schlägt vor, einen Community-based-tourism-Ansatz entlang der östlichen Grenze des Serengeti zu etablieren, anstatt die vorgeschlagene GCA zu verwirklichen. Dieses könnte ein erster Schritt sein, Naturschutz und die Existenzgrundlage von lokalen Gemeinschaften zu integrieren statt zu separieren.

1 Introduction

The discourse on land grabbing focuses mainly on the "triple F crisis" meaning the food, fuel and finance crisis (Hall 2011). Only recently attention was also paid to conservation as a driver of land grabbing.[1] However, one of the Aichi Biodiversity targets which was set at the 10th Conference of the Parties to the Convention on Biological Diversity (CBD) holds that at least 17 percent of the terrestrial land and inland water will be conserved by 2020.[2] Neil Burgess of the UNEP World Conservation Monitoring said in respect of this target:

> "It's a massive potential conservation plan - it's a lot of land, a lot of sea. Depending on how it's done, depending on how countries choose to do this, it could be a big land grab, it could be a big seas grab, or it could enhance community rights, it could give benefits to the communities - it could do a whole lot of different possible things." (IRIN 2013)

Tanzania is a leading country if it comes to the area which is set under conservation. "About 43.7% of the total land area in Tanzania is somehow protected (or conserved)" (United Republic of Tanzania 2009a). However, even though the Tanzanian government has recently also established a conservation approach which seeks to give benefits to the communities it appears that the conservation practice of Tanzania can still often be described as land grabbing for conservation (Benjaminsen et al. 2011, Ngoitiko et al. 2010, Igoe and Croucher 2007, Brockington 1999).

This thesis aims to analyze the socio-ecological impacts of a land grab case on the pastoral community Ololosokwan in northern Tanzania. Thereby this land grab is done in the name of conservation, even if it ironically reduces the size of one of Tanzania's wildlife protected areas. This is the Loliondo Game Controlled Area (GCA) which is adjacent to the famous Serengeti National Park (SNP) and covers at present the whole Loliondo division. After a legislative amendment in 2009 human activities such as grazing and agriculture are banned within GCAs (United Republic of Tanzania 2009b). But since GCAs comprise usually also of villages, the implementation of this amendment is challenging. In the case of the Loliondo GCA it is even more complicated due to a land conflict which has already lasted in the area for 20 years (Tanzania Natural Resource Forum and Maliasili Initiatives 2011). The land conflict emerged out of the fact that a hunting company has gained the hunting license of the Loliondo GCA. Thereby the company is mainly hunting on a strip alongside the northern border of the Serengeti. This strip is also the dry season grazing area of the Maasai, who live within the GCA. In order to implement the new act and to solve the land conflict the Tanzanian government intends to redraw the boundaries of the Loliondo GCA to the strip alongside the Serengeti (United Republic of Tanzania 2010). This strip amounts in total to around 150000 ha. However, the currently predominant argumentation of the government for the redrawing of the boundaries of the GCA is the protection of the broader Serengeti ecosystem, since within the new GCA the Maasai would not any longer be allowed to practice any land use, which is seen as destructive (Hon. Khamis Kagasheki 2013). The investigated village Ololosokwan is one of six villages being affected by this plan since the village is adjacent to the Serengeti.

[1] For instance in March 2013 a conference on „Conservation and Land Grabbing: Part of the Problem or Part of the Solution?" was held in London. But also some papers on conservation and land grabbing had already been

[2] See http://www.cbd.int/sp/targets/default.shtml (22.09.2013)

The establishment of the newly-proposed Loliondo GCA would thereby result in a loss of more than half of the village area of Ololosokwan.

Thus, it is known that Ololosokwan will lose considerable land resources if the newly-proposed GCA is established. However, the question is which specific socio-ecological impacts emerge from this land loss for the investigated village for instance in respect of their most significant socio-economic resource i.e. the livestock herd. These impacts are also dependent on the current level of use of the resources available on the village area. Thus this thesis aims to quantify firstly the current intensity of colonizing intervention into the terrestrial ecosystem of Ololosokwan by the inhabitants of the village. The term colonization has its origin in the Latin term for peasant ('colonus') (Fischer-Kowalski et al. 1997) and refers to "socio-economic interventions into natural systems that actively seek to increase the utility of these systems for socio-economic purposes." (Haberl et al. 2004: 200). Land use, on which this thesis is focusing, is thereby the socio-economic intervention i.e. colonization of terrestrial ecosystems (Fischer-Kowalski et al. 1997)[3].

The intensity of the colonization intervention is quantified in this thesis by applying the indicator "Human Appropriation of Net Primary Production" (HANPP) (Haberl et al. 2007). HANPP measures the Net Primary Production (NPP) which is appropriate by humans in two processes by 1) harvested and destroyed biomass during the harvest and by 2) modifying the average productivity of the landscape through land use changes (Fetzel et al. 2012, O'Neill and Abson 2009).

However, in order to apply the HANPP indicator for the analysis of the above given land grab case not only a HANPP calculation which measures the intervention into the ecosystem by the pastoral community Ololosokwan at the present time (i.e.2012) is conducted. In addition, the hypothetic intervention intensity on the reduced village area is assessed based on *ceteris paribus* assumptions. In order to account for inter-annual dynamics of biomass productivity these two calculations will be conducted for the year 2012, an on average high productive year and for a hypothetical less productive year. Beside the HANPP calculation an assessment on range forage availability in Ololosokwan and its alteration due to the establishment of the new Loliondo GCA is performed. This assessment will consider the intra-annual dynamics of biomass productivity in order to account for specific constraints for the land use systems. The data required for these calculations were mainly collected during a three-month fieldwork in Tanzania and especially in Ololosokwan in 2012. In the course of this fieldwork also qualitative interviews were conducted. These interviews will be used to give insights into the consequences of the newly-proposed GCA on the village Ololosokwan which cannot be obtained through the HANPP indicator.

On the basis of this approach conclusion can be drawn on the following questions: How intensively do the inhabitants of Ololosokwan intervene in the ecosystem of the village at present? How would this level hypothetically alter if the currently practice land use activities are conducted on the reduced village area? Is it feasible to conduct these land uses on the reduced village area or are the Maasai of Ololosokwan forced to alter their land use system due to the establishment of the new Loliondo GCA? Which implication has the land loss in turn of the livelihood of the Maasai?

This thesis firstly gives insights into the investigated case study (chapter 2). Therefore the

[3] Colonizing interventions can also be carried out on other levels such as the biological macromolecules, cells or cell groups and organism level. The domestication and breeding of animals is for instance another example of a colonization of natural systems which is however not considered in this thesis (Haberl and Zangerl-Weisz 1997).

village Ololosokwan is introduced (chapter 2.1) whereby the pastoral land use system and its current change is also described (chapter 2.1.4). Thereupon, the land conflict in the Loliondo area, where the investigated village is located, is described in addition to the emergence of the plan to redraw the boundaries of the Loliondo GCA (chapter 2.2). In a final section of this first chapter it is argued why the current attempt to establish the newly-proposed boundaries of the Loliondo GCA is regarded as a case of land grab (chapter 2.3). Afterwards the applied methods and data of this thesis are presented (chapter 3). After a general introduction into the HANPP indicator (chapter 3.1) the design of the different HANPP calculations in order to investigate a land grab is outlined (chapter 3.2). Furthermore the conducted expert interviews and their use in this thesis are described (chapter 3.3). Finally the data and collection process within the fieldwork for this thesis is presented (chapter 3.4). After the explanations of the methods applied in this study, the different steps of the HANPP calculations in addition to the assessments on range forage availability in Ololosokwan is presented (chapter 4). The results of these calculations in addition to the outcomes of the analysis of the expert interviews will be presented in the result chapter (chapter 5). In the final chapter the robustness of the conducted calculations will be carried out which also discusses methodological improvements of the approach applied in this thesis (chapter 6.1). The next section discusses the socio-ecological impacts on the establishment of the newly-proposed Loliondo GCA based on the previously presented results (chapter 6.2). Finally, some possible adaptive strategies for the Maasais of Ololosokwan are discussed (chapter 6.3)

2 The Case Study

This chapter aims to give an overview of the investigated case study. Therefore the village Ololosokwan is introduced. In a next section the long lasting land conflict in the Loliondo division will be discussed. Thereby the specific situation of the Ololosokwan will be presented as well. In the context of the land conflict the government of Tanzania proposed new boundaries of the Loliondo GCA which however, lead to a significant reduction of the village area of Ololosokwan. Thus, in the last section of this chapter the current attempt to establish this newly-proposed GCA is assessed as a case of land grabbing.

2.1 The village Ololosokwan

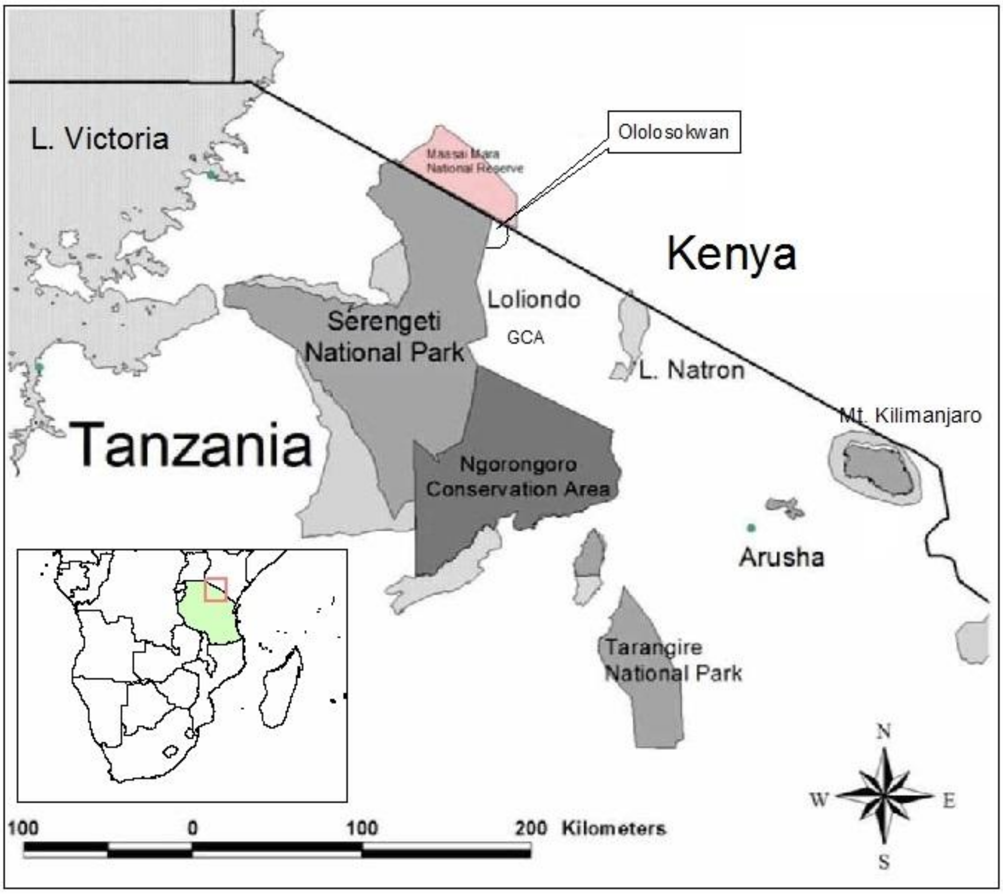
In the following the location, the ecology and the people of Ololosokwan will be introduced. The most important land use in Ololosokwan is grazing of livestock on natural pastures. Hence, a detailed description of the grazing patterns and the changes of these patterns will be provided.

2.1.1 The location of Ololosokwan

The village Ololosokwan is located in northern Tanzania in the corner between the eastern boarder of the famous Serengeti National Park (SNP) and along the Kenyan border to the north (see map 1). Administratively Ololosokwan is situated within –to start at the highest administrative unit – the Arusha region which is divided into five districts whereas Ololoskwan belongs to the Ngorongoro district, the district which is completely adjacent to the Serengeti National Park. The Ngorongoro district is again divided into three divisions: the Ngorongoro division, which completely overlays with the Ngorongoro Conservation Area (NCA) and includes the famous Ngorongoro Crater. The other two divisions are Loliondo and

Sale division which are situated to the north of the Ngorongoro division and are abut on the Kenyan boarder.[4] Ololosokwan village is located within the Loliondo division and within the Ololosokwan ward with consist since the year 2010 of Ololosokwan and Njoroi village (Ndoinyo, 21.10.2012). [5] Ololosokwan village itself is again subdivided in four sub-villages: Ololosokwan, Sero, Mairowa Juu and Mairowa Chini. [6]

Map 1: The location of the village Ololosokwan within Tanzania



Source: Map based on (Tanzania Natural Resource Forum and Maliasili Initiatives 2011), map of Africa from http://www.diva-gis.org/

Up to the present Loliondo and Ololosokwan in particular is quite isolated from the rest of Tanzania. From Arusha there are bus routes which go as far as Loliondo village (a trip of minimum 10 hours) but from there on no public transport is available. In addition the earthy roads are only passable during the dry season meaning that Ololosokwan is cut off during the rainy season (O'Malley 2000).

[4] Initially the Ngorongoro district consists only of the Ngorongoro and Loliondo divisions. In the 1980s the Loliondo division was sub-divided into the Loliondo and Sale divisions (Ojalammi 2006).

[5] Before the year 2010 Ololoskwan village belonged to the Soitsambu ward. In 2010 some wards where administratively reorganized. The Soitsambu ward consists nowadays of the village Soitsambu, Kirtalo and Sukenya village. The new established Ololosokwan ward, as already mentioned is made up of Ololosokwan and Njoroi village (Ndoinyo, 21.10.2012).

[6] Thereby “Juu” means “upper” and “Chini” means “lower”. These terms are alluding to the location of the sub-villages on a hilly side and in a valley.

The Purko-section (singl. *olosho pl. iloshon*) of the Maasai society has settled in the area of Ololosokwan after they were evicted from the Serengeti in 1959.[7] (See O'Malley 2000 for a description of the history of the Purko section in the Loliondo area see Nelson and Ole Makko 2003 and Ojalammi 2006 for more details on the designation of the Serengeti National Park and the eviction of the Maasai). However, Ololosokwan village was founded in 1975 and in April of that year a title deed was issued (elder 7, 27.10.2012). For this thesis it is important to note that Ololosokwan village was again mapped and registered in 1990 under The Local Government (District Authorities) Act No. 7 of 1987 and the title deed with the number 7262 was issued (Ndoinyo 2002). The issued certificate of land title guaranteed legal statutory property rights of Ololosokwan. Also other villages of Loliondo have received this certificate as a result of protests against the project of the Tanzanian government to establish large-scale wheat farming in the Loliondo division (Tanzania Natural Resource Forum and Maliasili Initiatives 2011, Ojalammi 2006).

In the first title deed Ololosokwan was registered with a village area of 51,320 ha. However, my own calculations show, based on an available map of Ololosokwan from 2008 and issued by the Ujamaa Community Resource Team (UCRT) that the village consists of 40,700 ha (see chapter 3.2 for details on this aspect).

As already indicated the two divisions Loliondo and Sale are surrounded by different boundaries especially those of conservation areas: the famous Serengeti National Park is located to the west, to the south lies the Ngorongoro Conservation Area, whereas both conservation areas are designated as World Heritage Sites. On the eastern border of the division one can find the Lake Natron Basin, which is declared as a Ramsar site (Gibson 2011). Finally the north of the divisions is bounded through the Kenyan border, where also the Maasai-Mara National Reserve can be found. But even the Loliondo and Sale divisions themselves are designated as Game Controlled Areas (GCA) (see chapter 2.2 for a detailed description). Ololosokwan is also a part of the Greater Serengeti Ecosystem which includes the Serengeti National Park itself and the Maasai-Mara National Reserve in Kenya. During the annual migration route of wildebeest between these conservation areas the ungulates pass as well through Ololosokwan (Nelson and Ole Makko 2003, United Republic of Tanzania 2010). Therefore it is hardly surprising that Ololosokwan is located “within one of the most wildlife-rich areas in the world.” (Nelson and Ole Makko 2003).

2.1.2 The ecology of Ololosokwan

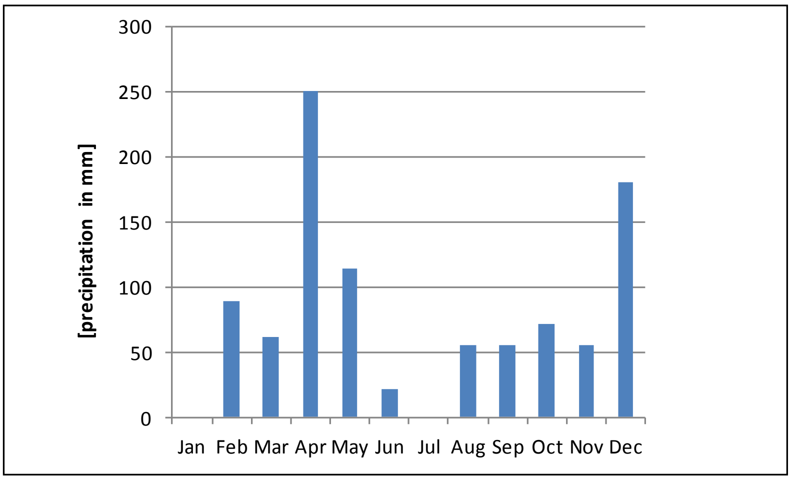
Ecologically, the northern part of Tanzania is classified as semi-arid (Ojalammi 2006). However, with a comparable higher precipitation, Ololosokwan can be classified in between the aridity categories dry sub-humid and semi-arid (Jahnke 1982, Pratt et al. 1966). Such ecosystems are characterized by inter- and intra-annual precipitation dynamics. Available data on annual precipitation of the Loliondo area in general range from 400 to 1500 mm annually (United Republic of Tanzania 2010, United Republic of Tanzania 2003, Ojalammi 2006). Annual rainfall data measured from 2005 to 2012 in Ololosokwan range between 731 to 1231 mm.[8]

[7] See later on in this chapter the description of the socio-political organization of the Maasai society but for more details also regarding the age-set (*olaji*) see Goldman (2006). The Loliondo division is inhabited by the Maasai-sections: Purko, Loita, Laitayok, Salei and Irkisongo (O'Malley 2000).

[8] Precipitation data of Ololosokwan was provided by the safari company *&beyond* which had measured the amount of rainfall in the village area via a rain gauge every day since 2005 (coordinates of the location of the gauge: S 01°50.111’/ E 35° 14.766’)

The intra-annual dynamics are dominated by bimodal rainfall patterns. In general it can be said that the rainy season lasts from January to June with a peak of rainfall in the months around April. The dry season is from July onwards to December. However, during November and December small showers can already occur so that these months are described as low rain season.

Figure 1: Precipitation patterns in Ololosokwan in 2012



Source: *&beyond*. There was no rainfall in January and July. In addition, there was atypical high precipitation in the dry season of 2012 especially in December if compared to the rainfall during the rainy season.

In a conducted focus group discussion held in Ololosokwan (focus group discussion 1, 06.10.2012) the participants described the climate of Ololosokwan in more detail (see also photo 15 in the annex for a poster which was conducted in the discussion for this purpose).The participants started with their description with the month of November because the pastoralist year begins from this month onwards. This is because the months of November and December are recognized by the pastoralist as "determinants or mixer months" (*Irkisirat Oloitushulndapan*). These months determined or predict, depending on the amount of rainfall these months received, if the following year is a good year for pastoralism or not. Within a good year of pastoralism November already received small showers which will increase during December. The month January is characterized by a "hot sun" (*Oladaly*) whereby February to April are typical the months where heavy rain falls (*Oloiborr Are* – "white waters") which will decrease in May and June. July and August are the months which are very cold and September and October are characterized as the main dry season (*Keokisho Irmotonyi* – "only bird's drink water").[9] However, the participants also reported that since approximately the year 2000 they have recognized a shift in this climate pattern which is mainly characterized by less rainfall and less predictable rainfall patterns (focus group discussion 2, 07.10.2012). In addition, Ololosokwan also received, as typical for semi-arid savanna ecosystems, periodical droughts events (Homewood and Rodgers 1991). Severe droughts occurred in Ololosokwan for instance in the years 1984, 1993, 2005 and 2009 (focus group discussion 2, 07.10.2012).

There is no specific temperature data available for Ololosokwan. However, O'Malley (2000) stated that the annual mean temperature of the Loliondo division is between 16°- 18°C similar

[9] However, in general the above mentioned subdivision into rainy season (January to June) and dry season (July to December) is applied in this study, as will be shown in the following chapters.

data is presented by (United Republic of Tanzania 2003) a broader range is reported by (United Republic of Tanzania 2010).

Several studies are available which describe the vegetation of the Serengeti or the Ngorongoro Conservation Area but there is a lack of studies which describe the vegetation of the Loliondo area and particularly Ololosokwan (Homewood and Rodgers 1991). However, the vegetation of Ololosokwan can in general be described as wooded and bushed savanna (see Pratt et al. 1966, whereby Pratt et al. prefer the term grassland instead of savanna, United Republic of Tanzania 2010, United Republic of Tanzania 2003). However, for instance within the sub-village Mairowa Chini, which is located in a valley, pure grassland can also be found. In general Ololosokwan also consists of several kopje, rocky outcrops which are also known as inselberg (O'Malley 2000). The corridor connecting the Serengeti National Park, Ngorongoro Conservation Area, Loliondo Game Controlled Area, Lake Natron and the Maasai Mara National Reserve in Kenya and which runs through the western part of Ololosokwan was described as "acacia wooded grassland" (United Republic of Tanzania 2010). "The most common species *are Acacia Tortilis, Acacia Drepanolobium and Comiphora Africana* as well as grasses like *Hyperania Ruffa, Chloris Gayana and Themeda Triandra*." (ibid.). A list of plants i.e. trees, shrubs and grasses that can be found in Ololosokwan is available in the annex of this thesis.

The topography of Ololosokwan village is hilly since the village is an extension of the Loliondo highlands and as such have several mountain peaks such as *Oldonyiokeri, Parmingat, Ng'asakinoi, Oloilole and Olosira Piding*' (Ndoinyo 2002). For the whole Loliondo division an altitude range between 1,400 meters to 2,500 meters above sea level is reported (United Republic of Tanzania 2010). In addition, Ololosokwan is blessed with several rivers. The backbone of the village is the permanent river *Ololosokwan*. However; several other water sources exist within the village area, for instance the permanent rivers *Leenet*, *Empiripiri Enkong'unairowa* but also seasonal rivers such as *Grumeti*, *Iretet, Samburrumburr and Esokuta* are available (Ndoinyo 2002).

This good drainage and the vegetation of Ololosokwan are reasons why the village is inhabited by abundant wildlife, as already reported. In the literature Ololosokwan is frequently quoted as a leading example of "community- based ecotourism" (Nelson and Ole Makko 2003). Ololosokwan has currently several joint venture agreements with companies which established tended camps within the village area. The most important cooperation is the one with the international ecotourism company *&beyond* which has leased a part of the village area, close to Klein's Gate of the Serengeti NP. The company has constructed a permanent lodge and offers their clients exclusive wildlife safaris within the village area of Ololosokwan. Tourism revenues are used by the village for several village development projects such as the construction of classrooms but also for individuals for instance for scholarships (Nelson and Ole Makko 2003).

2.1.3 The inhabitants of Ololosokwan

As already indicated Ololosokwan is, as likewise in Loliondo throughout, inhabited mainly by Maasai pastoralists of the Purko-section. A frequently applied definition of pastoralism is that of Swift who defined pastoralism in economic terms when he says that pastoralist households are those in which at least 50% of household gross revenue comes from livestock and related activities (Swift 1988). Thereby gross revenue considers subsistence but also income from marketed production (ibid.). Several studies already analyzed the phenomenon that pastoralist more and more incorporate crop production in their economic activities (O'Malley 2000, McCabe et al. 2010). For such pastoralists the term agro-pastoralist has become common and is defined by Swift as households which gain more than 50% gross revenue from crop cultivation and 10-50% from livestock (Swift 1988). However, I follow O'Malley's argumentation who classifies the Maasai in Loliondo as "generalized pastoralists" (O'Malley 2000). In her dissertation about the processes of adoption of cultivation among Maasai in Loliondo division O'Malley has worked out that the Maasai in Loliondo indeed cultivate some areas. However, what distinguishes them from agro-pastoralists is, that cultivating is for them an *additional* subsistence strategy with an annual decision-making process whether they want to cultivate or not. This means that the Maasai in Loliondo are not balanced between agriculture and pastoralism as in the case of agro-pastoralists rather they still focus on pastoralism, even though they augment their pastoral way of life with cultivating activities. O'Malley therefore described the process of adoption of cultivation by the Loliondo Maasai as a diversification of a former specialized economy, which is thus best classified as "generalized pastoralism" (O'Malley 2000). Based on my own observation I would still support this description. However, I also agree with Ojalammi (2006) observation which described a greater dependence on agricultural products and a decreased mobility in the Loliondo area as a result of reduction in accessible and productive pastures, and a decrease in livestock numbers (ibid.). In a focus group discussion held in Ololosokwan one of the participants reported:

> "Pastoralists in Ololosokwan have now started adopting other means of survival like practicing agriculture which is now practiced side by side with pastoralism. We now have food stores (Ikomben) that store cereals for future use especially during dry season. However, we pastoralists in Ololosokwan still identify ourselves as pastoralists regardless of other economic activities adopted in the area." (focus group discussion 1, 06.10.2012).

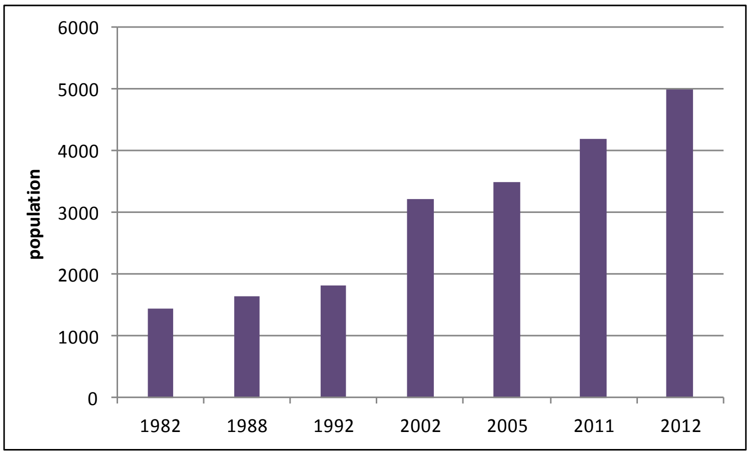
Other definition of pastoralist considers precisely this significance of the identity as pastoralist (see in Homewood 2008). However, it might be that the Maasai in Ololsokwan and in Loliondo in general are now at a tipping point regarding their future as pastoralists as will be outlined later on in this chapter..

Beside Maasai-pastoralists Ololosokwan is also inhabited by agriculturalists and as a minority by hunters and gatherers. In Ololosokwan sub-village, where the center of the village is situated, the most diversity of different groups can be found: beside Maasai the sub-village is inhabited by Merus, Pares and Sonjo who are all engaged in small businesses like the running of shops, working as mechanics or as handyman for building houses. However, the Sonjo are becoming the largest group in Ololosokwan sub-village. Sonjos are as well located in Mairowa Juu. Mairowa Chini is currently only inhabited by Maasai. Sero is the sub-village with the most people engaged almost exclusively in cultivation, this group is called Iraqw. But Maasai are also living in this sub-village and as well a small group of the Doboro, a hunter and gatherers society. However, the above mentioned groups still represent a minority compared to the Maasai living in Ololosokwan. Figure 2 presents population data of Ololosokwan.[10] Thereby it should be noticed that the time interval between the data points is

[10] Only the data for the years 1988, 2002 and 2012 are census data, all others are only projections. However, for the census 2012 only data for the Olosokwan ward is available. In the whole ward 6,557 people were living in 2012 United Republic of Tanzania (2013). It was estimated that 2012 5,000 people lived in Ololosokwan village and 1,557 in the much smaller newly-established Njoroj village, which was before a sub-village of Soitsambu. Since no data on factors which have impacts on the population (immigration and emigration, fertility and mortality), was available this estimation was based on the population increase of former years in Ololosokwan. The population in Ololosokwan has increased from 1992 to 2002 by about 80%. This means that a population increase from 2002 to 2012 of 60% is reliable. In the years 1967 and 1978 population census were also carried out, however no population data for Ololosokwan were available since Ololosokwan was officially founded in 1975.

irregular. However, it can be observed that within 30 years (from 1982 to 2012) the population has increased to 3.5 times.

Figure 2: Human Population of Ololosokwan



Source: Ndoinyo 2002, United Republic of Tanzania 1991, United Republic of Tanzania 2005, Ngorongoro District Council (NDC), Planning Department, United Republic of Tanzania 2013.

2.1.4 The grazing system of the Maasai in Ololosokwan

The main land use in Ololosokwan is extensive grazing of livestock on natural pastures. Since this is the dominant land use in the village I will discuss in the following the grazing patterns of the Maasai in Ololosokwan and its changes. I will firstly explain some socio-political units of the Maasai society, which are interesting in respect of the pastoralism of the Maasai.

The basic unit of the socio-political organization of the Maasai is the *enkaji*, the house. Thereby every house is associated with a married woman where she lives with her children and acts semi-autonomous. Maasai man lives polygamous i.e. different wives are associated with him. The term "gate" (*enkishomi*, pl. *inkishomi*) refers to all dependents of one particular man like co-wives, children, sisters etc.. In fact this is also the level where the term "family" (*olmarei*) can fit and were pastoralism i.e. the herding is practiced. In Ololosokwan the "gate" (*enkishomi)* incorporates all houses of the co-wives of a particular man which are located around a circular thorn bush enclosure (see photo 3 in the annex for a picture of a *boma*). In this enclosure, which also includes several gates, the livestock is kept during the night. Within the Maasai society it is common that several families live together in a so called *boma* (*enkang*, pl. *inkangitie*) which consists of a cluster of various "gates" (*inkishomi)* surrounded by grazing reserves (*olopololi*). There are several advantages in living in such an arrangement for both women and men because labor and knowledge can be shared and together they can for instance better protect themselves from predators. The formation of a *boma* can be based on family relationship but also, for instance, on friendship. The families within the *boma* are independent but resource management like the managing of the grazing reserves are conducted together whereby the most respected elder acts as the head of the *boma*. In some cases also the herding is carried out on the *boma* level. The elders of several *bomas* in the neighborhood (*elatia*), the next higher level in the social organization of the Maasais, are also consultants regarding the resource management of the particular neighborhood (Goldman 2006, O'Malley 2000).

To apply an operational definition of the Maasai household is somehow challenging as can be seen from the above. Among researchers it has become common to define the *enkishomi* and *olmarei*, respectively (gate or family) as household and the *enkaji* (house) as sub-household (O'Malley 2000). In Ololosokwan it is also the *enkaji* which is the smallest social entity and the associated woman of the *enkaji* has control and responsibility of the activities within her house. She controls for instance the labor of her children and herself and has responsibility over the allocation of milk. However, the husband has control and responsibility of all people living within his *enkishomi*. For this reason the above given definition of a Maasai (sub-) household is also appropriate in the case of Ololosokwan and is therefore applied as working definition of a Maasai (sub-) household in this thesis.

As already introduced in this chapter a semi-arid savanna ecosystem such as found in Ololosokwan is characterized by general low rainfall but with high inter- and intra-annual dynamics. Precipitation is the limiting climate factor in such ecosystems and therefore the spatial and seasonal availability of range forage and net primary production are in general dependent on these dynamic precipitation patterns. However, with pastoralism it is possible to turn sparse, patchy and transient net primary production into human food such as milk and meat, which is not possible with other modes of production within such ecosystems (Homewood 2008, Reid et al. 2008). Mobility is the key strategy of pastoralists, allowing to make use of the fluctuating availability of the range forage in terms of time and space while preventing the overuse of the rangelands (Scoones 1994a, Jode 2010). The great wildebeest migration between the Serengeti plains and the Maasai Mara follows the same ecological rationality and this similarity between the wildlife and pastoralist grazing pattern is among others the reason why wildlife and livestock has co-existed for ages (Rurai 2012, Homewood and Rodgers 1991). Igoe (2006) emphasizes in addition that Maasai never fenced their grazing area and therefore did not disturb the migration routes of wildlife.

Pastoralists can be subdivided into two categories depending on their mobility degree: nomadic and transhumance. Transhumance pastoralists are mobile only within a certain territory whereby nomadic people are not restricted to a particular territory. The latter move with their livestock wherever the rain leads to some range forage. The Maasai are classified as transhumance pastoralists (Cook 2007).

The Maasai, as in Ololosokwan keep typically Small East African zebu cattle (*Bos indicus*), Red Maasai sheep (*Ovis aries*) and Small East African goats (*Capra hircus*), and some donkeys are kept mainly for transport purposes. In addition to these traditional livestock breeds some Maasai of Ololosokwan also started to keep exotic breeds, as a survey conducted in Ololosokwan has revealed. The keeping of small and large ruminants is a strategy to cope with risk (Bayer and Waters-Bayer 1994, Lynn 2012).The mixed herd structure buffer for instance for losses during hard dry seasons. This is due to the fact that every species has its own feed demand and diet preference and thus available range forage can better be appropriated. In addition, this herd structure buffers the livestock owner against species-specific diseases (Lynn 2012). Nevertheless, the most important livestock species for Maasai are still the cattle not only in respect of the number which is held but also for the identification as a pastoralist (Homewood and Rodgers 1991, Ayantunde et al. 2011).

Traditionally the mobility of the different livestock species was conducted within localities (singl. *enkutoto*, pl. *inkutot*) whereby several localities are associated with a certain Maasai-section (O'Malley 2000). The localities were usually divided in uplands (*osopuko*) and lowlands (*olpurkel*) and utilized for grazing in seasonal rotation: lowlands were used during the wet season and uplands during the dry season, particularly because the uplands contain permanent water sources (Goldman 2006). Thereby the different sections define the right of use for the resources within their localities. Members from other sections have to ask for permission if they want use the rangeland of another section (Ojalammi 2006). However, the traditional spatial organization of the Maasai has started to erode since the Ujamaa Village Program, introduced by President Julius Nyerere in the Arusha Declaration of 1967, aims to implement villages (i.e. villagization). This results in a forced re-settlement and particularly sedentarization of Maasai in distinct villages (O'Malley 2000). Due to the isolation of the Loliondo division the pastoralists of this area were only resettled in villages in the late 1970s (ibid.). A Maasai elder from Ololosokwan also stated that the villagization was the beginning of the changes of the traditional grazing system of the Maasai:

> "After independence the first president Julius Kambarage Nyerere designed an ideology called Ujamaa - to bring people together. This Ujamaa was so disadvantageous to the Maasai because it over-crowded them and that was the beginning of problems. […] first because 80% of the Maasailand was taken […]. After this land was taken and villages were created it became a problem because it meant that the Maasais had to settle and were over-crowded compared to former times when they could move freely. This is now where the system or the patterns of organization of the Maasais started to erode." (elder 7, 27.10.2012).

The villagization was followed by a new spatial organization of resource management within these newly-established villages. Now not only the traditional localities were subdivided into dry season grazing area and wet season grazing area but also each village was zoned (Goldman 2006) . The village Ololosokwan was also subdivided into these zones and the mobility has been mainly limited to these areas, meaning restricted within the village boundaries (see map 3 in chapter 2.2).

The National Land Use Planning Commission (NLUPC) was founded to facilitate land use plan in different levels including on the village level. In the case of pastoral communities the village land use plans typically designate the dry season and wet season grazing areas. Also different NGOs are engaged in land use planning mainly on the village level. This is not least due to the slow process of facilitating such plans by the government (Makwarimba and Ngowi 2012). However, land use plans that were done by the Ujamaa Community Resource Team (UCRT) for Ololosokwan were rejected by the Tanzanian government (United Republic of Tanzania 2010). Nevertheless, the pastoralists of Ololosokwan told me that the zoning of the village in dry and in a wet season area as indicated in this plan conducted by UCRT are in general accurate even though the grazing patterns have been changed, as discussed later on in this chapter (focus group discussion 2, 07.10.2012). See map 3 in chapter 2.2 which also indicates the zoning of the village area of Ololosokwan into the two grazing areas as presented by the land use plan of UCRT.

Traditionally the Purko Maasai used the northwestern tip of Loliondo division, where now among others the village Ololosokwan can be found, as a drought reserve (O'Malley 2000). As can be seen in map 3 Ololosokwan also designated the strip alongside the Serengeti as dry season grazing area. The dry season grazing area is called by the Maasai "*ronjo*". However, Ololosokwan still serves as grazing puffer during hard dry seasons also for Maasais from other villages. This is mainly due to permanent water sources found in Ololosokwan (elder 4, 18.10.2012, O'Malley 2000). In the literature it is often described that the permanent *bomas* are located in the dry season area and that during this season the livestock is only watered on alternate days (Ojalammi 2006, Igoe 2006). However, the traditional grazing system in Ololosokwan village is somehow different which will be described in the following: During the wet season human and livestock inhabited the wet season area of Ololosokwan which is located to the east of the village (see map 3). In this area permanent houses are built and herdsmen move with their livestock different day routes, and return back to the permanent *boma* in the evening. Small and large ruminants are herded separately. Typically the herdsmen start to move with the cattle around 9 to 10 am and return to the *boma* at around 5 to 6 pm, whereby the sheep and goats start later meaning between 11 and 12am. Because throughout the rainy season water is abundant livestock are watered every day.[11] In the wet season area the already mentioned grazing reserves (*olopololi*) can also be found. During the rainy season only the grazing of calves or sick livestock is allowed in these reserves. The reserves, where forage has been accumulated during the rainy season will be opened for all livestock in times of range forage scarcity on the general grazing areas during the dry season. Nowadays also most of the infrastructures such as two primary and one secondary school, dispensaries, cattle-dips small shops and restaurants are found in the wet season area. In addition, every Sunday a market is held in the Ololosokwan sub-village. Also all agricultural fields are found in the wet season area of Ololosokwan. During the rainy season grazing in the dry season grazing area i.e. the *ronjo* is restricted to allow the replenishment and accumulation of biomass. However, with the start of the dry season the elders traditionally consult and decide when it is necessary to move to the *ronjo*. Originally after the "opening" of the *ronjo* herdsmen start to move with the majority of the livestock to the *ronjo* where they build temporary camps (see pictures in the annex for such camps). Some of the calves and sick livestock remain in the wet season area in addition to several lactating cows which provide the daily milk for the family members who remain in the permanent *boma* at the wet season area. These are especially women, who traditionally always stay in the wet season area. In the *ronjo*, meaning during the dry season the livestock is often only watered every second day, since this decreases the feed intake and thus conserves the dry season grazing resources (Perrier 1994; Igoe 2006). The herding day also starts earlier as compared to the wet season meaning for the cattle between 7 and 8 am, for small stock between 8 and 9 am.[12] With the beginning of the heavy rains the herdsmen return to the wet season area and the grazing rotation starts from the beginning.

In Summary, it can be said that two kinds of mobility are found in Ololosokwan. Firstly the Maasai are in general mobile within the grazing areas. Daily they utilize different grazing route in order to make use of the patchy available range forage regarding time and space, but also in order to avoid the overuse of one route. I will term this first mobility pattern "daily mobility". The second mobility pattern is the "seasonal mobility" meaning the alteration between two grazing zones depending on the season.

In the following I will describe the changes of the traditional grazing patterns of the Maasai in Ololosokwan. During my stay in the village I observed that the seasonal mobility pattern started to erode. This was also narrated by the Maasai for instance an elder reported:

> "Yes, those days [during the time in Serengeti] we used to have ronjo and even many, many years later we still had ronjo. But nowadays, because of population pressure and because of land scarcity it is becoming sort of a loose practice." (elder 4, 18.10.2012).

[11] These are results of the survey conducted in Ololosokwan (see chapter 3.4 for methods used in this thesis) Some of the interviewed pastoralists still practiced the traditional *linga* grazing system whereby the herding starts around 3 am until 8am from then on to 1pm the livestock will be milked and from 1pm to 5pm they will be grazing again.

[12] In the scope of the fieldwork it was measured, with the help of GPS-tracking that the herdsmen move with the large ruminants during the end of the dry season around 12 km daily.

That the *ronjo* is becoming a "loose practice" means that the seasonal grazing i.e. mobility patterns of the Maasai in Ololosokwan have eroded. For instance no families which were included in the questionnaire (n= 15) conducted in Ololosokwan practice the traditional seasonal grazing anymore. They prefer to spend the whole year with the majority of their livestock in the wet season area or in the *ronjo* (see chapter 3.4. for the conducted survey). Furthermore, those families who spent the whole year with their herd in the *ronjo* started to build semi or even permanent houses and *bomas* in the *ronjo*.[13] These families subdivided their household into two. Some family members stayed with some of the livestock, mainly lactating cows, in the former wet season area in the original permanent *boma.* The other family members (including women) live with the majority of the livestock in the newly-built (semi-) permanent *bomas* in the *ronjo*.[14] Thereby the family members move flexibly between both areas, but mostly without livestock. Thus, it seems that the mobility of the livestock has decreased whereby the mobility of the Maasai has remained constant or even increased in respect of the Maasai women. That even Maasai women stay in the *ronjo* is a consequence of the changes in grazing patterns, as one elder indicated:

> "There came a time when women started to follow the cows to ronjo and the people decided to let the women follow cows, because the cows are not returning anymore. […] Actually it was not a major pull factor that they [the women] wanted to make ronjo as a permanent place but rather it was an inconvenience that was brought up by labor. Because cows, especially those that give birth did not go back to the residential area [wet season area] in large numbers and of course young calves need a lot of attention. So women really came to have a closer look at the calves and the cows." (elder 5, 24.10.2012).

The quote indicates that women are for instance responsible for taking care of the young calves. Since the majority of the livestock of some families are nowadays found during the whole year in the *ronjo* the women also have to stay in the *ronjo* to carry out their work.

However, the above indicates that the village area of Ololosokwan is still subdivided into two zones: a main grazing area and a permanent or residential area and not into dry and wet grazing areas. This new zoning of the pastoral villages was already predicted by O'Malley (2000), when considering the whole Loliondo district. O`Malley predicted that in the future two resident sites will be established: one with a pastoral and the other with an agricultural focus (ibid.). O´Malley rightly emphasized changes of the social system resulting from such a development:

> "In the long term, one can imagine such differentiation having the potential to separate families by skills, interests, access to schooling and medical resources, degree of engaging with market, and, eventually, status, the ability to marry, types of rituals and ceremonies practised." (O'Malley 2000).

In addition, this separation of the land use system would also have presumably negative con-

[13] That the *ronjo* became a somehow permanent grazing area can be seen by the gradual increase of permanent structure of the Maasai houses found in this area. See the annex for pictures of these various types of houses found in the *ronjo*.

[14] Some of the Maasai also reported that for instance the majority of the small stock stay in the former wet season area together with the minority of the cattle, whereby the majority of the cattle and the minority of the small ruminants are found in the *ronjo*. This subdivision is also practiced the other way around.

sequences on the rangeland of Ololosokwan. If only grazing on the *ronjo* is practiced, the seasonal mobility is not maintained. However, (seasonal) mobility is regarded as an important range management within semi-arid environments (Ellis and Swift 1988, Behnke et al. 1993). Mobility does not only allow the utilization of patchy availability of range forage, in addition it allows the recovery of the grazing area (Scoones 1994b, Reid et al. 2008).

However, even though traditional grazing zones within Ololosokwan are eroding and some of the families have already constructed (semi-) permanent *bomas* in the *ronjo,* the *bomas* in the permanent area are still considered as the primary *bomas* as an interviewed elder pointed out:

> "Our permanent bomas and livelihood is there, in the permanent area. But we only come here [to ronjo] for grazing and the other activities like agricultural and schools are found there [in the permanent area]." (elder 3, 17.10.2012).

However, another elder reported that traditional rituals are nowadays also practiced in the *ronjo* which was in former days only practiced at the permanent *boma* in the wet season area (elder 6, 26.10.2012).

In order to account for these changes in grazing patterns of the Maasai of Ololosokwan I will apply the term "permanent area" rather than wet season grazing area in this thesis. The term "permanent area" indicates that all permanent structures like schools, dispensaries but also agricultural fields are found in the former wet season area. Since the Maasai still use the term "*ronjo"* to consider the dry season area and not all families stay in this area for the whole year I still refer to the dry season area as the *ronjo.* However, it should be borne in mind that this area is not anymore exclusively used during the dry season. However, this area still serves as a puffer during a hard dry season also for pastoralists outside the Ololosokwan village.

The conducted survey in Ololosokwan also revealed that the decision-making process for instance in respect of the question when and in which area the cows should graze, is done by each single family. In former days this was done by the elder of the village. This new decision making process was criticized by an interviewed elder and the Ololosokwan ward counselor (elder 7, 27.10.2012, Ndoinyo, 21.10.2012). In addition, the counselor pointed out that the settlement structure of Ololosokwan is poor. He claimed that the settlement structure gets even worse because families decide more independently where to settle and it is not anymore a community decision as in former times (Ndoinyo, 21.10.2012). One elder, who has built a permanent *boma* in the *ronjo* summarized the changes in grazing patterns in Ololosokwan village clearly:

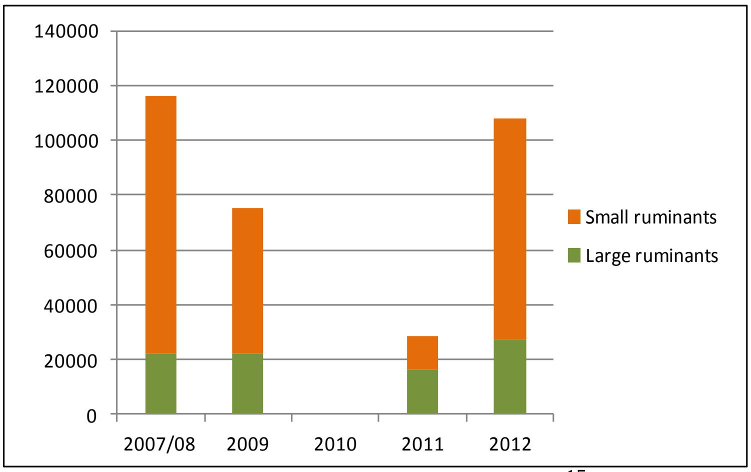
> "When I grew up, we used to live in Mairowa and this entire place [ronjo] was open land. We only came to ronjo when we followed the fresh, green grass, which came out after the land was burned. By then there was only a small population and the place was enough for the people and the animals. Then the system was like this: we only came during the dry season and then we went back to the permanent area where we spent the rainy season because there was enough grass and none would be left at ronjo. Then gradually the population of people and of livestock grew. Also during the dry season there was a large, growing number of livestock which stayed at the residential area for milking purposes and they left less biomass for other cows to come during the wet season. Now we started to settle here in the ronjo and there is no hope of going back to the residential places because already everything is full and we are also starting to fill ronjo and we already feel the pressure that we have felt at the residential area." (elder 5, 24.10.2012).

The quote indicated one reason for the mobility of the Maasais. When the Maasai and their livestock are on the move they look for “fresh green grass”, meaning the nutritional best grazing resources but also water sources (Jode 2010). However, the interviewed elders also reported that this reason for mobility has also eroded since they are nowadays mobile in order to find any range forage, regardless of the quality. Thus, the reason for mobility has changed from a qualitative aspect to a quantitative one (elder 3, 17.10.2012).

It should be noted that the changes in grazing patterns, which is particularly indicated by the fact that the *ronjo* is slowly becoming a permanent grazing area, was not an intended decision at the village level or the family level. It was rather a gradual process which was driven by several factors. In summary the interviewed Maasai reported the following factors as crucial for the process: An increase in permanent structures in the permanent area, an increase in population, whereby some interviewees refer only to the human population but others to both livestock and human population and that a part of the village area is not freely accessible anymore. All factors result in a decrease of grazing area in general and in the permanent area in particular.

The increase of the human population has already been shown in the figure 2. The increase is remarkable since the population has increased within 30 years by a factor of 3.5. Due to this significant population increase it is probable that more *bomas* and agricultural fields have been established over the time in the permanent area and complaints about the diminishing pasture in the permanent area are plausible. Figure 3 presents the livestock population in Ololosokwan between 2007 and 2012. It can be seen that there is over the period of five years no significant increase in livestock population in Ololosokwan.

Figure 3: Livestock Population in Ololosokwan



Source: NDC Livestock Department, Ololosokwan Village Office[15], (Porokwa et al. 2007), for 2010, no data were available

However, a general livestock population trend can hardly be shown by some few data points. This is also true due to the dynamics of the population owing to regular droughts and consequently massive death of livestock. The massive drop in the livestock population in 2011 is due to the drought that occurred in 2009. However, the figures of 2009 are pre-drought data

[15] It should be noticed that even official figures of the livestock population have to be treated with caution owing to the difficulties regarding the counting of pastoralist livestock. However, the latest indicated figures of the livestock herd in Ololosokwan i.e. those of the year 2012 are the most reliable ones because they were obtained through a gratuitous vaccination of livestock in the Ololosokwan village (pers. comm. Livestock Department of the Ngorongoro District Council 30.10.2012).

(pers. comm. Livestock Department of the Ngorongoro District Council 30.10.2012). There are no data available for the year 2010 but the figures of 2011 indicate that the Maasai of Ololosokwan first of all rebuild the large ruminant population, after the demise of livestock due to the drought. But, already in 2012 also the small ruminant population could be restocked.

The third factor contributing to the chancing of the grazing patterns refers to the ongoing land conflict in the Loliondo area and also Ololosokwan village. This conflict results in restrictions in the accessibility of specific grazing areas. This is described by an elder who has built a permanent *boma* in the *ronjo* as follows:

> "Actually we are having a problem to access especially during the dry season this area [the ronjo area close to the Serengeti]. You see this mountain, all this mountain is occupied by the Arabs [i.e. the hunting company OBC]. When we try to access the area during the dry season they do not like it, they chase us away. So we try to settle here [in ronjo] because whenever they see a bit of an open place they think it is not of use and they come and take it. So we try to settle here to try to secure our land and to thus secure our future" (elder 3, 17.10.2012).

This means the land conflict results not only in the insecurity to access the grazing area of Ololosokwan. In addition, it results in the fear of the Maasai that the *ronjo* will be easily grabbed due to the perception that the area is not used. Consequently the Maasai started to build permanent bomas in the *ronjo* to redress this notion.

In the following chapter the land conflict of the area will be described, which results in this development.

2.2 The land conflict in Loliondo division and Ololosokwan village

This thesis is focused on the newly-proposed boundaries of the Loliondo Game Controlled Area (GCA) and its impacts on the village Ololosokwan. However, the designation of this GCA has to be regarded in the light of a land conflict in Loliondo that has been lasting for 20 years. There are already many publications about this land conflict (see for instance Gardner 2012, Nelson et al. 2012, Rurai 2012, Tanzania Natural Resource Forum and Maliasili Initiatives 2011, Ngoitiko et al. 2010, Ojalammi 2006, Nelson and Ole Makko 2003). Therefore, the aim of this study is not to analyze the conflict per se. But it is important to understand the background of the situation in Loliondo in order to assess the current attempts to establish the newly-proposed GCA. In the following, I will give an overview of the conflict and add new developments which have arisen in the last few years.

The whole Loliondo division was gazetted in 1959 as Game Reserve by the British colonial government under the Fauna Conservation Ordinance. Later, in 1974, the area was categorized as Game Controlled Area (GCA) to allow commercial trophy hunting (United Republic of Tanzania 1974, Ojalammi 2006). The Wildlife Conservation Act of 1974 defined a GCA as a "protected area" in which hunting is allowed provided that a license is granted (United Republic of Tanzania 1974). In addition, land uses within GCAs, such as grazing or crop cultivation, were not restricted by this act (ibid.). The Loliondo GCA was used for hunting by the Tanzania Wildlife Corporation. However, in 1992/93, a 10-year hunting license was issued to Prince Brigadier Mohammed Al-Nayhan from the United Arab Emirates in addition to the existing license of the mentioned Corporation. Later on, an exclusive concession was granted to Ortello Business Corporation (OBC) owned by Brigadier Mohamed Abdul Rahim Al Ali, former deputy minister of defense of the United Arab Emirates (Ojalammi 2006, Nelson and Ole Makko 2003). However, Ojalammi (2006) reports that after heavy protests, the Tanzanian government acknowledged in 1999 that this hunting contract lacked any legal basis. Therefore, a new five-year contract was drafted in 2000 by OBC and the Director of Wildlife (the Ministry of Tourism, Natural Resources and Environment) who is responsible for managing all wildlife outside National Parks (Gardner 2012). The contract was renewed in 2007 (ibid.). The terms of the contracts were never made public, but it is known that they agreed on a system of benefit sharing (ibid., Tanzania Natural Resource Forum and Maliasili Initiatives 2011). The major revenues from the contract are obtained by the central government. The six villages located in the intensive hunting zone alongside the Serengeti National Park, including Ololosokwan, were also promised annual financial participation. In addition, they should receive aid in form of community development projects (Nelson and Ole Makko 2003).[16] Gardner (2012) reported that although the Maasai leaders were sceptical about OBC, they accepted the contract mainly because development projects were promised.

However, the hunting license granted to OBC for the entire Loliondo GCA caused a national and international controversy and it is popularly known by the term "Loliondogate" (Nelson and Ole Makko 2003, Alexander 1993).[17]As regards the implementation of the terms of the contract, the initial hopes of the Maasai leaders quickly turned into disillusion and complaint about OBC. For instance, Rurai reports that between 1992 and 2006, OBC only paid $3,000 to each of the six affected villages. In 2007, the villages received $5,000, in 2008 and 2009 $25,000 and in 2010, the villages didn't receive any money from OBC (Rurai 2012). The failure to pay has been explained by an OBC employee with the argument that OBC money has not been spent properly by the villages (Rurai 2012). Therefore, the employee argued that OBC would rather invest into community development projects (ibid.). However, complaints about insufficient development projects were also raised by the communities: Within ten years, only a secondary school, extensional buildings of the Wasso hospital and a bridge were built, in addition to the drilling of 25 bore holes (ibid.). Protest has also been raised because OBC initiated the construction of permanent buildings and an airstrip without any clear authorization (Nelson et al. 2012).

A government district officer from the Ngorongoro District Council argues that "OBC has done some good work for the communities" but simultaneously emphasizes that

> "[g]razing land here is an issue of livelihood. Maasai people have to graze their livestock to survive. That is their life. If you deny them their grazing land, that means you actually deny them their right to live. That is the problem. So all the development projects are fine, but you cannot compare anything to someone's life. You cannot compare people's livelihood with other people's leisure." (Rurai, 30.10.2012).

The process of hunting and the resulting restrictions for the Maasai and their livestock are

[16] It was reported that OBC pays the central government 560,000 $ on an annual basis and the Ngorongoro District Council 150,000 $ annually Tanzania Natural Resource Forum and Maliasili Initiatives (2011). In respect of the hunting-quota-fees it was reported that non-residents paid in total 4,640,000 annually in the Loliondo GCA whereby the currency was not specified, but it is guessed that it has to be Tanzanian Shillings (Tsh) (that equals to 2884,64 $ with the exchange rate of 2013) (United Republic of Tanzania 2010).

[17] The term refers to a gate that was created by OBC in the late 1990ies to control the access to the northern part of the Loliondo division. Later, the gate was reopened (http://www.maasaierc.org/loliondo/obc.html, 17.9.2013).

explained by one elder in Ololosokwan as follows:

> "Actually, these guys sometimes spend three months in the area during the dry season. During this time, animals and people are not allowed to access the area completely. But besides that, the extensive hunting usually takes six days or one week. After this week, they come back one month later to hunt for another week. What they do is that they prepare everything so that the wild animals come, especially those animals with big horns that are desired by the hunters. Then they call the guests and hunting starts. So actually, there are three months in which they are sometimes here, and that is the time we are not allowed to access the area. […] This year there was also much biomass, and for one week it was ok, but the fear of the future is big." (elder 6, 26.10.2012).

Even though the hunting license was granted for the entire Loliondo GCA, OBC is mainly using a strip along the Serengeti National Park as their hunting ground. This is mainly due to the abundant wildlife found in this area. It should be noted that the boundary of the Serengeti is not fenced. Thus, the wild animals protected in the Serengeti are the same as those than can be hunted during the hunting season (from July to December) once they have crossed the western boarder of the Serengeti and entered the Loliondo area.

Since OBC is only using the strip alongside the Serengeti as a hunting ground, the six villages which are adjacent to the Park – namely Ololosokwan, Soitsambu, Oloipir, Olorien, Oloosoito-Maaloni and Arash – are the most affected by the companies' activities in this area.[18] This is also shown by the fact that only these villages received payments from OBC. However, all affected villages received title deeds in the 1990s, as already discussed for Ololosokwan in the previous chapter (Ojalammi 2006). Moreover, the Loliondo division is demarcated as village land as per definition of village land in the Village Land Act of 1999 (United Republic of Tanzania 1999. According to this definition, village land is under the management of the village council (United Republic of Tanzania 1999, Tanzania Natural Resource Forum and Maliasili Initiatives 2011, Ojalammi 2006).[19] This means even though the villages have possessed clear land rights the hunting concession was issued without consulting the villages which are now restricted in the access to their traditional dry season grazing area, (Nelson et al. 2012). In addition, it should always be borne in mind that whenever the land conflict of Loliondo is mentioned, this concerns the area alongside the Serengeti.

The land conflict reached a peak when pastoralists were evicted from the hunting area in 2009. It is not the aim of this thesis to precisely reconstruct the situation of this eviction. However, I will give a short overview of the situation in 2009: In July 2009, the Tanzanian government's Field Force Unit and the security forces of OBC forcefully evicted the Maasai from the hunting area i.e. their dry season grazing area in order to establish a "free-grazing-zone" on the intensive hunting ground of OBC (Nelson et al. 2012). In respect of this eviction a fact-finding mission of several civil society organizations under the Feminist Activist Coalition (FemAct) network was carried out in August of the same year. The organization reported that

[18] In some sources there is talk of about eight affected villages, including also Piyaya and Malambo village (United Republic of Tanzania 2010).

[19] The land policy of Tanzania differentiates between three categories of land: "reserved land", which consists of all land which is under natural protection, "village land", which is land under the administration of villages, and "general land" which is a residual category since it "means all public land which is not reserved land or village land and includes an occupied or unused village land." (United Republic of Tanzania 1998).

around 200 *bomas* were burnt in the course of the eviction.[20] In addition, several human rights abuses, such as rapes, were claimed (Feminist Activist Coalition 2009). However, the Ngorongoro District commissioner Mr. Elias Wawa Lali stated that the accusations made by the civil society organizations concerning the abuses were false (Feminist Activist Coalition 2009). According to reports, a court case concerned with the eviction is still being delayed (Lakaika, 12.09.2012). In addition, the United Nations Special Rapporteur on the Rights of Indigenous People has examined the case.[21]

The Tanzanian government claims that the eviction was necessary due to the overgrazing of the area (Feminist Activist Coalition 2009, Tanzania Natural Resource Forum and Maliasili Initiatives 2011). However, the condition of the rangelands should be seen in the light of the drought which the region suffered in 2009. As already discussed, the affected area functions as the grazing puffer zone of the region in hard dry seasons. For this reason, the area incurred a temporarily high grazing pressure in 2009, which however did not automatically result in long-term environmental destruction (Tanzania Natural Resource Forum and Maliasili Initiatives 2011, Nelson et al. 2012, Behnke et al. 1993). Thus, the area was only on a temporarily basis overused due to the extreme drought event.

The memory and emotions of the eviction were still intense during my fieldwork in Ololosokwan. An elder reports:

> "In 2009, we were evicted. There were permanent bomas like this one, and whenever they found one, they burnt it and everything which was in the boma was reduced to ash. […] Personally, I lost 140 cows during that year because of the drought. That was caused by them [OBC and the government] because after they burned the area, they evicted people from the area [the hunting area i.e. ronjo] and all cows came to this small area [the permanent area] and actually there was no way to prevent death of livestock. […] The situation is now a little bit better because after the intervention of the civil society and international community there came a small agreement that allows us to enter the area when the Arabs are not there for hunting. But whenever they hunt we are not allowed to access the area and if we are found there you will find us in jail. And it will be our cows that we have to sell to pay the fee to come out of jail." (elder 6, 26.10.2012).

As the quote of the elder already indicates, the situation in Loliondo calmed down after 2009. However, with the new Wildlife Conservation Act of 2009 which came into force in June 2010, the legal basis concerning the land conflict changed. In the former act of 1974, land use activities were not restricted within a GCA (United Republic of Tanzania 1974). The new act, however, banned crop cultivation under Section 20 (1), (c) and the grazing of livestock under Section 21 (1) within GCAs (United Republic of Tanzania 2009b). According to the TNRF (Tanzania Natural Resource Forum and Maliasili Initiatives 2011), this new passage is "[...] effectively giving the GCAs the same legal meaning as Game Reserves." In addition, the new

[20] FemAct also reported that they have received the following text message as they travelled to Ololosokwan in the context of the fact-finding mission: *"Dear Guest, Welcome to the UAE. Enjoy the best network coverage and other unmatched services only with Etisalat. Please use<+> or <00>before the country code for international calls. For directory services call 181, for availability of GPRS, MMS 3G roaming services call Etisalat Travellers help line 8002300 & for inquiries on Tourism, entertainment, shopping, etc call 7000-1-7000(Roaming rates apply) Have a pleasant stay in the UAE*." (Feminist Activist Coalition 2009)

[21] See http://unsr.jamesanaya.org/cases-2010/32-united-republic-of-tanzania-alleged-forced-removal-of-pastoralists (12.06.2013)

act says: “[…] the Minister shall ensure that no land falling under the village land is included in the game controlled areas.” (United Republic of Tanzania 2009b). Since the whole Loliondo district is also officially registered as village land, this new section has led to further debates concerning the question whether the GCA or the village land has to be degazetted to implement the law (Tanzania Natural Resource Forum and Maliasili Initiatives 2011). This has fueled the land conflict once again.

The situation is even more complicated since villages like Ololosokwan were granted a village certificate. An officer from the Ngorongoro District Council explains the situation of Ololosokwan if the GCA should remain in Loliondo:

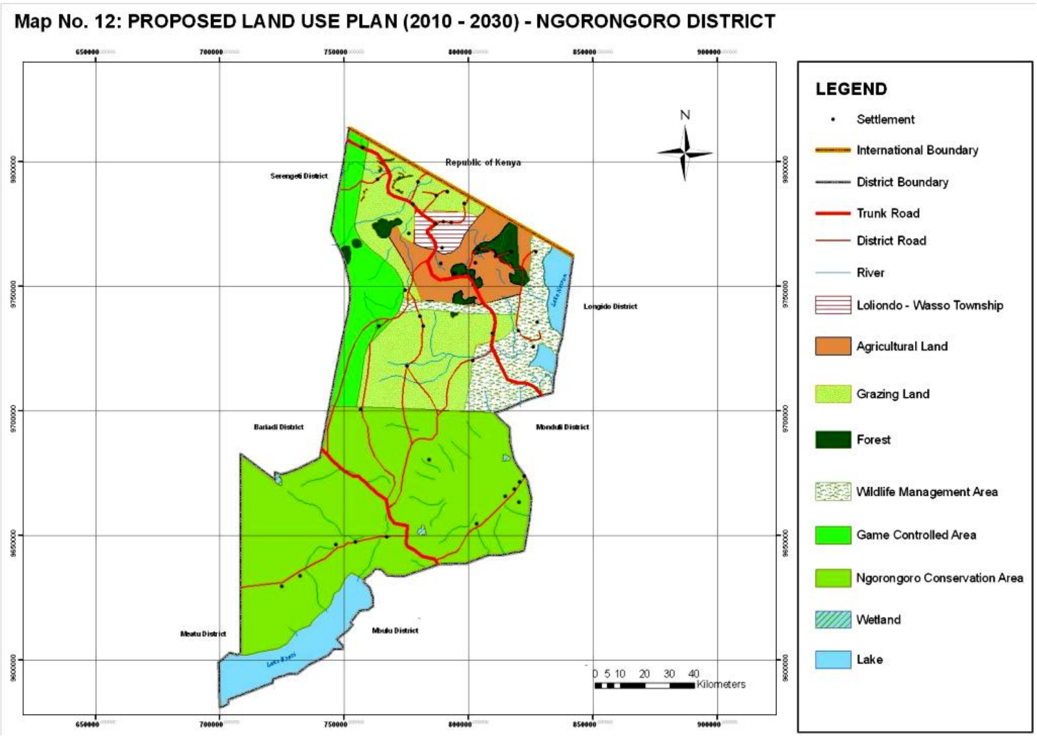
> “[…] if the government wants to acquire that land [the land of Ololosokwan village], it first has to degazette the land of Ololosokwan to make that certificate not applicable anymore. Ololosokwan then has to be given another land certificate. That is how it should be, because that certificate is a legal document given by the government. Otherwise, Ololosokwan has the right not to accept it. But of course the government has all the power. In the end the whole land of Tanzania is vested by the president. So the president can decide which land should be used for which purposes. In the end, when things go in that direction, then it has to be decided by the president.” (Rurai, 30.10.2012).

This quote indicates that even though Tanzania has one of the more progressive land laws in Africa, which gives clear land rights to villages, the power in the end is clearly centralized. Power culminates in the person of the president, since the “Fundamental Principles” of the Land Act says in Section 3 (1) (a): "[...] all land in Tanzania is public land vested in the President as trustee on behalf of all citizens" (United Republic of Tanzania 1998).

An effort by the government to implement the new wildlife act (i.e. to spatially separate the GCA from the village land) but also to appease the land conflict in the Loliondo area was the generating of a district land use plan in 2010 (United Republic of Tanzania 2010). This plan was thereby partly financially supported by OBC (Rurai, 30.10.2012, Rurai 2012). In the same year, a draft report of the Ngorongoro district land use plan with the name “District Land Use Framework Plan (2012-2030)” (hereinafter “Framework Plan”) was released (United Republic of Tanzania 2010). The Framework plan considers the Loliondo and Sale division of the Ngorongoro district and firstly presents a description of the divisions. This includes for instance a land resource inventory and information on the socio-economic setting of the area. However, in the end, it proposed a land use plan for the divisions which mainly says that the former GCA which cover 400,000 ha (i.e. the total Loliondo division) should be reduced to a 134,712.11 ha strip alongside the Serengeti. The remaining 265,287.89 ha of the division should then be designated as village land (see map2). [22]

[22] It should be noted that it seems as if the newly-proposed GCA is not a new idea. Gardner reports that a similar area was recommended in the Serengeti Regional Conservation Strategy (SRCS) in 1985 as “buffer zone”. In addition, the report advocated for the reclassification of GCAs such as Loliondo as buffer zones (Ngoitiko et al. 2010, Gardner 2012). Ngoitiko et al. (2010) reports other efforts to extend the boundaries of the Serengeti National Park.

Map 2: The original land use plan of the Loliondo and Sale division as proposed in the Ngorongoro District Framework Plan



Source: (United Republic of Tanzania 2010)

Indeed it seems as if the area of the newly-proposed GCA is the same area where OBC conducted their hunting activities in the past few years. In addition, there are plans to zone the village area in different land uses such as grazing and agriculture. Also Wildlife Management Areas (WMAs) are proposed within the village area (United Republic of Tanzania 2010).[23]

The suggestion of the total grazing area of both, Loliondo and Sale division within the Framework Plan already leads to concerns: The Framework Plan applies the carrying capacity concept and says that 1 Tropical Livestock Unit (TLU)[24] needs 2.5 ha in the Loliondo area (United Republic of Tanzania 2010). Since 428,125 TLUs are currently kept in the divisions (ibid.) the application of this carrying capacity would result in a demand 1,070,312.5 ha grazing land. [25] However, in the end only 292,927.86 ha of grazing area for both the Loliondo and

[23] Wildlife Management Areas (WMAs) are the proposed "administrative mechanism" of the Wildlife Policy of 1998 (Nelson and Ole Makko 2003). With the introduction of WMAs, which can only be established on village land, the government aims for "rural communities and private land holders to manage wildlife on their land for their own benefit" (Wildlife Policy of 1998 cited in Nelson and Ole Makko 2003). However, communities in the Loliondo area are sceptical about this community-based conservation approach because they believe that it is another attempt by the government to set large areas of community land under their central control (Nelson and Ole Makko 2003, Ngoitiko et al. 2010). Even though the establishment of a WMA is voluntary, villages of the Loliondo area were proposed by the government as a pilot area for the creating of WMAs. However, due to the explained fears, the villages, among them Ololosokwan village, have rejected the proposal (Captain Minja 13.11.2012, Nelson and Ole Makko 2003, Ngoitiko et al. 2010).

[24] "The tropical livestock unit (TLU) combines various livestock species into one standard unit based commonly on weight." (Fratkin and Roth 1990). Thereby one TLU is commonly taken to be an animal of 250 kg liveweight (Jahnke 1982).

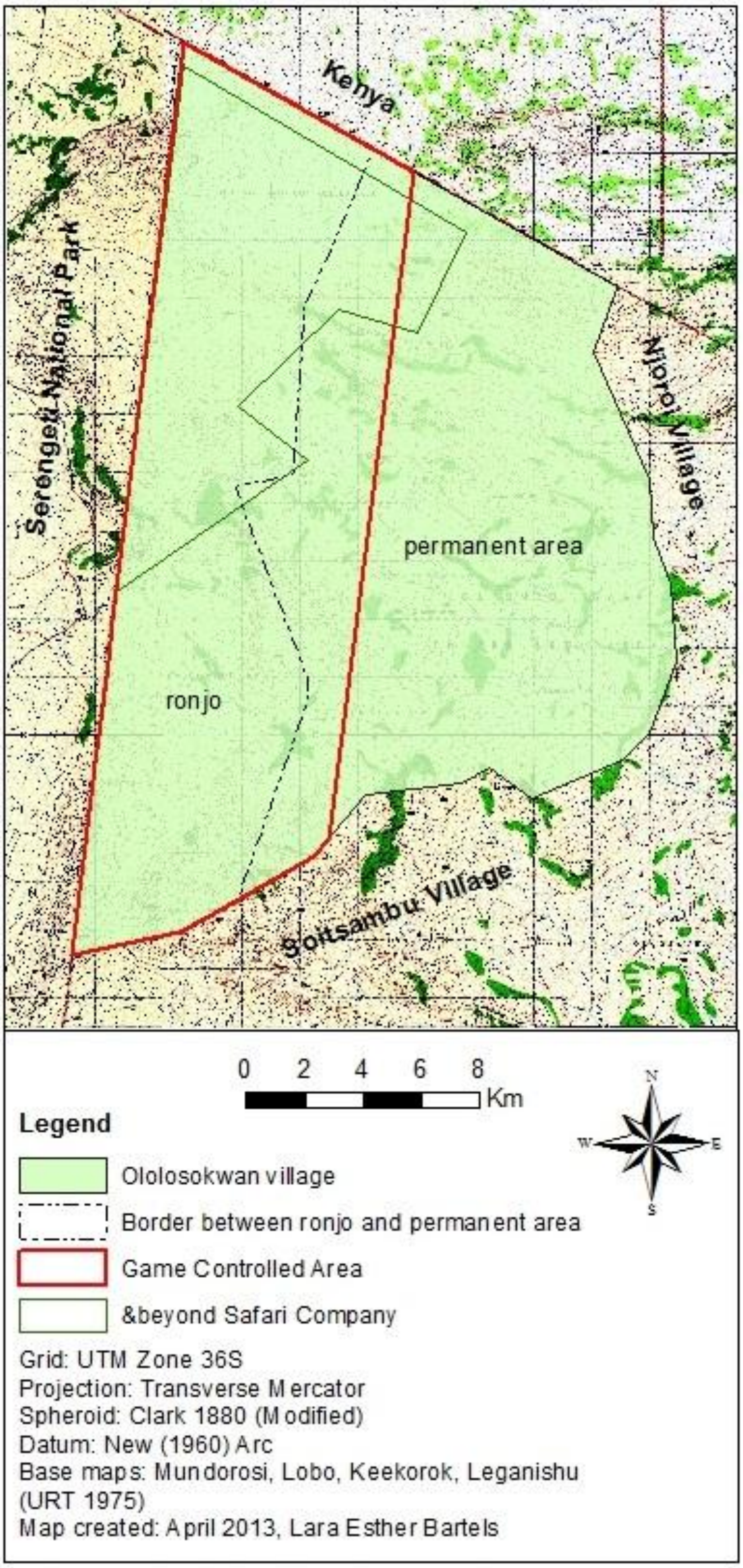
[25] It should be noted that a static carrying capacity has been criticized by the approach of the dis-equilibrium of African rangelands. It was argued that such rangelands are characterized by highly variable biomass productivity in time and space. Thus, it was concluded that a static carrying capacity is inappropriate to secure the sustainabil-

Sale divisions is proposed (United Republic of Tanzania 2010). Moreover, it was predicted that by the year 2030, 588,091 TLU will exist in the area (ibid.). If again the given carrying capacity is applied this means a grazing area of 1,470,228.00 ha will be needed by then. The indeed proposed grazing area covers only 20% of this future need of pastures. This small size of the proposed grazing area is maybe due to the suggestion of the Framework Plan that the area should be provided with major services and facilities such as improved pastures, dips and water dams. However, there is no assessment done about whether these are realistic possibilities (ibid.).

This already indicates that the establishment of the proposed GCA has significant consequences for the pastoralists in the Loliondo area. In addition, although the access to the hunting block of OBC i.e. the dry season grazing area of the Maasai is already restricted but once the newly-proposed GCA is established grazing is completely banned within the GCA. In other words the establishment of the newly-proposed GCA results in a significant loss of village land i.e. grazing land for the communities adjacent to Serengeti National Park. Ololosokwan, for instance, would lose 23,100 ha to the GCA if the Ngorongoro land use plan was implemented. This makes up 56.76% of the total village area of Ololosokwan. Thereby the whole dry season area and smaller part of the permanent area of Ololosokwan would be allocated to the proposed GCA, as my own calculation in chapter 3.2 shows. Map 3 depicts Ololosokwan village. The area which will be allocated to the newly-proposed GCA is indicated by a red line.

ity of the rangelands. Opportunistic range management allows for mobility and a flexible stocking rate should be rather practice in order to adapt to the dynamics of the ecosystem (see for instance Illius and O’Connor 1999, Behnke et al. 1993). For a good overview of the equilibrium and dis-equilibrium of rangelands see Vetter (2005).

Map 3: The village Ololosokwan and the fraction which will be allocated to the newly proposed Loliondo GCA



Before the proposed land use plan of the Loliondo area can be finalized, it has to be discussed and revised by different stakeholders (United Republic of Tanzania 2007). One of them, namely the councilors of the District Council General Assembly rejected the proposal in 2011. The councilors claimed that the plan was not performed in the participatory manner as intended by the guidelines of land use planning (Rurai, 30.10.2012). Rurai reports:

> "From there, things did not move forward. Until today, things are stuck, it is just a dilemma. […] The government announced that they want to create a buffer zone for the Serengeti. From the communities' point of view, this is like an extension of the Serengeti. These people here, they have a long reminiscing of the establishment of the Serengeti. You know the Maasai here - some of them are the ones who were evicted in 1959 […]. So they really do not understand when the government says they want to take more land. The communities have interpreted the government's intentions as another strategy to take community land to establish more conservation areas. That is why this framework has failed." (Rurai, 30.10.2012).

The surveys and interviews I did in Ololosokwan support this argument of Rurai in the sense that I was constantly told by the Massais about their fear that the government would take their land. But, also during my fieldwork it did not seem as if any new development or even a solution in respect of the proposed land use plan would occur in the near future.

However, on 26th of March in 2013, Hon. Khamis Sued Kagasheki, Minister for Natural Resources and Tourism, announced that the newly-proposed GCA would finally be established (Hon. Khamis Kagasheki 2013). In a second press release, the government of Tanzania pointed out:

> "[…] The Government of Tanzania recently made a decision to de-gazette 2,500 square kilometers of land, out of the gazetted 4,000 square kilometers, to allow local inhabitants of Loliondo area to freely utilize that land for their own community development. It was also decided that the remaining 1,500 square kilometers of land be retained as Game Controlled Area for continued protection of the wildlife and the environment for the benefit of the present and future generations of humankind." (Hon. Khamis Kagasheki 2013).

The following reasons were mentioned for this decision: The resolving of the land conflict in Loliondo and the providing of "land to the growing landless population in the area" (ibid.). Additionally it was argued that the area of the new GCA is "significantly important to the entire Serengeti and Ngorongoro ecosystem" as a crucial breeding area for wildlife, a corridor for iconic great wildlife migration and as a critical water catchment area (ibid.).

It is clear from this press release that the government does not acknowledge that the Loliondo area is also demarcated as village area and some villages even hold village certificates. Consequently, the Tanzanian Government frames the establishment of the newly-purposed GCA as the providing of land to the "landless" people of the Loliondo area. In contrast to this, a press statement of several civil society organizations in Tanzania in reaction to the decision of the government reads as follows:

> "It [is] important from the very beginning to make clear that enactment of Wildlife Conservation Act No.5 of 2009 neither altered the legal status of land owner-

> ship in the area nor transferred the ownership to the Ministry of Natural Resources and Tourism. It should be clearly understood that although the Director of Wildlife has legal powers to grant hunting permits for the game controlled area the same has no legal mandate whatsoever regarding the land of the said villages. […]It is utterly not true that the Government is giving 2,500 km^2 to the aforementioned villages. The truth is […] that the Government is grabbing 1,500 km^2 from the land falling within village boundaries." (Pastoralists Indigenous NGOs Forum et al. 2013)

Moreover, the civil society organizations have asked the government to reveal the truth, namely that they are mainly intending to give the 1,500 km^2 to the hunting company OBC (Pastoralists Indigenous NGOs Forum et al. 2013). The controversy about the government's plan to bring into force the newly-proposed GCA was also covered intensely in the media (see for instance Kimati 2013, Athumani 2013b, James 2013, Nkwame 2013a, Athumani 2013c, Patinkin 2013).

In addition, to the efforts made by civil society organizations, Loliondo residents themselves also strongly protested against the decision of the government. For instance, Maasai elders travelled to Dar es Saalam with the intention of meeting President Jakaya Kikwete (Kisanga 2013). It seems as if the protest was acknowledged by the government after the Maasai elders met with Prime Minister Mr. Mizengo Pinda who temporally suspended the land use plan and therefore the proposed redrawing of the boundaries of the Loliondo GCA (Nkwame 2013b, n/a; Tanzania Daily News 2013). In September of this year (2013) the Prime Minister ordered the abandonment of the plan to implement the redrawing of the boundaries of the Loliondo GCA (Nkwame 2013c, Makoye 2013). However, it is questionable if this decision secures the village and grazing area of the Maasai in Loliondo also in the future. In addition, this is no solution to the land conflict in the area.[26]

In conclusion, the frequently described land conflict in the Loliondo division is a conflict about the land use of a strip alongside the eastern border of the Serengeti. As indicated and analyzed by Rurai (2012) in detail, many stakeholders and interests are involved in this dispute. To resolve the conflict and also to implement the new wildlife act which prohibits the spatial overlapping of village land and GCA, the government proposed new boundaries of the Loliondo GCA. However, for the villages located within this newly-proposed GCA, the implementation would lead to significant land loss. Thus, the affected communities and NGOs fight for the right to acknowledge the fact that the area of the newly-proposed GCA was also demarcated as village land and is used as dry season grazing area by the Maasai. Opposing them is the Tanzanian government, which first supported the exclusive use of the area as hunting block of OBC by granting the hunting license and facilitating the eviction of the Maasai from the area in 2009. But with the newly-proposed boundaries of the Loliondo GCA, it seems as if the argumentation of the government has focused now on the need to conserve the nature of the area. In the following, it will be discussed why the attempt in March 2013 of the Tanzanian government to implement the proposed redrawn boundaries of the Loliondo GCA is regarded as a case of land grabbing.

[26] The design of this thesis is based on the development up to March 2013 i.e. when Hon. Khamis Sued Kagasheki, Minister for Natural Resources and Tourism, announced that the newly-proposed GCA would be established.

2.3 The implementation of the newly-proposed Loliondo Game Controlled Area (GCA) as a case of land grab

The debate about land grabbing has constantly intensified in the mid 2000s, driven by an increase of large scale international investments into land mainly for food or biofuel crop cultivation. The term "land grab" was therefore defined in this sense (Grain 2008, Cotula et al. 2009, Daniel and Mittal 2009). However, through the intensive study of land acquisition and dispossession, it became clear that the land grabbing phenomenon is not limited to the above-mentioned types of investments. Rather, land grabbing also includes acquisitions on smaller scales and can also involve domestic investors as well as foreign and national governments. In addition, it was revealed that land grabbing is not limited to the global south and the purposes of the land grabbing are not restricted to the above-mentioned. In addition, to the revealing of "green grabs", it was recognized that the phenomenon is not limited to land but also includes other natural resources like water (see for instance Borras et al. 2012, Borras and Franco 2012, see Zoomers 2010 for an early enhancement of the purposes of land grabbing, see Fairhead et al. 2012 for a discussion of "green grabs", see Bues 2012 for an insight into water grabs and see Franco and Borras 2013 for land grabs in Europe).[27] Consequently the definition of land grabbing was constantly enhanced (Borras et al. 2012). The Tirana Declaration of the International Land Coalition on "Securing land access for the poor in times of intensified natural resources competition" defines land grabbing or rather natural resource grabbing as

> "acquisitions or concessions that are one or more of the following: i) in violation of human rights, particularly the equal rights of women; (ii) not based on free, prior and informed consent of the affected land-users; (iii) not based on a thorough assessment, or are in disregard of social, economic and environmental impacts, including the way they are gendered; (iv) not based on transparent contracts that specify clear and binding commitments about activities, employment and benefits sharing, and; (v) not based on effective democratic planning, independent oversight and meaningful participation."(International Land Coalition 2011).

This definition of land or resource grabbing is used as working definition in this thesis. The definition already indicates that the newly-proposed GCA cannot be per se declared as a case of land grabbing. Rather it is dependent on the way the decision on the establishment of the proposed GCA was made. In January 2013, Hon. Khamis Sued Kagasheki, Minister for Natural Resources and Tourism still said about the land conflict in Loliondo:

> "We have to work closely with all parties; that is the investors, local communities living around investment areas, and local government, including your Member of Parliament, Mr Kaika Ole Telele. We will put in place a mechanism that will help solve the problem step by step." (Athumani 2013a).

However, these promises were not fulfilled in the decision to establish the new boundaries of the Loliondo GCA conducted by the Tanzanian government two months later (i.e. March 2013). Several of the mentioned aspects in the above-cited definition of land grab would be violated by the government, particularly the participation of all stakeholders, if the new GCA is established based on the decision made in March 2013. Thus, the implementation of the

[27] However, it was also criticized that "land grab" has become a "catch- all framework" (Borras and Franco 2010).

GCA based on the decision of March 2013 is regarded in this thesis as a case of land grabbing, as will be agued in the following in more detail:

The intention of the government behind the establishment of the new GCA is unknown. The government itself states that its intention is the conservation of the area whereby civil society organization says it is the providing of an exclusive hunting ground for OBC (see previous chapter). But regardless of the actual intention of the government if they designate the newly-proposed GCA without the agreement of the councilors of the District Council General Assembly, as they attempted, this will be an injury of their own guidelines of participatory land use planning (National Land Use Planning Commission 1998).

In order to implement the provisions of the new wildlife act of 2009, it has been stated that the village land has to be degazetted in the Loliondo area. This is based on the argumentation that the GCA had already been gazetted in 1959 and therefore happened previously to the gazetting of village land in Loliondo (Captain Minja, 13.11.2012). However, the gazetting of village land within a GCA was not banned by any law before 2009. Moreover, land uses within a GCA were not prohibited. But regardless of whether the village land or the GCA are now to be degazetted it remains out of question that the area has been inhabited by locals now for “some 40 years”, as Minister Hon. Khamis Sued Kagasheki also acknowledged (Athumani 2013a). Thus, there is a need to include the local communities in the planning process.[28]

The report of the Framework Plan indicates that stakeholders like local communities were included in the field-work stage of the preparation of the Framework Plan (United Republic of Tanzania 2010). However, in the end, the drafting of the proposed district land use plan was done after the field work stage, and - although presumably based on the previous insights of the consultant stakeholders - without the involvement of affected stakeholders. But, in order to speak of a participatory procedure, an approval of the purposed land use plan by all stakeholders, including the affected communities, is needed. A “discussion and revision” of the proposed Framework Plan by all stakeholders of the district is also required by the Land Use Planning Act of 2007 in Section 32 (3) (b) (United Republic of Tanzania 2007). Even in the Framework Plan itself, it is stated that the Framework Plan is in a draft stage and therefore needs input from different stakeholders (United Republic of Tanzania 2010). The current protest from inhabitants of the Loliondo area shows that they disagree with the establishment of the newly-proposed GCA. So, an approval of the land use plan in its current design is more than unlikely.

The attempt to establish the newly- proposed GCA is a top down approach, in which the government does not give specific alternatives or compensation to the affected villages that will suffer from the land loss. Indeed, the Framework Plan does indicate potential future land uses and managements (ibid.). But these plans are made in respect of the whole district. There are no precise suggestions or alternatives for villages like Ololosokwan, which will lose more than 50% of its village area if the proposed land use plan is really implemented. The only concrete suggestion for Ololosokwan is the establishment of a WMA (ibid.).[29]

It was stated that the decision about the designation of the newly-proposed GCA of the government was done on the basis of “various research reports”, without giving more details (Athumani 2013b). However, the Framework Plan itself just says that the new GCA will be

[28] Actually the District Framework even states that the area was inhabited even “long before the colonial area” (United Republic of Tanzania 2010).

[29] The possibility to implement this and some other suggestions will be discussed in the final chapter of this thesis (see chapter 6.3).

established as a 134,712.11 ha strip alongside the Serengeti border (United Republic of Tanzania 2010). At the same time, it lacks details on the assessment why especially this area has to be set as GCA. However, in respect of the above (see chapter 2.2) mentioned reasons given by the government, it seems as if they only considered the undoubtedly desirable protection of the Serengeti ecosystem. But it appears that the government does not investigate or even care for the socio-ecological impacts on the villages that will suffer from the loss of a significant amount of village land due to the establishment of the proposed GCA. In addition, it has not even been discussed if there are any alternatives to the GCA in order to protect the greater Serengeti ecosystem without excluding the inhabitants from the area (United Republic of Tanzania 2010).

In the following, I will present the methods, materials and data sources which were applied in this thesis to precisely investigate the socio-ecological impacts on the village Ololosokwan if the proposed GCA is implemented.

3 Methods, Materials and Data Sources

This chapter will present the concept of the Human Appropriation of Net Primary Production (HANPP) and how I adapted it in this study. Moreover, additional methods which were applied in order to cover aspects of the impacts of the newly-proposed GCA on Ololosokwan which cannot be captured by the HANPP analysis will be presented. Finally I will give some insights into the fieldwork process in Tanzania and specifically, in Ololosokwan.

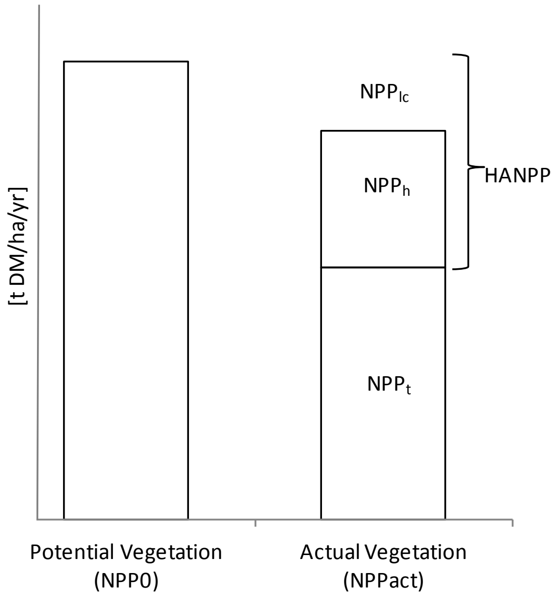
3.1 The concept of Human Appropriation of Net Primary Production (HANPP)

"Human Appropriation of Net Primary Production" (HANPP) is an integrated socio-ecological indicator which quantifies the intensity of the human use of natural ecosystems, in other words, colonizing interventions in ecosystems by humans (Erb et al. 2009, Fischer-Kowalski et al. 1997). The term Net Primary Production (NPP) is a measure which denotes the amount of biomass that is produced annually on a defined area by autotrophic organisms like plants through the process of photosynthesis. In contrast to Gross Primary Production (GPP), the term Net Primary Production does not include the energy needed for the plants' own respiration and therefore considers only the build-up of new biomass (Haberl et al. 2004). NPP is the annual biomass flow which is the energetic basis of all consumers and destruents, including humans.

Humans can appropriate NPP in two ways: 1) through land conversion (NPP_{lc}), taking into account current and past changes in land cover and use, as well as their consequences, for instance soil degradation, which alters the productivity of the former natural ecosystem and 2) through harvesting (NPP_{h}) which includes not only harvested crops and wood, but also grazed biomass and the biomass which is destroyed during harvest or due to fires caused by humans (Fetzel et al. 2012). This interpretation of HANPP is made from a societal perspective. From an ecological perception, HANPP quantifies the human impact on the amount of NPP which is available in ecosystems and therefore to all other heterotrophic organisms (Erb et al. 2009). This is the biomass which remains after the intervention of humans (NPP_{t}). This remaining biomass can be measured by taking the difference between the potential NPP, meaning the biomass which would be produced in the absence of human activity (NPP_{0}) and the portion of NPP of the current vegetation (NPP_{act}) that remains in the ecosystem after harvesting (ibid.). Thus, HANPP is an interdisciplinary concept.

Figure 4 illustrates the different HANPP components based on the definition of HANPP by (Haberl et al. 2007) which is also applied in this study.

Figure 4: The HANPP indicator



HANPP can be calculated as $NPP_{lc} + NPP_h$ or as $NPP_0 - NPP_t$

By measuring HANPP and its components, it is possible to evaluate the impact of different land use practices on the ecosystem (Erb et al. 2009). HANPP closely links to ecosystem patterns and processes e.g. biodiversity, productivity and thus carbon balance (Fetzel et al. 2012, Haberl 1997). In general, it can be said that HANPP has been developed "to provide insights into the sustainability of society–nature interaction." (Haberl et al. 2004).

HANPP was first applied on a global scale, whereby in these early studies, only biomass directly consumed by humans was included (Whittaker and Likens 1973). However, over time, various studies on global level were published with a progressively inclusive definition of HANPP (Vitousek et al. 1986, Wright 1990, Imhoff et al. 2004, Haberl et al. 2007, Krausmann et al. 2013). HANPP studies were also conducted for defined territories (Fetzel et al. 2012). A HANPP analysis was also already conducted for protected areas on a global scale (O'Neill and Abson 2009). HANPP studies on national level are prevailing. These are primarily in the design of time series analysis in order to be able to analyze patterns, drivers and trajectories of the HANPP in a specific country (Prasad and Badarinth 2004, Kastner 2009, Kohlheb and Krausmann 2009, Musel 2009, Schwarzlmüller 2009, Niedertscheider et al. 2012). HANPP applications on local level are rare and the methodology is not as developed as for applications on national scale. For a local HANPP in Thailand see (Grünbühel et al. 2003), for a HANPP on an Indian island see (Singh et al. 2001, Singh and Grünbühel 2003), for the methodology to calculate HANPP on national level see (Krausmann et al. 2008). Some ideas for developing HANPP methodology for local scale are presented in (Schandl et al. 2002).

This thesis aims at conducting a local HANPP calculation for the village Ololosokwan. This is done in order to analyze a specific case of land grabbing which has been described in the previous chapter. In the following, the application of the HANPP concept in this study will be presented and explained.

3.2 The application of the HANPP approach in this study

In order to examine the impacts of a particular land grab case with the help of the socio-ecological indicator HANPP, at least two HANPP calculations have to be conducted: Firstly, a HANPP assessment which quantifies the current intervention into the ecosystem, and secondly, a HANPP assessment which estimates this after the land grab has occurred. Consequently, for the case study investigated in this thesis, the status quo of the colonizing interventions of the inhabitants of Ololosokwan has to be calculated first. For the purpose of this calculation, the year 2012 has been set as the reference year. This is the year in which the fieldwork for this thesis took place.

The interviewed Maasai of Ololoskwan reported that the newly-proposed GCA would certainly have a great impact on their future as pastoralists however; they could not give strategies how they would adapt to the land loss. In addition, the Tanzanian government has not yet presented concrete alternatives in respect of future land uses and socio-economic activities for the villages which suffer from land loss due to the newly-proposed GCA.[30] Thus, the second HANPP calculation of this study is not based on scenarios showing possible land uses and management changes in the village as outcomes of the creating of the newly-proposed GCA. This thesis already starts one step earlier by calculating the hypothetically alteration of the HANPP of the village Ololosokwan ceteris paribus but with a reduced village area. This means the second HANPP calculation considers the reduced village area but all other factors stay equal to those of the status quo calculation.

In Ololosokwan, 2012 was a year with an averagely high primary production. However, African semi-arid savannas are characterized by high inter-annual precipitation and, since precipitation and Net Primary Productivity is highly correlated, also by high NPP dynamics (Lieth 1974). This means that a single HANPP calculation for one year, in this case 2012, does not reflect the whole picture since the potential vegetation (NPP_0) and the actual vegetation (NPP_{act}) - and thus the HANPP - can variegate significantly between years and months.

The present study accounts for these NPP dynamics. Thus, conclusion on the question can be drawn whether the impacts of the establishment of the newly-proposed GCA will only serious during an averagely drier year. This is done by calculating the HANPP of Ololosokwan based on a year with an average lower NPP in addition to the calculation for a year with an averagely higher NPP (i.e. the year 2012).[31] The historical NPP data of the year 2008 will serve as an example for a year with lower NPP.

The example years, 2012 and 2008 were not only chosen because of their on average higher and lower NPP. They were also described by the Maasai in Ololosokwan as example years for a "good year" (2012) and a "bad year" (2008) for pastoralism.[32] Thereby the classification "good" means that they have no severe problems to sustain the livestock even though it is quite normal that the livestock gets thin during the dry season. In a "bad" year, it already be-

[30] As already mentioned in chapter 2.2, the government has only proposed to establish a WMA in the Ololosokwan village. Until now Ololosokwan has refused to agree, but as discussed in the final chapter, it would be interesting to establish a scenario for this option.

[31] Droughts are common in Ololosokwan as in all semi arid savannas. This means that years with an averagely very low NPP occur regularly, such as the years 2005 and 2009 in the case of Ololosokwan.

[32] The classification of the different years was done in focus group discussions on 6th and 7th of October 2012, at the beginning of the fieldwork in Ololosokwan. In Maa, a good wet season or a good dry season for pastoralism are called *Olari Seur* and *Olameyu Sidai* respectively; a bad wet season is called *Olari Sarash* a bad dry season is called *Enkarri*, a drought is also called *Enkarri*.

comes hard to sustain the livestock with the available range forage. One indicator for such a situation is for example the need to cut branches off trees as fodder for the livestock. During such a year, several of the livestock will die, but not as many as during a drought (focus group discussion 2, 07.10.2012).[33] However, this classification of the indicated years is only valid in the case of pastoralism. For instance, the beginning of the agricultural year 2012 was a good one for crop cultivation. However, this changed in the second half of the year, which resulted in a moderate crop yield, as reported by the agriculturalists Iraqw during the conducted survey in Ololosokwan.[34] But since pastoralism is the major land use in Ololosokwan, the above classification was used to identify appropriate example years.

In conclusion, this study will include four HANPP calculations which differ only by two factors i.e. the size of the village area and the productivity. As shown in figure 4 the HANPP calculations which consider the original village area are named "base calculation" whereby the calculations which considers the reduced village area are called "land grab calculation". Both of these HANPP calculations are conducted for a year with averagely higher ("good year") and averagely lower ("bad year") biomass productivity.

Figure 5: The HANPP calculations conducted in this thesis

size of the village area	Annual Net Primary Productivity: averagely higher	Annual Net Primary Productivity: averagely lower
without land grab	**base calculation - good year** (status quo)	**base calculation - bad year** (counterfactual)
with land grab	**land grab calculation - good year** (counterfactual)	**land grab calculation - bad year** (counterfactual)

The calculation "base calculation – good year", which refers to the original village area of Ololosokwan and the year 2012 is also named "status quo calculation". This is because the calculation is based on the land use activities which have really taken place and were surveyed in 2012. The land use activities carried out in 2012 were thereby also applied to the other three calculations. Thus, the other calculations are counterfactual calculations of the current (that of the year 2012) situation of Ololosokwan. Each counterfactual calculation thereby gives another insight into the question how the HANPP patterns would look like:

- if the year 2012 had been a year with averagely lower NPP productivity ("base calculation – bad year").
- if the proposed GCA had already been established in 2012 ("land grab calculation – good year")

[33] For example, due to the drought of 2009, 55.6 % of the cattle population of Ololosokwan died (rough estimation of the Ngorongoro District Office, Livestock Department).

[34] The third biomass-related activity practice in Ololosokwan is wood collection for various purposes. This activity is not dependent on the level of precipitation in one year, since a stock is harvested.

- if the proposed GCA had already been established in 2012 and 2012 was a year with averagely lower NPP (“land grab calculation –bad year”)

Consequently these three HANPP calculations are hypothetical. However, in order to assess how realistic the outcomes of these calculations are, an additional set of calculations on the range forage availability in Ololosokwan will be conducted. These calculations assess the maximal exploitability of the pastures of Ololosokwan for all situations investigated in this thesis. Since pastoralism is the most significant land use practice in Ololosokwan conclusion can be drawn if the particular counterfactual HANPP level of Ololosokwan can be indeed reached on a less productive and/or reduced village area or if these factors restricts the currently conducted land use activities. In addition, it can be shown if the current appropriation of biomass through grazing of livestock already reached the maximal exploitability of the original pastures of Ololosokwan or if there is still some leftover of range resources. To account for the intra-annual NPP dynamics this calculation will be conducted on a monthly basis.

The discussion about the design of the different HANPP calculations goes hand in hand with the question of the system boundaries of this study. HANPP is a spatially explicit indicator. Therefore, it is important to determine the geographic boundaries; likewise, the analyzed social system, which is another type of boundary, that is essential to define (Singh and Grünbühel 2003). In the following, I will start to describe the last mentioned boundaries, followed by an explanation of the spatial boundaries applied in this thesis.

The social system under investigation is the Maasai Community of Ololosokwan. This means all land uses undertaken by the inhabitants of Ololosokwan are considered in this study. The aforementioned also relates to the livestock population of Ololosokwan. This means only the appropriation of biomass through the current livestock, belonging to inhabitants of Ololosokwan is considered in the HANPP calculations. In addition, only the grazing within the village area of Ololosokwan is taken into account.[35]

This denotes already the geographic boundaries of this study. The geographic boundaries refer to “the domestic environment” (ibid.) of Ololosokwan, meaning the territory where the inhabitants of Ololosokwan are able to conduct their land uses. Unfortunately, the size of the village area is not that clear. According to the Ololosokwan village office and the document of the village title deed Ololosokwan received in April 1975, the village comprises of 51,320 ha. However, other values are presented in different sources: According to Ndinyo (2002) the village area amounts to 51,230 ha, to 46,539 ha according to Nelson and Ole Makko (2003), who refers to the village certificate Ololosokwan got in the 90s, and to 46,000 ha according to Sosovele (n/a). It is difficult to comprehend which of the data may be correct, since the coordinates of available maps of Ololosokwan are missing.[36]

Thus, I georeferenced two maps of Ololosokwan with the program ArcGIS 10.0, which were

[35] However, livestock keepers from Ololosokwan sometimes also move to areas outside the village boundaries in search of better pastures. But due to the favorable condition of their own pastures, this does not happen that often. The conducted survey shows that none of the livestock keepers moved out of the village boundaries in the year 2012, hence it is realistic to include the whole livestock population of Ololosokwan in the calculation.

[36] Coordinates are missing in the official map, facilitated by the Ministry of Lands, Housing and Urban Planning (pers. Comm. 29.01.2013 with Jackson L. Saitabau, the officer who did the survey of Ololosokwan) and in the land use map the NGO Ujamaa Community Resource Team (UCRT) produced for Ololosokwan in 2008 (pers. Comm. 22.09.2012, with Dismas Partalala Meitaya from UCRT who coordinated the land use mapping process in 2008).

available as soft copies: the land use map facilitated by UCRT in 2008, and a land use map that was created in 2003. After the digitalization of the village boundaries, the program calculated that the village area of Ololosokwan amounts to 40,700 ha based on the map from 2008, and to 39,700 ha based on the map from 2003.[37] I decided to use the results from the map from 2008 in this study. The size of the village area is the second lowest that was found amongst all available data. However, there was no other option than to use one of the values generated with the help of ArcGIS. This is because for the land grab scenario, it must become clear how much of the village area of Ololosokwan would be allocated to the proposed GCA. Data specifying this area are not available, but GIS data, of the proposed Ngorongoro land use plan, which gives the total area of the newly-proposed GCA, are available. Thus, it is only possible to calculate the fraction of the GCA which would fall within Ololosokwan village land with the use of GIS techniques. However, for this calculation, the boundaries of the village Ololosokwan also have to be available in GIS. For that reason, it is not possible to use data that is reported in literature without presenting an accurate map. I decided to use the value 40,700 ha, generated from the 2008 map in favor of the value generated from the map of 2003. This is because the aforementioned figure is based on the latest available map of Ololosokwan, also in respect of the different land uses, which are indicated on the map.[38] Consequently, all HANPP calculations are based on the value 40,700 ha as the size of the village area of Ololosokwan.[39] However, the spatial boundaries for the base calculations do not comprise the whole 40,700 ha because the inhabitants of Ololosokwan cannot use the whole village area for their land use activities. Ololosokwan has leased out 10,117 ha (25,000 acres) of their village land to the luxury safari company *&beyond*.[40] Therefore, the inhabitants of Ololosokwan are only able to conduct their land uses on the remaining 30,583 ha. For the base calculations I refer to these 30,583 ha as the domestic environment or the geographical boundaries, respectively.[41] The GIS calculation showed that after the establishment of the newly-proposed GCA, the size of the Ololosokwan village would amount to 17,600 ha, i.e. the GCA would occupy 23,100 ha of the original village area. [42] This is 57 % of the entire original village area, i.e. 40,700 ha.[43] Thus, the geographic system boundary for the land grab

[37] The slight differences between the results are caused by a lower angle of the boundary line between Ololosokwan and Njoroi village at the height of the Kenyan border in the map from 2003 compared to the map from 2008. Nevertheless, the similar results show that the calculation of the village area must be correct.

[38] As already mentioned earlier, the land use plan generated by UCRT was not accepted by the Tanzanian government. The reason, however, was not the position of the indicated boundaries. Rather, the government claimed that the plan was not done in accordance with the Participatory Land Use Management Guidelines United Republic of Tanzania (2010).

[39] Several permanent and non-permanent rivers flow through Ololosokwan. It was not possible to exclude these water bodies from the village areas in order to get only the land surface. However, especially in the dry season, the overall expanse of these water bodies might be insignificant.

[40] According to registered plan no. 26356 of the year 1993, the Farm no. 520 belonging to *&beyond*, consists of an area of 9,290 ha (22956.09 acre). However, the manager of *&beyond* and the inhabitants of Ololosokwan reported that the company has leased 25,000 acres (10,117.14 ha). Because these two parties have to agree on the conditions of the rent, I use their reported data for this study.

[41] If in the following there is reference to the village area of Ololosokwan, only these 30,583 ha are considered, and not the actual 40,700 ha of the village.

[42] For this calculation, minor corrections of the GIS-data which indicate the whole area of the newly-proposed GCA have to be undertaken. The polygon of the new GCA did not entirely overlap with the boundaries of Serengeti NP, as indicated in the used base maps Leganishu (15/2) and Lobo (15/3) dated in 1978 and produced by the Government of the United Republic of Tanzania.

[43] If only the 30,583 ha are considered, which already excludes the rented area of the company *&beyond*, 32% of the village land will in addition not be accessible for the villagers. This is due to the fact that the area of

calculation is related to these 17,600 ha.[44]

The HANPP calculation is carried out on an annual basis. The study only refers to above-ground processes; only terrestrial; soil processes or belowground productivity are not taken into account (indicated by the prefix "a", e.g. aHANPP).

HANPP can be defined as a material flow (measurable in kg dry matter biomass), as a substance flow (kg carbon) or as an energy flow (Joule) per unit of time (Haberl et al. 2004). This study will express aHANPP in kg dry matter (i.e. water content 0%) biomass per year. However, the data can be easily converted into the other units by assuming that "1 t DM is equivalent to 0.5 t C and that the calorific value of dry matter biomass is around 18.5 Megajoules per kilogram" (Erb et al. 2009:253).

3.3 Expert Interviews: additional data for the analysis of the land grab

In order to also cover impacts of the establishment of the newly-proposed GCA which cannot be detective by the HANPP approach I conducted semi-structured expert interviews with Maasai elders of Ololosokwan (see also the next chapter, for the method of expert interviews see Bogner et al. 2002).

For instance, the HANPP approach considers NPP in a solely quantitative manner and does not, for instance, distinguish between more or less nutritious biomass. If an area is grabbed which is characerized by nutritious grasses, its loss will have a disproportionally higher influence on the diet and health of the grazing livestock and consequently on pastoralism as such. This impact will not be reflected by a HANPP analysis as well as aspects which are not related to biomass. Thus, the research design i.e. the combination of different qualitative and quantitative methods was selected to ensure a certain triangulation of the results. Triangulation is thereby understood as a comprehensive coverage of different aspects of the same phenomena due to a mixture of applied methods (Kelle and Erzberger 2007).

For the purpose of the expert interviews in this study it is sufficient to capture the manifest statements of the interviewed Maasai in respect of the impacts of the establishment of the newly-proposed GCA on their village. Thus, a summarizing content analysis inspired by Mayring (2010) was conducted. However, it should be noted that the results of the expert interviews will reflect the perspective of the Maasai people in Ololosokwan. The fact that the selected experts are also the people who are affected by the land grab can lead to a bias in the results. It was attempted to mitigate this problem by testing the interviews of their own inner coherence (Meuser and Nagel 2002). In addition, the design of the part of the expert interviews used to explore various impacts of the land grab was done in a standardized but still open manner (Bogner and Menz 2002, see also next chapter). Hence, a comparison of the different interviews i.e. statements is possible. Thus, after the summarizing content analysis, a frequency analysis of similar statements referring to impacts of the land loss was carried out. Thus, it could be investigated whether a particular mentioned impact is just a single impres-

&beyond spatially overlaps with the newly-proposed GCA. However, even though Ololosokwan inhabitants can currently only access 30,583 ha of their entire 40,700 ha village area, they are still the "owners or managers" of the entire 40,700 ha. If the GCA were established, they would only "own" 17,600 ha.

[44] Only a small area of the *&beyond* concession still belongs to the reduced village area (17,600 ha) that would remain after the establishment of the GCA. However, I did not subtract this area from the reduced village area in order to only consider the area were land uses can be carried out. For this study, the rented area of *&beyond* is negligible since it almost completely overlaps with the area of the new GCA. In addition, it is not clear what will happen with the area of this safari company if the new GCA is established.

sion of one person or if the argument can be regarded as an opinion shared by several individuals of the community. However, the qualitative manner of the statements will still be given place.

3.4 Data collection, availability and quality

A HANPP analysis on national or global level mainly uses statistical data from official sources like the Food and Agricultural Organization (FAO). In contrast to this, HANPP studies on local level are dependent on data gathered through empirical fieldwork (Singh and Grünbühel 2003). Thus, I spent from the end of August to mid-November 2012 in Tanzania for data gathering purposes.

For the whole October, i.e. the end of the dry season, I stayed in Ololosokwan. During the stay in Ololosokwan I gathered most of the valuable data for this study. Direct observations, on-site measurements and estimations, focus group discussions in addition to semi-structured expert interviews and a survey via a standardized questionnaire were conducted.

During September, the pre-processing phase, I prepared the direct fieldwork in the Maasai Community Ololosokwan. This was done in Arusha as an intern at the Tanzania Natural Resource Forum (TNRF). The preparation did not only include logistic and bureaucratic issues. Explorative expert interviews in Dar es Salaam and Arusha were carried out to gain first insights into the specific problems of pastoralists related to land in Tanzania (see Bogner and Menz 2002 for explorative expert interviews). Afterwards, more and more focused explorative expert interviews, especially with NGOs concerned with pastoralism, were conducted. The interviews were held with the purpose of enlarging my knowledge of the pastoral system, but also to shape my awareness of the specific situation of the Maasai in Loliondo. These interviews were used mainly as background information and were already used in this sense in the previous chapters. Moreover, the findings gained from the interviews have been used to finalize the guideline of the semi-structural expert interviews with the Maasai elders and the design of the questionnaire.

The post-processing phase of the direct fieldwork in Ololosokwan was characterized by a last gathering of data in Loliondo village, Arusha and Dar es Saalam. Additional interviews were conducted in order to validate the first findings of the fieldwork in Ololosokwan and to discuss the Ngorongoro District Framework Plan with some representatives of the central government (see the references for a detail list of interview partners).

In the following, I will go into more detail regarding the collection, availability and quality of data concerning the fieldwork in Ololosokwan: In Ololosokwan I lived with one Maasai family in a traditional *boma*. Thereby I spent time in both areas: the permanent area and the *ronjo*. I was accompanied by my field research assistant Paul Ole Saing'ue who grew up in Ololosokwan, but left the village some years ago for his studies and job employment. Paul was most essential for this thesis. He not only ensured my access to the field, but also translated all interviews, questionnaires, focus group discussions in addition to everyday conversations from the Maasai language Maa directly into English. Moreover, he served as a "cultural translator" for both me and the Maasai of Ololosokwan. Before we went to Ololosokwan, we had long meetings and discussions during which I made Paul familiar with the topic of this thesis and particularly the aims of the fieldwork in Ololosokwan. In turn, Paul prepared me with practical but also cultural issues for my stay in Ololosokwan. Together we discussed and finalized the questionnaires and the question catalogue for the qualitative Interviews. During but also after the fieldwork in Ololosokwan, we had long discussions about practical issues, but we also regularly reflected on the interviews we had conducted.

Of course, the question might arise as to whether there is a bias in my research because my assistant is a member of the community I investigated. However, because of the long lasting land conflict and the suspicion of non-native people resulting from this, it is impossible to gather credible data without a field research assistant who is well known by the interviewee and has their trust. In addition, it was advantageous that Paul knew the area and had no difficulties in identifying useful interview partners and interview them. In addition, the quality of the obtained data seems to be reliable since the interview partners reported the data without any sign of fears. This could be due to the fact that I was not an official and could gain their trust since I lived with them. However, even though Paul translated almost every conversation, there was of course a language barrier. Without this barrier I would surely have been able to gain an even deeper insight into the community.

A majority of the quantitative data needed for the aHANPP calculations was obtained through a survey Paul and I conducted together in Ololosokwan. The applied questionnaire was designed to cover a whole *boma* and consisted of several parts which were allocated to different interviewees in respect to their responsibilities: the household part, which included questions about the members and organization of the *boma,* was asked mainly to elder women of the *boma*. The pastoralism part included questions about the livestock of the *boma* and their management and was asked to one of the young herders of the *boma*. The last three parts of the questionnaire were asked to all married women of the *boma*. These parts included the livestock production part, consisting mainly of questions regarding the milk production, the agricultural part, covering all question regarding crop production, and finally the wood part, where questions regarding wood collection were asked.

It was not possible to conduct a random sample for the survey. There was no list available which indicates the names of all *bomas* of Ololosokwan and where the *bomas* are located. However, the total number of the *bomas* of each sub-village was available. Therefore we decided to apply a weighted sample according to the *boma* numbers of the sub-villages. We also took into consideration to include larger and smaller *bomas,* in respect to the size of the livestock herd and the number of *boma* members, into the sample.

Several fieldwork restrictions have occurred. For example, it was a challenge to interview the young herders, who were always out grazing with the livestock. Another restriction was the lack of means of transport which resulted in long walks to relevant *bomas* which are scattered within the village. Therefore, it was only possible to interview in total 19 Maasai *bomas* out of 102 within the limited fieldwork period in Ololosokwan. Four of the conducted questionnaires were done in the *ronjo*. In this case several questions were added to the questionnaires in respect to the ongoing process that even the *ronjo* is becoming a permanent settlement area. In addition, two interviews could be conducted with the agriculturalists Iraqw. Here, amended questionnaires were applied, which mainly excluded the pastoralism part and included more questions regarding crop production. The sample size of 21 in total (19 pastoralists, two agriculturalists) is critical in respect of its representation. This is still true even though the sample size of the parts from which I derived the main data for the aHANPP calculation is larger (up to 50), as all women of the Maasai-*boma* were interviewed. Therefore, the data used for the aHANPP as well as the results of the calculation were always cross-checked if secondary data were available (see also chapter 6.1).

Also other limitations occur: As discussed in chapter, 2.1.4 the transhumant Maasai have a traditional grazing pattern in which they alternate between dry season pastures and wet season pastures. Even though these traditional patterns have already started to erode, there still exists a spatial division of the village area into two parts, which I named "*ronjo*" and "permanent area". While in the *ronjo,* only the biomass-related activities grazing and firewood collection are taking place, farming is also an important factor in the permanent area. Because of this spatial separation of land uses in the domestic environment of Ololosokwan, the initial plan was to conduct aHANPP calculations separately for the *ronjo* and for the permanent area. However, due to data limitation it was not possible to realize this plan (see also chapter 6.1). For instance, it was not possible to reflect the livestock distribution over these two areas particularly for the whole year; patterns generated from the conducted survey are not representative. Thus, only aHANPP calculations for the whole village area were conducted. However, the separation of land uses and its implications will be considered in a qualitative manner in this thesis.

In addition to the survey we carried out, eight semi-structured expert interviews with male elders from Ololosokwan village were conducted, as already discussed in the previous chapter. [45] All interviewees used to live and graze their livestock in the area before 1959, where today the Serengeti National Park can be found. These interviews had several aims: First of all they helped me to get a deeper understanding of the Maasai society and their interaction with the natural environment, and particularly changes occurring in these interactions over time. It was also crucial to gain this understanding for the performance of the different aHANPP calculations. In addition, the interviews were conducted to get an additional insight into impacts of the establishment of the new Loliondo GCA, as discussed in the previous chapter. Due to these aims the interviews were structured in a precise design: The first part of this interview was not structured. As an opening question, I always asked if they could give me an insight into the major challenges and developments the Maasai in Ololosokwan faced beginning from the early days in the Serengeti. That means in the first part of the interview I found myself only listening to their narratives without interrupting them. Often, I had not even asked an opening question in order to get those insights. Over time, the expert interview became more and more focused, as I had developed precise follow-up questions, or asked specific HANPP related questions. The interview then develops into "systematized expert interview" (see Bogner and Menz 2002 for a typology of expert interviews). In contrast to the more explorative initial phase of the interview, this later phase was designed to get comparable data. For that reason it was essential to ask standardized questions, even though they were still open in a way, as the interviewees were not restricted in regard to their answers. These questions were all related to the broader leading question: What will the inhabitants and particularly the Maasai of Ololoskwan lose if they cannot access their dry season grazing area anymore? The aims of this systematized part of the expert interviews have already been discussed in the previous chapter.

The conducted qualitative interviews and quantitative surveys are the major data source of this thesis. However, as already indicated, observations, measurements and estimations were also done on site. In addition, focus group discussions were organized in the beginning of the field work in Ololosokwan in order to get a first overview of the situation and the specific problems in Ololosokwan. In addition, diagrams were developed in the focus group discussion which shows the different seasons and the availability of grazing resources of different

[45] I conducted the expert interviews with male elders because I was mainly interested in pastoralism, particularly the grazing system and its change over the time. Therefore, it was important to interview men because of the role allocation of the Maasai in which boys are responsible for the herding of livestock while elder men overview the herd management and act as consultants. The women are responsible for many other activities, including the management of sub-households, the milking and the crop production. That is why women were asked about these activities in the surveys.

example years (see annex for a picture of a diagram conducted for the year 2012) Moreover, Paul and I also accompanied the herders on grazing. During these day trips we developed a vegetation list of Ololosokwan together with the herders (see annex for the list). The majority of the local names of the trees, bushes and grasses were later translated into the botanic names. However, it was not possible as a part of this thesis to conduct a complete and quantitative vegetation survey. This would of course have been helpful, as it would have made it possible to draw conclusions about the different range resources available on the *ronjo* and on the permanent area. Because of the lack of such data, this thesis has to rely on the qualitative narratives of the Maasai in Ololosokwan in respect of this matter.

4 AHANPP Calculations

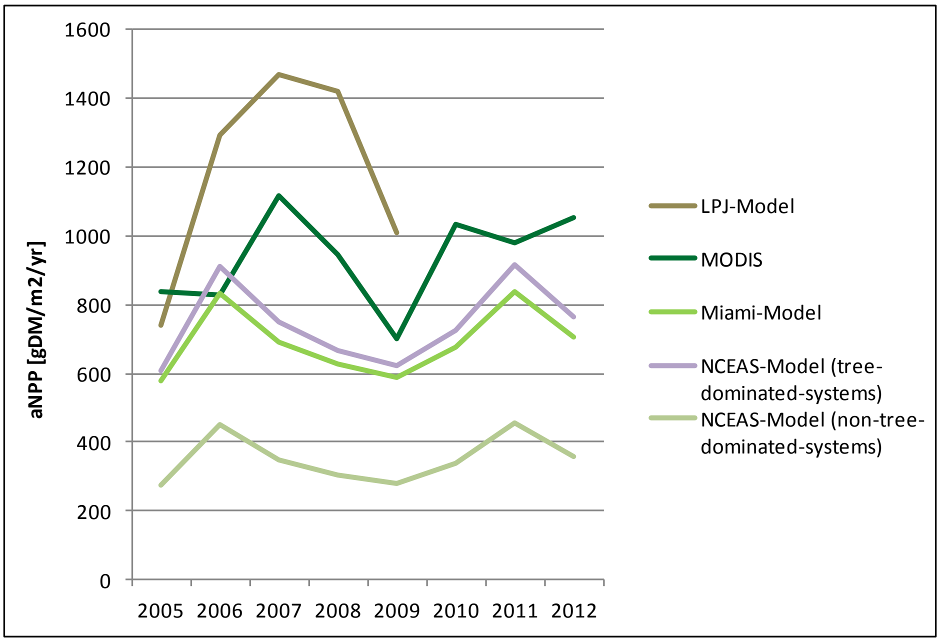
This chapter presents a detailed description of the calculation of the different aHANPP components which are needed in order to compute the aHANPP. Thereby the applied methodologies will be explained in connection to the used data sources. In addition further calculations on the range forage availability will be presented.

4.1 Aboveground productivity of the potential vegetation ($aNPP_0$)

The productivity of the potential vegetation ($aNPP_0$) indicates the NPP that would prevail in the absence of human influence (Tüxen 1956). To derive the potential vegetation, ($aNPP_0$) usually a Dynamic Global Vegetation Model like the Dynamic global vegetation model of Lund-Potsdam-Jena (LPJ-DGUM) is used (see for details on the model Stich et al. 2003). However, $aNPP_0$ data generated through the LPJ model for the study area investigated in this thesis are certainly too high if compared to outcomes resulting from the use of other models (for details on the applied LPJ model to derive the $aNPP_0$ for this study see Krausmann et al. 2013). This can be seen in figure 6, which presents five different figures of $aNPP_0$ concerning the area of Ololosokwan village. The figures of $aNPP_0$ were obtained by applying different models.[46] $ANPP_0$ data originally expressed in gram carbon, like the one of the LPJ model, was converted into the measuring unit of g DM by assuming that 1 g DM is equivalent to 0.5 t C (Erb et al. 2009). Almost every model shown in figure 6 considers total NPP (tNPP). But since this study only takes aboveground NPP into account, the ratio of 1:1 between above- and belowground NPP for “tropical savanna and grasslands” was applied (Saugier and Mooney 2001).

[46] In the case of LPJ-NPP, data was only available until 2009.

Figure 6: Potential Vegetation (aNPP0) of Ololosokwan derived from different models



Sources: see text

The second highest $aNPP_0$ figure for the study area is a result of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor that provides global primary production algorithm at 1-km resolution (namely, MOD17). For details on the used MOD17 products, see Zhao et al. (2005), who discussed the most current version of the algorithm. The only change to the algorithm applied for this study is that the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) reanalysis data were used as the meteorological input data (Zhao et al. 2006). However, Zhao et al. (ibid.) reports that the reanalysis of NCEP/NCAR results in a generally high estimation of NPP due to overestimation of solar radiation and underestimation of vapor pressure deficit. In general, the authors emphasize that the "tropics contain the largest uncertainties in GPP and NPP owing to the large uncertainties in the meteorological reanalysis of the region, combined with the high productivity and the large vegetated areas" (ibid.). In addition, it seems as if the NPP data for Ololosokwan generated through the MODIS products seems to have a time lag if compared to the precipitation data of Ololosokwan. But this time lag is not really significant if compared to the NPP figures of the LPJ Model. MODIS data does not actually report the potential NPP (NPP_0), but the actual NPP (NPP_{act}), since they incorporate near-real time satellite remote sensing data. However, the vegetation of Ololosokwan is not shaped by land use changes (see chapter 4.2 and 4.3). For that reason, MODIS data are in this case even applicable as an approximation of $aNPP_0$. In addition to the LPJ and MODIS data, I have also generated $aNPP_0$ data through data derived models. The so-called Miami model of Lieth was one of the first models which estimate NPP simply using the input parameters precipitation and temperature (Lieth 1974). The model is based on Liebig`s law which says that the minimum factor, meaning mean annual precipitation or mean annual temperature, respectively controls the productivity (ibid.). In the case of Ololosokwan, the productivity is limited by precipitation. Precipitation data of Ololosokwan was provided by the safari company *&beyond* which had measured the amount of rainfall in the village area via a rain gauge every day since 2005 (coordinates of the location of the gauge: S 01°50.111'/ E 35° 14.766'). The $aNPP_0$ value obtained by applying the Miami model is significantly lower compared to the results of the LPJ model, but also as compared with the MODIS figures.

Del Grosso et al. (2008) evaluate the Miami model as well as a similar model published by Schuur (2003). Schuur mainly enlarged the data basis of the Miami model with NPP data of tropical forests. The evaluation of Del Grosso et al. resulted in the establishment of a new model, namely NCEAS, which is based on the Schuur model. The NCEAS model distinguishes not only between aNPP and tNPP. In addition to that, different regressions for tree-dominated and non-tree-dominated systems were established. This was done due to the obtained result that tree-dominated systems fixed more g C per m^2 a year compared to non-tree-dominated systems. Thus, Del Grosso et al. (2008) conclude that the NPP of non-tree-dominated systems was generally overestimated by both the Miami and the Schuur-model. Del Grosso et al. (ibid.) named grassland, scrublands, deserts and savannas as examples for non-tree-dominated systems and boreal, temperate and tropical forests as examples of tree-dominated systems. Since the vegetation of the village Ololosokwan can be at best described as wooded and bushed savanna (see chapter 2.1.2), the classification as a non- or as a tree-dominated system is quite arbitrary. However, the classification makes a difference: The figure obtained via the NECAS model is significantly lower compared to any other of the obtained results of $aNPP_0$ if the vegetation of Ololosokwan is classified as non-tree-dominated system (see figure 4). On the other hand, if the regression of tree-dominated systems is applied, the figure is a bit higher than the figure derived by the Miami model.

In conclusion, I will apply the aNPP figures of the NCEAS model of tree-dominated systems as the potential vegetation ($aNPP_0$) of the village Ololosokwan because it seems that they are the most fitting values among the obtained results: The LPJ figures are far too high and out of the range and thus not applicable as $aNPP_0$ figure for this study. The other extremes are the NCEAS figures of non-tree-dominated systems which seem not to be suitable. This indicates that the vegetation of Ololosokwan is not appropriately described as a non-tree-dominated system in the sense of the Del Grosso et al. (2008) study, even though savanna is given as an example for such systems. In this study, the NCEAS model of tree-dominated systems was applied in favor of the MODIS and Miami model results, primarily because the NCEAS model is build on a broader database as the Miami model. A further reason for choosing NCEAS model of tree-dominated systems in favor of the MODIS figures is the fact that MODIS tend to overestimate the NPP of the tropics, whereby in general, uncertainties exist for this region.

4.2 Aboveground productivity of the actual vegetation ($aNPP_{act}$)

The vegetation of Ololosokwan village, as already described in chapter 2.1.2, is a diverse mosaic of bushed and wooded savanna. However, in absence of any specific studies on current aNPP figures for different land covers, several estimations have to be applied in order to be able to obtain figures on the actual vegetation ($aNPP_{act}$) of Ololosokwan. The great majority of the village area of Ololosokwan is used as pastures for free grazing livestock. Livestock graze everywhere, except for the specific areas where grazing is not possible, like areas occupied by settlements or infrastructure. In neither narratives, nor in interviews or in focus group discussions I have held with the inhabitants of Ololosokwan, complaints of bush encroachment or any other sign of a productivity change of the rangeland of Ololosokwan were expressed. Thus, in the case of natural pastures in Ololosokwan, the conservative assumption that the actual vegetation ($aNPP_{act}$) is equal to the potential vegetation ($aNPP_0$) was applied.[47]

[47] The Tanzanian government complains about the overgrazing of the area (United Republic of Tanzania 2010). However, no reference or any details on this claim was given. In addition, no study is available which has inves-

However, one exception has to be taken into consideration: It was reported and observed that some areas suffered from trampling by livestock or by humans and thus experienced productivity losses (see annex for photos of such areas). It is roughly assumed, based on own observation, that the size of the area amounting to 12 ha. Zika and Erb (2009) suggest that a strong degradation in drylands leads to a productivity loss of averagely 56.5 %. This figure was also applied in this study. Thus, a productivity of 43.5 % of the aboveground potential productivity was applied for areas suffered from trampling.

Areas within Ololosokwan which are not pastures or have suffered from a productivity loss due to trampling are cropland and areas of settlement or infrastructure. The aNPP on these areas are assessed as follows:

To estimate the actual aNPP of the actual vegetation ($aNPP_{act}$) on cropland, the total crop harvest was calculated in addition to the crop residues (see chapter 4.4.1 for details on the calculation). However, to account for the aNPP of weeds and for biomass losses occurring for instance due to pest or herbivores even before the harvest has taken place, a so called pre-harvest loss factor has to be included in the calculation. The factor 1.36, reported by Haberl at al. (2007) in the supporting information for "least development countries", was adopted for this study. A pre-harvest loss of 36% in the case of Ololosokwan seems plausible, since alone 31.4% of the surveyed women (n=35) reported a partly or a total crop loss due to elephants or other wildlife, and this accounts only for the observed pre-harvest losses. The actual vegetation ($aNPP_{act}$) on cropland was allocated to the total cropland area in Ololosokwan (see chapter 4.4.1 for details on the calculation of the cropland area).

The $aNPP_{act}$ on settlement and infrastructure areas was assigned as zero because no biomass is grown on these areas. In this category, the total area of private houses in addition to public buildings like schools, dispensaries and shops, livestock enclosures and the main road which passes through the village was considered. The average area of each kind of settlement was estimated on site. The length of the road was measured with the help of GPS (30 km with an average breadth of 4 m). The average area of private houses (25 m^2) was thereby extrapolated to the estimated total number of sub-households in Ololosokwan (1000, for details on the calculation see chapter 2.1.3 and chapter 4.4.2). In addition to the private houses, it was estimated that the area of public buildings like shops, schools and offices are in average 50 m^2. A typical *boma* in the permanent area consists of three different livestock enclosures: a big one for cattle (100 m^2) and two smaller enclosures, one for sheep and one for goats (each 36 m^2). Furthermore, additional bigger enclosures for cattle are also built in the *ronjo*. These enclosures are much more flexible than on the permanent area. It is assumed that every *boma* builds approximately one cattle enclosure in the *ronjo* on a yearly basis. The total area of all four enclosures was multiplied with the total number of Maasai-*bomas* in Ololsokwan, namely 102.

4.3 Aboveground biomass appropriated by humans through land conversion ($aNPP_{lc}$)

Land use changes can lead to a higher NPP productivity of an area compared to the potential vegetation, for instance due to the application of fertilizers. On the other hand, land use changes can also result in a decreased productivity. In the previous chapter it already became apparent that on the majority of the area i.e. the grazing area of Ololosokwan, the actual

tigated the condition of the rangeland of the study area.

productivity is not altered significantly compared to the potential vegetation of the area. Only some areas have suffered from productivity loss due to different land use activities: These are areas of cropland, settlement, infrastructure and areas which experience degradation. According to the aHANPP approach, the aNPP loss in these areas has to be considered as the aNPP appropriated by humans through land use changes ($aNPP_{lc}$). This figure is calculated by the difference of the potential vegetation ($aNPP_0$) and the actual productivity of the respective area ($aNPP_{act}$), which were both discussed above.

4.4 Aboveground biomass harvested by humans ($aNPP_h$)

The aboveground biomass harvested by humans ($aNPP_h$) considers all biomass humans destroy during their biomass related activities such as biomass harvest. Thereby it is irrelevant whether the destroyed biomass is used for further socioeconomic uses, like for food, or not. For instance, in the case of agricultural crop harvest, not only the primary product, which is consumed by humans, is included in $aNPP_h$, but also aboveground crop residues, even if they are not recovered as fodder but left on the field or burned. Biomass which is not used by the society for any purpose is indeed included in $aNPP_h$ but is mentioned separately as "unused extraction" or "backflow to nature" (Erb et al. 2009). In contrast to the unused residues, crop residues which are recovered for instance as fodder will be included together with the harvested primary crops in the used fraction of $aNPP_{h.}$ In this broader definition of harvest and therefore $aNPP_h$, even anthropogenic fires have to be incorporated. This is because humans actively destroy biomass when they induce fires. It has been reported that fires are used as a rangeland management tool by pastoralists in order to keep areas open for grazing, or to stimulate the regrowth of green grasses during the dry season (Lamprey 1983). However, the Maasai in Ololosokwan reported that they did not set fires any longer because during the dry season, there is simply no more grass available that could be burned (elder 1, 09.10.2012).

In summary, biomass is harvested through three main activities by the inhabitants of Ololoskwan:

- Agriculture, i.e. biomass harvest on cropland
- Wood gathering, i.e. wood harvest for firewood and building materials
- Pastoralism, i.e. biomass grazed by livestock on natural pastures

The calculation of these components of $aNPP_h$ is mainly based on data from surveys carried out during the fieldwork in Ololosokwan. However, results of the different components will be later cross-checked with available secondary data (see chapter 6.1). The secondary data can be found in the annex of this thesis. But in the following the detailed calculation of the components of $aNPP_h$ will be presented first.

4.4.1 Biomass harvest on cropland

As already discussed, biomass harvest on cropland considers all aboveground parts of crops i.e. primary crops and crop residues which are destroyed during the harvest process. Data for harvested crops were generated through surveys in Ololosokwan.[48] Women were asked about

[48] The field work was done during October i.e. the dry season. Harvest time is mainly throughout the heavy rain season (for instance 84% of the sample harvested beans during April and 47% harvested maize in July). This means no harvest was taking place during the fieldwork of this study, and therefore it was not possible to measure the harvest directly. Thus, the harvest data relied mainly on the recollection of the surveyed women. However, the stable crops, i.e. maize and beans are usually filled into standard sacks of 100 kg. For that reason, the

their agricultural activities, in particular regarding their harvest in the year 2012. It was possible to interview 40 women, whereby five women did not cultivate land. So, the sample for this issue existed of 34 women, 32 Maasai and 2 Irawq.[49] Out of this sample, the average agricultural area of one woman was calculated (see table 1) in addition to the average amount of harvest per woman (see table 2).

Table 1: Average agricultural area per women in Ololosokwan in the year 2012

	[ha/woman]
Maize	0.50
Beans	0.43
Other crops	0.05
total	0.98

The stable crops in Ololosokwan are maize and beans, while tobacco, sunflower, sorghum, millet, potato and pumpkin are only grown in small amounts, mostly by the agriculturalist Iraqws. Therefore, the latter is subsumed in the category "other crops". However, the amount of primary crops and crop residues harvested (see below) were calculated for each single crop.

Table 2: Average primary crop harvest per women in Ololosokwan in the year 2012

	[kg DM/woman/yr]
Maize	352.6
Beans	98.7
other crops	20.9
Tabacco	3.6
Sunflower	6.4
Sorghum	1.5
Millet	1.5
Potato	0.1
Pumkin	7.7

In order to extrapolate these figures to the total amount of harvest and the total agricultural area of Ololosokwan, the following assumption was applied. This assumption was confirmed by my field research assistant (pers. comm. Paul Saing'ue, 12.02.2013). Maasai women are responsible for agriculture in Ololosokwan. Usually every married Maasai woman practices agriculture if she is in the physical condition to do so. Thus, the total figures are calculable if all women in a marriageable age (i.e. from 15 upward) and with a physical condition allowing them to practice agriculture (i.e. until the age of 54) are considered in the extrapolation.[50] The estimation of the total population that conducted agriculture in 2012 was conducted as fol-

reported numbers of sacks which could be filled during the agricultural year 2012 are quite reliable.

[49] See chapter 3.4 for more information regarding the sampling procedure.

[50] In the case of agriculturalists like the Iraqws, both women and men practice agriculture. However, also if only the Iraqw woman is questioned, the agricultural data for the whole household can be obtained. Therefore it is possible to extrapolate the harvest figures via the female population. In addition, the agricultural figures are dominated by the Maasai even though they are mainly pastoralists since the majority of the population of Ololosokwan is Maasai. The survey has revealed that Iraqw agriculturalists do not necessarily cultivate a larger area compared to the pastoralist Maasai. However, their cultivated crops are more diverse.

lows: The total population of Ololosokwan in 2012 was firstly divided into female and male population. This was performed with the help of data on the sex distribution of Ololosokwan ward in 2012 (United Republic of Tanzania 2013) (see chapter 2.1.3 for the estimation of Ololosokwan village population in 2012). The estimated female population of Ololosokwan village in 2012 was then divided into different cohorts, as indicated in the age distribution apparent in the census of Ololosokwan village 2002, since this information was not available in the census of 2012 (United Republic of Tanzania 2005, United Republic of Tanzania 2013). Afterwards, the total number of women aged between 15 and 54 years was taken as the figure for women who potentially practiced agriculture in Ololosokwan village in 2012. The number of women obtained in this way is 1063 women. However, because only 87.5 % out of the total sample reported that they were actually engaged in farming, it was calculated that only 935 women really participated in the cultivation and harvest of crops in 2012. Consequently, the average agricultural figure of one woman was extrapolated to 935.

The amount of harvested crops was given in fresh weight. Therefore, standard factors were applied to convert the fresh weight into dry matter units. Table 3 presents the water content in percentage of all crops cultivated in Ololosokwan in 2012.

Table 3: Water content of crops cultivated in Ololosokwan

Commodity	Water content [%]
Dry Beans	10
Maize	14
Tabacco	10
Sunflower	7
Sorghum	11
Millet	12
Potato	78
Pumpkin	91

Source: Watt and Merrill 1975, Löhr 1990

In order to incorporate crop residues in the calculation on biomass harvest on cropland, a standard harvest index for each crop cultivated in Sub-Saharan countries was applied. The harvest index indicates the ratio between the fraction of the crop consumed by humans (i.e. primary crop) and total aboveground biomass (i.e. primary crop and crop residues together) (Kastner 2009). Table 4 presents the applied harvest index for every crop which was cultivated in Ololosokwan in 2012.

Table 4: Harvest indices for crops cultivated in Ololosokwan

Commodity	Harvest Index
Dry Beans	0.3*
Maize	0.78
Tabacco	0.4*
Sunflower	0.7
Sorghum	0.78
Millet	0.78*
Potato	0.5
Pumpkin	0.4*

Source: Standard factors for sub-Saharan Africa (Wirsenius 2000) and own estimations (*)

As already discussed earlier, crop residues are destroyed during the process of harvesting and are therefore included in $aNPP_{h.}$ Nevertheless, crop residues can either enter the socio-economic system or remain unrecovered. For instance, most of the maize crop residues enter the socio-economic system since they are grazed by livestock on the respective fields. However, I observed that the lower part of the stalks remains ungrazed. Therefore, I applied a maize-specific recovery rate reporting the fraction which enters the socio-economic system and is thus considered as “used extraction”. Wirsenius (2000) determines a maize recovery rate of 0.9, which fits in with my observation and was hence applied in this thesis. The total amount of maize crop residues which enter the socio-economic system by grazing of livestock is later (see next subchapter) subtracted from the total amount of feed intake of the livestock in Ololosokwan. This is done in order to separate the part of the feed intake that is covered by crop residues, which is allocated to $aNPP_{h\ –Agriculture,}$ and the part which is satisfied by grazing and browsing on natural pastures, which is allocated to $aNPP_{h\ –Pastoralism}$. The part of the maize crop residues which remains unrecovered is considered in $aNPP_h$ as “unused extraction”. Likewise, all other crop residues are considered as unused extraction: Bean crop residues are usually burned. In the case of the other remaining crop residues like sunflower, sorghum or millet, the agriculturalist Irawq reported that they left the crop residues on the field as manure. However, it cannot be ruled out that livestock graze these crop residues directly on the field. However, if this is the case, the grazed residues are negligible, since all other crops apart from maize and beans are only grown on a very small scale.

4.4.2 Wood harvest (firewood and woody building material)

In Ololosokwan, wood is harvested as firewood and as a building material, which is why both harvest processes are considered in this study.[51] In the following, I will first present the calculation process for firewood then the wood harvest for building purposes will be estimated.

Gathering firewood and wooden building material lies in the responsibility of Maasai women. For this study, 48 Maasai women and two Iraqw (n=50) were asked to report how often they gathered a load of firewood in a week for their sub-household. This was reported separately for the dry season and the rainy season. The average figures are presented in table 5.

[51] Some inhabitants of Ololosokwan produce bricks as commercial commodity. For this, firewood is needed to burn the bricks. Since there is lack of data on the amount of firewood needed for this activity, only the private consumption of firewood is considered in this study.

Table 5: Firewood collection per household and week in Ololosokwan in the year 2012

	[loads/houshold/week]
dry season	3.6
rainy season	3.7

In addition, it was measured that one load of firewood weighs in average 28 kg. In order to convert the weight of the firewood into dry matter, it was estimated that during the dry season, the water content on the gathered wood is only 10% since Maasai women only collect dead or dry tree branches for use as firewood. However, the water content increases during the wet season. Thus, a water content of 15% was assumed for this season.

In fact, aHANPP considers all aboveground parts of felled trees. Therefore, it would be necessary to multiply the wood removals by a wood recovery rate in order to include the unused felling losses of a harvested tree. But since the Maasai women only collect the "natural losses", no unused extractions were produced during firewood gathering. Thus, it is not needed to apply a recovery rate. The results of the average amount of collected firewood in kg DM per sub-household and day were extrapolated through the total number of sub-households in Ololosokwan in 2012.[52]

Traditional Maasai houses are made of wood, mud and dung. In addition, wood is needed as building material for the different enclosures of the livestock. Building is traditionally a responsibility of Maasai women. For woody building materials, the women harvest mainly fresh and bigger branches from trees or even whole trees, although they usually leave at least one main branch on the tree in order to secure its regrowth (elder 2, 11.10.2012). However, even if bigger branches are cut smaller felling losses and even leaves are used as building materials. For that reason I did not apply any recovery factor in this case.

The amount of wood needed to build a traditional Maasai house (*enkaji*), an enclosure for cattle (*orpaashe lengang'*) and the enclosure for sheep or/and goats (*emwatata*) was estimated on site and is presented in table 6. The wood requirement for the enclosures for small stock is higher even though their area is smaller because these enclosures are built by long logs rammed into the earth next to each other. For the building of cattle enclosures the much lighter thorn bushes are used (see annex for photos of the enclosures types). An average of 20% water content was assumed for the wood used as construction material.

Table 6: Wood needed for Maasai buildings in Ololosokwan

	[kg DM/building]
Maasai huts	743.7
Cattle enclosure	320.0
Sheep/goats enclosure	576.0

The result of the average amount of building material for one traditional Maasai house in kg dry matter was projected to the total number of sub-households in Ololosokwan in 2012 (1000).[53] In the case of the different enclosures, the results were extrapolated to 102 because it

[52] The Population and Housing Census of 2012 says that the average sub-household size in Ololosokwan ward is 5.0 (United Republic of Tanzania 2013). I estimated that 5000 people lived in Ololosokwan in the year 2012 (see chapter 2.1.3); therefore 1000 sub-households existed in Ololosokwan in 2012.

[53] Iraqw use another construction technique for houses, compared with Maasai, however, they are also using

was estimated that 102 *bomas* currently exist in Ololosokwan, with every *boma* having three indicated enclosures built alongside their permanent *boma* in the permanent area. The extrapolated result for the cattle enclosures was multiplied by two in order to consider the fact that cattle enclosures are, in addition to the ones at the permanent *boma*, also frequently built in the *ronjo*.

The annual growth rate of newly-built houses and enclosure is not known. Thus, the total amount of building material for houses and enclosures was divided by the length of life of these buildings. This result is an estimation of the average annual quantity of building materials needed to build all the houses and enclosures in Ololosokwan. Maasai usually live in the same *boma* for ten years, provided that nobody dies or tradition makes them move to another place. After ten years, the houses start to disintegrate, so that smaller repairs are no longer sufficient (Perlov 1984, Dunne 1979 in Homewood and Rodgers 1991). However, the projected result for the total amount of needed wooden building materials was divided by nine and not by ten (years), simply to take into consideration that some wood is also needed for repairs within the indicated ten years.

4.4.3 Biomass grazed by livestock on natural pastures

The feed intake of the livestock in Ololosokwan is met by direct grazing on natural grass- and bushland. Only a small part of the feed intake is covered by grazing of maize crop residues, as indicated in chapter 4.4.1. Thereby, the livestock is herded by young Maasai men throughout the day.

There are different methods to measure the feed intake of grazing livestock (Cordova et al. 1978). A frequently applied method measures the digestibility of the pasture in vitro, for instance from samples collected by esoghageal-fistulated animals, or by quantifying the fecal output of the livestock, for example with the help of faecal collection bags which are fitted on the animals. The feed intake of organic matter is then calculated by fecal organic matter output divided by the percentage of organic matter indigestibility (see for a discussion and for other methods Cordova et al. 1978, Ayantunde et al. 1999, Schlecht et al. 1999.)[54] However, in the scope of this study, it was not possible to conduct such feed intake measurements. But in order to get, through primary data an estimation of the feed intake of the livestock in Ololosokwan a linear regression, established by Krausmann et al. (2008) was applied. This regression relates the average daily milk yield of cows to the average daily feed intake which is needed to produce the particular milk yield. The regression results in the following formula:

Feed intake (milk) [kgDM/head/day] = 0.00155 * milk yield [kg/head/yr] + 4.8375 (1)

In order to gather primary data to apply this regression, Maasai women (n=46) were asked to report how much milk they got from one cow on an average day (i.e. the milk from the morning and the evening milking).[55] Data was given in average for the rain season and for the dry

mainly wood as building material. Particularly in the sub-village Ololosokwan houses are also made out of bricks. Nevertheless, I extrapolated the results of wood needed to construct a traditional Maasai house to the total number of households in Ololosokwan because, as already described elsewhere in this study, the Maasai started to build (semi-)permanent houses, in addition to their houses at the permanent area, in the *ronjo*.

[54] The same equation can be used in order to calculate the dry matter intake. However, organic matter is more commonly used by researchers because of the relatively high ash content in range forages (Cordova et al. 1978).

[55] The result was cross checked by the question how many cows they usually milked and how many liters of milk in total they get from these cows in total. When the women did not have perception how much one liter is, we asked how many big cups they usually milked. The Maasai in Ololosokwan typically use standardized enamel cups, half a liter fits into the big ones.

season for the year 2012, a generally good year for pastoralism. However, the milk milked by the women considers only a fraction of the total milk production (i.e. the milk offtake). In order to get the total milk production, also the milk that the calves suckle has to be considered (i.e. the milk intake). The Maasai women narrated that they practice two different suckling regimes: In the first regime, two teats are milked by a Maasai woman while the calf can simultaneously suck milk from the other two teats. The second regime, however, allows the calf only a short sucking time at the beginning to stimulate the led down of the milk. Then, the calf is tied securely until the Maasai woman has finished the milking. Now, the calf can suck the remaining milk. The women assumed that especially if the first suckling regime is practiced, the ratio between human milking offtake and intake by the calf is close to 1:1. The women reported that within the second suckling regime they tried to milk the same amount as the calf suckled but sometimes they even milk more than the half of the total milk production. This could be the reason that the actual reported milk intake is lower compared to the amount of milk gained for human use, especially during the dry season. Table 7 presents the average daily milk offtake, intake and the total yield per cow in 2012, reported by Maasai women in Ololosokwan.

Table 7: Average milk production of cows in Ololosokwan in 2012 (good year)

	[l/cow/day]	
	dry season	rainy season
milk offtake (Maasai)	1,07	1,90
milk intake (calves)	0,57	1,27
milk yield	1,64	3,17

Studies which investigate the milk intake of calves within a restricted suckling regime confirm the lower milk intake by the calf compared to the milk offtake. The total milk productions in these studies were considerably higher when compared to the results of this study. However, the treatment of the cows and calves and the milking process are in general comparable to the second method practiced in Ololosokwan (Coulibaly and Nialibouly 1998, Mejia et al. 1998). Beside this fact my obtained results of the milk production of cows in Ololosokwan (table 7) correspond well with those presented in table 8. These milk data (n=202) were also collected for Maasai systems in northern Tanzania, namely in the Kiteto and Longido districts. In addition, the survey was also conducted in the late dry season of 2012 (pers. comm. Tim Loos, 16.08.2013).[56] Therefore, the obtained milk production data of this study seems adequate and reliable.

Table 8: Average milk production of cows in northern Tanzania reported for the year 2012

	[l/cow/day]	
	dry season	rainy season
milk offtake (Maasai)	0.96	2.02
milk intake (calves)	0.8	1.13
milk yield	1.76	3.15

Source: (pers. comm. Tim Loos, 16.08.2013)

[56] The milk data was collected as part of the study "Livestock Data Innovation in Africa Project & Living Standards Measurement Study - Integrated Surveys on Agricultural Projects (LSMS-ISA)" by Tim Loos and Alberto Zezza, but was not included in the final report.

The reported milk production in liters of this study (see table 7) was converted into kg in order to apply the above given formula (1). Therefore, the milk was measured on site with the result that in average, one liter cow milk weighed 1.03 kg. Table 9 reports the feed intake of lactating cows in Ololosokwan during a good year resulting from the application of the formula (1).

Table 9: Average daily feed intake of lactating cows in Ololosokwan in 2012

	[kg DM/cow/day]
dry season	5.79
rainy season	6.69
average	6.24

Different feed intake studies for grazing animals in pastoral systems are available (see table 10). These studies have applied field methods to measure the feed intake like those described above.

Table 10: Feed intake [kg DM/TLU/day] of grazing cattle reported for different seasons and African countries

Study area	trail	rain season	dry season	late dry season
Ethiopia (Rift Valley) [1]	enclousing			4.53
Ethiopia (Rift Valley) [2]	walking			4.54
Niger (Sadorè) [3]	day grazing (4 week)			5.43
Niger (Sadorè) [4]	day grazing (8 week)			3.95
Mali (Niono) [5]	grazing only natural pasture (1990)	5.50	6.22	4.64
Mali (Niono) [6]	grazing only natural pasture (1991)	5.79	6.36	6.14
Kenya (Kiboko) [7]	watering once a day	4.60		
South Africa (Nylsvley Nature Reserve) [8]		7.6	6.4	7.1
Central Sahel (Toukounous) [9]		6.24	6.57	5.70

Sources: 1 (Nicholson 1987), 2 (Nicholson 1987), 3 (Ayantunde et al. 2002), 4 (Ayantunde et al. 2002), 5 (Schlecht et al. 1999), 6 (Schlecht et al. 1999), 7 (Musimba et al. 1987), 8 (Zimmermann 1980), 9 (Ayantunde et al. 1999), * data was only read from the diagram, monthly data was aggregated to the different seasons.

Most of them investigate factors which might affect the feed intake of grazing animals. For instance, Nicholson (1987) studied the effects of night enclosing and walking on the feed intake, while Musimba et al. (1987) concentrated on the influence of water frequency of the feed intake of grazing cattle. Table 10 presents some results of these and other studies. Thereby only the figures of the respective study-trail were taken into consideration which represents a treatment of cattle comparable to the one which can be observed in Ololosokwan. The originally reported data were already converted into kg DM per TLU and day. It is common to express feed intake in g dry matter (DM) or organic matter (OM) per metabolic bodyweight (expressed in kg $^{0.75}$) and day (Cordova et al. 1978). For the conversion in kg DM per TLU, a bodyweight of 250 kg i.e. 1 TLU was presupposed. Original data expressed in OM was converted into DM by assuming an ash content of 12% in 100 g DM (Schlecht, pers. comm., 03.04.2013).

The results of the feed intake of lactating cows obtained in this study (table 9) are in the range of the feed intake data generated from secondary sources expressed in TLU (table 10). In addition, Schlecht reports: "[…] despite the capacity to ingest up to or even more than 120 g OM/kg^{0,75}/day, the voluntary intake of Zebu cattle is in the range of 80 to 100 g OM/kg^{0,75}/day." (Schlecht et al. 1999). If again an ash content of 12% in 100 g DM is assumed, the feed intake of grazing animals expressed in kg DM/TLU/day is in the range of 5.7 to 7.1. Schlecht (ibid.) reports also that a feed intake less than 5.7 kg DM/TLU/day indicates that the intake is limited by the available biomass. Consequently, a constant feed intake less than 5.7 kg DM/TLU/day is critical since it cannot sufficiently sustain the animal i.e. one TLU any longer. Considering this, my obtained results for a good year for pastoralism (see table 9), indicate that during the rainy season, the average feed intake is quite high and declines during the dry season, but not below a point that can no longer sustain the cattle. This seems plausible for a good year for pastoralism in particular if compared with the narratives of the Maasai in this regard (see chapter 2.2). It should be noted that these feed intake figures are actually appropriate for lactating cows. However, since the annual average feed intake of 6.24 kg DM/cow/day (see table 9) is in the range of feed intake per TLU reported by Schlecht and others this figure is applied as an approximation of the feed intake of one TLU in this study.

Table 11: Livestock population in Ololosokwan in 2012

	Head	TLU conversion factors	TLU	%
Cattle	27526	0.8	22020.8	73.27%
Sheep	36242	0.1	3624.2	12.06%
Goats	44112	0.1	4411.2	14.68%
Total	107880		30056.2	100.00%

Source: Livestock numbers of 2012 were reported by the Ngorongoro District Council, Livestock Department. The applied TLU conversion factors are based on the common practice of the NLUPC (pers. comm. Michael Mdoe, 5.9.2012) but adapted by (Jahnke 1982).

In a next step the figure has to be extrapolated to the total TLUs kept in Ololosokwan to account for the total appropriation of biomass by grazing livestock. Therefore, different TLU conservation factors were applied for all livestock species kept in Ololosokwan (see table 11).[57] In order to calculate the total appropriation of biomass through livestock grazing the feed intake of 6.24 kg DM/TLU/day has to be extrapolated to 30056.2 TLU and to 365 days. However, this total appropriation of biomass through livestock grazing includes also the ingestion of maize crop residues, which were already incorporated in $aNPP_{h\text{-}Agriculture.}$. In order to account only for the feed intake satisfied by grazing on natural pastures this fraction has to be subtracted from the total feed intake. The result is then applied for $aNPP_{h\text{-}pastoralism}$.

The calculation of the total appropriation of biomass through livestock grazing was the last component needed for a full performance of the aHANPP of Ololosokwan.

[57] Actually in Ololosokwan some donkeys are also kept. However, no numbers are available and therefore donkeys were not included in the calculation. But the conducted survey in Ololosokwan indicates that only a negligible amount of donkeys are kept.

4.5 An assessment on range forage availability in Ololosokwan

Additionally to the aHANPP calculations which analyze the whole land use system of Ololosokwan, the focus is drawn on pastoralism in the following. The maximal exploitability of the pastures of Ololosokwan is approximated for all four scenarios considered in this thesis. Moreover, an assessment of the minimum and *ad libitum* feed intake is conducted. Both approaches will help to interpret the general aHANPP of Ololosokwan and its alteration due to the establishment of the new Loliondo GCA.

4.5.1 Maximal exploitability of the pastures of Ololosokwan

In order to better understand the values for aHANPP on pastures, it is necessary to develop an understanding of the maximum exploitability of pastures in Ololosokwan through the livestock herd of the village. This is because not all aNPP is available as range forage: some of the aNPP is unpalatable, for instance due to toxicity. Similarly, some aNPP is not accessible, particularly if it comes to tree-leaves. Furthermore, aNPP is destroyed by roaming, animals are not able to harvest the entire plant, but leave stubbles and spoil patches of vegetation by trampling and dropping faeces. In addition, competition with other herbivores such as wildlife reduces the availability of range resources for the livestock herd of Ololosokwan. Moreover, grazing cannot usually exploit 100% of the annual NPP: Seasonality as well as patchiness of the resource renders it impossible for livestock to fully exploit the productivity in an area.

The free-roaming livestock in Ololosokwan are in particular sensitive to the intra-annual dynamics in range forage production, as feed is not stored by society. During the rainy season more range forage is produced than the herd can actually consume. In the months of the dry season a range forage deficit emerges which is compensated by feeding on dead leaves, pruning, and which results in a thinning of the livestock. Ongoing decay processes lead to losses of range forage over time when fresh leaves dry out. Thus, the possibility to compensate the range forage deficit in the dry season with the surplus of the rainy season is limited.[58]

Due to lack of data it was not possible to calculate the fraction of range forage which is lost due to this circumstance. Therefore, within the assessment of the maximal exploitability of the pastures of Ololosokwan through the livestock herd of the village, it is assumed that the complete surplus of the rainy season is consumable in the dry season, regardless of any decay losses. However, still not the whole productivity of the pastures is available as range forage due to toxity, inaccessibility and other factors, as indicated above. Thus, in the following the available fraction of aNPP on the pastures of Ololosokwan which is consumable as range forage for the livestock kept in the village will be assessed.

For this assessment it is first of all necessary to separate the aNPP into herbaceous aNPP and ligneous aNPP. This is due to the fact that the available and edible fraction of aNPP differs between the two. In this study a ratio of 7:3 between herbaceous and ligneous layer has been applied. This is the mean of the partition of the herbaceous and the ligneous layer within savanna ecosystem derived from different studies reported in (House and Hall 2001).

From the 70% of the total aNPP of the herbaceous layer and from the 30% of the total aNPP of the ligneous layer the fraction which is available and consumable for the livestock herd has

[58] With the establishment of grazing reserves (see chapter 2.1.3) range resources of the rainy season area are actually reserved for the dry season. However, this standing hay is also exposed to weathering and other decomposition processes. The storage could lead to a minimizing of these processes. However, a simple storage would also lead to losses, and the quality of the forage would also decrease over time. Advance technologies like silage would further reduce losses but would need investment into the livestock system.

to be estimated individually for both layers. In the literature, some figures are given which report the consumable fraction of herbaceous layer. Le Houèrou and Hoste (1977) assume that in the Sahelian and Sudanian zones of Africa, on average 40% of the annual production of grasses and forbs is consumable forage. However, they state that this assessment could be slightly conservative (ibid.). Penning de Vries and Djiteye (1982) reported a general fraction of consumable forage of 30% in the Sahel zone. Ridder and Breman (1993:110) assumed "that at most half of the biomass on offer can be consumed when pastures are grazed during rainy season only, and one third when grazed during the dry season or all year-round". Schlecht (pers. comm., 03.04.2013) reports that a maximum of 70% of the aNPP is consumable forage. In conclusion a range from 30% to 70% is given in the literature as the consumable fraction of the annual NPP of the herbaceous layer.

In this study it is distinguished between the consumable fraction of the herbaceous layer that is offered to the livestock herd of Ololosokwan in the rainy season (January to June) and in the dry season (July to December). Thus, it is possible, to account for the fact that other herbivores such as wildlife and livestock from other areas migrate, in particular in the dry season to Ololosokwan. This leads to a reduction of range forage on offer for the livestock herd of Ololosokwan. It was estimated that during the rainy season 50% of the produced aNPP of the herbaceous layer is edible and available for the livestock herd of Ololosokwan. This is the mean of the range reported in the literature. It is further estimated that the available range forage for the livestock herd of Ololosokwan will decrease to 30% in the months of the dry season. As indicated above, this is due to the increased competition over grassing resources between the livestock of Ololosokwan and other herbivores. In general competition occurs mostly in times when "limit[ed] resources become scarcer" i.e. during the dry season (Butt and Turner 2012:4). However, this competition commonly described as "exploitation competition" (ibid.), is aggravated in Ololosokwan due the fact that especially wildebeest and zebras of the great migration route between Serengeti National Park and the Maasai Mara National Reserve pass by the village during the dry season (Nelson and Ole Makko 2003). In addition, also livestock from surrounding villages move to Ololosokwan since the village and in particular its *ronjo*, serves as a grazing puffer during the dry season. The increase of wildlife and livestock population during the dry season leads not only to a higher feeding competition, but also to further reduction of range forage due to additional trampling and fouling of the pastures by these herbivores. In line with the narratives of the Maasai elders and herdsmen it was thus assumed that the available fraction of range resources for the livestock of Ololosokwan further decreased in the dry season by 20% i.e. a consumable fraction of 30% of the aNPP of the dry season was assumed.

The consumable range forage of the ligneous layer that is offered to the livestock herd of Ololosokwan was also separately assessed for the rainy and the dry season. Schlecht (pers. comm. 03.04.2013) reports that the consumable fraction of ligneous layer amounts to 30%, but can increase if the share of bushes in the vegetation is high. In this study, 40% was applied for the rainy season, as the vegetation of Ololosokwan can be classified as a bushed and wooded savanna (see chapter 2.1.1.). It was assumed that this fraction decreases to 35% in the months of the dry season. This decrease is considerably lower than the decrease which was assessed for the herbaceous layer. This is mainly due to the fact that the competition for browsing resources with wildlife is, during the dry season not as high as for the grazing resources since most of the migrating animals are grazers. In addition, the available fraction of the ligneous layer is primarily limited by the accessibility of leaves, which is not altered by the seasons. However, also some browsers like goats coming from surrounding communities visit the village during the dry season resulting in a small reduction of the ligneous resources which is available for the livestock of Ololosokwan. In addition, if the range forage of the herbaceous layer becomes scarce, grazers will also satisfy their feed demand by an increase in browsing (Le Houèrou 1980). To account for these factors, I applied 35% as the consumable fraction of the ligneous layer which is available for the livestock herd of Ololosokwan during the dry season.Table 12 gives an overview of the above discussed percentages which are needed to assess the maximal exploitability of the pastures of Ololosokwan. From these fractions a single value for the maximal exploitability of the total aNPP was derived separately for the rainy and the dry season. It should be noted that it is not appropriate to directly derive a single annual percentage for the maximal exploitability of the pastures of Ololosokwan out of the values of the maximum of the rainy and of the dry season. This is due to the fact that the annual productivity is not uniformly distributed over the two seasons. Thus, the more the productivity differentiates between the rainy and the dry season so the more the de facto maximal exploitability differs from a directly derived annual maximum.

In this study monthly aNPP of the pastures of Ololosokwan were derived in order to assess the maximum exploitability of these pastures for a good year (2012) and for a bad year (2008). Then, the derived values on the maximal exploitability in the rainy and in the dry season can be applied separately for each month of the rainy and of the dry season, as explained in the following. Thus, it is at the same time possible to present the monthly dynamic on range forage availability.

Table 12: Assessment of the maximal exploitability of the pastures of Ololosokwan

	herbacous aNPP of total aNPP	ligenous aNPP of total aNPP	consumable range forage of herbaceous aNPP	consumable range forage of ligenous aNPP	maximal exploitability of total aNPP
rainy season	70%	30%	50%	40%	47%
dry season	70%	30%	30%	35%	32%

The maximal exploitability of the total aNPP of the rainy was calculated as followed: Firstly the fraction of the herbaceous aNPP was multiplied by the fraction of the consumable range forage of the herbaceous aNPP in order to derive the fraction of herbaceous range forage of the total aNPP (0.7*0.5 =0.35). Similarly, this was also performed for ligneous (0.3*0.4=0.12). The accumulation of both results gives the maximal exploitability of aNPP in the rainy season. This calculation was accordingly performed for the dry season.

In chapter 4.1 it was discussed that annual figures of $aNPP_0$ generated through the NCEAS model are the most suitable for the area of Ololosokwan. In addition, it was assumed that the productivity of the natural pastures of Ololosokwan is not altered as compared to the potential vegetation. Thus, $aNPP_0$ data can be applied as the actual aNPP of the pastures of Ololosokwan. However, the NCEAS model was developed to approximate annual NPP values, and was not suited to depict intra-annual dynamics. But, monthly MODIS data on net photosynthesis (PsnNET) per m^2 are available.[59] In an approximation, I used these dynamics to derive monthly aNPP values and reconcile the resulting intra-annual dynamics with the annual total assessed with NECAS model. This was done for the year 2012 and for the year 2008, the example years for a good and a bad year of pastoralism.

The derived monthly aNPP per m^2 for 2012 and 2008 was each extrapolated to the area that is available for grazing in order to get total figures of the aNPP available on the grazing area of Ololosokwan. Because livestock can graze wherever it is possible, the natural pastures of

[59] In contrast to NPP data, PsnNET data do not consider growth respiration but it considers, like NPP, the maintenance respiration Zhao et al. (2005).

Ololosokwan is the total area of the village, excluding the area of cropland, settlement, infrastructure and the area that has suffered severely from degradation. [60] By subtracting the indicated areas from the total village area, the natural pasture of Ololosokwan amounts to 29,491 ha if the original village area is considered. This grazing area would be reduced to only 16,508 ha if the newly-proposed GCA was implemented.[61] Thus, the derived monthly aNPP (for 2008 and 2012) data was each extrapolated to both these areas to solve for monthly total aNPP on the original pastures and the reduced pastures of Ololosokwan. Based on this data the above given percentages could be applied separately for the months of the rainy and of the dry season of 2008 and 2012. In order to derive the annual maximal exploitability of the pastures in Ololosokwan in 2012 and 2008 however, a mean value has to be calculated out of the seasonal ones.

4.5.2 Minimum and ad libitum feed intake of livestock in Ololosokwan

The maximum exploitability of the pastures of Ololosokwan depicts the hypothetical maximum of forage availability for the livestock herd of Ololosokwan. As discussed above, intra-annual dynamics prevent this maximum to be exploitable. In months where forage supply strongly exceeds feed demand, a certain fraction of potential forage is not exploitable as livestock can only intake a certain amount of feed. In Ololosokwan, neither forage nor feed is stored. Storage would be a way to make use of this surplus in certain, high-productive months in low-productive months, and thus increase the actual exploitability of forage.

An approximation of the surplus of the rainy season can be assessed if the supply perspective (maximum exploitability) is combined with the feed demand perspective. Therefore, the amount of forage which is ingested by the livestock herd of Ololosokwan *ad libitum (*i.e. without any restrictions, it can consume as much forage as needed for its biological needs) was estimated. It was assumed that one TLU would ingest 6.69 kg DM/day maximum *ad libitum*. This assumption is based on the feed intake calculation done in the previous chapter. 6.69 kg DM/day was derived as the average feed intake of a lactating cow in Ololosokwan during the rainy season within a good year for pastoralism, i.e. in a time where the intake was not limited by the available range forage. This figure is an assumable mean value for cattle in Ololosokwan since pregnant and lactating cows in average consume more than dry cows and adult males but require a similar feed intake like young stocks (Bayer and Waters-Bayer 1994, Elliott and Fokkema 1961, see as well Allison 1985, Subcommittee on Beef Cattle Nutrition et al. 1996). In addition, also the minimum feed demand which sustains one TLU (i.e. 5.7 kg DM/TLU/day), which was reported by Schlecht et al. (1999, see also chapter 4.4.3) is considered.

These maximum and minimum feed demands are then applied to the already derived monthly range forage that is offered to the livestock herd of Ololosokwan in order to assess the available surplus. However, also maize crop residues are offered to the livestock. If these crop residues are available there are even first feed to the livestock. Thus, the monthly data on the range forage resources has to be enlarged with these crop residues. Therefore, the total avail-

[60] The area which suffers from degradation i.e. productivity loss is also available for grazing. However, the area is negligible due to its small size of only 12 ha. Thus for the sake of simplification, it was excluded from the calculation of the area potentially grazed by livestock.

[61] It is assumed that the area which will be lost due to the establishment of the new boundaries of the Loliondo GCA is pasture area: In fact the whole *ronjo* will be grabbed which is indeed only pasture area. Only a small fraction of the permanent area would be in addition allocated to the GCA. However, it is assumed that the agricultural fields and houses found in this area will be reestablished on the reduced village area which in turn leads to a reduction of the pasture area but the size of the other land use categories would be remain constant.

able maize crop residues of the year 2012 (see chapter 4.4.1 for the calculation of this crop residues) were subdivided into the months when the harvest of maize primary crops was conducted. The derived amount was then added to the monthly available range forage.[62]

5 Results

In this chapter I will present the results of the aHANPP calculations, interpreting the different aHANPP components. First the final aHANPP calculation of the status quo will be presented, describing the overall picture of the status quo of the aHANPP of Ololosokwan, followed by the presentation of specific results of the particular aHANPP components. This will lead to an understanding of the current colonizing intervention of the inhabitants of Ololosokwan. In a next step I will show how the aHANPP will be altered if 2012 had been a bad year for pastoralism (base calculation – bad year), if the newly-proposed Loliondo GCA is established (land grab calculation – good year) and if, in addition the area would only receive an averagely lower NPP productivity (land grab calculation –bad year).The composition of the aHANPP of Ololosokwan will be only discussed for the status quo calculation since land uses were not altered in the other three counterfactual calculations. In addition, the assessment of the maximal exploitability on the pastures of Ololosokwan will be presented. This assessment helps to draw conclusions on the feasibility of a reduced and/ or less productive village area. Moreover, results of the conducted expert interview will be presented. These results will allow to reflect that particularly the whole dry season grazing area of Ololosokwn will be grabbed if the newly-proposed boundaries of the Loliondo GCA are implemented.

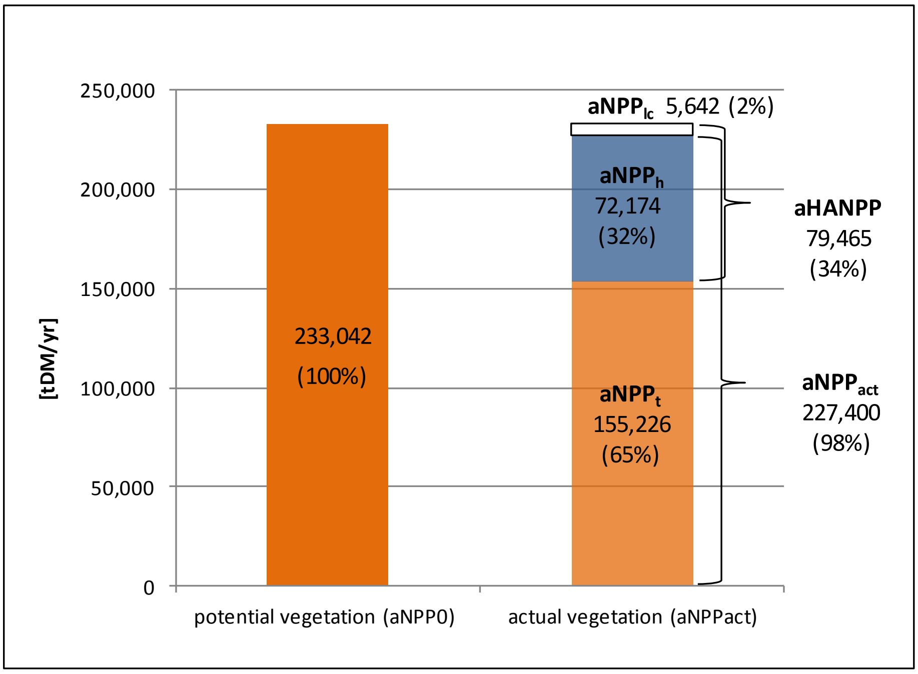
5.1 The current intervention into the ecosystem – aHANPP calculation of the status quo of Ololosokwan

Figure 7 presents the current intervention of the inhabitants of Ololosokwan into the ecosystem of their contemporary accessible village area i.e. 30,583 ha during the year 2012, a generally good year for pastoralism.

The results of this status quo aHANPP calculation reveal that out of total 233,042 t DM/yr aNPP, which would be prevailing in the village in the absence of human influence (NPP_0), 34% (79,465 t DM/yr) are appropriated through a decrease in productivity, inducted through land use changes ($aNPP_{lc}$) and harvesting of biomass ($aNPP_h$). $ANPP_{lc}$ is almost negligible since it only contributes 2% to the total 34% of aHANPP. Consequently the actual vegetation ($aNPP_{act}$) of the village Ololosokwan is with the productivity of total 227,400 t DM/yr aNPP almost unchanged compared to the potential vegetation ($aNPP_0$). In addition, the aHANPP of the village Ololosokwan is thus dominated by the harvesting of biomass ($aNPP_h$) which leads to the appropriation of in total 73,822 t DM/yr aNPP. That makes up 32% of the potential vegetation. The aNPP which remains in the ecosystem after the harvest has taken place ($aNPP_t$) amounts to 153,578 t DM/yr. That is 66% of the potential vegetation.

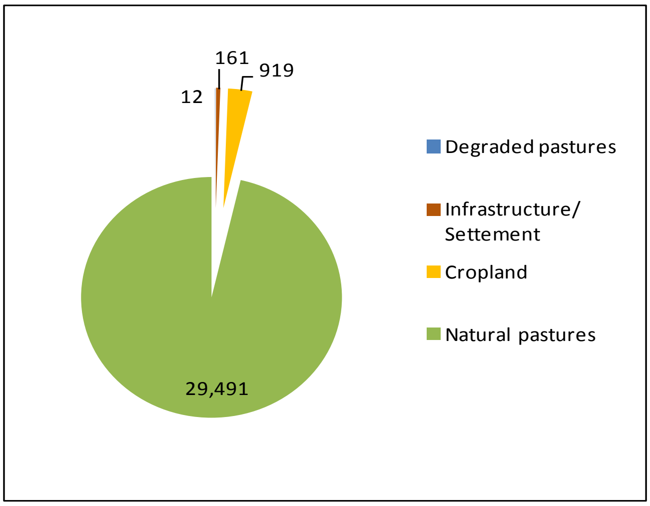
[62] The conducted survey of Ololosokwan included a part in which the women are asked to report when they harvested the different crops they had cultivated in this year (2012). Maize was harvested from May to September with a peak in July. The agricultural harvest, and thus the incurrence of maize crop residues was in addition regarded as moderate (see chapter 3.2 and 4.4.1).

Figure 7: General picture of the status quo aHANPP of Ololosokwan



It was already indicated that the actual vegetation ($aNPP_{act}$) within the village Ololosokwan is almost unaltered compared to the potential vegetation ($aNPP_0$) of the village. This is mainly due to the fact that the majority (96%) of the village area is used as natural pastures (see figure 8) and it was assumed that the productivity of this pasture is mainly not altered compared to the productivity which would be prevailing in the absence of grazing by livestock. Only an area of 12 ha is degraded pasture due to trampling of livestock and humans (see below).

Figure 8: The current village area of Ololosokwan in hectare



However, to a limited extent land use changes which results in an alteration of the productivity of the respective area has also taken place in Ololosokwan. Figure 9 show that biomass is mainly appropriated by turning natural vegetation into cropland (i.e. 1.9% of total 2.4% $aNPP_{lc}$). This is due to the much lower productivity of the cropland of Ololosokwan (2.9 t DM/ha/yr) compared to the productivity of the potential natural vegetation on these areas (7.6 t DM/ha/yr).

On the area of infrastructure and settlement which includes the main road, public and private houses and the enclosures of the Maasai *bomas* no biomass can be grown. However, this area is with total 161 ha much smaller than the area of cropland with 919 ha (see figure 8). Thus, these land use changes contribute only 0.5% to the total 2.4% $aNPP_{lc}$.[63] Negligible but important to report is the productivity loss of the area which suffers from degradation due to trampling by humans and livestock. These losses contribute only with 40 t DM/yr to the total $aNPP_{lc}$ and therefore only make up 0.02% of the potential vegetation ($aNPP_0$).

Figure 9: ANPP appropriation through land use change ($aNPP_{lc}$) in total number (a) and as percentage of $aNPP_0$ (b)

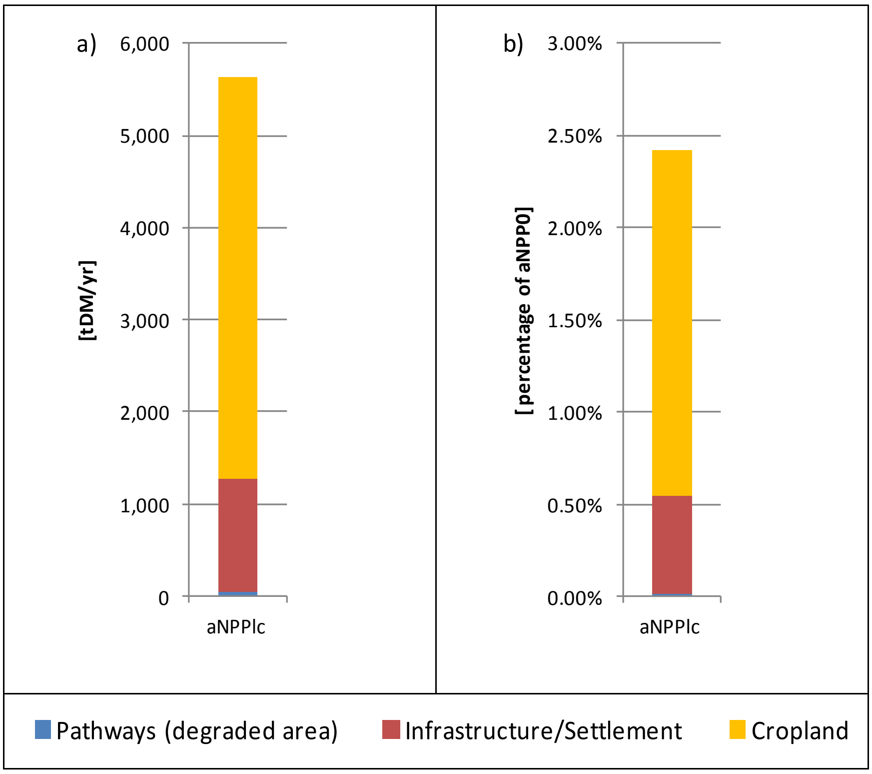
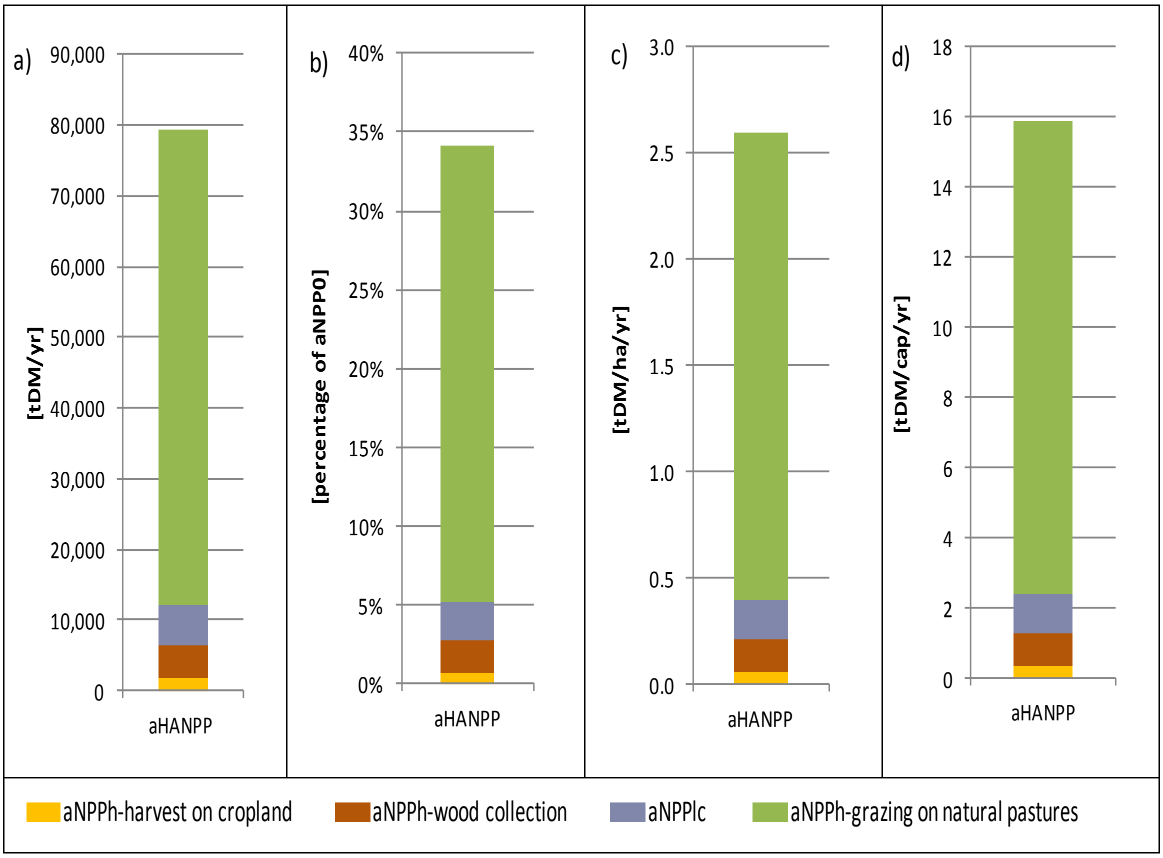


Figure 10 gives details on the aHANPP including the already discussed alteration in NPP due to land use changes ($aNPP_{lc}$) and all components of biomass harvest ($aNPP_h$). It can be seen that the aHANPP of Ololosokwan is dominated by appropriation of biomass through livestock grazing on natural pastures. 85% (67,404 t DM/yr) of the total aHANPP (79,465 t DM/yr) is made up of livestock grazing on natural pastures. All other appropriations of biomass are in comparison negligible. In addition, aHANPP expressed in per capita (figure 10d) shows that the inhabitants of Ololosokwan appropriate 15.9 t DM/yr biomass per capita in the year 2012. The per ha appropriation is much lower with 2.6 t DM per ha and year as can be seen in figure 10c. Consequently, one inhabitant of Ololosokwan needs in average 6.1 ha to appropriate the above given 15.9 t DM/yr biomass per annum. Thus, the land use system of Ololosokwan can be described as extensive.

[63] For a better presentation the main road, public and private buildings and the enclosures were summarized in the category infrastructure and settlement. Details on the sub-categories are given in the table 17 in the annex.

Figure 10: The current aHANPP in Ololosokwan in total number (a), in percentage of $aNPP_0$ (b), per ha (c) and per capita (d)



In the following different $aNPP_h$ components are discussed. Firstly figure 11 gives details on the harvest on cropland. It can be seen that the harvest is dominated by harvest of maize crop residues. These crop residues make up 60% of the total biomass appropriation on cropland (66 kg DM/cap/yr or 34 kg DM/ha/yr). Maize crop residues are those that are grazed by livestock. Consequently the share of the aHANPP which is allocated to pastoralism is slightly increasing from 85% to 86% of the total aHANPP if both livestock grazing on natural pastures and grazing of maize crop residues are taken into account. The high share of grazed and thus used maize crop residues on $aNPP_{h-}$ cropland is also the reason of the high efficiency of harvest on cropland in Ololosokwan. This efficiency can be assessed if the share of used biomass which is extracted from cropland is compared to the unused extraction from cropland.

Figure 11: ANPPh of cropland per ha (a) and per capita (b)

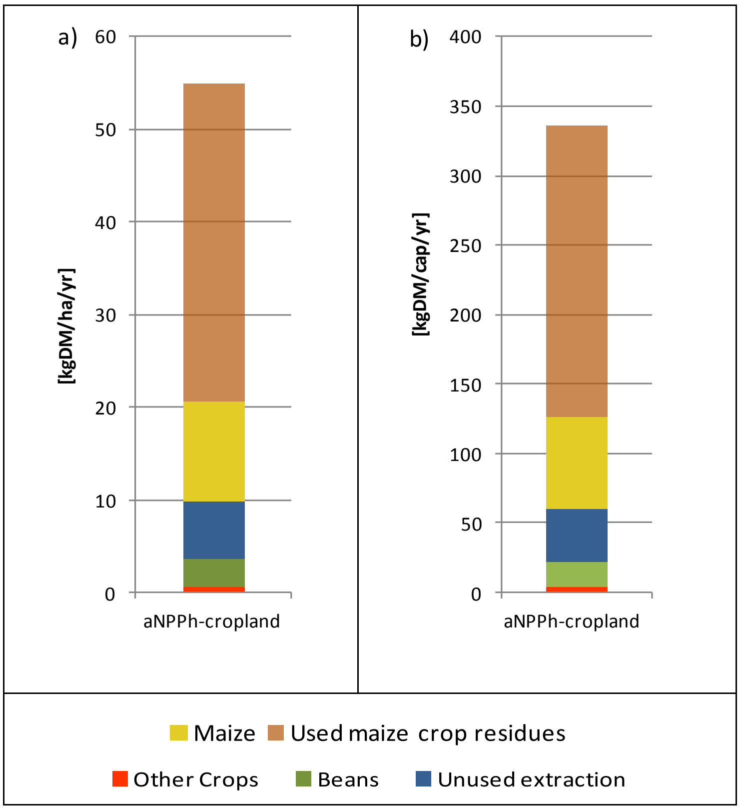


Figure 11 shows that the unused extractions, i.e. crop residues of beans and other crops which are burned and thus not entering the socio-economic system, are in comparison to the used extraction (the total of maize, maize crop residues, beans and other crops) negligible. But, if the used maize crop residues are in addition to the unused extraction excluded of the biomass appropriation on cropland only 26% of the total harvest on cropland is appropriated for direct crop-food consumption. This are 14 kg DM/ha/yr and shows that the per ha extraction of primary crops is quite low. This is true even if the crop production is divided by the agricultural area and not by the total area of Ololosokwan. The yield would then amount to 0,23 t DM/ha/yr (see table 14 in the annex).

Figure 12 separates the $aNPP_h$ component "wood harvest" into wood that is used as firewood and wood that is collected as building materials for traditional Maasai houses and enclosures. It is apparent from the figure that the majority of the harvested wood is used as firewood. Each inhabitant of Ololosokwan collected on average 927 kg DM/ of firewood in the year 2012. This is 2.5 kg DM per day and capita.

Figure 12: $ANPP_h$-wood harvest per ha (a) and per capita (b)

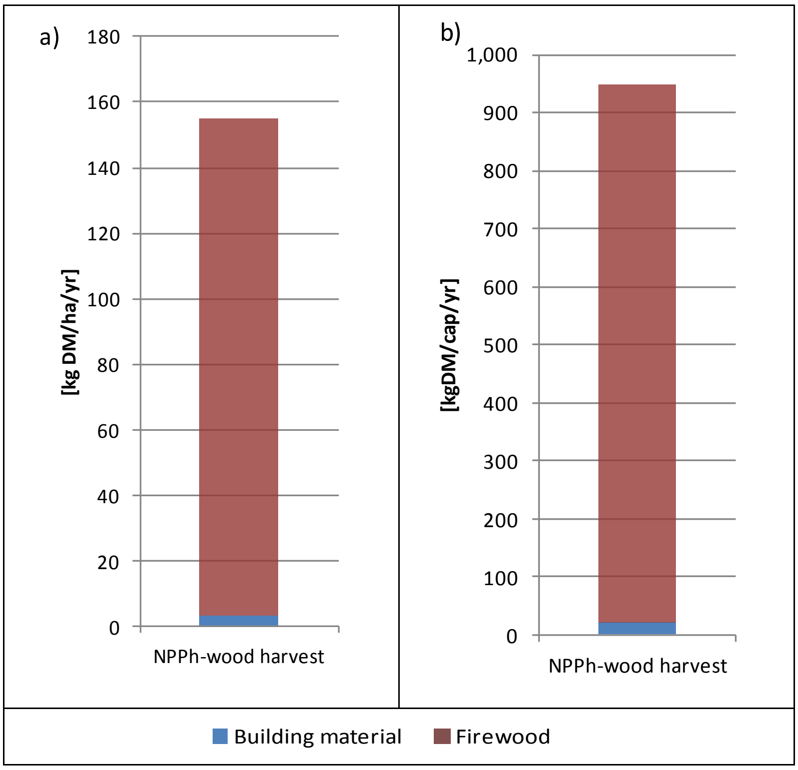
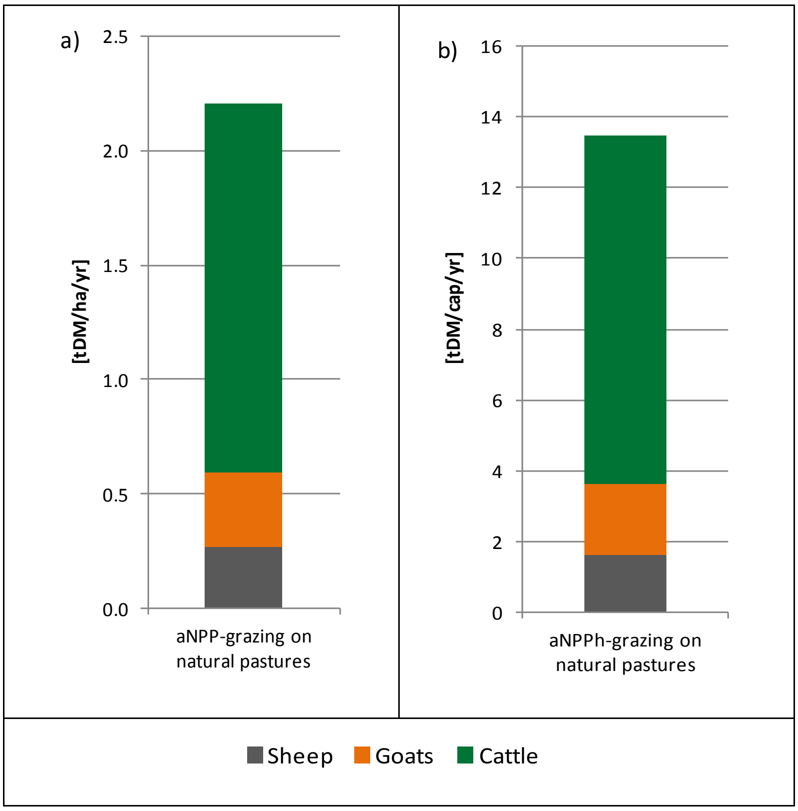


Figure 13 presents details of the $aNPP_h$ component "grazing on natural pastures". It already shows that grazing on natural pastures by cattle makes up 1.6 t DM/ha/yr of the 2.2 t DM/ha yr biomass appropriation by all livestock species. However, sheep and goats are also kept in Ololosokwan which appropriate an equal share of 0.3 t DM/ha/yr.

Figure 13: ANPPh-Grazing on natural pastures per ha (a) and per capita (b)



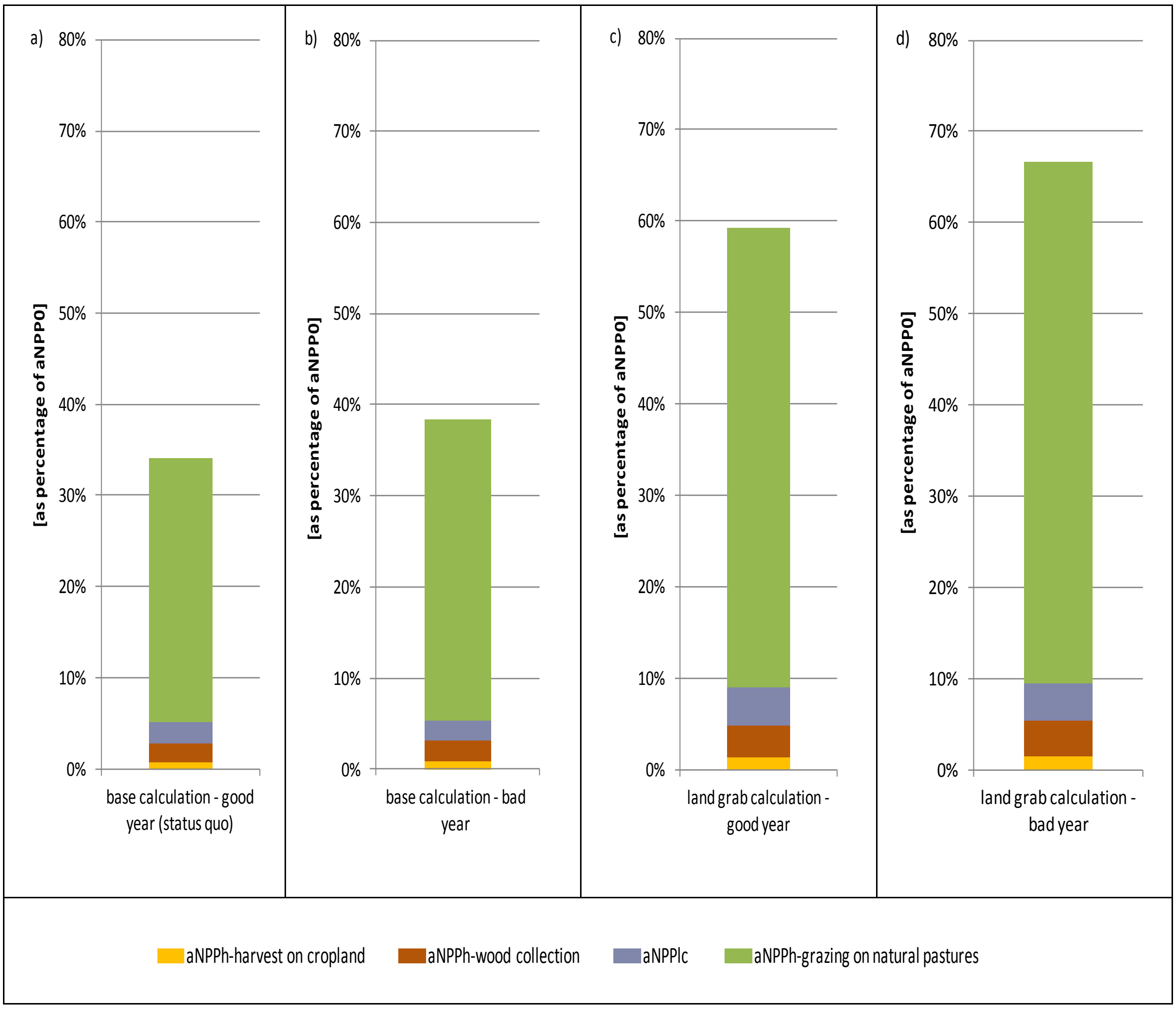
This chapter has shown that the inhabitants of Ololosokwan currently appropriate 34% of the potential vegetation. The aHANPP is defined by harvest of biomass ($aNPP_h$). Biomass appropriations due to productivity loss results from land use changes ($aNPP_{lc}$) are, in contrast, negligible. In this sense the land use system of the village can be described as efficient. This is due to the fact that in general the aHANPP of Ololosokwan is determined through pastoralism i.e. grazing of livestock, which do not alter the productivity of the potential vegetation of the village. Grazing of livestock on natural pastures makes up 85% of the total aHANPP. AHANPP induced by livestock increases to 86% if grazing of crop residues is also taken into account. In addition it was indicated that the land use system of Ololosokwan is extensive, since one inhabitant of Ololosokwan needs in average 6.1 ha to appropriate 15.9 t DM biomass per annum. In the next chapters I will discuss how this aHANPP of Ololosokwan will be altered if a year with lower aNPP productivity is considered or/and a significant part of the village land is lost to the newly-proposed GCA.

5.2 Counterfactuals to the status quo aHANPP of Ololosokwan: Assessment of a bad year situation and/or under the establishment of the new Loliondo GCA

Figure 14 presents the result of all four aHANPP calculations conducted in this thesis. The aHANPP is given as percentage of $aNPP_0$.Thereby it should be borne in mind that each calculation differs in terms of the applied $aNPP_0$: the value is smaller in a bad year and even smaller in the land grab situation (due to the reduced area). In other words the underlying $aNPP_0$ decreases from the status quo calculation to the land grab calculation – bad year. In contrast, the aHANPP in absolute numbers (t DM/yr) of the village is based on the status quo and remains constant over all calculations.[64] Thus, the figure 14b-c shows the status quo aHANPP of Ololosokwan if the current land use activities would be conducted on the reduced village area and/or in year with lower biomass productivity.

Figure 14 indicates that the aHANPP of Ololosokwan is increasing from 34% in the status quo to 38% in the base calculation – bad year. This is due to the fact that the last mentioned calculation considers a 12% lower productivity ($aNPP_0$) on the original village area.

Figure 14: The alteration of the aHANPP of Ololosokwan under the counterfactuals, in percentage of $aNPP_0$



[64] See also the annex for an overview of the different aHANPP calculations and results.

The establishment of the newly-proposed GCA will lead to a reduction of the Ololosokwan village area to 17,600 ha, a land loss of 57% of their entire original village area (40,700 ha). This are 32% if the already rented area of the company *&beyond* is already excluded from the village area (30,583 ha). The reduction of the village area has a significant impact on the aHANPP of the village: If the newly-proposed Loliondo GCA is established the aHANPP of Ololosokwan would increase to 59% provided that a year with the same productivity like in 2012 occurs. The aHANPP of Ololosokwan would further increase to 67% if the current land uses are restricted to the reduced village area and in addition a bad year would appear.

It was already showed in the above section that grazing on natural pastures determines the aHANPP of Ololosokwan. The fraction of $aNPP_h$-grazing on natural pastures in addition increased from 29% of the total aHANPP as percentage of $aNPP_0$ in the status quo to 57% in the land grab calculation – bad year. This is due to the fact that then the current absolute appropriation of biomass through livestock grazing must be appropriated on a less productive and in addition smaller village area. The next section will show if it is actually possible to appropriate the amount of biomass that was grazed by the livestock herd in 2012 also after the newly-proposed Loliondo GCA is established.

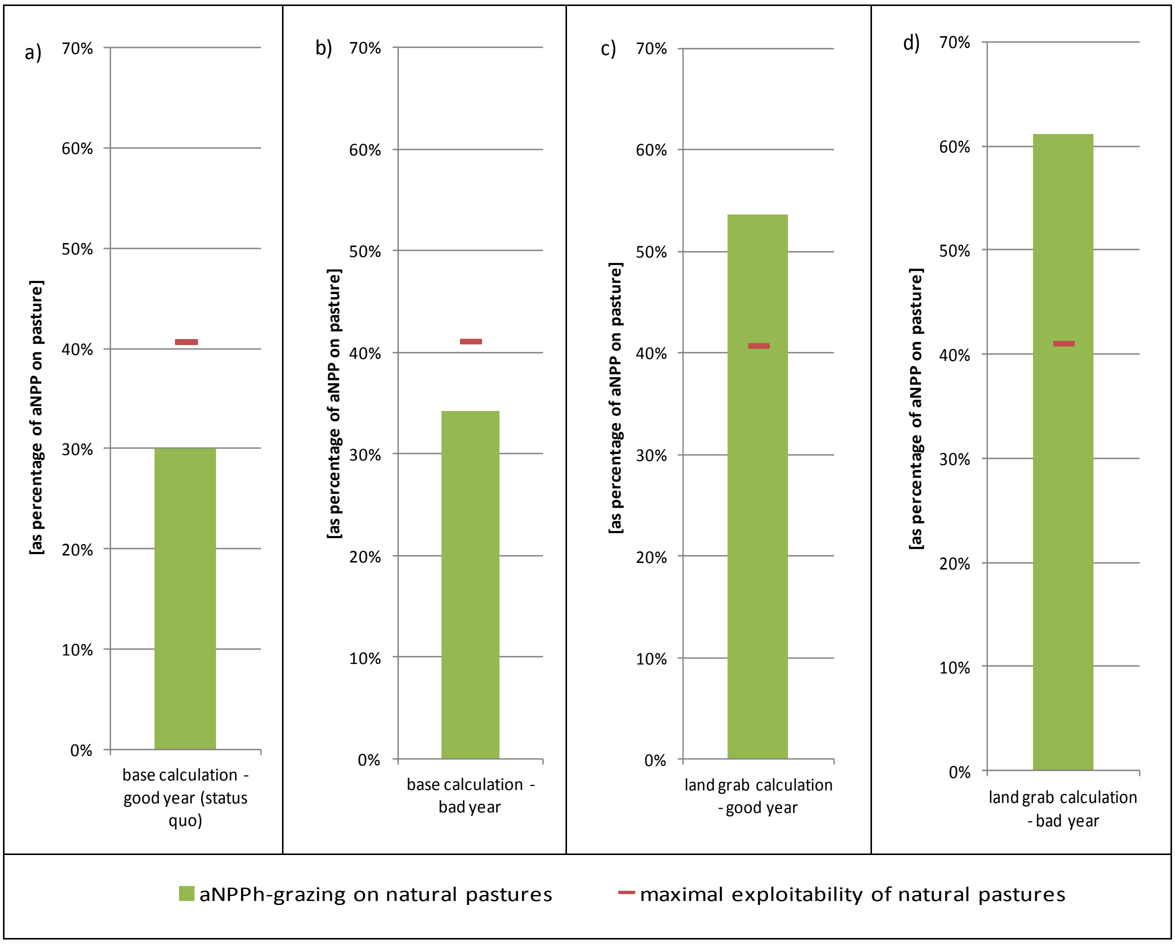
5.3 The current availability of range forage in Ololosokwan and its alteration due to the establishment of the new Loliondo GCA

The above presented results of the counterfactual aHANPP calculations are hypothetical since they are calculated under the hypothetical assumption that land use activities would continue unaltered on a smaller and/or less productive village area. In the following it will be shown if the above presented intervention into the ecosystem is indeed possible on a smaller and/or less productive village area. Since pastoralism is the most significant land use of Ololosokwan this assessment was conducted for grazing of livestock on natural pastures only. In order to do so a maximal exploitability on the pastures of Ololosokwan was calculated (see chapter 4.5). This maximum defines 100% of the range forage that is available on the pastures of Ololosokwan for the livestock herd of the village.

In order to show if the currently appropriation of biomass through grazing of livestock can be de facto also appropriated on a less productive and/or reduced village area the assessed maximum is compared to the $aNPP_h$ - grazing on natural pastures (see figure 15).

Figure 15a depicts that the available range forage is at the present not exhausted by the current livestock herd kept in Ololosokwan. Only 30% of the total aNPP on the pastures of the village is appropriated. However, since not the entire productivity of the pastures of Ololosokwan is also available as range forage the appropriation cannot increase by 70% i.e. to the total productivity. The maximal exploitability of the pastures of Ololosokwan shows that only 40% of the productivity of the pastures is available as range forage. Thus, it is revealed that only a further increase by 10 percentage points is possible. The maximal exploitability assessed in this study does not account for the fact that surplus of the rainy season cannot entirely be appropriated in the dry season since forage is not stored. Consequently, the possibility to increase the current appropriation of range forage is even less. The same applies for a bad year for pastoralism (see figure 15b).

Figure 15: The maximal exploitability of the pastures of Ololosokwan, the status quo and the counterfactual assessment of livestock grazing in percentage of aNPP on pastures.



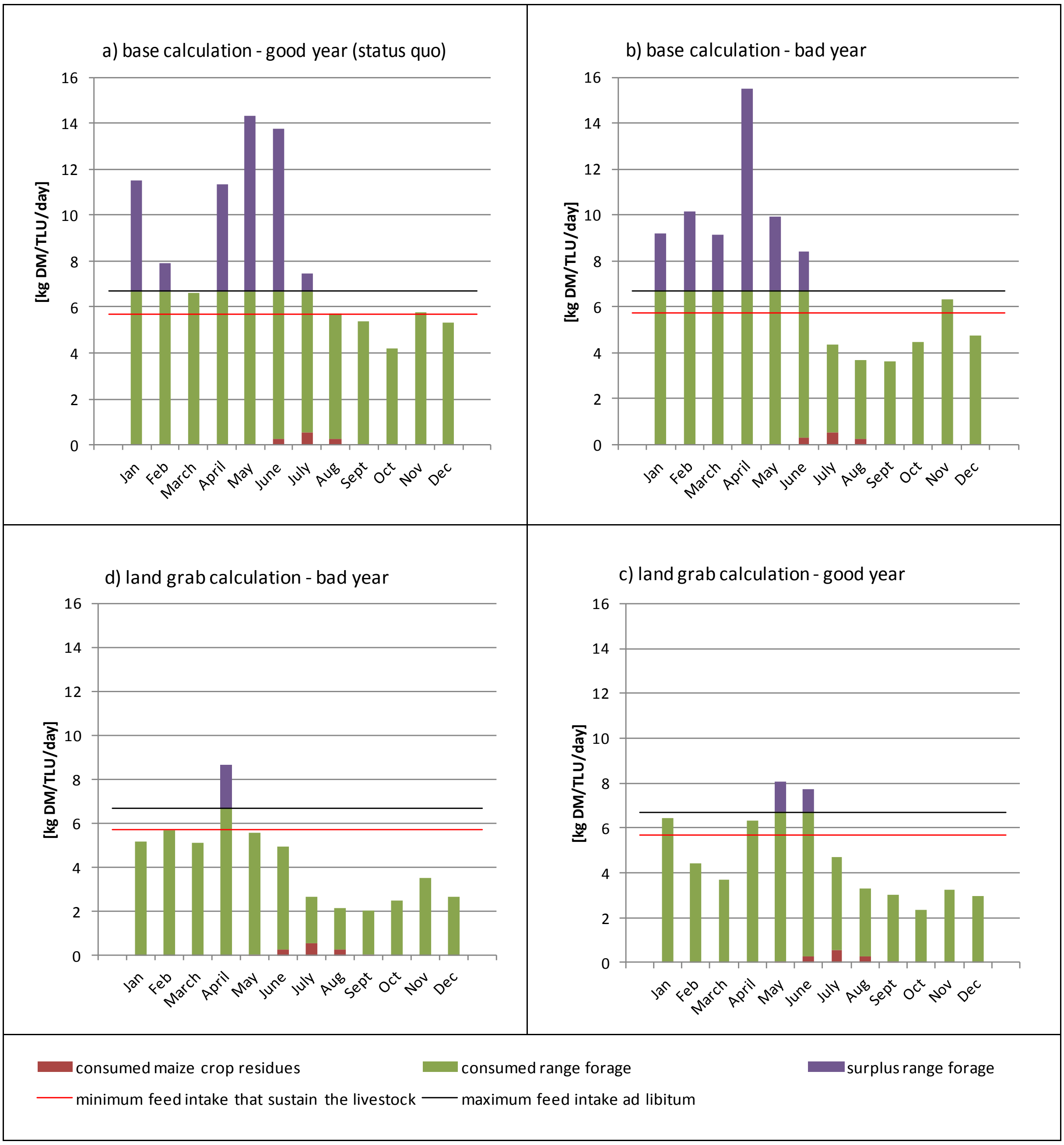
Note there is a difference between the maximal exploitability of the pastures during a good and during a bad year. This is due to the fact that a maximal exploitability of the aNPP of the rainy (47%) and those aNPP of the dry season (32%) was assessed (see chapter 4.5). Thus, the maximal exploitability of the pastures of Ololosokwan is slightly higher during a bad year since in the example year 2008 more biomass was produced during the rainy season then during the same season in 2012 (good year).

If a part of the village area is grabbed due to the establishment of the new boundaries of the Loliondo GCA the situation is aggravated. Figure 15c and 15d show, that the current livestock herd of Ololosokwan cannot appropriate 54% or 61% of the aNPP on the pastures of the village since the maximum exploitability on the pastures of Ololosokwan is determined by 40% and 41%, respectively.

The maximal exploitability of 40% on the pastures of Ololosokwan translates - on the reduced area - in a feed availability of 50,649 t DM/yr, within a good year. Assuming a feed level of 5.7 kg DM/TLU/day, the minimum feed intake level, this corresponds with 2.0805 TLUs that can be fed. This is 81% of the current livestock in Ololosokwan. Thus, the current herd would be reduced by 19%. Assuming a range forage availability of 50,649 t DM/yr but a feed intake level of 6.24 kg DM/TLU/day, the current feed intake, this translates in 22,238 TLUs that can be fed. This is 74% of the current livestock in Ololosokwan. Thus, the current herd would be reduced by 26%. If, instead, the maximal exploitability is assumed to be too optimistic, and only an exploitability of 30%, as currently, is assumed, livestock will even drop to 55% of the current livestock herd. That is a reduction of 45%.

The maximal exploitability of the pastures of Ololosokwan does not account for the fact that not the entire surplus of the range forage of the rainy season is appropriable in the dry season. However, at least the monthly available surplus could be approximated based on the assessment of the forage which is ingested by the livestock herd of Ololosokwan *ad libitum*. Figure 16 presents the results.

Figure 16: The intra-annual dynamics of the range forage on the pastures of Ololosokwan



The range forage available on pastures is expressed in kg DM/TLU/day. Therefore the currently kept livestock herd was considered i.e. 30056.2 TLU.

Figure 16a shows that also during a good year a deficit in range resources occurs in three months of the dry season. However, it is also apparent that the surplus of the rainy season can compensate this deficit.[65] The degree of the compensation could not be assessed in this study. However, if only the consumed fraction of the range resources (green bar in figure 16a) is considered this would amount to an appropriation of range forage that is slightly under the amount of range forage that was indeed appropriated in 2012. This means that some of the surplus forage could be de facto appropriated in 2012. Nevertheless, it is not known to what extent this compensation could be increased.

Figure 16b shows that during a bad year a much higher range forage deficit occurs. However, it is still presumable that a compensation of this deficit with the surplus of the rainy season is feasible. However, it should be borne in mind that over time also the quality of the range forage decreased. Thus, the more range forage has to be compensated the more serious it gets for the diet and health of the livestock.

Figure 16c and 16d show, if the newly-proposed Loliondo GCA is established, the range forage is in 9 or even 11 months in the year not at all sufficient to even satisfy the minimum feed demand, of the livestock herd of Ololosokwan. The small surplus during the rainy season is in addition not sufficient to compensate for the periods where range forage scarcity occurs. Also maize crop residues are not sufficient as a supplementation. It is furthermore unlikely that other drought strategies that are practiced by the Maasai such as cutting tree branches to enlarge the range forage resources are sufficient to bridge the large period of deficiency of range forage.

5.4 The specific impacts of losing a dry season grazing area

In order to get additional insights into impacts of the establishment of the new Loliondo GCA on the village Ololosokwan also semi-structured expert interviews with Maasai elders were conducted. In the following the insights gained from these interviews are presented.

In general it was revealed that the impacts on pastoralism and thus also on the livelihood of the Maasai of Ololsokwan are in particular serious because the herdsmen would lose the access to their dry season grazing area if the newly-proposed boundaries of the Loliondo GCA are established. The dry season area has specific characteristics which distinguish it from other grazing areas of Ololosokwan. These characteristics make the dry season grazing area in particular important for the pastoral system of the village. Based on the conducted qualitative interviews I will therefore discuss these specific characteristics of the dry season grazing area of Ololosokwan in the following.

The ward councilor of Ololosokwan explained that the strip alongside the Serengeti is an area which is comparably longer humid. Thus, they choose this area as their dry season grazing area i.e. *ronjo*:

> "In the past for example it [ronjo] was evergreen throughout the year and even today it continues to be so. It was always the last place to get dry also regarding water sources except near to the Kenyan border. So they choose this area because of the grass and water." (Ndoinyo, 21.10.2012).

It is striking that all the other interviewed elders also stated that they will obviously lose land

[65] Actually the maximal exploitability on natural pastures is the sum of the consumed (green bar) and surplus (purple bar) range forage accumulated over the whole year.

if the GCA is created but at the same time they always emphasized that they will lose *quality* grazing land for the dry season. One elder narrated for instance:

> "When we lose ronjo we will lose a lot of things beside the additional land. This is valuable land because more grass and in particular nutritional grass grows there. A calf can grow up quickly there and even fetch more money when we sell our cows which grow up there healthily." (elder 6, 26.10.2012).

Another elder explained the difference between the available range forage in more detail:

> "There is also a huge difference regarding the fodder because in the Serengeti the fodder grew like tender maize and then it sprouted as long grass and when it dried it became sort of greyish but here [in the permanent area] when grass grows and becomes dry it turns sort of reddish. In this part [permanent area] the grass is also a bit thicker and quite hard not tender grass like in the Serengeti." He added that the ronjo area of Ololosokwan is still characterized like he explained for the area of the Serengeti. But he empathized that: "gradually as you come further away from the Serengeti you will find less healthy grasses for livestock." (elder 1, 09.10.2012).

In summary the area close to the Serengeti is described as good dry season grazing area. This is, according to the interviewee due to the fact that the range forage in the *ronjo* is also in the dry season comparably abundant, gets more slowly dry and thick and is more nutritional.

In addition to the loss of an area with valuable grazing resources three of the eight interviewed elders also mentioned that they will lose water sources, as already indicated in the first quote. Even though the African Zebu (*Bos indicus*) which is traditionally kept by the Maasai can withstand drought and can thus stay without water for two or three days the availability of water sources apart from rainwater is essential during the dry season (Lynn 2012). In the *ronjo* several water sources can be found which most of them are also available during the dry season. Commonly used rivers in the *ronjo* are *Kilamben*, *Ilusien*, *Leenet*, *Orkimbai*, and *Engorika.*

Furthermore five elders reported that if the GCA is established they also do lose access to salty areas. However, salt is important for the diet of the livestock (elder 2, 11.10.2012). Salt for the livestock cannot only be found in some grass species like *Enkampa*, which are grown in the *ronjo* but also some parts of the *ronjo* are in particular characterized by a salty ground (ibid.). An elder mentioned the areas *elenborkokoni, oltigomi, celior* are such salty areas found in the *ronjo* (elder 6, 26.10.2012). The last mentioned area is located within the *&beyond* concession, to which the inhabitants already do not have access. In addition salty rivers can also be found in the area of *&beyond*, as an elder reported (elder 2, 11.10.2012).

The conducted survey in Ololosokwan also reveals that out of 15 interviewed *bomas* 14 feed commercial salts to mostly both small and large ruminants. The supplementation of natural salt with commercial salt to increase the salt in the diet of the livestock was a frequently-mentioned reason for this practice. However, 10 *bomas* reported that they feed commercial salt to their livestock because they have to substitute for the natural salt which they cannot access anymore due to the presence of the OBC hunting block or/and the *&beyond* concession:

> "[…] formerly when we could access the Serengeti and the Arab land [the hunting block of OBC], which is full of salt, we did not use commercial salt. But we were forced to move out of the land and we have to substitute the natural salt with the commercial salt." (elder 4, 18.10.2012).

A statement of one interviewed elder in respect of the already established hunting concession can serve as a conclusion of the findings of the conducted expert interviews in respect of additional impacts of the establishment of the newly-proposed GCA on the village Ololosokwan:

> "There are three major things that we are losing. After the government of Tanzania took massive land from eight villages, that border the Serengeti and gave this land to an Arab company the villages can no longer access grass, quality grass, we cannot access water and we cannot access salt licks, salty areas for our animals. This is the place [the area of the OBC hunting concession] where we used to graze during the dry season and that used to save us during the dry season." (elder 2, 11.10.2012).[66]

6 Discussion and Conclusion

In the following I will discuss the results of this thesis presented in the previous chapter. Thereby I will start with an assessment of the conducted aHANPP calculations. Thus, I will discuss the reliability and limitations. After this methodological evaluation I will discuss in a second sub-chapter the socio-ecological impacts of the establishment of the newly-proposed boundaries of the Loliondo GCA on the village Ololosokwan. Based on this, I will present in a final section some consideration on the future of the village Ololosokwan.

6.1 The reliability of the results

In this section the reliability of the above presented results will be discussed. Moreover, methodological enhancement of the approach applied in this thesis will be discussed as a prospect for further studies.

The results show that the average agricultural yield within Ololosokwan amounts to 0.23 t DM/ha/yr (see also table 14 in the annex). This is an extremely low yield especially, if the yield is compared to the yield of the Arusha region. In the Agricultural Census concerning the agricultural year 2007/2008 various crop yields of the Arusha region, to which Ololosokwan belongs, are reported (United Republic of Tanzania 2012a).[67] Table 15 in the annex presents the reported average yields for the Arusha region. If the same crop mix as in Ololosokwan is taken into account, the average yield amounts to 1 t DM/ha/yr. As reported by the agriculturalist in Ololosokwan the yield of 2012 was only moderate. But beside this the comparably low

[66] The elder speaks in the past because actually the access to the area which is planned to be the new Loliondo GCA is already restricted. This is because the area of the newly-proposed GCA is the same area as the current hunting block of OBC. The Maasai herdsmen are fighting to access the area of this hunting block particularly during the dry season (see chapter 2.2)

[67] The village Ololosokwan was also included in the survey on which the results of the Agricultural Census are based on (United Republic of Tanzania 2011).

yield in Ololosokwan also can be explained by the circumstance that most of the inhabitants of the village focus on pastoralism. Agriculture is for the most only a recent explored additional strategy to diversify the subsistence production, but the focus is clearly still on pastoralism as discussed in chapter 2.1.3. Thus, it could be assumed that less work and maybe also experiences are spent on crop cultivation by most of the inhabitants of Ololosokwan which could partially explain the low yield within the village. Climatic conditions can presumably not explain the difference, since also the whole Arusha region is in general described as semi-arid (see also chapter 1.1.2).

The result of the agricultural area of Ololosokwan in this thesis is in the range of figures given in literature (see table 13 in the annex). In summary, it can be said that the secondary data indicates that between 1% and 5% of the area of Ololosokwan are farmed. My result that 3% of Ololosokwan is farmed is quite in the middle of this range and thus seems reliable.

The result of the wood harvest in Ololosokwan has shown that in average 2.5 kg DM firewood per day and capita is collected. This is a comparably high consumption if compared to the median of firewood consumption data reported by others for different African countries. This median amounts to 1.58 kg DM/cap/day (see table 16 in the annex). An explanation of this comparably high firewood consumption in Ololosokwan could be the fact that plenty of firewood is available within the village and therefore the firewood is also collected and used abundantly. This phenomena was described by other studies (see for instance Agea et al. 2010, Hosier 1984). Agea et al. (2010) reported that an indicator for the adequate or even high availability of firewood is the using of firewood not only for cooking purposes but in addition also for social purposes, for instance in order to sit together around a fire. During my fieldwork I have observed these situations very often. Other factors which influenced the firewood consumption are for instance the diet of the people and the climate of the specific region (Nilsson 1986). McPeak (2002) for instance reported that firewood consumption increased if the diet is switches from animal production based diet to a maize based diet. I observed that beside milk the stable crops are maize and beans which the Maasai are now cultivating. However, there are no data available which indicate the diet or firewood consumption before agriculture was also adopted by the Maasai of Ololosokwan.

There are studies available defining the amounts of wood needed for the construction of houses and enclosures of the Amboseli Maasai in Kenya (Jensen 1984) and the Ngisonyoka pastoralists in South Turkana, Kenya (Ellis et al. 1984). However, the figures reported for these houses are for instance much lower compared to my results (see chapter 4.4.2). This could be due to the different building technique (round instead of square buildings) and generally smaller houses (3x4 meters compared to 5x5 meters in Ololosokwan).

These discussed differences between the result of this thesis and values reported in literature are, however, not large enough to alter the annual aHANPP results. In overall terms, aHANPP due to agriculture and wood harvest is negligible (3% of the total status quo aHANPP of Ololosokwan).

As already discussed the aHANPP pattern of Ololosokwan is dominated by pastoralism i.e. the appropriation of biomass through livestock grazing. Consequently the reliability of the applied data-set in respect of pastoralism is the most important for the robustness of the overall results. Although large efforts were pointed out especially for this data-set, uncertainties and limitations remain. These will be discussed in the following.

In this thesis it was assessed that only 12 ha of the rangelands of Ololosokwan suffers from degradation mainly due to trampling. It was assumed that the productivity of the remaining rangelands of Ololosokwan has not been altered compared to the potential vegetation that would prevail in this area without grazing of livestock. This assumption was based on the fact that in no narratives of the inhabitants of Ololosokwan claims about an altered productivity of the natural pastures through processes like bush encroachments were expressed. Furthermore, in the absence of livestock, large wild herbivores would be more dominant. Conversely, it has to be noticed that the Tanzanian government claims about overgrazing of the area. However, no details of these claims are given (United Republic of Tanzania 2010). Actually, no data are available which support one or the other argumentation. Due to the lack of such a study and since the Maasai did not claim productivity losses a conservative approach was chosen in this thesis by assuming that the actual vegetation ($aNPP_{act}$) of the rangelands of Ololosokwan equals the potential vegetation ($aNPP_0$).However, an assessment of the range condition would give clarity on the question if and to which degree the rangeland of Ololosokwan suffers from long term productivity loss due to livestock grazing.

The approximation of the current appropriation of aNPP through grazing of livestock can be assessed as reliable, as a comparison with data from the literature reveals. The applied data of the milk production are in the scope of secondary data collected in the same area and during the same period as the data gathered for this study (see chapter 4.4.3). Moreover, the results of the feed intake per cow are in line with available secondary data (see also chapter 4.4.3).[68] However, it should be noted that the assessment of the feed intake conducted in this study does not account for mobility in particular for seasonal movements of the livestock of Ololosokwan. This means that it is assumed that the livestock herd of Ololosokwan is able to graze all over the rangeland of Ololosokwan regardless of the designation of different grazing zones. However, since the traditional grazing zone has already started to erode the seasonal mobility might not have been a great impact on the feed intake estimation. However, this could only be assessed if data on the current seasonal livestock distribution were available. This is an argument for a separate HANPP calculation for the *ronjo* and for the permanent area, as will be further outlined below.

In summary it can be concluded that the results of the aHANPP assessment are relatively robust. It could even be a conservative approximation if the claim of the Tanzanian government of the overuse of the rangelands of Ololosokwan is verified.

In the following the robustness of the assessment of the maximal exploitability of the pastures of Ololosokwan will be discussed. The single fractions which were applied to derive the available range forage for the livestock of Ololosokwan out of the total productivity of the pastures of the village were already described and discussed in chapter 4.5. However, it should be emphasized that due to the absence of precise data the applied factors remain rough estimations. However, as has been showed (see chapter 4.5) these are in line with other expert estimations. In addition, the dynamic of the range forage availability over time in the year

[68] The aHANPP of Ololosokwan was only calculated with the size of the livestock herd of Ololosokwan in 2012. However, the livestock numbers kept in Ololosokwan vary over the years due to frequent occurrence of droughts. Since the aHANPP of Ololosokwan is dominated by livestock grazing thus, the aHANPP level would also fluctuate over time depending on the size of the livestock herd. For instance the aHANPP level is presumably still high at the beginning of a drought year provided that former years received a high precipitation. This is due to the fact that the herd size is still large but the NPP productivity decreased. In the end of the drought the aHANPP level would decrease because of the deaths of livestock due to the drought. The following year, if it is a year with a high precipitation, a lower aHANPP level has to be expected since the size of the livestock herd is still low but the NPP productivity is high. In order to show precisely this variability of the aHANPP level over time a time series analysis would be interesting to conduct.

2012 (see figure 16a) shows that the range forage on offer is abundant for the livestock herd during the rainy season, but gets scarce during the dry season. This fits well with my own observations on site, as well as in the narratives of the Maasai in Ololosokwan. The Maasai report that 2012 was a good year for pastoralism, even though the available range forage in the dry season got scarce. But the scarcity in the dry season could be bridged due to the abundance of range forage in the wet season (see also photo 15 in the annex for a resource-diagram which was done with a focus group for the year 2012).

Figures for the consumable fraction of the herbaceous and ligneous layer were applied for all situations investigated in this study. It should be noted that during the dry season of a bad year, the available range forage for the livestock could be even less: Assuming a still poorer forage condition in the area, even more livestock from other areas would be certain to come to the village land and make use of the averagely better pastures of Ololosokwan. In contrast if the newly-proposed Loliondo GCA is established the competition on range forage is maybe reduced within Ololosokwan since then the best pasture of the village will be grabbed. In addition, this pasture is also the area where most competition with wildlife occurs. However, in the absence of reliable data a modeling of these dynamics is challenging. In addition, further estimations in respect of the quantification of these dynamics would make the already conducted rough assessment even more complex and prone to errors.

It can be concluded that the maximal exploitability of the pastures of Ololosokwan is a reliable rough approximation in particular for a good year for pastoralism. For a bad year the assessment is slightly conservative, which is however presumably balanced if the GCA is established.

However, research which surveys and quantifies the range forage on offer for the livestock herd of Ololosokwan on a monthly basis would be valuable and improve the rough estimation of this study. Such a study should not only incorporate the dynamics of range forage availability due to the palatability of aNPP but also quantify the range forage loss for the livestock herd of Ololosokwan due to grazing competition with other herbivores. For the last-mentioned aspect an additional assessment of the incoming wildlife and livestock from other areas outside of Ololosokwan and the duration of their stay would be necessary. In addition, it would be valuable to model the alteration of the incoming wildlife and livestock into the reduced village area i.e. if the dry season grazing area is no longer accessible, due to the establishment of the newly-proposed GCA. In addition, it would be an improvement of this study to precisely assess the possible compensation of the range forage deficit of the dry season with unconsumed range forage of the rainy season. Thus, it would be possible to calculate the actual maximal exploitability on the pastures of Ololosokwan within the pastoral livestock system of the village.

Studies which calculate the carrying capacity of a specific area often apply a so-called "proper use factor" (Hocking and Mattrick 1993, Mulindwa et al. 2009). This single multiplier considers not only aNPP losses due to unpalatability or unavailability and grazing inefficiencies, but also includes a factor which defines a fraction of biomass which has to remain after grazing in order to practice a sustainable range management (ibid.). The assessment done in this study, in order to estimate the maximal exploitability of range forage through the livestock of Ololosokwan, does not include the aspect of a sustainable range management. Due to the dynamic in range resource availability in time and space an assessment of the maximal exploitability under the guidelines of an efficient but sustainable range management has to be much more complex than by applying a static proper use factor (Behnke et al. 1993). Nevertheless, under the assumption of the proper use approach the assessment of the maximal exploitability of the pastures of Ololosokwan conducted in this thesis are conservative, since no proper use factor was applied. However, it should be noted that within the above (chapter 4.5) cited literature in respect of the fraction of the total aNPP which is available as range resources, it is sometimes difficult to determine whether the proper use was included in the reported factor or not. For instance, Le Houérou and Hoste (1977) do not t explicitly report that they include the proper use aspect in their applied factor. However, authors who cited these studies simply say that they did (Hocking and Mattrick 1993).

In order to get an insight into the dynamic availability of range resources monthly data of range resources were derived. Moreover, the surplus of range resources was assessed by the application of an *ad libitum* feed intake. First of all the applied *ad libitum* feed intake of 6.69 kgDM/TLU/day seems reliable since it is in the range reported by Schlecht et al. (1999) and others presented in chapter 4.4.3. In addition, it was calculated that with an average feed intake of 6.69 kg DM/TLU/day, diet preferences, as indicated by Peischel (2005) for cattle, sheep and goats, can still be satisfied during the rainy season of a good year but also during the rainy season of a bad year if the original grazing area of Ololosokwan is considered. With the help of this *ad libitum* feed intake the surplus of the rainy season could be estimated. However, it could not be assessed how much of this surplus is still appropriable as standing hay in the dry season. Therefore a "disappearance rates" (Leeuw et al. 1993:146) has to be applied. Leeuw has estimated such a rate for Mali but he also emphasized: "[i]n the view of large variation in disappearance rates, it is not clear how dry season feed supplies should be adjusted." (ibid.). But, the approach in this study to assess the available surplus could be a starting point for further research in this direction.

In general, a dynamically explicit calculation of the aHANPP of Ololosokwan (but also of the maximal exploitability of the pastures of the village), which takes differences in productivity and land use into account would be promising. This is due to the high dynamical aNPP in time, but also in space. In addition, the main land use (i.e. pastoralism) is also highly dynamical in terms of space: Mobility is an inherent function of the pastoral land use system. As already indicated in chapter 2.1.3, the traditional grazing system of the Maasai alters between a dry season grazing area (*ronjo*) and a wet season grazing area. Although it was reported that this pattern erodes in Ololosokwan, the land use of the dry season grazing area is still mainly characterized by pastoralism. In contrast to that, permanent *bomas* and services and facilities like schools and dispensaries in addition to agricultural fields are found in the former wet season area. . Thus, an assessment of the appropriation of biomass separated for these two areas would make it possible to reflect the land use pattern of Ololosokwan more appropriately and consequently enhance the approach of this study.

6.2 Socio-ecological impacts of the establishment of the newly-proposed GCA on the village Ololosokwan

The results of the aHANPP status quo calculation have shown that the inhabitants of Ololosokwan currently appropriate 34% of the potential vegetation. This is 15.6 t DM biomass per capita and year, and 2.5 t DM/ha/yr. Thus, it was concluded that the land use system of Ololosokwan is extensive. The aHANPP of the village is defined by harvest of biomass ($aNPP_h$). Biomass appropriations due to productivity loss results from land use changes ($aNPP_{lc}$) are, in contrast, negligible. This indicates that the land use system of Ololosokwan is efficient: only a small amount of the total aHANPP cannot be used by humans or the ecosystem since it results from land use change inducted productivity losses (Fetzel et al. 2012).[69] Grazing of livestock on natural pastures makes up 85% of the total aHANPP and increases to 86% if grazing of crop residues is also taken into account. Due to this dominance the following discussion on the impacts of the establishment of the Loliondo GCA on Ololosokwan will focus on pastoralism.

The assessment of the maximal exploitability on the pastures of Ololosokwan has shown that not all range forage which was available within the year 2012 was appropriated by the livestock herd of the village. However, it was also revealed that the potential to further increase the appropriation by livestock grazing is not large. Since grazing of livestock dominates the aHANPP of Ololosokwan this result also indicates that the current aHANPP level of the village can not significantly increase within the present land use system practice in Ololosokwan.

The discussion in chapter 1.1.4 has shown that already at present the traditional range management such as the seasonal mobility within Ololosokwan started to erode. The current high appropriation of range forage might be an indicator for the decline of the seasonal mobility. However, this result is only one picture within a very dynamic ecosystem and even land use system. Thus, only a time series analysis which in addition distinguishes between the aHANPP of the *ronjo* and the permanent area could reveal if the seasonal mobility between both of these areas started to erode due to the level of grazing pressure.

The counterfactual aHANPP calculations have revealed that the aHANPP level of Ololosokwan would increase to 38% of $aNPP_0$ if a bad year for pastoralism would occur. Furthermore, if the newly-proposed GCA is established, the aHANPP of Ololosokwan would increase to 59% $aNPP_0$ provided that a year with the same productivity like in 2012 occurs. The aHANPP of the village would further increase to 67% $aNPP_0$ if in addition a year with a lower aNPP occurs.

In the case of the base calculation – bad year the intra-annual variability of the range forage production has shown that much more deficit of forage in the dry season of a bad year exist, than during the same season in a good year. Even though it was presumed that a compensation of this deficit is still reliable, the bad year is notwithstanding hard for the livestock. Other factors could become limiting in a bad year as for example the poorer quality of standing hay (Hary et al. 1996, Coughenour 2008).

This situation is harshly aggravated if the new Loliondo GCA is established. The aHANPP of the village would increase – *ceteris paribus* - to 59% or 67% of the $aNPP_{0.}$ However, such an increase of the aHANPP is not achievable due to the maximal exploitability of the pastures of Ololosokwan. In fact, it was assessed that only 81% of the current livestock herd could be sustained on the reduced pastures of Ololosokwan in a good year (i.e. a reduction of 19% of the current herd). This estimation is very conservative since the reduced livestock herd has

[69] Land use efficiency can in addition be assessed by the ratio between the used extraction which enters the socio-economic system and the unused extraction of biomass (also named “backflows to nature) which is not entering the socio-economic system (Fetzel et al. 2012). The result depends also on the chosen system boundary which defines the unused extraction. For instance earlier HANPP studies also consider feces dropped by livestock as unused extraction (see for instance Kastner 2009, Niedertscheider 2011). However, this study does not account for this backflow to nature because, consequently a part of the feces dropped by humans (since Ololosokwan mainly does not have sanitary facilities) would have be also considered. Since it is difficult to assess how much of the diet of the inhabitants is satisfied by food that was produced within the village this backflow to nature is difficult to estimate. Due to this restriction this second assessment of land use efficiency cannot be performed for this study. However, this is not a crucial limitation for the aim of this study.

therefore to exploit the reduced pastures to a maximum but could still in average only ingest 5.7 kg DM/TLU/ day, which is the minimum feed intake that sustains the livestock. It is rather assumable that the currently kept livestock herd would be reduced by 26% to 45 %, if the new boundaries of the GCA are established. The lower end means that the reduced livestock could ingest as many as currently (i.e. 6.24 kg DM/TLU/day), but the livestock would still have to exploit the pastures maximal (i.e. 40% of the productivity on pastures). The upper end means that the reduced livestock herd could ingest as much forage as today and could also exploit the pastures as in the present (i.e. 30% of the aNPP on pastures). Currently the pastures are not exploited to a maximum, but there is already a deficit of range resources in the dry season which has to be compensated with surplus of the rainy season. However, an entire appropriation of the surplus of the rainy season in the months of the dry season is not possible with the livestock system practice in Ololosokwan, as discussed earlier (see chapter 4.5.1). But, in fact this is assumed in the lower value of the above given range on the livestock loss in Ololosokwan. Thus, the lower end of the above given range is still rather a conservative estimation. Consequently, the reduction of the livestock tends rather towards 45% of the current herd than to 26%.

It should be emphasized that the estimations on the reduction of the livestock herd of Ololosokwan due to the establishment of the new Loliondo GCA are based on the specific condition of the year 2012. Altough the year 2012 was assessed as an example for a good year for pastoralism it should be born in mind that also “good years” differ between the biomass productivity and its distribution over the year. In addition, also the size of the livestock herd kept in Ololosokwan is dynamic within “good years”. Moreover, the estimations on the reduction of the livestock herd are based on the fact, that in 2012 no livestock of Ololosokwan grazed outside the village boundaries. Thus, the conducted estimations can only serve as an approximation of the expectable livestock loss during a good year.

Furthermore, it should be noted that with all above given approximations on livestock loss it could not be considered that the whole dry season grazing area of Ololosokwan is grabbed if the Loliondo GCA is established. This is essential since no linear relationship exists between the size of the lost area and the amount of the lost livestock (Coughenour 2008). The spatial and qualitative heterogeneity of the pastures of Ololosokwan could not be assessed in this study. However, in chapter 5.5 the importance of the dry season grazing area of Ololosokwan was already emphasized. In fact, the *ronjo* used to sustain the livestock during the dry season. In the words of Hary et al. (1996: 229): “The essential point to be made here is that even a severe reduction in stocking rates on wet-season pasture cannot compensate for the loss of dry-season grazing reserves.”

Livestock fluctuations are actually normal within traditional pastoral livestock systems in semi-arid environments. However, these fluctuations exist due to drought and are desired in the light of a sustainable range management (Ellis and Swift 1988, Standford 1994, Illius and O'Connor 1999). But, the livestock loss of 26% to 45% of the currently kept herd would already arise in a good year for pastoralism. Within such a year pastoralists actually build up an extra large livestock herd in order to buffer against bad years or even droughts (Illius and O'Connor 1999, Perrier 1994). This means that future drought situations will hit the Maasai more seriously if the newly-proposed GCA is established since they are not able to build up a “livestock-puffer” during good years.

An indicator for the effects of the livestock loss on the livelihood of the Maasai in Ololosokwan is the declining TLU per capita ratio. The current ratio amounts to 6 TLU/cap. Thus, even though the livestock system is at the present time already eroding, it still seems that pastoralism sustains the Maasai of Ololosokwan in general.[70] This is, since Pratt and Gwynne's (1997 in Fratkin and Roth 1990) estimated that 4.5 TLUs per capita is the minimum level, to sustain pastoralists. Similar figures are presented by Sandford (2006) if the TLU conversion factor applied in this thesis is used. However, he also emphasized that this minimum level can be halved for agro-pastoralists (ibid.). In this thesis the Maasai in Ololosokwan were classified as "generalized pastoralists" rather than "agro-pastoralists" (see chapter 2.1.3). However, even if pastoralism is still dominant, it cannot be denied that the Maasai of Ololosokwan have diversified their livelihood strategy by incorporating farming in this strategy. Thus, they are not completely dependent on their livestock anymore. Nevertheless, if the newly-proposed GCA is created it is more than likely that pastoralism can no longer play a dominant part in the livelihood strategy of the Maasai in Ololosokwan: the livestock loss of 26% to 45% of the current herd translates to a TLU per capita ratio between 4.5 and 3.4. It was discussed that a livestock loss of 45% is more appropriate. However, with the pressure to sustain their living it is assumable that the Maasai would try to exploit the pastures as much as possible. However, a maximal exploitability of the pasture of Ololosokwan (40 % of the aNPP) would, if practice on a long term basis, certainly induce overgrazing of the rangelands, which in turn results in a decrease in (range forage) productivity.

In conclusion it could be revealed that the current land use system of Ololosokwan is already under pressure and thus it is likely that the system is sooner or later facing a tipping point. This would be truly aggravated by the establishment of the new Loliondo GCA. The resulting reduced natural resource basis of Ololosokwan would clearly diminish the socio-economic backbone of the pastoral village i.e. the livestock herd, even if the Maasai try to keep as many livestock as possible to sustain their living.

This discussion seems to draw the same pessimistic scenario for the future of pastoralism in Ololosokwan as Sandford (2006) did in his thesis on "Too many people too few livestock". However, the attestation of a crisis of pastoralism (ibid.), also depends on the question of how far pastoralists are "allowed" to change in order to still speak of "pastoralism". For instance Devereux and Scoones (n/a) argue that the "viability" of a pastoral system is not dependent on the TLU per capita ratio since for instance a diversification of the livelihood can also cushion the declining ratio. However, with regard to the case study of this thesis it is predictable that the current "generalized pastoralism" (see chapter 2.1.2) practice in Ololosokwan cannot be maintained if the newly-proposed GCA is established and the pastoralism is restricted to the reduced village area. But, it is a different question as to whether there are adaptive strategies that could be reliable options to sustain the livelihood of the pastoralists in Ololosokwan. A follow-up study which develops future livelihood strategies and thus land uses in Ololosokwan, at best in a participative manner, would be valuable to answer this question in detail. However, in the following chapter I will discuss some consideration in this regard.

[70] The ratio is derived from the total TLUs kept in the village and the total human population of Ololosokwan. However, since not all inhabitants of Ololosokwan are pastoralists and thus dependent on livestock the ratio would be higher if only pastoralists are considered. On the other hand pastoralists who have also migrated from the village, for instance due to employment opportunities often still own livestock that are herded by family members in the village. Although the family has user right to this livestock they cannot be slaughtered or sold without the permission of the owner. This means this livestock might contribute only partly to the livelihood of the pastoralists of the village. In addition, it should be borne in mind that the ratio of 2012 is a comparably high ratio since the livestock herd is presumably extra large due the keeping of a "livestock-buffer".

6.3 Possible adaptive strategies on the pastoral system in Ololosokwan

Moritz et al. (2009) show in their study on pastoral system in West Africa that the Sandford thesis on the crisis of pastoralism cannot be verified for West Africa since pastoralists adopted various strategies to cope with the pressure on grazing resources. In the following I will discuss some of these adaptive strategies and whether these are strategies which could also be adopted in the Ololosokwan village. In addition, some ideas which were stated by the Tanzanian Government in the Framework Plan are also discussed.

A successful adaptive strategy described by Moritz et al. was the movement to other grazing areas i.e. the movement to a more sub-humid zone (ibid.). But could this also be a solution for the investigated village in this thesis?

The spatial system boundary of this study was set on the village of Ololosokwan where the land uses of the inhabitants of Ololosokwan could be carried out (see chapter 3.2). There is theoretically the possibility that the current livestock herd could survive even if the newly-proposed GCA is established if the Maasai of Ololosokwan would also move beyond their village boundary. [71] First of all the pressure on the grazing resources of Ololosokwan would be certainly decreased if the herdsmen would also make use of the grazing resources of surrounding villages. But it should be borne in mind that not only Ololosokwan will lose significant grazing area due to the establishment of the newly-proposed GCA. If all Maasai from the seven other affected villages would move with their livestock to the neighboring villages the competition on the range forage would expand from the village level to the division level. In the Maasai society there are precise grazing regulations as roughly explained in chapter 2.1.4. However, in general Maasai clans permit the grazing of livestock from other Maasai clans on their grazing land if for instance a drought occurs. Nevertheless, in order to make up for the loss of their grazing land, the Maasai of the affected villages would have to let their livestock graze on a more permanent basis on the grazing area of other villages. If the situation in other affected villages is similar to the one in Ololosokwan it is questionable whether the grazing area of other villages in the Loliondo division can compensate for the rangeland loss due to the establishment of the newly-proposed GCA. It is particularly questionable since the strip alongside the Serengeti, which will be designated as the new Loliondo GCA, serves for the whole area as a drought reserve area (see also chapter 2.2). The conflict that arose in 2009, which was also caused by the drought, has shown that at present problems can already occur during a drought situation (see also chapter 2.2). This means that presumably the movement of all affected communities into other grazing areas of neighboring villages could result in social conflicts over grazing resources.

In summary it can be said that the migration to surrounding villages will not be a long-lasting solution for the Maasai of Ololosokwan and the other affected communities. With the creation of the new boundaries of the Loliondo GCA the Tanzanian government aims to solve the long-lasting land conflict in Loliondo (United Republic of Tanzania 2010). However, it seems likely that the newly-proposed GCA would only shift the land conflict spatially. In addition, a shift from the conflict parties would occur namely from a conflict between the Maasai and the Tanzanian government and the hunting company OBC, respectively to a conflict between the Maasai themselves and to the Maasai and the agriculturalists within the Loliondo division.

A second adaptive strategy described by Moritz et al. (2009, but see also Bayer and Waters-

[71] Actually the example of Moritz et al. (2009) refers to an outmigration beyond national boundaries. In this thesis I will only discuss the option to move within the Loliondo division.

Bayer 1994) which is practiced for instance in the Sudanian Zone is the integration of pastoralism and agriculture which results in an intensification of both land use systems. For instance the agriculture land use system was improved by using animal traction and the faeces of the livestock as manure. On the other hand the herd productivity was increased by feeding crop residues and cottonseed cakes. Thereby the integration was not as typically done on the household level, but instead on the regional level (ibid.). This could also be a possibility for Ololosokwan and for the Loliondo division in general. In Ololosokwan it seems that both land use systems are more or less independent from each other. In other areas of Loliondo division conflicts between pastoralists and agriculturalists were also reported (Ojalammi 2006). However, this integration can clearly only be a part of an adaption strategy. For instance Moritz et al. (2009) emphasized also that the possibilities for the integration of both land use systems is more feasible in West Africa than in East Africa due to the better bioclimatic condition for agriculture in West Africa.

In the Ngorongoro District Framework Plan the Tanzanian government gives some general suggestions for the pastoral system in the Loliondo division, which also aims to increase the productivity of the system (United Republic of Tanzania 2010). For instance ideas like the establishment of livestock markets and dips, the providing of education "to the livestock keepers on cultivation of improved pastures, modern and commercial livestock farming methods" (ibid.:57) were pointed out. However, it is questionable if the general underlying policy assumption, to establish modern ranches with improved pastures and breeds within the Loliondo division (ibid.) is applicable. Studies have shown the limits of such approaches within semi-arid variable environments (Bayer and Waters-Bayer 1994). For instance Homewood and Rodgers (1991) emphasized that breeds with high production potential like *Bos taurus* could not withstand the hard conditions in semi-arid rangelands, but zebu cattle like the Small East African zebu (*Bos indicus*) do. This is for instance due to the fact that indigenous zebu-cattle can adapt their basic metabolism faster to sub-maintenance conditions in order to sustain feed shortage in the dry season than breeds with higher genetic potential (Bayer and Waters-Bayer 1994). In respect of ranchesScoones (1994b) stated that the increasing of mobility efficiency is the development challenge of pastoral systems rather than the establishment of ranching systems as proposed by advocates of the equilibrium paradigm. In addition Homewood and Rogers (1991) reported:

> "There is no evidence that any system of paddocking and rotation could improve on traditional patterns of migration and transhumance despite the enthusiasm of administrative staff for such systems." (Homewood and Rodgers 1991: 225)

The authors give the Kenyan group ranches as an example for a failure to establish the idea of ranch system into drylands (ibid.). In addition, it is emphasized by various authors that "pastoral systems have higher returns than ranches under comparable conditions" (Scoones 1994b: 35, but see also Jahnke 1982 and different sources in Jode 2010). The Tanzanian government also stated that they want to provide livestock-keepers with titles (United Republic of Tanzania 2010) In addition, some ideas, which were expressed by the Ololosokwan ward councils, go in the same direction (Ndoinyo, 21.10.2012). Reid et al. (2008) state that it is the classic way to address insecurity of landownership by titling land, whereby the access to this land is then restricted to individuals (private property) or to a distinct group (common property). However, the authors caution that problems due to the so called 'paradox of pastoral land tenure' will then arise. This means that pastoralists actually need both secure access to grazing land and also the flexibility to move in order to make use of dynamic availability of range forage in time and space and to respond to social and political changes (ibid.).

A classis suggestion to tackle the pressure on the pastoral system is to diversify the economic activities. This is a third strategy presented by Moritz et al. (2009). Within Ololosokwan this has already happened with the migration of young male family members to find study and employment opportunities in larger cities. However, the government has to invest heavily in education and employment opportunities if the newly-proposed GCA is established since then the need for such alternatives will be drastically increased. Such intention was not made public until now.

Another activity which already diversifies the economy of Ololosokwan works in particular on the village level. This is the engaging of Ololosokwan in tourism activities. As already described in chapter 2.1.2 Ololosokwan is often given as an example for the successful implementation of community-based tourism. However, for instance the most important partner of Ololosokwan, namely *&beyond*, an enterprise engaged in luxury safaris, is operating within the area which would be designated as the new Loliondo GCA. Since *&beyond* would no longer be operating on the village land of Ololosokwan, if the newly-proposed GCA is established, the financial profit which Ololosokwan has gained through this partnership would be gone. This also means that scholarships, which were paid out of these funds, could not be offered anymore. However, in the land use plan of the Loliondo and Sale division the Tanzanian Government does not only propose the new boundaries of the Loliondo GCA, they also suggest to particular villages, including Ololosokwan, to establish Wildlife Management Areas (WMA) (United Republic of Tanzania 2010). This is an approach to legally introduce community-based tourism in Loliondo and in Tanzania in general (Sulle et al. 2011, United Republic of Tanzania 2012b). Nevertheless, it would be somewhat ironical if Ololosokwan has to give up the already existing cooperation with *&beyond* if the newly-proposed GCA is created only to establish a new cooperation, but this time within the framework of a WMA. In addition, the most lucrative area for safari-based tourism, namely the strip alongside the Serengeti would then already be designated as GCA. It is questionable if a WMA would still work in the remaining village area of Ololosokwan, which is less blessed with wildlife.

In the light of the here presented results, the establishment of the newly-proposed Loliondo GCA is associated with so destructive consequences that an alternative should be search. The establishment of a WMA instead of a GCA alongside the eastern boarder of the Serengeti could be such an alternative: The aim of WMAs is also the protection of nature. Moreover, the Tanzanian government would enable the villages, which are located alongside the Serengeti National Park, to diversify their economic activities, instead of reducing their village area and thus restricting their current livelihood strategy.

TNRF has calculated that the economic return of the area which is now proposed as the area for the Loliondo GCA would be higher if instead of the current hunting block of OBC photographic tourism, comparable to that which is practiced in the Serengeti NP would be carried out (Tanzania Natural Resource Forum and Maliasili Initiatives 2011). Even though it was also calculated that pastoralism is the land use with the highest economic profit the designation of one or several WMAs in this area could diversify the economic activities of the inhabitants of the area (but see further down). In addition, within a WMA the land use can be managed more flexibly than in other nature conservation categories like GCA (United Republic of Tanzania 2012b). Ololosokwan could also already gain from their experiences with community-based tourism and could enforce the engagement with *&beyond* and other tourism companies. However, it should also be noted that criticism on the WMA approach has arisen (see for instance Sulle et al. 2011, Igoe and Croucher 2007, Nelson 2007). For instance it was claimed that WMAs still give only limited authority to local people and thus extend the central control over wildlife and tourism (Nelson and Ole Makko 2003). This was also one reason why Ololosokwan rejected earlier the suggestion of the government to establish a WMA within their village area (see chapter 2.2). In addition, the current engagement into wildlife tourism of Ololosokwan might be in economic terms more profitable then within the framework of a WMA. For instance 35% of the revenues of a WMA go directly to the Wildlife Divisions (Sulle et al. 2011). More-over, if hunting is practiced within a WMA "all fees for these activities continue to be paid directly to the WD [Wildlife Division] and not to the village managing the WMA." (Igoe and Croucher 2007).

Nevertheless, to establish a WMA instead of a GCA alongside the eastern boarder of the Serengeti could be a starting point to resolve some of the challenges that the Maasai are currently facing, which are multiplied if the newly-proposed GCA is established (Igoe 2006, Gibson 2011). Further research which investigates this option in a participative manner, also in respect of necessary improvements of the WMA approach, would be valuable.

In the light of the here presented results it can be said that the pastoralists of Ololosokwan and their land use system already face challenges, some of which evolve from the ongoing land conflict but some, such as the increasing human population are independent from this conflict. However, both contribute to the erosion of the mobility patterns of the Maasai in Ololosokwan and thus also to the traditional land use and livestock system of the Maasai. This is also identified by the Maasai of Ololosokwan, as the interviews and survey conducted in Ololosokwan show. However, until now an adequate strategy to cope with these challenges is missing even though ideas of such strategies have already been discussed (Ndoinyo, 21.10.2012). If the proposed boundaries of the Loliondo GCA were to be indeed established the present challenges will be aggravated dramatically. The resulting reduced natural resource basis of Ololosokwan would massively reduce the socio-economic backbone of the pastoral village and thus the current livelihood strategy. Moreover, the Maasai of Ololosokwan would not have the time to develop and implement adaptive strategies for their current land uses and livelihood strategy if the newly-proposed GCA were to be ad hoc created as has been tried recently (see chapter 2.2). This means if the GCA were created this should be at least accompanied by a development and implementation of real alternatives for the current livelihood strategy of the villages which will suffer from the inducted land losses. The development of such alternatives should be thereby done in a participative manner. But maybe the time has come to find solutions which combine nature conservation and local communities' livelihood instead of separating them (Neumann 1998). The establishment of a WMA instead of the GCA alongside the Serengeti could be a step in this direction.

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Rurai, Masegeri; forest Officer at Ngorongoro District Council and PLUMP member of the Ngorongoro District Framework Plan (30.10.2012), Wasso

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Captain Willness, A. Minja; principle game officer and responsible for community based conservation (WMA) at the Ministry of Natural Resources and Tourism (13.11.2012), Dar es Salaam

Chacha, Lucia; livestock officer at Ministry of Livestock and Fisheries (13.11.2012), Dar es Salaam

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Appendix

I Secondary data

Table 13: Agricultural area of Ololosokwan, Loliondo and Ngorongoro

Study area	Total size of the area [ha]	Agricultural area [ha]	% of study area
Ololosokwan village [1]	5,123	512	1
Loliondo division [2]	2,898,000	8,079	3
Ngorongoro district [3]	1,403,600	26,718	1.9 *
Loliondo division [4]	n/a	n/a	5
Loliondo division [5]	n/a	n/a	4.4

1 (Ndoinyo 2002), 2 (Ojalammi 2006), 3 (United Republic of Tanzania 2010), 4 (Tanzania Natural Resource Forum and Maliasili Initiatives 2011), 5 (Nelson and Ole Makko 2003)* Actually it was reported that 1.73% of the total district area is agricultural area, without presenting at this point the figures for the district area. However, earlier, 14,036 km2 were reported for this area, consequently 1.90% of the district area is cultivated land.

Table 14: Yield per primary crop harvest in Ololosokwan village in 2012

	[t DM/ha/yr]
Maize	0.07
Beans	0.23
Other crops	0.45

Source: based on primary data collected in Ololosokwan in 2012 (see chapter 3.4.1)

Table 15: Yield per primary crop harvest in Asuha region in 2007/08

	[tDM/ha/yr]
Maize	1.45
Beans	0.92
Other crops	0.64

Source: (United Republic of Tanzania 2012a), data originally given in fresh matter but now already converted with the factors presented in table 3 into dry matter. The category “other crops” subsumed all crops cultivated in smaller amounts in Ololosokwan (see table 2).

Table 16: Firewood consumption in different African countries

Study Area	Firewood consumption [kg DM/cap/day]	Source
Tanzania (Mwanza, Shinyanga)	1.13	Gilliusson and Persson in Nilsson 1986
Tanzania (Dodoma, Morongoro)	1.54	McCall in Nilsson 1986
Tanzania (Dodoma, Sigida, Arusha, Shinyanga, Mwanza)	1.59	IRA 1983 in Nilsson 1986
Tanzania	2.38	different sources in Johnsen 1999 *
Tanzania	1.99	Malimbwi and Zahabu 2009 *
Kenya (national survey)	1.75	Hosier 1984
Kenya (Turkana)	1.02	Ellis et al. 1984
Kenya (Amboseli Maasai)	0.97	Jensen 1984
Burkina Faso	1.35	Ernst 1997 in Wood and Baldwin 1985 *
Burkina Faso	1.00	Floor 1977 in Wood and Baldwin 1985
Gambia	1.72	Floor 1997 in Wood and Baldwin 1985
Liberia (Monrovia)	1.86	Roitto 1970 in Wood and Baldwin 1985
Nigeria (Batagawara)	2.01	Makhijani et. Poole 1975 in Wood and Baldwin 1985
Nigeria (Ibadan)	1.43	Ay 1980 in Wood and Baldwin 1985
Kenya	1.57	Marquands/Githinji 1978 in Wood and Baldwin 1985
Kenya	1.43	Murchiri 1978 in Wood and Baldwin 1985
Kenya	2.15	Western and Ssemakula 1978 in Wood and Baldwin 1985 *
Kenya	1.46	O'Keefe et al. 1984 in Wood and Baldwin 1985
Tanzania	3.00	Openshaw 1978 in Wood and Baldwin 1985
Sudan (Bara)	6.30	Digernes 1980 in Wood and Baldwin 1985
Median	1.58	

*Original data reported ranges, the arithmetic mean for this ranges was taken.
Figures originally presented by Wood and Baldwin (Wood and Baldwin 1985) in energy (Joule) were converted to kg dry matter biomass, applying the factor of 18 MJ/kg DM reported in the same publication for oven-dry wood . Data which originally presented in cubic meters were converted into kg dry matter by using the standard factor of 580 kg DM/m^3 reported for wood density of non-coniferous wood in tropical zones of Africa by Krausmann (Krausmann et al. 2008) in the supplementary materials. The figures originally presented in fresh kg were transformed, assuming an average water content of 12.5% for fresh weight. This percentage consequently was applied to calculate amounts in kg dry matter.

II aHANPP calculations

Table 17: AHANPP calculation of a good year for pastoralism (with and without land grabbing)

aHANPP calculation of 2012 (good year)	base calculation (satus quo)			land grab calculation		
	Area [ha]	Productivity [t DM/ha/yr]	aNPP [t DM/yr]	Area [ha]	Productivity [t DM/ha/yr]	aNPP [t DM/yr]
aNPP of the potential vegetation ($aNPP_0$)						
Wooded and bushed savanna	30,583	7.6	**233,042**	17,600	7.6	**134,112**
aNPP of the actual vegetation ($aNPP_{act}$)						
wooded and bushed savanna (natural pastures)	29,491	7.6	224,721	16,508	7.6	125,790
Cropland	919	2.9	2,628	9,186	0.3	2,628
Main road	12	0	0	12	0	0
Buildings	3	0	0	3	0	0
Enclosure	147	0	0	147	0	0
Degraded area (pastures)	12	4.3	52	12	4.3	52
Total $aNPP_{act}$	---	---	**227,400**	---	---	**128,470**
Percentage of $aNPP_0$	---	---	**97.58%**	---	---	**95.79%**
Appropriation through harvest ($aNPP_h$)						
on cropland	---	---	1,682	---	---	1,682
Firewood	---	---	4,633	---	---	4,633
Building Materials	---	---	103	---	---	103
by grazing on natural pastures	---	---	67,404	---	---	67,404
Total $aNPP_h$	---	---	**73,822**	---	---	**73,822**
Percentage of $aNPP_0$	---	---	**31.68%**	---	---	**55.05%**
Appropriation through land use changes ($aNPP_{lc}$)						
Cropland	919	---	4,372	919	---	4,372
Main road	12	---	91	12	---	91
Buildings	3	---	20	3	---	20
Enclosure	147	---	1,119	147	---	1,119
Degraded area (pastures)	12	---	40	12	---	40
Total NPP_{lc}	1,093	---	**5,642**	1,092	---	**5,642**
Percentage of $aNPP_0$	---	---	**2.42%**	---	---	**4.21%**
Total aNPP appropriation (HANPP)						
Biomass in physical units	---	---	**79,465**	---	---	**79,465**
Percentage of $aNPP_0$	---	---	**34.10%**	---	---	**59.25%**
aNPP remaining in ecosystem (NPP_t)						
Biomass in physical units	---	---	**153,578**	---	---	**80,038**
Percentage of $aNPP_0$	---	---	**65.90%**	---	---	**40.75%**

Table 18: AHANPP calculations of a bad year for pastoralism (with and without land grabbing)

aHANPP calculation of a bad year	base calculation			land grab calculation		
	Area [ha]	Productivity [t DM/ha/yr]	aNPP [t DM/yr]	Area [ha]	Productivity [t DM/ha/yr]	aNPP [t DM/yr]
aNPP of the potential vegetation (aNPP$_0$)						
Wooded and bushed savanna	30,583	6.7	204,294	17,600	6.7	117,568
aNPP of the actual vegetation (aNPP$_{act}$)						
Wooded and bushed savanna (natural pastures)	29,491	6.7	196,999	16,508	6.7	110,273
Cropland	919	2.9	2,628	919	2.9	2,628
Main road	12	0	0	12	0	0
Buildings	3	0	0	3	0	0
Enclosure	147	0	0	147	0	0
Degraded area (pastures)	12	3.8	45	12	3.8	45
Total aNPP$_{act}$	---	---	**199,672**	---	---	**112,946**
Percentage of aNPP$_0$	---	---	**97.74%**	---	---	**96.07%**
Appropriation through harvest (aNPP$_h$)						
Farming	---	---	1,682	---	---	1,682
Firewood	---	---	4,633	---	---	4,633
Building Materials	---	---	103	---	---	103
Grazing	---	---	67,404	---	---	67,404
Total aNPP$_h$	---	---	**73,822**	---	---	**73,822**
Percentage of aNPP$_0$	---	---	**36.14%**	---	---	**62.79%**
Appropriation through land use changes (aNPP$_{lc}$)						
Cropland	919	---	3,509	919	---	3,509
Main road	12	---	80	12	---	80
Buildings	3	---	17	3	---	17
Enclosure	147	---	981	147	---	981
Degraded area (pastures)	12	---	35	12	---	35
Total NPP$_{lc}$	1,092	---	**4,622**	1,092	---	**4,622**
Percentage of aNPP$_0$	---	---	**2.26%**	---	---	**3.93%**
Total aNPP appropriation (HANPP)						
Biomass in physical units	---	---	**78,444**	---	---	**78,444**
Percentage of aNPP$_0$	---	---	**38.40%**	---	---	**66.72%**
aNPP remaining in ecosystem (NPP$_t$)						
Biomass in physical units	---	---	**125,850**	---	---	**79,328**
Percentage of aNPP$_0$	---	---	**61.60%**	---	---	**33.28%**

III Photo documentation

Photo 1: Overview of the village Ololosokwan (Kirtalo hill)

Photo 2: The *&beyond* concession within the *ronjo* of Ololosokwan

Photo 3: A *boma* within the Mairowa-Juu sub-village, permanent area

Photo 4: A permanent *boma* within the permanent area

Photo 5: A semi-permanent *boma* within the *ronjo*

Photo 6: A simple structure *boma* within the *ronjo*

Photo 7: A former maize field

Photo 8: A typical load of firewood

Photo 9: A traditional Maasai-hut under construction

Photo 10: Herding of small stock, permanent area (Mairowa-Juu)

Photo 11: Herding of cattle, permanent area (Kirtalo Hill)

Photo 12: Cattle coming home, *ronjo*

Photo 13: Poster describing the season and range forage availability in Ololosokwan 2012

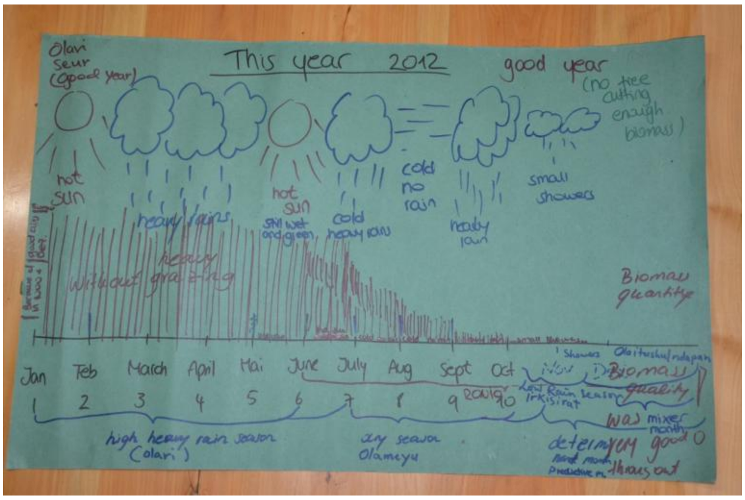

Photo 14: Area suffered from trampling by livestock and humans

Photo 15: Iretet river at the end of the dry season 2012

Photo 16: Grazing reserve, permanent area

Photo 17: Cattle enclosure, permanent area

Photo 18: Small stock enclosure, permanent area

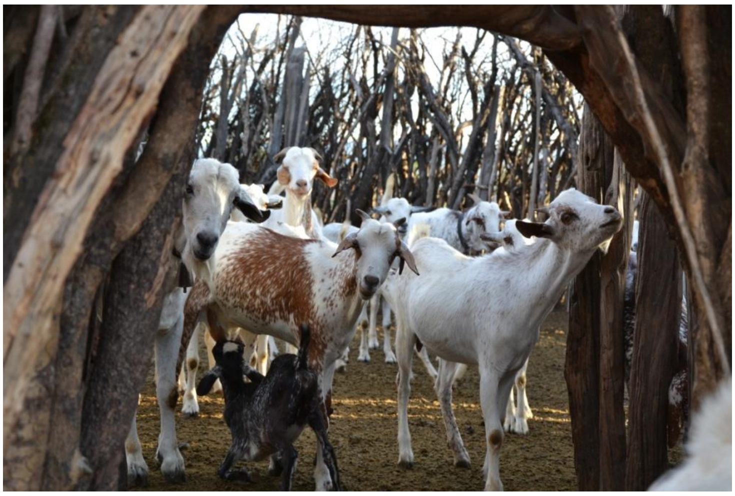

Photo 19: Milking of a goat

Photo 20: Milking of a cow with the help of a calabash

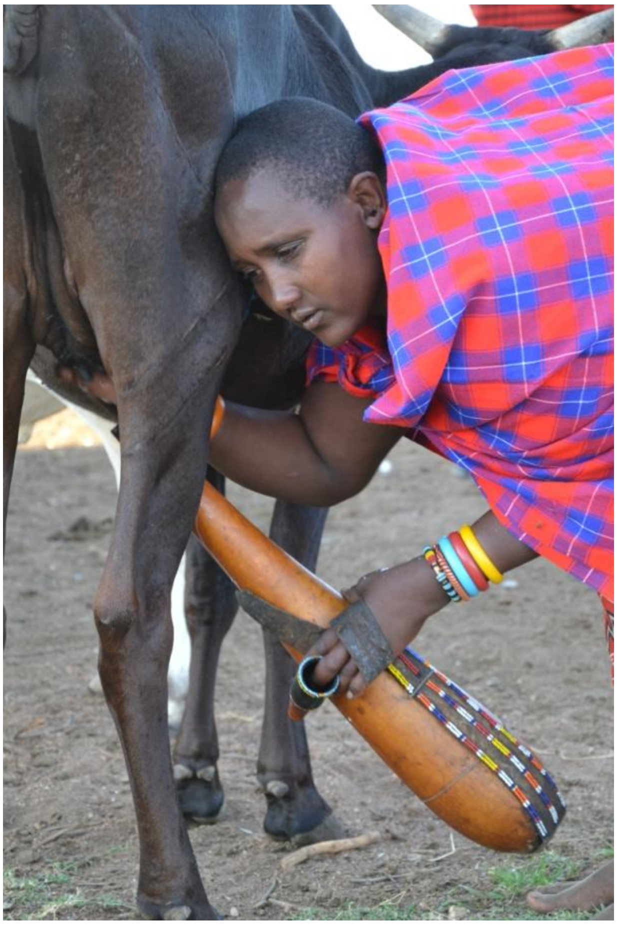

Photo 21: Measurement of the live weight of cattle

Photo 22: Vegetation list in progress

IV Vegetation list

The translation from the Maasai-names into botanical-names was performed by Dr. Nathan Ole Lengisugi. Maasai- names were mainly reported by Oldupoi Ole Oloinyo.
*Maasai names of the Purko-section in the Loliondo division,
x indicates that the plant is eaten.

No.	Maasai-Name *	Botanical-Name	Eaten by cattle	Eaten by goats	Comment
1	Ormisigiyoi	Rhus natalensis or Rhus tenuinervis		x	Used to fatten goats and lambs
2	Orkilenyai	Euclea divinorum	x	x	Branches are cut during hard dry season for cattle
3	Oloiborrblenek	Croton dichogamus		x	
4	Orkiloriti	Acacia nilotica	x	x	Also seeds are eaten
5	Olchorrai	Acacia seyal		x	Also seeds are eaten
6	Oiti	Acacia mellifera		x	Also seeds are eaten
7	Osilalei	Commiphora schimperiana		x	
8	Olodong'anayoi/ Olodong'anayok/Oloilalei	Zizyphus murcunata		x	Deworm goats
9	Oloilei	Euphorbia tirucalli		x	Bark eaten by donkeys
10	Oloiroroi/ Enkoireroi	Flacourtine indica		x	Branches are cut during hard dry season for cattle, deworm goats
11	Orgilai	Teclea nobilis		x	
12	Orkakawa/ Orkokola	Ramnus sp.		x	
13	Olaimurunyai/Alaimurunyai	Maytenus putterlickioides or Maytenus heterophylla		x	
14	Orkisikong'u/ Oitimigomi or natua-eng'ongu	Pappea capensis		x	Branches are cutting during hard dry season for cattle
15	Orng'ong'wenyi/ Oldebbei	Acacia gerardii		x	
16	Ormorijoi	Acokanthera friensiorum or Acokanthera oppositifolia		x	Poisonous
17	Enjani enkashe	Hibiscus aponeus		x	Stomach medicine
18	Orketurai	Albizia schimperiana	x	x	

19	Oloirien	Olea europaea var. africana	x	x	Branches are cutting during hard dry season for cattle, used to fatten goats and lambs
20	Orgumui	Euphorbia uhligiana or Euphorbia candelabrum			
21	Ormaroroi	Combretum molle	x	x	
22	Combretum molle	Juniperus procera		x	Also used as building material
23	Oloponi	Erythrina abyssinica			
24	Orkisayen/Loliondo	Olea hochstetteri		x	
25	Naibung'i akiti	Acacia senegal		x	
26	Ormasei	Olea capensis subsp. hochstetteri		x	Branches are cutting during hard dry season for cattle
27	Olairamirami/Alairamirami	Kalonchoe densiflora´		x	Used to fatten goats and lambs
28	Ormotoo	Azanza garckeana	?	?	
29	Oloisesiai	Osyris abyssinica	?	x	
30	Oluaai	Acacia drepanolobium		x	
31	Orpandi/Orupande	Lannea schwenfurthii var. (stuhlmannii)		x	
32	Orgumui	Euphorbia uhligiana (?)		x	
33	Oldule	Oxytenanthera abyssinia		x	
34	Esambukike	Phyllanthus sp		x	
35	Olerai	Acacia xanthophloea		x	
36	Org'wengwenyi	Acacia gerradii		x	
37	Osurkututui	Sida cordifolia (climber)			
38	Oldarboi	Kigelia africana			
39	Org'aboli/Olgnagboli	Ficus sycomorus			
40	Enyirma	?		x	
41	Oloilupai	?	x	x	
42	Olnyalugai	?	x	x	Branches are cutting during hard dry season for cattle, Used to fatten goats and lambs
43	Oltepesi	?	x	x	
44	Oreteti	Ficus thonningii	?	?	
45	Osukunwa/ Osukuroi	Aloe volkensis	x	x	Also seeds are eaten
46	Oloiragai	Zyzygium cordatum	x	x	Also seeds are eaten
47	Olerai	Acacia xanthophloea	?	x	
48	Olokoromwai	Pavenia patens			

49	Enjarkatta	?		x	
50	Enkinyasirkon	Flacourtia indica			
51	Olemeneng'a	?	x	x	
52	Olorook kileleng'	Oldenlandia wiedemannli		x	
53	Enang'ou ng'oroyok	?		x	
54	Ngaiseretia	?			
55	Osoket			x	Also seeds are eaten
56	Orkobobit	Synadenium grantii		?	
57	Sankilen	?	x	x	In particular for cows after giving birth
58	Orkerkai	?		x	
59	Oltyasimbol	?		x	
60	Orkirrusha	?		x	
61	Olomeei	Asparagus racemosus		x	
62	Olawo/ Alawo	Ximenia americana	x	x	
63	Olamai	?		x	Babu medecine
64	Empurda Oontare	?	x	x	
65	Osokonoie	Warbugiasataris		x	
66	Orbangi	?		x	
67	Ormungushi	Rhus vulgaris	x	x	
68	Engairrabai	Hermannia alhienisis		x	
69	Orng'oswa	Balanite aegypticum		x	
70	Engailupai	Cammiphora africana		x	
71	Engunetia	?		x	
72	Olagumati	?	?	?	
73	Oloilalei	?	?	?	
74	Olaimurunyai/ Alaimurunyai	Maytenus putterlickioides or Maytenus heterophylla		x	
75	Oladardarr	Ochna ovata		x	
76	Osuguroi	Aloe fibrosa		x	Branches are also eaten
77	Osanangurruti	Scutia myrtina		x	
78	Olamuriaki	Caris edulis		x	
79	Esikirianjoy/ enkosikiriandoi	Bersama abyssinica		x	
80	Oltiameletei	Ipomea hilderbrandii		x	
81	Oltiakuleti/ Orkipirelekima	Gomphocarpus stenoiphyllus		x	
82	Osupakuper	?		x	
83	Oltutu	?	x	x	Also fruits are eaten
84	Oltulelei	?	x	x	
85	Olairepirepi	Silene macrosolen		x	
86	Olokunonoi	Ozoroa insignis	?	?	
87	Ole Parmunyo	Toddalia asiatica	?	?	

88	Osikaoi/ Oloisuki	Zanthoxylum chalybeum		x	
89	Enkayakuji	Rubus friesiorum	x	x	
90	Oloisugi	Zanthoxylum chalybeum (?)		x	
91	Orkirashai	Baderia sp	x	x	
92	Oloitodorraik	Bacium sp	x	x	
93	Osentui	Cassia didymobotrum	x	x	
94	Oledat	Trimeria tropica		x	
95	Olemurran	Osimum lamiifolia	x	x	
96	Ologumati	Vernonia brachycalyx	?	x	
97	Olemudong'o	Gomphocarpus stenophyllus			
98	Ormasitet	?	x	x	
99	Ormasiligy	Cotyledon barbeiyei			
100	Orgisoyan	Vigna fragrana	?	x	
101	Oltiameletei	Ipomea hildebrandtit			
102	Enchani oosirkon	Maerua trichoylla	x	x	
103	Empere e papa	Asparagua african		x	
104	Osupukia	Dombelye goetzenii		x	
105	Naing'ong' u Ndeyo	?		x	
106	Orkushurrui	Euphorbia sp			
107	Orng'alayoi	?		x	
108	Entamejoi	Tragia sp			
109	Olakardadai	Ochna ovata		x	
110	Olaturdoi	Capparis cartilageana		x	
111	Orng'eriandu	Rubia cordifolia		x	
112	Orkisarng'atuny	?		x	
113	Orbibiai	Leonotis sp		x	
114	Ormomoi	Solanum nigram		x	
115	Orpalek	Recinus communis		x	
116	Entepeu	Kleinia Kleinioides		x	
117	Enkoilei	Euphorbia sp	x	x	
118	Oltopisianoi	?	x	x	
119	Nayobia	Phamphicarpa heuglini		x	
120	Eseketeti	Myrsirie Africana	?	?	
121	Olchartuyan	Diospyros abyssinica	?	?	
122	Olodong'anaiyoi	Zizyphua mucronata	?	?	Branches are cutting during hard dry season for cattle
123	Oltuyesi	?	?	?	Branches are cutting during hard dry season for cattle
124	Ositeti	Grewia bicolor or Grewia tephrodermis	x	x	Used to fatten goats and lambs

125	Oseki	Cordia monoica or Cordia ovalis		x	
126	Orkinyiei	Olinia usambarensis	x	x	Branches are cutting during hard dry season for cattle
127	Olabaai	Psiadia arabica or Psiadia punctulata		x	
128	Osinoni	Lippia javanica	x	x	
129	Orkirgirri	Acacia brevispica		x	Also seeds are eaten
130	Oiyrriy	Grewia tembensis		x	
131	Olosida	Justicia flava	x	x	
132	Oltakurukuriet	Gardenia jovis tonantis		x	
133	Emurwa	Cynodon dactylon	x	x	
134	Erikaru	Pennisetum squamulatum	x	x	
135	Enkampa	Chloris pycnothrix	x	x	
136	Orperesi Orasha	Sporubolus sp. (Themeda triandra)	x	x	
137	Porori Ong'wan	Panicum maximum (?)	x	x	
138	Orparraan	Setaria plicatilis	x	x	
139	Olopi Kidong´oi	Harpacne schimperi	x	x	
140	Orpusaan	Andrupogon greenwaji	x	x	
141	Oseiyai	Pennisetum squamilatum	x	x	
142	Orpalakai	Panicum maximum (?)	x	x	
143	Olosida	Justicia flava	x	x	
144	Oloitodorr aik	Bacium sp.	x	x	
145	Ormagutian	Pennisetum schimperi	x	x	
146	Entapipi	Tricholaena	x	x	

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