Animal Production Systems Group

Msc Thesis

Creation of communal grazing areas for goats in southern Mozambique: future perspectives

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APS- 80436
Credit Points: 36

October 2012

WAGENINGEN UNIVERSITY
ANIMAL SCIENCES

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MSc Thesis
Master of Animal Sciences

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October 2012

Preface

This study, determining the future perspectives of the creation of communal grazing areas for goats in Mozambique, is part of my MSc programme in Animal Sciences at Wageningen University. I had the opportunity to conduct my field work in Mozambique within the ImGoats project, conducted by ILRI and implemented by CARE, where I gained experience in an applied research approach in a development project, which has contributed to shaping my perspective on development work in general, and which I find highly relevant for my future career plans.

This thesis would have not been possible without the help of enthusiastic and dedicated people. I am exceptionally grateful to Birgit Boogaard from ILRI and Simon Oosting from Wageningen University who supervised my work and gave me insights that were needed for this thesis to become a reality. I highly appreciated their willingness to share their knowledge, criticize and support during all stages of my thesis.

In addition, my field work would not have been possible without the ImGoats team, especially CARE extension officers Feliciano Majesso and Faustino Jose who facilitated my interviews and joined and helped me during the pastures' visits, Arthur who has been a very enthusiastic translator for my interviews, and Birgit again who supported my work. A special thanks to ILRI country representative Saskia Hendrickx for supporting my material needs as for making at our disposition a car and to Arnaldo, our fearless driver from ILRI, without whom my grasses' measurements would have been transformed in the stations of cross... No bush could resist him and his 4W-drive! I cherish all this field work's experiences and will memorise this favourite time in Mozambique.

But my stay in Vilanculos would not have been that enjoyable without all the people I met, especially Sonja, Kassie and Serge.

At last but not least, I would like to thank Caren Krul, who literally shared all these 3 months in Mozambique with me, making my experience unexpected and full of life!

I also would like to thank Mats Lannerstad for its very valuable comments on my thesis and therefore his support despite the far distance.

This thesis is dedicated to my parents, my sponsors as they call themselves, who have always supported and encouraged me to follow my adventurous dreams.

Executive summary

This thesis was carried out within the project ImGoats, a project led by ILRI and implemented by CARE in Mozambique, aiming at increasing the incomes and food security of poor smallholders through innovations in the meat goat value chain. From a bottom-up approach, the project developed different interventions and this thesis was focusing on one of them, the implementation of communal grazing land for goats, land that was not currently in use. From a literature review, it was defined that communal grazing lands were prone to land degradation and even more if goat was an actor, mainly due to its feeding behaviour. Furthermore, sociologists and economists explained this resource degradation by involving the communities of livestock smallholders and their ways of managing the grazing land. From this outlook, the main research question was defined as "What are the future perspectives of the newly designated communal grazing areas for goats in the ImGoats project communities?". Perspectives that had two views: a more technical one that focused on the inventory of the pastures' natural resources and the calculation of their different grazing capacities; and a more social part that implied interviews of the communities on their ideas about the future management of these pastures. For the field work, 6 communities and therefore 6 different pastures were visited. Concerning the pastures' characteristics, it was found that there were differences among the different grazing land, especially in their sizes as it was going from 265 to more than 5.000 ha. The average grazing land was a savannah woodland, composed of a vegetation of grasses with a shrub/tree coverage of 35%. The average primary grass production was of 1.400kg $DM.ha^{-1}$. It were wide differences for the grazing capacities of the whole pastures, from less than 400 goats to 23.600 animals. From the interviews, two different themes were defined: the natural resources management (NRM) and issues on labour. From the NRM part, the topics that were developed were: the grazing pattern, the animal keeping system, the grazing dynamics, the mix cattle/goats, the burning practices, the water sources and the implementation of a maximum number of goats on the pastures. Concerning the labour, three different management types were found: the first system was described as a maximal intervention of producers, the second as the intervention of producers and paid labour and the third one as the minimal intervention of producers. From the obtained results, perspectives could be drawn on the future of these different pastures. Part of the perspectives were the main constraints that could hamper the success of the pastures' implementation. These limits were identified as the herd mobility, the water and labour availability. It was therefore recommended that these three topics should be further discussed with the communities and that from the data collected for this thesis individual pasture management plans could be developed for the project communities. Recommendations concerning topics to be discussed with the communities were favoured over giving direct use rules that should be blindly followed. The pastures' organisational charts should come from communities' brainstorming with the help of experts, as one of the ImGoats project's core principle was to adopt a bottom-up approach.

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1. Introduction

1.1. General context

Goat has been the first livestock to be domesticated, around 9500 B.C., in the middle-East (*Naaktgeboren, 2006*). Nowadays, goat is one of the most geographically spread out livestock species in the world, with an estimated population of more than 860 million animals (*Mahmoud, 2010*). In Africa, most of the countries have seen their goat numbers growing in recent years: between 1993 and 2003, it has increased with 24%. This trend is even stronger in the least developed countries where the goat population doubled between 1969 and 2003 (*Boyazoglu et al., 2005*). From the last animal census done by INE (National statistics Institute) in 2008, Mozambique had a stock of 4.3 million goats (*ImGoats, 2012*).

In many developing countries, goat plays a role in development assistance for the poorest smallholders. Population pressure and land inheritance traditions lead to a smaller and smaller individual farm size and small ruminants as goats are a good alternative to large cattle (*Peacock, 2005*). Furthermore, the starting investment is low, the increase of the initial stock is fast and goats are recognised for its great resilience and adaptability under harsh conditions (*Boyazoglu et al., 2005*).

Mozambique has a huge potential for livestock production given the vast rangelands and the suitability of various areas for forage production. Early post-independence projects characterised communal pastures, but focused on cattle (*Maposse et al., 2003*). In Mozambique, land, forest and wildlife resources are state property. In relation to land, individuals can only acquire usage rights. For the local communities, the land law (law n˚ 19/97) recognizes community title to the land through long-term occupancy (more than 10 years) based on oral testimony of community members. There have been experiences of natural resources management based on common property rights in the country e.g. in Gaza province, where plain areas were used for extensive cattle grazing. Following the country's independence, community members owned cattle and grazing regulation became necessary with the increased number of animals. Cattle owners used the pastures in common and they had the power to exclude others.

Following the country's independence in 1975, a civil war occured from 1977 to 1992. During that period, the country's livestock stocks (mainly cattle, goats and chicken) were almost decimated; they had disappeared from Inhassoro district. The government – supported by international organisations – started to distribute livestock (cattle, poultry, goats and donkeys) to people in order to restock the country's livestock population. However, as people had not reared livestock for a long period, their knowledge, measured by their training on goat rearing, was very poor (*ImGoats, 2012*).

The ImGoats project or "small ruminant value chains as platforms for reducing poverty and increasing food security in dryland areas of India and Mozambique", aims at increasing the incomes and food security of poor smallholders from India and Mozambique through innovations in the meat goat value chain. The project started at the beginning of 2011 and will end by December 2012. It is financed by the European Commission through the International Fund for Agricultural Development (IFAD), led by International Livestock Research Institute (ILRI) and implemented by CARE in Mozambique and BAIF in India. One of the project's main features was to set up a bottom-up design:

thanks to a baseline study and the implementation of innovation platform (IP) which entails a meeting with all actors of the goat value chain (producers, traders, sellers) every two months, the participants were allowed to define the main constraints of the current goat sector, which were: lack of production, weak organisation of the producers and weak infrastructure (goat shed, slaughterhouse, roads, etc…). From it, specific project interventions were selected, such as: creation of goat fairs, training of paravets, identification and implementation of communal grazing areas and building of improved goat housing.

This study is focused on one specific intervention, the communal grazing lands. Each community identified an area within their communal area that was not used by any community member, and would be suitable for livestock grazing. A pre-requisite was that the whole community agreed on the selected plot(s). The area would then be presented to the government (cadastre) in order to be registered as communal grazing land, protecting it from possible future housing implementation.

1.2. Thesis scope and objectives

Problem delineation:

One of the project's aims is to increase goat production (either by increasing the herd size or increase productivity per animal), in order for the smallholders to be able to sell more goats and as such earn a higher income from goats. As stated in the project proposal, the project objective is to transform subsistence-level goat production to a viable, profitable model, increasing incomes and thereby reducing poverty and enhancing food security, "*while preserving community and national natural resources*". As stated before, one of the project interventions is to implement a communal pasture area in each community, currently non-existent for goats, in order to improve the goat feeding and management. However, these newly identified areas have not been assessed in terms of carrying capacities or how many goats could be sustained by the forage production of the land. Furthermore, as described by *Hardin* in the paper "The tragedy of the Commons" (1968), the specific status of a communal territory can easily lead to ecological disaster as no one is willing to decrease its animal pressure (animal number) on the land if its neighbours do not do it as well. This has been proven in many situations, sometimes even with the support of governments (*Peacock and Sherman, 2010*).

In line with the studies in the literature, the current study departs from the idea that sustainable communal pasture areas involve a more technical part – i.e. to assess potential grazing capacities of the areas - as well as a more social-oriented part – i.e. the management of the area by smallholders.

Hence, my research question can be drawn from it: What are the future perspectives of the newly designated communal grazing areas for goats in the ImGoats project communities?

The related research sub-questions are the following:

- What are the different carrying capacities of the communal lands found in the project communities?
- Which plant species identified as goat fodder dominate in the different pastures?
- What are the perspectives of the communities' members on grazing lands' future management?
- Which main constraints could limit the shared grazing areas' implementation success?
- How are the labour-related aspects included into the management strategies?

Research objectives:

The study has for objective to assess the different project communities' grazing areas and their carrying capacities. Furthermore, as a combination of technical and social approach is seeking, the communities' smallholders' point of views on the present and future of these grasslands will be incorporated. Following the results, recommendations will be formulated in order to implement communal grazing lands in the most sustainable way.

1.3. Background information

1.3.1. ImGoats project and goat production systems in Inhassaro district

During the baseline study of the ImGoats project, 6 project communities and 3 control communities have been interviewed, covering 108 household interviews. From the results obtained and analysed in the baseline report (*ImGoats, 2012*), several features of the current goat production systems can be found.

Goat keeping system

Goats have always been kept in Inhassoro District. However, during the civil war of 1977-92 the goat population in the district was severely depleted. Respondents had kept goats for relatively short periods (on average, 7 years for female-headed households and 12 for male-headed households) with a range of 1 to 30 goats kept per household and an average of eight. From the last 5 years, the average flock size and number of goats increased. 85% of the households have also chicken (median value of 14 animals).

Goats are mainly tethered (75% of households) within the homestead area; few smallholders have traditional kraal (almost exclusively present in the interior zone). Only two households had an improved kraal. A kraal is an enclosure for livestock surrounded by a woody palisade, with a circular shape. The traditional kraals are built on the ground while improved ones are elevated, with a wooden floor and a roof.

The majority of the goat owners are engaged in goat sales in order to meet expected or unexpected household expenses (food, education, human health and more). The goats are sold alive, mainly directly at home, to individual traders, other smallholders or to consumers. Only few goat keepers were selling their goats to a butcher or abattoir.

Goat production is not seen as a main activity, as 70% of the respondents said that their goat keeping was neither their first nor second occupation. The main activity presented by the households was crop production.

Feeding management

Concerning the feeding management, the main feed type is the natural pasture (68% during the dry season and 71% during the wet season). All grazing area is communal land; no one owns a grazing plot. In natural pastures, most of the smallholders use a mixed of two grazing practices: free-range and tethering. However, in all villages with grazing areas the grazing is controlled by tethering the animals: either all of them, or only the old, male or leading goats.

Two villages that had no grazing area did not control the animals, because of a lack of money or because grazing was considered "natural". Grazing under the surveillance of a herder was hardly practised. When comparing the grazing practices for the different seasons, the vast majority of goats were tethered during the wet season but not during the dry season (81% against 16% of the households, respectively). In complement of pasture, the goats were fed different fodders, mainly tree leaves.

Table 1: Feed types given to goats by season at household level (*ImGoats, 2012*)

Feed types	Rainy season		Dry season	
	n	%	n	%
Natural pasture (green vegetation)	79	70.5%	78	68.4%
Tree leaves (green fodder)	27	24.1%	33	28.9%
Dry pasture (dry vegetation -'feno em pé')	6	5.4%	3	2.6%
Total (number of responses)	**112**	**100%**	**114**	**100%**

As presented in the table above, tree leaves represent an average of 27% of the total feed types. This fodder originated from two kind of trees: fruit trees, planted for human consumption and indigenous trees, plants or shrubs. The latters are often found on communal land. Tree leaves' collection was not considered as an activity *per se* but was done on the way to or back from the cropping fields (*machamba*). In none of the interviewed villages trees had been specifically planted for goat fodder. The main reasons for not planting trees were: trees already naturally exist; there is sufficient tree/feed/pasture; lack of knowledge. Hence, most of the green fodder (grasses and tree leaves) came from communal land. Dry pastures or hay were scarcely provided.

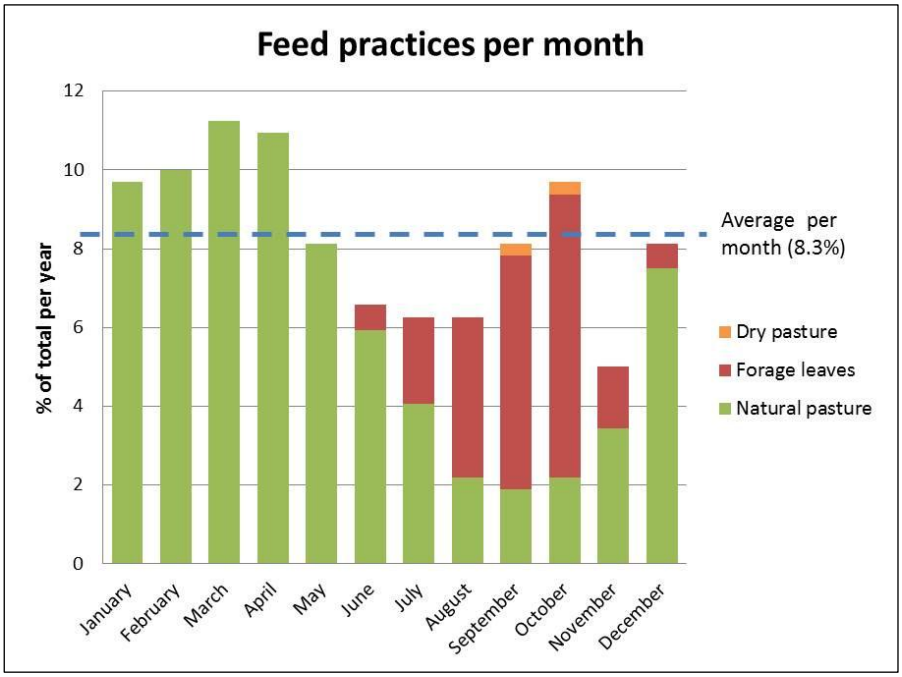

Figure 1: Feed practices per month (in % of year total) at village level (*ImGoats, 2012*)

The feed availability is varying throughout the year. Despite the yearly access of pasture, high feed availability was from December to May and with a sharp decline from July till November, as shown in Figure 3. Tree leaves could be collected all the time but they were given to the animals only from June to December, with a high proportion fed from August to October. Hence, tree leaves are used as a compensation strategy in order to deal with the shortage of grazing materials. November is the

month where less feed is given to the goats: the first rains have just fallen so the natural pasture is still limited combined with less time to collect tree leaves (a lot of agricultural labour are needed on the cropping fields) leads to less feed, despite the availability of tree leaves.

1.3.2. Theory

a. Carrying capacities

Carrying capacity (CC) describes the number of grazing animals a management unit is able to support without depleting rangeland vegetation or soil resources (*Chaudhry et al., 2010*). Put in other terms, it is the veld potential to carry animals as determined by its productive capacity (*Tainton et al., 1993*). While describing the natural pastures in Mozambique, *Timberlake* (1985) used various factors to determine their different carrying capacities, such as:

- Primary pasture productivity

It is defined by the total dry matter production that can be expected from natural grassland under rainfed conditions with no special management practices. It is normally measured in tons per hectare per year (*Timberlake, 1985*).

- Density of tree and bush cover

Blair Rains and Kassam (1979) studied the effects of shrubs and/or trees on the potential grass production of a pasture. Next is the figure presenting their results.

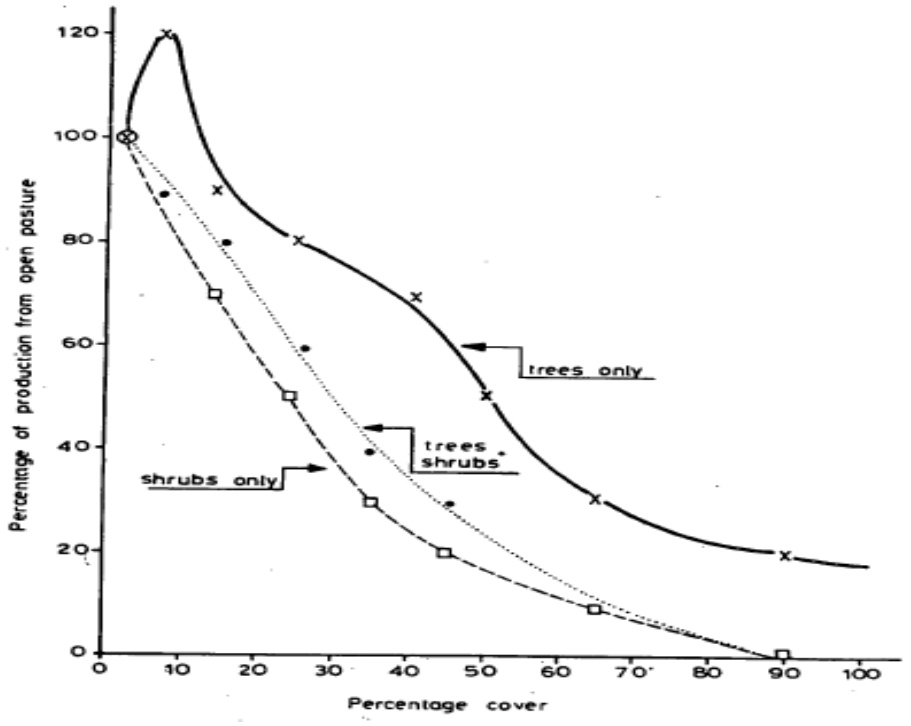

Figure 2: Effect of woody cover on pasture productivity (*Blair Rains and Kassam, 1979)*

As shown on Figure 2, trees alone have a lesser impact on grass production than shrubs. 90% of shrub coverage on a pasture suppress all possible grass growth, while 90% of tree coverage still allows a grass production of 20% (compared to 100% in an open pasture). Furthermore, until about

10% of tree coverage, the grass production increases compared to an open pasture, grasses benefiting from trees' nutrients e.g. from trees' organic matter, without entering in competition e.g. for light. This difference between shrub and tree can be partly explain by the plants' heights. Trees, thanks to their high canopy, enter less in competition with grasses for land than shrubs. The production of grass is halved (compared to an open pasture) with 25% shrub coverage, about 30% of shrub and tree coverage and over 50% of tree coverage.

- Percentage of pasture utilisable on a sustainable basis

It is defined by the amount of the primary productivity that can be utilised by livestock (*Timberlake, 1985*). The percentage of pasture utilisable on a sustainable basis has been defined at 50% of defoliation (*Timberlake, 1985; Abel, 1997*). *Tainton et al.* (1993) explained that grass plant's roots stop growing after any relatively intense defoliation which removes more than about 50% of photosynthesising leaf material from a tiller (lateral shoot from the base of the stem). In less extreme cases, root growth slows down but does not stop altogether. Increased defoliation intensity will thus increase the length of the period during which the roots will remain inactive, increasing the plant regrowth's period.

- Dry matter intake per animal per year

From the Nutrient Requirements of Small Ruminants' guide (*NRC, 2007*), for a non-dairy adult female goat weighing from 20 to 30 kg, the daily feed intake (in dry matter) for maintenance was estimated to be between 2,26% and 2,5% of the animal body weight (BW).

Goats are intermediate feeders, meaning that they can eat ligneous plant materials such as shrubs and tree leaves. Table 2 shows the yearly evolution of the goat diet in a savannah woodland: From wet season when grasses are abundant to dry season with less available feed, goats rely more and more on browse, becoming by far the major feed component (85% of the total diet).

Table 2: Goat feeding behaviour in savannah woodland

Goat feeding behaviour following the season in a savannah woodland	**Diet composition (%)**	**Feed quantity (kg DM/d)**	**Yearly feed quantity (kg DM/yr)**
Wet season (November to March, 150 days)			
grass	65%	0.439	66
browse	35%	0.236	35
Late wet-early dry (April to June, 123 days)			
grass	51%	0.342	31
browse	49%	0.333	30
Dry season (July to October, 91 days)			
grass	15%	0.101	12
browse	85%	0.574	71
Year			
grass	44%	0.294	109
browse	56%	0.381	136
total diet	100%	0.675	246

Adapted from *Safari et al.* (2011) and *Kam et al.* (2012)

A carrying capacity should be setting up in such a way that animals are able to take in sufficient forage to allow them to perform at some predetermined level. In addition, the CC should not stress the veld to the extent that either its species composition or its cover degrade to unacceptable levels (*Tainton et al., 1993*).

However, other factors can affect the carrying capacity, such as the rainfall pattern but also the grass composition of the pasture.

- Seasonality of veld forages' value

In tropical conditions, the carrying capacity of a pasture often varies throughout the year. In southern Africa, there are different types of pastures according to its season of use: sweet, mixed or sour.

Sweetveld applies to range which has the capacity to support animals year-round. It implies that plant material, produced during the wet or growing season, remains sufficiently palatable and nutritious during the subsequent winter to support a reasonable level of animal performance. Grass composition is dominated by *Themeda triandra, Panicum maximum, P. staphianum and Setaria neglecta.*

Sourveld, in contrast, loses its palatability and nutritive value when it matures, so the forage produced by sourveld will support animal performance only during the active growing season. It is due to the fact that plant material becomes fibrous as it matures and a large proportion of the nutrients contained in the herbage is withdrawn to basal region of the plant at the end of the growing season (*Tainton et al., 1993*). The main sour grasses are *Sporobolus nitens, S. smutsii, Heteropogon contortus (Rattray, 1960), Hyparrhenia rufa, Urochloa mosambicensis and Digitaria eriantha*.

Mixedveld is intermediate in its characteristics between these two extremes. The grazing season may vary from what found in sweetveld (12 months) to that found in sourveld (6 months). This variation is described by terms like sweet-mixed (9-11 month grazing season) and sour-mixed (6-9 month grazing season) (*Tainton et al., 1993*). Principal grasses found in mixed veld are *Themeda triandra, Tristachya leucothrix, Diheteropogon amplectens among others.*

b. The Commons concept

The Commons are land that falls between the concept of private property and state control, having thus a vague definition of tenureship. Communal pastures are part of the "Commons" concept, defined by "land or resources belonging to or affecting the whole of a community" (*Oxford dictionary*). Communal grazing lands are important sources of livestock feed in developing countries (*Gebremedhin et al., 2004*). Over 90% of the rural population of sub-Saharan Africa rely for their livelihoods on resources held under communal tenure. Rangelands in Africa (grasslands, savannahs and woodlands) provide about 80% of the nutrition for Africa's livestock population of about 184 million cattle, 372 million small ruminants (sheep and goats), and 17 million camels (*Taylor, 2007*).

Natural resources management (NRM) on communal lands

Natural resources held by a group of private stakeholders are nowadays often referred as "common-pool resource" (CPR) (*Ostrom, 1990*). Current constraints to sustainable natural resources management in communal lands include soil degradation, water resource shortage, vegetation

degradation, biodiversity loss, poor management capabilities (knowledge and skills) and weakness of social organisations (*Dapaah et al., 2001*).

Smith et al. (2002) agree with this inventory in presenting the main constraints to goat production in Tanzania as water scarcity and variable rainfall; forage availability and quality of pastures. According to *Timberlake and Reddy* (1986), water distribution is probably the most important determining factor for grazing patterns and intensity.

The major environmental concerns affecting the communal lands nowadays are desertification and loss of biodiversity. The main presented explanations or "culprits" for the land degradation are overgrazing and bush encroachment (*Dapaah et al., 2001*). Range scientists state that a land is degraded if (*Abel, 1997; Abule et al., 2005; Allred et al., 2012*):

- Herbaceous species composition is shifting from perennial to annual grasses and from more to less palatable species
- Shrub encroachment is occurring
- Grass and litter cover are decreasing
- Rate of soil loss is increasing.

The consequence of range degradation is a reduction in productive capacity of the pasture. If there is no permanent damage to the environment, such as soil loss or undesirable species changes, damage can be repaired relatively easily. However, especially in arid and semi-arid areas, prolonged stress may bring about a complete or near-complete breakdown in the cover, resulting in its most conspicuous form in desertification (*Tainton et al., 1993*).

Goats have been presented as a major player in land degradation, especially due to its feeding behaviour. Following their food preference and dental set-up, *Lu (2011)* characterised the feeding behaviour of goats as versatile: even if they preferably select plant parts that are more digestible when possible, they are tolerant toward bitterness. On the positive side, they can eat fibrous feed and have an efficient use of marginal land, while on the negative side it underlines their capacity of inducing severe damages to vegetation (*Devendra, 1999; Madsen et al., 2007*). Compared to other ruminants, goat can be used to modify vegetation cover by clearing areas thick in bushes, shrubs and thorny vegetation (*Boyazoglu et al., 2005*). However, as they can debark trees and bushes and ultimately destroy it, an uncontrolled or over grazing can lead to land degradation: desertification (arid climates), increased woody plant cover in semi-arid, subtropical rangelands and deforestation (humid climates) (*Madsen et al., 2007*). Areas in Mongolia and China have seen their natural resources being dangerously depleted to a desertification level due to goat overpopulation and overgrazing, caused by the boom of Cashmere industry. However, *Peacock and Sherman* (2010) argue that goats are the best livestock species able to cope with degraded environments and are frequently and ignorantly blamed for causing it when in fact they are the only species that can continue to survive. They highlight the part of responsibility the goat herders have in not controlling their stock numbers or grazing management, but also the governments in giving monetary incentives to goat keepers to develop their production without boundaries.

However, there is a debate concerning livestock as the main cause behind these lands' degradation. African rangelands have been defined by some scientists as nonequilibrium systems (*Mata et al. (2010); Okayasu et al. (2011)*). Nonequilibrium environments are often characterised by fluctuations

in parameters such as rainfall and the resulting fluctuations in biomass (*Ellis and Swift, 1988*). According to *Mata et al.* (2010), In this situation the condition of the ecosystem is more determined by abiotic aspects (soil and climate) than by biotic ones (animals and plants). Hence, grazing strategies would be more stressed by abiotic elements (especially intra and inter annual climatic variation) than by the animal-plant interactions.

Theories on the Commons' resources degradation

Communal lands are described as uncontrolled and free grazing system and this particular characteristic is solely used to explain the severe degradation occurring in developing countries' grazing lands (*Gebremedhin et al., 2002*). Commons are often regarded as every man's land – or no man's land, depending on the theoretical viewpoint. The term "open access" is widely accepted for a situation where a resource is free to anyone to enter and extract units from. However, it would be false to say all Commons provide open access. Sub-forms of tenureship to Commons, such as demarcated village pasture, do make the issue of commonly owned land more complex. Conception (or misconception) of the Commons as no man's property had led some scholars and policy-writers to argue that nobody would ever care to put in management efforts into those resources, and that the Commons inherently are doomed to overuse and destruction (*Nilsson, 2001*).

Ostrom (1990) reviewed the different views on the Commons in order to explain the different management strategies that had been applied to them around the world. According to her, the three models that were mainly used to provide management recommendations on Commons were: the tragedy of the Commons (*Hardin, 1968*), the prisoner's dilemma and the logic of collective action (*Olson, 1965*).

- **The tragedy of the Commons**

Hardin with the paper "The tragedy of the Commons" (1968) was one of the pioneers in defining a (controversial and powerful) theory on the Commons and the consequences their management would have. He used the example of a pasture that is open to all, without restriction. For him, it is expected that each livestock owner will try to increase his herd as much as possible on the Commons, thus focusing more on his own benefit than thinking of the community's good. As the pasture disposes of a finite pool of resources, the uncontrolled increase of each herd would inexorably lead to a tragedy, that is a land degradation because of over stocking/grazing.

- **The prisoner's dilemma game**

In order to explain the second theory, a game was developed to observe the decision-making process in Commons' situation. Two herders are using a common grazing land. The grazing area has an upper limit to the number of animals that can graze on the pasture for a season and be well fed at the end of the season. The prisoner's dilemma game is conceptualised as a noncooperative game in which all players possess complete information, however, communication among players is forbidden or impossible or irrelevant (*Ostrom, 1990*). The choices (or strategies) open to each herder is either "cooperate" (cooperative grazing on the Commons) or "defect" (grazing at a level, while advantageous to the individual, would result in exploitative overuse of the Commons). For self-protection, if not self-interest, each has a sufficient reason to defect whatever the other does. In the

logic of the prisoner's dilemma, no one will have an incentive to cooperate and all will defect, resulting in overgrazing (*Runge, 1992*).

- **The logic of collective action**

Olson (1965) presented his theory on the Commons as " Unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interest".

At the heart of each of these models is the free-rider problem. It results when an individual shirks responsibility to the community or group (*Runge, 1992*). The "free-ride" or the 'rational' temptation to put too many grazing animals on a communal pasture comes as a result of that the benefits (in terms of additional extracted fodder units) accrues to the free rider alone, while the costs (in terms of overstocking and land degradation) are borne by the whole community (*Ostrom, 1990*). However, if a too large share of the appropriators chooses to free ride, then the tragedy is a fact, and they all end up where no one wanted to be (*Nilsson, 2001*).

The answers of these theories given by the scientists and/or policy makers were either the centralisation of the land by the state or the land privatisation.

The centralisation of the decision-making by an external authority was justified by the fact that without public control, overgrazing and soil erosion of communal pastures would result. Hence, if private interests cannot be expected to protect the public domain then external regulation by public agencies, governments or international authorities is needed (*Ehrenfeld, 1972*). In this system, the external agency will be the one to determine the capacity of a common-pool resource, to assign this capacity and to monitor and finally sanction the non-compliance. If this centralised power is accurate and reliable, the Hardin's theory would be transformed to generate an optimally efficient equilibrium for the herders (*Ostrom, 1990*). However, in this vision little consideration is given to the cost of creating and monitoring such an agency. Furthermore, if this central agency makes errors e.g. on imposing punishments, the herders will be facing the prisoner's dilemma. They will defect (overgraze) rather than cooperate (graze within the carrying capacity) (*Baland and Platteau, 2000*).

The privatisation of grazing land was supported by *Smith* (1981) who argued that the only way to avoid the tragedy of the Commons in natural resources and wildlife is to end common-property systems by creating a system of private-property rights. Hence, the establishment of full property rights is necessary to avoid the inefficiencies of overgrazing (*Welch, 1983*). Applied to grazing land, the pasture would therefore be divided among the herders who would have each property rights on one plot of the total pasture. In this context, these herders would be playing against nature in a smaller terrain instead of against the other herders in a larger area. Furthermore, they would have to invest in possible fencing and their maintenance, as well as monitoring and sanctioning actions to enforce their division of the grazing area (*Ostrom, 1990*). Problems of this model occurs in erratic conditions (variability of fodder availability and rainfall over time) when resources are not distributed evenly throughout the territory. Hence, some herders could get plots with enough grass/fodder to sustain their animals all year round while others would not, bringing a situation of disequilibrium and probable subsequent conflicts.

According to *Ostrom* (1990) both centralisation and privatisation advocates accept as a central tenet that institutional change must come from outside and imposed on the individuals affected. She proposed an alternative management strategy in which herders themselves can make a binding contract to commit themselves to a cooperative strategy that they would have themselves worked out. Herders would therefore have to negotiate before placing animals on the grazing land. This vision is nowadays more and more shared by other scholars such as *Berkes and Feeny* (1990), who argued that Hardin did not consider the auto-regulation capacity of commons' users. It is argued that in many communities natural resources' users are driven by social pressure to be in conformity with enforcement rules and conducts prescribed (*Chilundo et Cau, unpublished*). Furthermore, devolving rights to local communities to manage resources, establish use rules and regulations and enforce the rules are only necessary conditions for successful community resource management (*Gebremdhin et al., 2002*). Contracts that would be enforced, however, only if unanimously agreed by the herders (*Ostrom, 1990*).

However, situations differ from each other and the optimal natural resource management's strategy of a particular case could not be relevant in another location. Furthermore, a combination of two different models could also be applied.

2. Material and methods

2.1. Project location and agro-climatic conditions

The project in Mozambique is situated in the south of the country, in the Inhassoro district, located in the north of Inhambane Province, as shown on the maps below. The project is working in 18 communities, for a total of 350 smallholders.

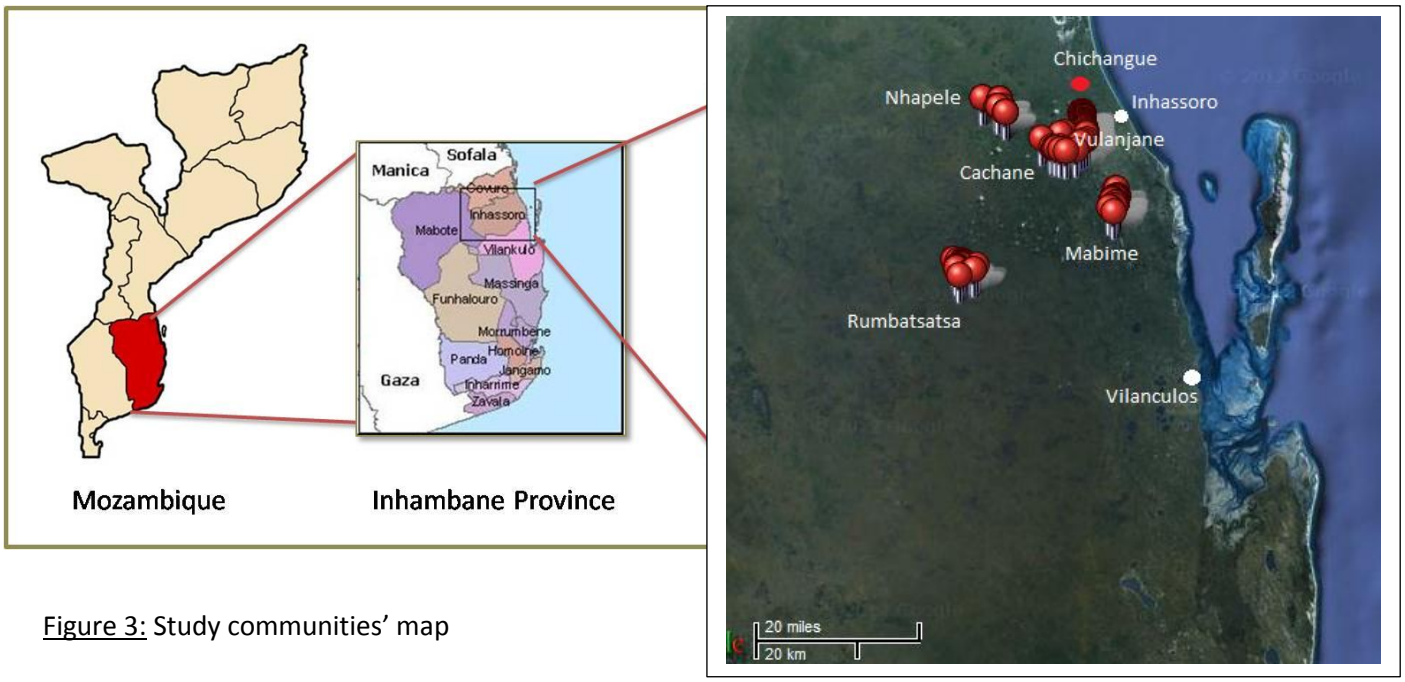

Figure 3: Study communities' map

The Inhassoro district is crossed from north to south by the EN1, the national road. The other main road is from the EN1 to the district capital Inhassoro, situated on the coast; most other roads are dirt roads.

Inhassoro district is located in the northern sector of the Inhambane Province in the subtropical, anti-cyclone zone of the southern hemisphere. The dry period is typically from July to October with moderate temperatures. The rainy season is usually from late October to March, with typically hot, humid conditions, a prevailing southerly wind and thunderstorms. The average annual rainfall is between 800-1000 mm per annum near the coast to less than 400 mm in the interior (*CARE, 2006*). There has been no declared drought, but there have been subsequent 3 very dry years (2008-2011), which caused extensive crop failure for smallholder farmers (*ImGoats, 2012*). February-March, corresponding of the end of the rainy season, is the most risky period in terms of incidental heavy rainfall and thus flooding.

Inhassoro district can be divided into two different agro-ecological zones: a "coastal" and an "interior" zone. The EN1 separates the two zones: on the eastern side is the coastal zone while the interior is situated on the west. The climate is relatively drier in the interior and more humid on the coast (*MAE, 2005*). The coastal zone has a white sandy soil profile, poor on nutrients and organic matter. The interior is characterised by brown-red soils, more fertile and with more diverse

vegetation. All visited communities but Rumbatsatsa are of "mixed Brachystegia Woodland and Deciduous Forest" types; Rumbatsatsa' vegetation type is Miombo Savannah.

Study communities:

The communities that participated in the present research were the same as the ones visited during the baseline study (the ones part of the ImGoats project). In total, 6 communities were visited.

Table 3: Communities characteristics

Community name	Agro-ecological zone	Community code	Number of the ImGoats project's participants	Total number of goats among the ImGoats' participants
Chichangue	coastal	C1CCHI	32	238*
Cachane	interior	C2ICA	57	423*
Vulanjane	interior and coastal	C3ICVU	25	208
Nhapele	interior	C4INHA	24	279
Mabime	coastal	C5CMA	25	98*
Rumbatsatsa	interior	C6IRUM	23	235

*Number calculated from the community's average goat number per household

As seen on the table above, three communities were situated interior or west of the EN1 while two communities were coastal or east of the EN1. Vulanjane was characterised by two separate communal lands, one coastal and the other on the interior zone. Thanks to the GPS coordinates, a map of each community and its communal grazing area was processed and can be found in Appendix 2. In order to refer to the communities in the results without hindering its reading, a code for each community was applied. The ImGoats project had on average 31 participants, Cachane being the biggest group with 57 participants. The total number of goats per community for the ImGoats project's participants was either computed or calculated from the community's average. Mabime had the smallest herd with about 100 animals while the average was of 247 goats per community. The 57 participants in Cachane would represent more than 400 animals.

Besides, a commercial goat farm was visited in order to discuss with the farmer its pastures' management i.e. grazing pattern, burning strategy, water supply, etc... The farm was situated in an interior agro-ecological zone. It had about 9.000 ha, with 150 goats and 350 heads of cattle.

2.2. Communal lands' carrying capacities

The followed method to determine the grazing potential of the communal pastures is the scheme of *Timberlake* (1985), presented in the theory section.

- Land grass production from standing biomass (kg DM)

At least 4 samples of 1m² of grasses were collected from each communal grazing land. They were collected in different zones and on spots that were visually estimated to be representative of the average vegetation's density of the zone. Each grass sample was put into a 50-kg rice bag and then hanged on an outside drying line, as shown on Figure 4. The drying was carried out outside because of a lack of infrastructure but also because the dry weather conditions would permit it. In case of a

rainy event, the bags were transported in the building nearby. The rice bags were chosen for their solidity but also for their aeration. In order to enhance this airing characteristic, small holes were perforated with scissors on the upper part of the bags. Every few days, each bag was open and the grasses were mixed in order to avoid any possible fermentation process. After two weeks of drying, each grass sample was weighed with a precise weighing scale in order to obtain its DM weight (g/m^2), then converted into potential grass productivity (kg DM /ha) by being multiplied by a 10 factor (*Chaudhry et al., 2010*).

Figure 4: Drying method of the grass samples

- Bush and tree coverage (%) that leads to a decrease factor in grass productivity

During the pastures' visits and thanks to the taken pictures, a visual observation and then determination of the bush and tree cover of each area were applied. This method is not as precise as it could be using GPS/remote sensing data, but it was favoured over the latter because of a lack of time within this study. However, thanks to a camera with GPS, pictures of each pasture area were processed on Google maps in order to map the area. Visual observations could then be backed up from the available Google maps' data.

Consequences that bushes and trees have on the grass productivity of a mixed pasture have been studied by *Blair Rains and Kassam (1979).* They developed the Figure 2 presented in the introduction, figure that was taken into account in order to obtain a more exact estimation of the grass productivity for each community's communal grazing area.

- Grasses, bushes and trees' species determination

From interviews with each community, local names of the plants eaten by the goats were gathered. During each pasture's visit, the guide, a person part of the community, was asked to show the plants on the list and the plant was then collected. For herbaceous plants, all the aerial part was collected while for the bushes and trees, only a bough was taken. If present, flowers and fruits were also collected. Plants were also photographed in their natural habitat.

Plant samples were afterwards dried in old magazines (newspapers were not available) and glued and/or taped on solid paper sheets in order to make a herbarium, examples of it can be found in Appendix 3. Thanks to it as well as the pictures taken, a plant determination was carried out. A large part of the plants was determined by the *LMA Herbário* in the *Instituto Nacional de Investigacão Agronomica*, in Maputo, where the herbarium was sent. The other plants had been identified thanks to the book written by *Van Wyk and Van Wyk (1997)* for bushes and trees and thanks to internet databases e.g. *tropicalforages.info* for the herbaceous ones.

- Communities' pasture sizes

Each pasture area had been visited during the field work. GPS coordinates were taken for the approximated borders, allowing visualising on Google maps via the software Map Utility. From it, GPS points were linked (for each pasture) using the Windows software "Paint". As the Google map had a scale, each pasture area could then be calculated in ha.

- Feeding pattern of goats

For this study, an on-field observation on browsing/grazing pattern was not applied but a literature review permitted to estimate this parameter (see Table 2). The average live weight of an adult Landim goat, the predominant breed of indigenous goats in Mozambique, was fixed at 27 kg (*FAO, 1995*), despite that it could be a high estimation for the current situation. In order to get conservative carrying capacities' values, the maximum feed intake was applied, thus 2.5% BW. Hence, the daily feed intake (grasses and browse) was fixed at 0.675kg $DM.d^{-1}$. It was assumed that this value was representative during the whole year. Concerning the grazing capacities of the communal pastures of this study that were calculated from the harvested grass' biomass, the feed intake of the late wet-early dry season was used, meaning 51% grass 49% browse.

Based on the different pastures' grass productions and the grass intake of goats, grazing capacities or the number of goats that can be grazing on the pasture were calculated (for the time t). As presented before, the feeding pattern of goats was set up at 51% grass and 49% browse (except for special areas). In the grazing capacities' calculations, only the grass intake was taken into account, assuming that the browsing part was equally found on the pasture. Hence, it could give an idea on how many goats could be sustained on the pastures at the end of the rainy season of this year.

The determination of the shrub/tree coverage as well as the determination of the browsing species could allow to qualitatively define the carrying capacities of the different pastures.

2.3. Focus group interviews

As mentioned earlier, the management of newly implemented communal grazing lands for goats is a crucial factor in the project's success. Therefore, interviews were set up in order to understand how people were planning to organise these areas. Focus group interviews were favoured over individual ones as the community management of a communal pasture implies collective action; and group discussion would allow ideas to be exchanged among the participants. The number of respondents was fixed at 10 people maximum in order to avoid some shortcomings of group interviews e.g. only few people out of the whole group give their ideas while the others remain silent. Moreover, every respondent was given the chance to speak.

The interviews were divided in two parts: the first one consisted of a mapping exercise of the community's communal pasture area(s). The whole group (all men and women together) were given a big paper sheet and felt pens of different colours. The extension officer was conducting the exercise by translating the instructions. First, the community's territory had to be delimited and the area(s) representing the households and the one(s) allocated to the pasture had to be defined. Afterwards, questions concerning the pasture were asked, such as: presence of water source,

different types of vegetation within the pasture, local names of grasses, shrubs and trees eaten by goats (see Appendix 1). Next is an example of a communal pasture's sketched map (see Appendix 2 for all communities' maps).

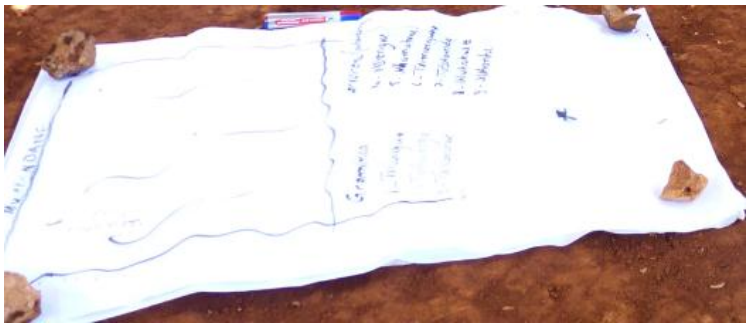

Figure 5: Area mapping's exercise in Rumbatsatsa community (C6IRUM)

The second part of the interviews consisted of collecting people's ideas on the possible management options of the communal pasture(s) and goat herds. As mentioned earlier, community management of communal pasture was a new concept for the respondents so the discussion was structured as a brainstorming with respondents' ideas (thus possible scenarios) instead of questions about existing management. For this second part, a gender-segregated group interview was preferred over mixed group interviews as it was experienced in the first community that in the discussion men were taking the lead over women. Moreover, it gave the opportunity for male and female goat keepers to express different views.

Table 4: Focus group composition

Community code	Interviewees (number)		Respondents' total number of goats	Interviews type
	Men	Women		
C1CCHI	5	5	92	mixed
C2ICA	7	6	n.a.	separated
C3ICVU	6	6	n.a.	separated
C4INHA	2	8	114	mixed
C5CMA	4	0	n.a.	men only
C6IRUM	5	11	101	separated

Table 4 shows the focus group composition in each community. All interviews were gender-separated except for 2 communities (C1CCHI and C4INHA) where the focus group was mixed. The former was the first interviewed community, when gender-segregated interview was not implemented yet, while in the latter it were not enough men to perform a separate discussion. In one village (C5CMA), only 4 male community members came so it was not possible to interview any women. Most of the interviews within each community were even in respondents' numbers; only in 2 communities (C4INHA and C6IRUM) women were over-represented compared to men. In one case (C6IRUM), the interview was held simultaneously with a training of the goat producers' group so only 5 men were able to participate in the focus group interview.

A semi-structured questionnaire on the management issues of the pasture was designed for facilitated brainstorming. Main topics were presented in order to structure the group discussion but

they remained open so the respondents could extensively express their point of view. The different topics were the following: day-grazing management, water supply, night management, grazing period (season), herding system. A summary of people's ideas was made before asking for the benefits and challenges of their new goat system. A question was then asked on how the challenges could be overcome. The last question concerned the possible implementation of a maximum number of animals on the pasture (see Appendix 1 for the complete questionnaire).

As community members speak Chitswa, a translator was required. The focus groups were facilitated in Chitswa, Portuguese and/or basic English. My Portuguese was basic, which influenced the interviews' dynamic (time-consuming) and there was a risk of losing information through the translation process. Moreover, as the open questions led the groups of focusing on different topics, some subjects were not spoken in all communities e.g. burning management. The time allocated for each interview varied depending on the group dynamics, but it ranged between 1.5 to 2 hours.

The focus groups' answers were processed into text-documents (one per community) and subsequently analysed by grouping/categorizing answers to identify the different tendencies/patterns proposed by the communities' members on the pasture future management. Two principal topics emerged: natural resources management (NRM) and labour issues.

3. Results

3.1. Communal grazing areas – carrying capacities

3.1.1. Pasture production

Half of the communities had one wide grazing land while the others had their pastures divided in different grazing areas. These different areas were geographically separated and had mainly different pasture's characteristics (e.g. vegetation, bush/tree coverage).

Table 5: Characteristics and grass production of the different communal pastures

Communities	Bush/ tree cover (%)	Grass production % from open pasture *	Average grass density (g DM.m^{-2})	Total area surface (ha)	Total grass production (t DM)
C1CCHI	25	60	180	5000-6000**	**5408-6489**
C2ICA	40	34	283	528	**507**
C3ICVU					
Area 1	70	7.7	216	360	**60**
Area 2	5	100	142	770	**1090**
Area 3	30	49	293	350	**502**
All areas	35	52	217	1480	**1652**
C4INHA					
Area 1	15	80	198	975	**1544**
Area 2	25-30	54.5	211	200	**230**
Area 3	25-30	54.5	402	245	**537**
All areas	23	63	270	1420	**2311**
C5CMA					
Area 1	50	23	215	120	**59**
Area 2	< 5	100	48	145	**70**
All areas	28	62	131	265	**129**
C6IRUM	25-30%	54.5	596	810	**2631**

*100% represents an open grassland without any shrub/tree. This parameter was calculated from the Figure 2 developed by *Blair Rains and Kassam (1979)*

**GPS coordinates could not be obtained so the size estimation was made by the car's kilometres' counter, less precise than GPS coordinates, explaining the application of a range instead of a precise value

As we can see in Table 5, there were variations between the different communal grazing lands. Concerning the bush and tree coverage, it was found that most of the pastures were savannah woodlands, composed of grasses with trees and shrubs forming a light canopy (*Encyclopaedia Britannica*), with an average bush/tree coverage of 35%. However, some pastures were greatly varying: two grazing areas were more of open pastures (area 2 in C3ICVU and area 2 in C5CMA) with a bush/tree coverage of no more than 5%. The community having the widest bush/tree coverage rate within its grazing areas was Vulanjane (C3ICVU). The first grazing land had a very high density of bushes (70%) while in the second one high vegetation was very scattered. The last grazing area was more of an average savannah-type pasture, with about 70% of grasses (see Appendix 2 for its map).

As for the bush/tree coverage, the grass production was greatly varying between the different communities, from 48 (area 2 in C5CMA) to about 600g DM.m^{-2} (C6IRUM), with an average of 253g DM.m^{-2}. The area with a density of 48g DM\m^2 had been recently burned, explaining this very low value compared to the others. The two pastures with the highest grass densities had an average of more than 400g DM.m^{-2} (402g for the area 3 in C4INHA and 596g in C6IRUM).

Concerning the surface of each communal pasture, we can see that the areas were wide, being from 265 to more than 5.000ha (C5CMA and C1CCHI, respectively) with an average of 1.650ha. The two communities that had three different grazing areas (C3ICVU and C4INHA) had both one area far bigger than the two others. The two communal pasture areas of the fifth community (C5CMA) were of about equal sizes, but their grass densities were very different (215 g DM.m^{-2} against 48 g DM.m^{-2}) as one area had been recently burned. However, as the first area had a dense trees and bushes' canopy (50%), its grass production was quite similar with the second area which was an open grassland (494 and 480kg DM.ha^{-1}, respectively).

The community that had the highest total grass production (C1CCHI, with a range of 5400-6500t DM) had by far the widest communal pasture but not a high grass density (180g DM. m^{-2}, lower than the average of 253g DM.m^{-2}). In comparison, the community with the highest grass density had an average of 596g DM.m^{-2} (C6IRUM). This community was situated in a Miombo woodland ecosystem. The coastal communities (Communities 1, 5 and areas 1&2 of community 3) had a very poor soil due to low organic content, high porosity and lack of water retention capabilities and the saline, marine influence (*CARE, 2006*).

From the total DM of grass produced, the grazing capacities or how many goats can be sustained per ha at that period were calculated. Different goat feeding patterns were applied, depending on the bush/tree coverage of each pasture area.

Feeding pattern 1: goats have the possibility to graze and browse
Feeding pattern 2: goats have only the possibility to graze
Feeding pattern 3: goats have more the possibility to browse than to graze

These different feeding patterns led to set up different average yearly grass intakes (t DM). For the feeding pattern 1, the values were presented in the theory part (51% grasses and 49% browse) while for the pattern 2, it was assumed that the daily feed intake was entirely made of grasses. For the feeding pattern 3, the values presented for the dry season were applied (15% grasses, 85% browse).

Besides, the factor of 50% pasture utilisation was applied on the different grass productions.

Table 6: Communal pastures' carrying capacities (from the grass production)

Pastures' carrying capacities (from the grass production)		Total utilisable grass production (t DM)	Number of goats for grazing	
			per ha	total
C1CCHI	**5000 ha**	2704	4.3	21654
	6000 ha	3245	4.3	25984
C2ICA		254	3.8	2031
C3ICVU	**Area 1**	30	2.3**	810**
	Area 2	545	1.6*	2211*
	Area 3	251	5.7	2012
	All areas	826	3.2	5033
C4INHA	**Area 1**	772	6.3	6184
	Area 2	115	4.6	921
	Area 3	268	8.8	2149
	All areas	1156	6.6	9255
C5CMA	**Area 1**	30	2.0	237
	Area 2	35	1.0*	141*
	All areas	64	1.5	379
C6IRUM		1316	13.0	10536

*Values obtained from the feeding pattern 2; **Values obtained from the feeding pattern 3

The results obtained show high variations between communal pastures but also between grazing areas within the same community. The average was of 5.6 goats per ha and a total number of about 5.500 goats on the whole pasture. The smallest grazing capacity was found for the grazing area 2 in the fifth community (C5CMA), with only 1 goat per ha. As already explained, this land was an open grassland that had been recently burned so it is expected that this value would increase with the grass growth. However, goats would not be able to browse so their grazing intensity will be higher than in the case of a mixed feeding. This community scored the lowest grazing capacity of all communities (goats/ha but also total number of goats), with a total maximum number of 379 goats.

The highest grazing capacity was for the same community that had the highest grass production (C6IRUM), with a capacity of 13 goats per ha and as much as 10.536 animals throughout the grazing land. The community with the widest differences between its grazing areas (C3ICVU) was the one with the most varied vegetation type, as described in the previous section. Its grazing capacities were from 1.6 goats per ha in the open grassland to 5.7 goats per ha in the savannah woodland. The open grasslands showed the lowest grazing capacities, the feeding pattern or grazing intensity having thus an impact on the results.

However, these grazing capacities only took into account the grass consumption of goats. For the savannah woodland but especially the area dense of high vegetation, browsing would be an important part of the feed intake so neglecting it would lead to an underestimation of the potential carrying capacities of the communal pastures. Hence, in order to get a more realistic picture, the browsing part in the goat diet needs to be assessed.

3.1.2. Composition of pastures and availability of browse

Rainfall, soil type, fertility and land use history determine the types of grasses and abundance of it on a pasture (*Timberlake, 1985*). The table below presents the plants that mainly occurred on the different communal pastures.

Table 7: Main plant materials eaten by goats, presence per community

Plants/ Communities	**C1CCHI**	**C2ICA**	**C3ICVU**	**C4INHA**	**C5CMA**	**C6IRUM**
Grasses						
Panicum maximum Jacq.	×	×	×	×	×	×
Heteropogon contortus		×	×			×
Hyparrhenia rufa (Nees) Stapf.	×	×	×	×	×	×
Rhynchelytrum sp.		×	×	×		
Forbs						
Landolphia petersiana	×		×		×	
Cocculus hirsutus (L.) Diels				×		×
Shrubs & trees						
*Strychnos spinosa **	×	×		×	×	
Synaptolepis kirkii oliv.	×				×	
Trichilia emetica vahl.		×		×	×	
Garcinia livingstonei T. ardens			×		×	
Crotalaria capensis Jacq.	×	×	×			×
Crotalaria montinoi Taub. Ex Bak. F.	×	×	×			×
*Clemodendum glabrum E. Mey. **	×	×	×	×		
*Commiphora africana (A. Rich.) Engl. **	×	×				
Artabotrys brachypetalum Benth.	×			×	×	

*Deciduous trees

We can see that the two dominant grass species were *Panicum maximum* and *Hyparrhenia rufa*, both perennial grass species. *P. maximum* has a better palatability than *H. rufa*, the latter being better digested when young (*FAO Grassland Database*). *H. contortus* and *Rhynchelytrum sp.* were both found in half of the communities, occurring both in two communities (C2ICA and C3ICVU). *H. contortus* is characterised by sharp, barbed seeds (see Appendix 3) that can penetrate the animal skin, causing infections. The two communities that had the fewest grass species were both coastal (C1CCHI and C5CMA).

Only few forbs were mentioned and only two were found in more than one community: *L. petersiana* and *C. hirsutus*.

Concerning the shrubs and trees, the three dominant species, *S. spinosa*, *C. capensis* and *montinoi*, were all present in 4 out of the 6 communities. *S. spinosa* is a deciduous tree (it loses its leaves in the dry season) widespread in Mozambique, known for its characteristic glossy, yellow hard skin's fruits; fruits that can also be eaten by goats. The last community (C6IRUM) had less common shrubs/trees species, only two *Crotalaria* types being on the above list. It does not mean that the pasture had a limited diversity of shrubs and trees but that the other woody species were different from the other

communities. This community was the furthest East from the coast (most interior), which might explain a change in the shrubs and trees' cover.

All grazing areas but two (area 2 in C3ICVU and in C5CMA) had a canopy of shrubs and trees, their coverage varying from 15% (area 1 in C4INHA) to as much as 70% (area 1 in C3ICVU) of the total land. This availability of browse is very important for goats as they are mixed/intermediate feeders: when face with a mix of browse, forbs and grasses, goats will select a diet containing much more browse than would be selected by sheep or especially cattle (*Solaiman, 2010*). Furthermore, goats that are in free-range are very selective with their feed, favouring eating different types of plants during the day (*Devendra, 2007*) and *Hendricks et al*. (2002) observed during the course of a day that up to 16 different plant species were eaten by goats.

For the period of the study (late wet - early dry season) the goat diet was set up at 49% browse of the total feed intake (see Material and Methods), implying that goats were feeding equally on browse as on herbaceous plants. Hence, a goat would take daily about 335g DM of browse. This number would be even higher later in the dry season as the goat diet would be composed of 85% of browse when the grasses are dry (which represents 574g $DM.d^{-1}$). Hence, evergreen shrubs and trees are as much important components as the grasses within a pasture, allowing the goats to be sustained all year round. From the major bushes and trees encountered, three were deciduous, losing their leaves during the dry season and hence could not be part of the goat diet at that time.

3.1.3. Risk of bush encroachment and fire

From the commercial goat ranch's visit, a particular tree species was defined as prone to encroachment: *Acacia nigrescens*. The problem can become critical, the plant forming thickets that could ultimately hinder the grazing of animals but also the grass growth. Furthermore, Acacia trees are deciduous thus they are not eaten all year round. Different Acacia types were found in two communities (C5CMA and C6IRUM).

Concerning the risk of fire, slash-and-burn practices are popular all over Mozambique (*Schaffer, 2010*), occurring before the growing season when the people burn the savannah to settle their crop. These fires are often going out of control and can spread dangerously. From the mapping of the pastures (see Appendix 2), we can see that for most of the communities (except C1CCHI) their communal pastures shared a border with people's households and/or people's crops. Moreover, most of the communal pastures had their territory going until the next community, increasing the risk of undergoing fire from outside. Hence, the risk of uncontrolled fire was high for all the communities' communal pastures.

3.1.4. Distribution of water sources

Repartition of water supply(ies) impacts on carrying capacity as a poor water distribution (or uneven) throughout the grazing area would lead to an uneven grazing distribution, decreasing the whole pasture's carrying capacity (*Timberlake and Reddy, 1986*).

As presented on the pastures' maps (Appendix 2), half of the communities (C1CCHI, C3CVU and C5CMA), all coastal, had access to the Govuro river on their pastures. One of these communities (C5CMA) disposed also of additional lakes.

The three other communities, more inland, would have to rely on the water pumps present in the community's households' area.

3.2. Communal grazing areas - communities' views

3.2.1. Historical background of the interviewed communities

Communities' history, related to goat keeping, allowed the determination of past practices such as herder, grazing pattern as well as the impacts the war could have had on the current production. Moreover, as the present is built on past experiences, history was required to define future perspectives. *Boogaard (2012)* interviewed the communities on their past goat production systems, in relation to their history. An empty timeline was presented to them and people were requested to share their memories, using key events to structure it. Some of the key historical events that all the communities indicated were the following:

- Mozambique's independence in 1975
- Civil war from 1980 to 1992
- Flooding in 2000/2001

For all communities, goats were already kept during the colonial time. The livestock numbers were estimated to be higher before the civil war than nowadays. During the civil war, many inhabitants had to flee their villages because of the conflicts and most communities were destroyed and abandoned; some places were left for about 10 years. Hence, during that time goat production had stopped: the animals were either eaten by the soldiers, eaten by the community members, taken along the people's escape or just left behind when they had to flee in a hurry. At the end of the war (1990-1994), when people returned to their homes, there was very few – if no – livestock anymore. The goat flocks were partially restocked by mutual aid among the communities' members but also via governmental, non-governmental and international aid organisations. However, changes in the way the goats were kept were made before and after the civil war.

Before the civil war, all but one community (C4INHA) were using a communal pasture where the goats could graze. However, the area was not collectively managed; people were living more spread out and goat density was relatively low so they could use the communal grazing land around their houses to take their goats. The herders were all children (most likely young boys) as there was no school. They were responsible for bringing the animals to the pasture and watch them while they were grazing freely. In 3 of the 6 communities traditional corrals were reported as goat housing, mainly to protect them against predators (C2ICA, C4INHA and C5CMA). Only 2 out of the 6 communities were giving water to their animals (C1CCHI and C5CMA), from a natural source (river). The others had either no access to water within their community boundaries or they would not see the need to provide it.

3.2.2. Problems perceived in the present system

After the civil war, none of the communities was using its communal pastures anymore. It was only recently (more or less 10 years ago) that two communities (C2ICA and C3ICVU) decided to use it again, but only for their (very few) cattle. The goats were then (and still) kept next to people's households and tethered, for different reasons: there was no herder anymore to watch them as the children were going to school and/or goats needed to be tethered at least during the growing season to protect the crops. Conflicts with neighbours could arise if the goats would escape and eat on nearby fields. The communities that did not give water started to give it when: goats that they had

received from an organisation were dying; they built a water pump on the community, but it was distributed only when the temperatures were very high. Some community members were still not providing water to their animals. One community experienced a lot of problems with predators during its history: with hyenas before the civil war and with snakes afterwards (C4INHA). During these two periods, they had implemented traditional corrals for goats but they had to stop it as the animals were killed by the predators.

3.2.3. Communities' ideas on natural resource management (NRM)

From the interviewees' answers, practices concerning the NRM were identified and structured according to specific indicators. Interviews' analysis and literature search led to set up two different impacts' categories for the NRM practices, depending on the impacts' time scale of the NRM practices: short-term or long-term impacts. Furthermore, two different types of NRM practices were distinguished: the ones having low pressure on the land and the ones having a high pressure. Below, the categories and selected indicators are presented (Table 8) and their relevance is discussed in relation to carrying capacity of communal grazing areas.

Table 8: NRM practices and the time scales of their impacts

NRM practices		Low land pressure	High land pressure
Category 1: Practices with short-term impacts on natural resources	**Grazing pattern**	Rotation between plots or area	all-year round without rotation
	Animal keeping system	Free-range	Tethered
	Grazing dynamics	Dispersed from the corral	Close to the corral
Category 2: Practices with long-term impacts on natural resource	**Mix cattle/goat**	Yes	No
	Burning	No or controlled every 4 years (or longer)	Yes, every year or not controlled
	Water sources	Natural	Borehole
	Maximum number of animals	Applied	Not applied

Concerning the grazing pattern, it has been found that restricting the grazing in certain parts as in rotational grazing can lead to a decrease of forage availability in short-term. However, as it helps reducing resource degradation by eliminating overexploitation, it can also improve the availability and quality of forage (*Benin and Pender, 2001*). Distinction was made between grazing plots and grazing areas. Grazing plots had the same vegetation while different grazing areas were characterised by different vegetation (i.e. one area was mainly composed of grasses while the other had a high density of trees and bushes). Furthermore, different areas were often separated from each other geographically (e.g. by the community households, a road or a river).

Tethering goats and/or keeping them next to the corral while grazing are techniques with high land pressure as they both can lead to a fast overgrazed zone (i.e. grazing is concentrated on a small part of the pasture). The grazing dynamics parameter was extrapolated from the questionnaire (question on estimated grazing time of the goats (h/day). See Appendix 1, Question 1.8).

In Category 2, practices with long-term impacts on the natural resources can also have short-term effects but the focus was only made on the long-term ones.

As stated by *Devendra* (1999), the best long-term integrated animal production system is a mix of goats and cattle on the same grazing plot. It is recognised as the best-suited combination for the control over woody species and improvement of the range vegetation. Hence, mixed grazing has environmental advantages over mono grazing. Concerning the use of fire, slash-and-burn techniques have been applied since long time by African farmers in order to implement crops and control bush encroachment on pastures. *Trollope* (2011) stated that the use of fire in management of vegetation for domestic livestock is widely recognised and deemed necessary by both commercial and communal land users. Concerning the battle against bush encroachment on pastures, several practices has been carried out in Mozambique in the 70s, such as aerial spraying, hand clearing and application of aboricides, as well as the use of controlled fires. *Sweet* (1980) analysed many different techniques and concluded that the controlled burning of the area every four years was the most efficient way. However, this was carried out for cattle rangelands. Dissimilarly, goats are known as having a high digestive efficiency for coarse roughage such as bushes and trees (*Boyazoglu et al., 2005*). Increasing the number of goats on a grazing area can thus keep bush invasion more under control (*Timberlake, 1985*).

In contrary, the non-controlled use of fire on the pasture or its repeated application (e.g. every year) can have negative impacts on the soil fertility and vegetation composition. *Fashing* (2001) stated that long-term studies had been completed in different parts of the world to determine the effects that burning has on soil quality. All concluded that long-term burning of grasslands has a negative effect on soil quality, which directly relates to reduced production. Furthermore, repeated cycles of fire accentuate ecological instability, resulting in loss of protective vegetative cover, soil compaction and unprecedented runoff and accelerated rates of erosion (*Maiangwa et al., 2007*). Hence, uncontrolled fire or yearly burning have a high land pressure.

Concerning the water supply's sources, the use of surface water (e.g. river, lake) has a lesser impact on the natural resources than the use of groundwater (i.e. water coming from a borehole), as the replenishing speed of groundwater in area where the precipitations are slight or fluctuating is considerably lower than the one for surface water (it could take centuries for a groundwater's aquifer to be refilled) (*Hogan et al., 2010*).

The implementation of a maximum number of goats to graze a pasture has been recognised as one of the most critical factors for the natural resources. As stated by *Peacock and Sherman* (2010), the consequences of overgrazing due to goat overpopulation in one pasture are known as a major environmental issue (e.g. desertification). At the beginning of the pastures use, if this criterion is not included to some organisational chart, in long-term the number of animals could increase to a point of overpopulation without any implemented security system to avoid it.

Following the framework presented in Table 8, each community' ideas on the future management of the communal pastures were assessed for their natural resources management (NRM). The results obtained are presented in Table 9.

Table 9: Communities' NRM characteristics

Communities \ NRM practices		C1CCHI	C2ICA	C3ICVU	C4INHA	C5CMA	C6IRUM
Grazing pattern	1		×	×	×	×	×
	2	×					
Animal keeping system	1	× (long-term)	×	×		×	×
	2	× (short-term)			×		
Grazing dynamics	1	×	×	× (women)			× (women)
	2			× (men)	×	× (men)	× (men)
Mix cattle\goats	1		× (women)		×	×	×
	2	×	× (men)	×			
burning	1	×	×	×	×		×
	2					×	
water sources	1	×		×			
	2		×		×	×	×
Max number of animals	1						
	2	×	×	×	×	×	×

1: low land pressure; 2: high land pressure

Practices with short-term impacts on natural resources; Practices with long-term impacts on natural resources

As we can see, the communities had different ideas on their natural resources management. Concerning the practices with short-term impacts, most of the communities scored a low land pressure for the grazing pattern and the animal keeping system. All but one community (C1CCHI) had the idea of rotating their animals between plots or areas, depending on their pasture's layout. Besides, most of the communities were willing to let their animals grazing freely, thus ready to make a shift from their current tethered system. One community (C1CCHI) was eager to implement a free-grazing system, but only after an adaptation period (fear of animals' escape). Only one stated that they would keep a mixed-tethering system (C4INHA) where the dominant animals would remain tethered. Concerning the grazing dynamics, the views were diverging. Four focus groups (3 men groups) mentioned the need for the animals to come back to their corral at midday. Some mentioned reasons were: goats could rest and have water there (C5CMA and C6IRUM) and the goat herder could take his lunch break (C4INHA). In a community (C3ICVU, men), the situation was even strengthened: the goats would go to drink water two times a day (before reaching back to their corral) at a specific spot, implying that they would not be able to graze far from both the water point and the corral. The other focus groups would keep the animals all day on the pasture and would bring them back to their corrals at the end of the afternoon.

Regarding the practices with long-term impacts, the possibility of mixing goats and cattle on the same grazing spot was accepted by three communities (C4INHA, C5CMA and C6IRUM) and by the female respondents of another (C2ICA). The main motive for not mixing goats with cattle was that the two species were not eating the same diet: goats favoured trees and shrubs while cows ate only grasses (C3ICVU). Burning practices related to the communal pasture were mentioned in only two communities (C1CCHI and C5CMA). The former mentioned the practice of controlled fire for establishing the pasture. However, the pasture would be afterwards protected against other fires (e.g. coming from outside) thanks to a protection corridor. The latter had a complete different view

on the topic. For this community, fire was applied every year (in May) on one pasture area as it was believed that goats would not eat dry forage (especially *Hypanrrhenia rufa (Nees) Stapf.*, the dominant grass specie). They had no doubt on the grasses' regrowth and said controlling the fire on lighting it in late afternoon when there was less wind.

For the type of water source, it was more related to the community's geographic position (half of the communities did not have natural water source within their communities' boundaries) than to their own choices. However, one of the community that had natural water source on its communal pasture (C5CMA) proposed to use groundwater as water supply for the goats (because of predators).

None of the communities was currently thinking of implementing a maximum number of goats on their pastures; all scoring "high land pressure". Several motives were expressed: either it was not applicable because all producers wanted to increase their herds (C1CCHI), either it would not be possible to control the animal numbers as it was natural that it increases as the goats reproduce (C2ICA). For two communities (C4INHA and C6IRUM; both men and women), this could not be discussed before knowing how many animals would be using the pasture. For others, their pastures were too big for being concerned about keeping animal records (C3ICVU). Three communities gave an estimation of their pastures' carrying capacities (CC). One evaluated the CC of one area at more than 3.000 animals while for another area at no more than 300 animals (C3ICVU). Another community thought that more than 1.000 animals could be sustained on its grazing land (C6IRUM) while the other estimated a number of 600-700 animals (C4INHA). Two of these communities (C3ICVU and C4INHA) were asked for what would be the symptoms of an overgrazed pasture. Both gave the same answer: the overgrazed area would not have grass anymore.

3.2.4. Communities' ideas on labour

In analysing the interviews, it was found that some communities had the same ideas on how managing their animals, related to the labour forces. The different components of this topic are presented on the Table 10: herd management (day and night), water supply and type of housing (implying the labour needed for the construction). From the interviewees' responses, it was possible to set-up different systems. The communities could be categorized by 3 systems, depending on the degree of involvement of the goat producers for the communal pasture's management:

- System 1: Maximal intervention of producers
- System 2: Intervention of producers and paid labour
- System 3: Minimal intervention of producers

The first system consisted of a goat production that relies only on its goat producers, without any paid labour. Only one community met these criteria (C6IRUM). Men and women had different responses but all agreed that having paid herder(s) would be too expensive. Both groups presented the idea of making herding shifts between the producers, with the support of the others; the women expressed the additional need of fencing the area. In complement, they would implement a shift between the producers for opening and closing the corral; the shift person would also be responsible for herding the animals during the day. For the night, the women were not planning to have a night watchperson while the men would have one or more producers, depending on the animal number. Concerning the water supply, as the community did not have natural source within its territory, the water should be brought from the households' water pump to the pasture. The water pump was

situated about 1h walk from the grazing zone. Water would be carried out by all producers and the shift person would be the one supplying it to the goats. Men thought of installing a water tank next to the corral to store more water. Regarding to the corral(s), it would be of traditional type. Hence, everything would be managed by the producers themselves, with implementation of shifts among the group.

Table 10: Labour-related communal pastures' management strategies

Labour-related communal pastures' management strategies			
System characteristics	**System 1: Maximal intervention of producers**	**System 2: Intervention of producers and paid labour**	**System 3: Minimal intervention of producers**
Day herding	By producers, with or without fenced area	By producers or paid herder	By paid herder, with fenced (totally or partly) area
Night watching	Shift of producers or no night watching	Shift of producers or paid person or not needed	By paid person
Water supply	By producers, from borehole	By producers or paid herder, from natural source or borehole	By paid herder, from natural source
Housing	Traditional corral on pasture	Traditional/improved corral on pasture or next to one producer's home	Corral on pasture
Community	C6IRUM	C1CCHI, C5CMA, C2ICA, C4INHA	C3ICVU

The second system concerned four communities and implied the intervention of paid labour, in complement of the producers. For the day herding, the animals could be looked after by their owners or by a paid herder. This paid herder was described by all communities as a young adult man, part of the community (C2ICA), or from outside (C4INHA). A respondent in one community (C4INHA) expressed the unease of giving this job to a young person, preferring offering it to an older man who could deal better with challenges such as the destruction of neighbouring crops by the herd (the herder should then have to pay the damage costs to the crop's owner). The day-herder would have the responsibility of opening the corral the morning, controlling the goats while grazing, bringing them back to their corral at lunch time for 1-2h (or not) and/or at the end of the afternoon. The communities planning to bring back their animals to their corral at midday did not have natural water source, so water should be supplied from the communities' water pump, situated in the housing zone. One community had a river at the edge of one pasture's side (C1CCHI). The goat owners were planning to herd themselves their animals during the day, bringing the herds to the river during the afternoon, just before reaching back the improved corral(s). For the night, all the producers would pay someone from the community to guard the animals. The other communities had different ideas: one was thinking of having producers' shifts (C2ICA) and two mentioned that they did not need any night watchman. One declared that the pasture zone was quiet so they would not expect any trouble (C4INHA). The other was planning to have few producers who would group their herd together and then build a corral next to the producer's home that is the closest to the pasture, so it would not be necessary to hire anyone (C5CMA). Hence, these communities were thinking of systems that would involve paid labour, mainly coming from within the community.

The third goat production system was only mentioned by one community (C3ICVU). The main feature was that goat producers would not have a direct intervention towards their herds. They would devolve all the daily work to paid herders and night watchmen. The pasture would even be partly (male respondents) or totally (female respondents) fenced, in complement of the herders, protecting the animals against thieves and to avoid them to escape and destroy nearby crops. The men were seeing the herding management as a partnership between the herders and the night watchmen, both living on the communal pasture next to the goats' corrals. Women mentioned the need of hiring someone for the night as the job behoved to men. Goat producers would still have to come and check on their animals, but the male respondents even mentioned it as a challenge, being time and energy-consuming. Hence, in this system, goat producers would only play a role of supervisors while the daily herd management would be performed by the paid herder and night watchman.

3.2.5. Systems' benefits and dealing with perceived problems

After summarising their new goat production systems, people were asked the benefits and challenges of it. The main benefits identified by the respondents were:

- More animal production from free-range grazing
- Better reproduction
- No more conflict
    - with crops
    - With neighbours
- No injury from rope when tethered
- Others

All communities stated that using their communal pasture should bring an increase in animal production, one focus group explained that free-range would allow better animal feeding (C3ICVU, men). The free-range system but also the collective herding would permit the bucks to better reproduce (male respondents of C2ICA and C5CMA and women in C6IRUM). For one community it would bring the possibility to rotate the bucks within the collective herd (i.e. as the producers would have their animals together in the same grazing spot, males would be able to reproduce with females owned by different smallholders) (C1CCHI). Animal production and its increase thanks to the communal pasture and free-range system was one of the topics discussed with the communities by the ImGoats' extension officers. Hence, the respondents' answers could have been influenced by that.

Another benefit was having an identified communal area separated from the community's households. This would avoid the current conflicts with crops and family/neighbours (C2ICA, women and C6IRUM, men). Besides, two female respondents' groups (C3ICVU and C6IRUM) brought the fact that if the animals would be free, they would not have problems with a rope anymore as goats get often twisted in it, causing leg injuries. Other benefits were mentioned: the area itself as it was large and with plenty of feed (C1CCHI), using the communal land would allow the goats having more water (C3ICVU). With a better animal productivity, goat keepers could increase the commercialisation of goats (C6IRUM, men).

In comparison, respondents identified challenges for the communal grazing area and their suggested solutions. The main challenges were:

- Predators
- Theft
- Animal health
- Others

Predators was the challenge the most recalled by the respondents (C1CCHI, C6IRUM and men in C2ICA and C3ICVU). Among the animals that could harm the goats, it was mainly snakes (*Jiboias*) and dogs. Fencing the area was an option (C1CCHI) while another was that the only way of getting rid of the *Jiboias* was to find and kill them (C6IRUM, women). Thieves were considered as hampering the goat production in half of the communities (C2ICA, C3ICVU and C6IRUM). Having a herder was a solution but for one community (C3ICVU) the producers should also make several controls themselves, checking on the animals while they are grazing. The concerns about the animal health were expressed in two places (C2ICA and C3ICVU). Health problems could occur from disease transmission (because of animals' proximity with each other) but also from bad health surveillance from herders as goat producers could not check their animals as often as before. Tick treatment could solve some of the disease problems (C2ICA).

Besides, other topics emerged. Animal identification within the collective herd - or which animal belongs to whom - was highlighted in one community (C3ICVU). To solve it, they came up with different ideas, such as cutting the goats' ears or tying up some pieces of clothes around the animals' neck. Their other concern was that they lack of experience in communal pastures' management. They were willing to create a registered goat producer's association in order to be more organised and to support each other.
One community was worried by the corrals' construction (C5CMA) as finding good-quality wood within the community area was nowadays becoming difficult. They did not have any solution about it if there was no money involved.

4. Discussion and recommendations

4.1. Carrying capacities of the communal lands

The primary production of the pastures (mean (all communities): 1.400kg DM.ha^{-1}; min.(community level): 500kg DM.ha^{-1}; max. (community level): 3.250kg DM.ha^{-1}) were lower than the average value of 3.000 kg DM.ha^{-1} presented by *Lamprey* (1983) for dry sub-humid to semi-arid savannah, except for the community with the most productive pasture (C6IRUM). However, *Timberlake and Reddy* (1986) found that the pasture production in the Urrongas area (North Inhambane Province, Mozambique) was of 2.100kg DM.ha^{-1}. This area was presented as good potential pastures for cattle, with a 20% tree and shrub coverage. As it was presented, the shrub and tree coverage has an important effect on the grass production and the majority of the studied grazing lands had a higher shrub and tree coverage, which could explain their average lower grass productions. The 1m^2 quadrat approach used to calculate the pasture productivities, considering the timeframe allocated to this thesis as well as the provided tools and funds, was an adequate one. Moreover, several quadrats were taken in different zones of each pasture area so the whole territories could be well represented. However, the different pastures' carrying capacities (from grass productions) were calculated with the assumption that the pastures were evenly grazed. This could not reflect the real situation and as mentioned by *Bailey et al. (1998)*, uneven grazing distribution can reduce the carrying capacity of grasslands and the efficiency of livestock production. In *Solomon et al. (2007)*, half of the interviewed Ethiopian pastoralists declared that their available rangeland was not utilised to its maximum potential, some of the reasons being its inaccessibility (too far) and/or unavailability of water. *Bailey et al. (1998)* recommended that developing trails in rugged terrain would reduce energetic costs for traveling to remote feeding sites, and thus increases their desirability to grazing livestock.

Besides, vegetation availability in the savannahs fluctuates throughout the year (and the rainfalls), implying that one pasture cannot continuously sustain the same number of animals; the carrying capacities change throughout the year. As *Abel (1997)* interprets it, "choosing a stocking rate is an ethical decision but it should be socially, not technically determined and that it is but one level among many possible densities." He also argued that "fixed carrying capacities are the antithesis of adaptability". *Bembridge and Tapson* (1993) go even further in stating that stocking rates should follow variations in carrying capacity so as to reduce losses and pressure on grazing when carrying capacity falls. This is why several grass production's measurements should be performed in order to obtain a more complete picture. Hence, this thesis, which is a snapshot of a determined period, should be taken as a starting point for the collection of at least one-year measurements, thus continuing the work.

Furthermore, when entering the dry season the goats will rely more on tree leaves. Hence, it would be very valuable to estimate the tree fodder's capacities of the pastures, which has not been done in the areas of study. Environmentalists or biologists would be needed to make a complete vegetation survey of the existing trees and bushes, applying, for example, a 50m×50m sample plots (*Van Rooyen and de Castro, 2010*), sample size more appropriate when trees are taken into account.

4.2. Plant identification

The identified grasses in the different pastures show that the studied grazing land are either of sour or semi-sour type as some grasses (*Heteropogon contortus, Hyparrhenia rufa*) being not available for grazing during the whole (or part) of the dry season. These results follow the study of *Timberlake and Reddy* (1986) where they determined the pastures in the Urrongas area as semi-sour pastures. The collection and identification of the grasses, shrubs and trees eaten by the goats were carried out from the focus group interviews. Goat producers had knowledge about goat diet and were able to identify a large number of plants but some responses were different following the communities. In one (C1CCHI), it was said that the goats were not eating *Heteropogon contortus* while in the others they would. This could imply that some plants that were normally eaten by goats would not have been identified in communities where they could be present. Concerning the drying method of the collected samples, a lack of convenient materials (no newspaper was available) had hampered the process in certain samples and few plant materials were not kept for the herbarium. However, there is a registration of all plants as they all had been photographed on-site. A cooperation with the country herbarium (in Maputo) allowed a faster identification of the plants, allowing more time for their characteristics' search. Hence, livestock development projects should keep in mind that biologists/plant taxonomists could be valuable assets and help them in defining the available local animal fodder.

4.3. Future grazing land management's perspectives

The choice of combining technical and social components into one topic that is communal pastures was found relevant in the literature. *Le Houerou and Hoste (1977)* identified the various factors that influence pasture production as climate, nature of soil, botanical composition and vegetation structure but also type and intensity of management e.g. grazing patterns, stocking rate and fire. Furthermore, *Bembridge and Tapson* (1993) stated that the simple imposition of grazing schemes without detailed local community involvement in planning is doomed to failure. From the results, it was shown that the communities had different pasture layouts and management ideas, however they had some common features. It was found that all communities disposed of wide territories, of several hundred (or more than thousands) hectares. Furthermore, despite that the different pastures had different grass productions, there was one cohesive characteristic: the grass availability varies throughout the year and the different seasons. Besides, the ImGoats project participants were all small groups of people (average of 30 people), representing in average about 250 goats. From this common base, perspectives could be drawn.

4.3.1. Natural resource management

When comparing the measured grass productions (kg DM.ha^{-1}) with the yearly feed intake of a herd of 250 goats, the needed grazing area ranged from 19.2ha (C6IRUM) to 167ha (area 2 in C5CMA), with an average of 46ha. Only one community could easily reach its whole grazing land's maximum carrying capacity (C5CMA). Its current ImGoats project's herd is of about 100 animals but it would normally be increased in the future (e.g. more producers will use the grazing land and/or producers will increase their herds) and as it was just presented, the grassland (area 2) would already be overgrazed with a herd of 250 goats. However, as the community households are geographically divided in two, each being next to a different grazing area, the goat owners could divide themselves in two groups following their living location and each group would use only one of the two areas. This

management type would have advantages: it would allow having less animals on one area, the smallholders would also be able to better develop their herds and it could avoid conflicts between the different community members (rivalry from the two community's sides had been mentioned from the project's officers and was observed during the interview). However, a feeding shortage could occur during the dry season in the grassland area. The grassland edges being trees and bushes, goats could be led there but longer-term solutions should be sought.

Besides, for the other communities, in terms of practicability the current producer groups would better focus on only a (small) part of their whole pasture territory to implement their goat herds, as using all of it could be very overwhelming, especially with the current limited number of participants. To support this view, *Stocking and Murnaghan (2001)* indicated that extensification of farming onto larger areas of land leads to poorer land management and more land degradation. Furthermore, some communities expressed the will of fencing a part or the whole pasture. This should be more thoroughly thought in order to see its feasibility, taking into account the material costs and required labour.

The grazing area would better be chosen not far from the households (when possible) as it would be easier for the producers to go for their herding shift or for checking on their animals (in case of paid labour). Subsequently, in communities that are widespread (e.g. C4INHA), different groups of farmers could be created so each one could manage the grazing area next to its households. The free-range grazing system with herder would avoid the destruction of possible nearby crops from the goats. The selected part of the whole pasture area(s) would be itself divided into grazing zones, allowing the herd to be rotated within these zones on a short-term basis, giving the opportunity for the grass to regenerate. *Benin and Pender (2001)* stated that applying grazing rotation and thus restraining the animals to a limited territory would put a pressure on this grazed plot, rapidly deteriorating the conditions of those resources. However, in the situation of a low number of animals in a wide territory, this would unlikely occur as they could easily move to another plot as there would not be strong stocking rate's pressure.

As stated before, the grass availability varies throughout the year. During the dry season, the grasses' aerial part is mostly dry or dead (*Science Encyclopaedia*), not edible for the goats, their diet being switched to more trees and bushes' materials. Hence, for the dry season grazing, the herds should be moved to a grazing zone more dense in bushes and trees. For the communities having more than one pasture area (C3ICVU, C4INHA and C5CMA), clear distinctions could be made between the areas and their time of use (e.g. the area 1 in C3ICVU, a 70% tree-dense pasture, had good characteristics for dry season grazing while the area 2 of C5CMA, an open grassland, could not be grazed during the dry season). However, the wide pasture territories bring also a new opportunity: grasses in non-grazed zones could be harvested and dried in order to make hay that could be provided during the dry season, as basal diet or as a complement to the trees/shrubs' leaves. The most favourable harvesting period would be when the grasses are in early-mid flowering. This hay, conveniently stored close to the corral, could be provided in the late afternoon when the goats would come back from the pasture.

Burning the pasture as a management tool is a complex issue. Literature search brought conflicting views that have all their place in a debate. For *Trollope (2011)* who conducted fire researches and formulated fire management plans in African grasslands and savannahs over more than 40 years, the

use of fire in the management of vegetation for domestic livestock is widely recognised and deemed necessary by both commercial and communal land users. According to *Trollope*, the necessity for rangeland to be burn or not depends upon its ecological status and physical condition, the condition of the grass sward being a critical factor. He recommends controlled burning when the grass sward has become overgrown and moribund or to prevent the encroachment of undesirable plants. He continued that depending on the purpose, the timing of the controlled fire differs. In order to remove moribund grasses, the controlled fire should be applied after the first rains, at the beginning of the growing season, while for controlling encroaching plants, the fire should be conducted before the first rains when the grass sward is very dry, ensuring a high intensity fire. The burning frequency would depend on the stocking rate of grazers and on the amount of rainfall received on the area. On the other side, *Fasching (2001)* compiled several studies on the effects of burning on soil quality and stated that the long-term burning of grasslands had a negative result on soil quality, directly resulting in reduced production. In addition, article 40 of the Mozambican National Forest and Wildlife Law criminalises fires that destroy all or part of forest, bush, thicket or savannah; this no-burn policy making no distinction between wildfires and controlled burns (*Schaffer, 2010*). Hence, until the national legislation would remain in this form, controlled burning of pastures cannot be one of the project's recommendations.

The fact that all communities responded not implementing a maximum number of animals in the communal pastures could be partly explained by the theory of collective goods. A pure collective good has three properties: non-excludability (anyone can have access to it and benefit from it), non-rivalry in consumption (one person's consumption does not impair that of another) and externalities (effects of a use decision by one set of parties on others who did not have a choice and whose interests were not taken into account). According to this theory, land degradation emerges when users can exploit environmental goods such as grazing areas, without contributing to their maintenance or conservation (*Watcher, 1992*), meaning that the respondents would see communal pastures as a resource they all can access, without the need of restraining its use as no one would bear the full costs of a possible land degradation. Hence, no one has the incentive to conserve the land because the benefits of conservation are dissipated among all users. However, this common theory could not be applicable for the communities of the study, as their pastures are not yet in use so the concept of overgrazing could not be understandable; they currently see their grazing land as endless: some respondents thought that their areas were too wide for this kind of constraint and with the current situation of a small group of producers with no more than 250 goats, the pasture could carry these animals and much more (C3ICVU). Another explanation would be that people do not foresee a long-term situation. As the communal pasture are not yet in use, the ideas of setting up a restriction on the animal numbers would seem strange as they would need to see in practice how the pastures are actually being used (as in C6IRUM). Furthermore, people do not tend to think years ahead when their lives are dictated by unpredictable factors such as flooding, drought, cyclone and diseases. There are just too many uncertainties to think about the future.

In addition, communities' ability of applying conservative methods of goat production and of avoiding land degradation could be hampered by the fact that organizing farmers into effective and stable groups for collective action has been experienced difficult (*Maiangwa et al., 2007*). *Bromley and Cernea (1989)* emphasised that establishment of strong and competent farmers' groups is a long-term process. In their discussion paper for the World Bank, they presented several development projects that had been either failure or success, explaining what had been the driving forces for their

fate. One of the successful projects was the Senegal Livestock Development Project (from 1976 to 1983) that focused on implementing pastoral groups to manage an immense grazing territory under common property regime. It is mentioned that it took over *four years* to establish all the farmer groups and have them running properly. In short, communal grazing areas' development must not be seen principally as a technical issue but rather as a process of social and economic change that, to be sure, needs a sound technical base but which principally calls for motivation, training and participation of the livestock owners (*Bromley and Cernea, 1989*). This procedure takes time and could not be achieved within the Imgoats project's 1.5-year timeline. Furthermore, *Bembridge and Tapson* (1993) stated that livestock and grazing management programmes in communal grazing systems suffer from a singular lack of success. They propose to initially implement communal grazing schemes on a "pilot basis" in a few areas in accordance with the ability of the state to supply institutional and infrastructural support. In addition, *Benin and Pender (2001)* concluded that collective action in the case of communal grazing land was likely to be successful in communities that had large areas, far from markets and where wealth among the community members was more evenly distributed. Wealth of the project communities has been only roughly approached in the baseline study. Further research could then be made into community's wealth distribution.

However, if the project is successful, the adoption of the communal pastures could be fast and they could be used not only by the ImGoats participants but by the whole communities. In that case, the grazing capacities could be reached in some communities. The next table summarises it:

Table 11: Differences between the current grazing capacities and the possible goat numbers

Communities	Current grazing capacities	Possible number of goats for the whole community
C1CCHI	21654 – 25984	1350
C2ICA	2031	2550
C3ICVU	5033	2600
C4INHA	9255	1050
C5CMA	379	4500
C6IRUM	10536	1500

The potential numbers of goats that could graze the different pastures were calculated in taking into account, for each community, the different percentages of households with goats and the district's average number of goats per household (8.1 animals) (*ImGoats, 2012*). We can see that two communities would currently not have enough grazing land to support all the goats (C2ICA and C5CMA). For the latter (C5CMA), this grazing capacity's difference is very wide and therefore very alarming for the future. Furthermore, as the grazing capacities fluctuate throughout the year and is likely to be lower during the dry season, the potential situation of overgrazing in these communities could be worsened.

4.3.2. Other managerial issues

The pastures should be identified and recognised as communal pasture land by the government, protecting them against other land purposes in the future, which may be internal community activities (e.g. cropping (*Abule et al., 2005*) or housing area) as well as projects or international

companies from outside the communities (e.g. 'land-grabbing'). Moreover, if land rights are unclear, unspecified, disputed or non-existent, then land users are less likely to be interested in conserving resources or in making investments that improve the long-term productivity of the resources (*Bembridge and Tapson, 1993*). Hence, the land resource users would have no incentive to take care of their land resources and use them in a socially optimal way (*Maiangwa et al., 2007*). In addition, for *Ostrom* (1990), communal rights to land must not only exist, they must be enforceable to attain any real value for the group of right-holders. Furthermore, as the process of using the communal pastures is at its outset, discussion should be brought about implementing (or not) usage rules for the grazing area. These rules could concern, among others, restriction of certain grazing zones, animal species, period of use or time for resource regeneration (*Benin and Pender, 2001*). However, according to *Lutz and Young (1990)*, land use regulations have been inapplicable in developing countries, because the institutional capabilities are generally weak, enforcement difficult and monitoring expensive and that, often, the literacy skills of farmers are also limited. Interestingly, *Benin and Pender (2001)* found that the increase of restricted grazing land had robust negative impact on quality of the other unrestricted grazing resources and that restrictions in general brought for the producers a feeling of less forage available, conflict over pasture use and uncertainty about the benefits obtained.

Concerning the housing, it should be defined for each community whether the corrals are going to be collective or individually owned and used. Four communities mentioned the possibility of sharing a corral between few producers (C3ICVU, C4INHA, C5CMA and C6IRUM). One explained that each collective corral would be built next to one of the producers' house (C5CMA) while another defined a collective corral as a partnership between two producers (C6IRUM, women). However, for another, the preferred type would be separate (C4INHA). For this community, as their grazing area was wide, separate housing would be better in order to avoid conflicts among each other; collective housing would be for the producers who would not have enough resources to build a corral on their own or in the case of family members regrouping their herds.

Another important topic is the traditional spiritual world. It is omnipresent in Mozambican communities and can have a very important impact on people's way of life and actions. For example, *Boogaard (2012)* found that the yearly burning of pasture area also has to do with traditional beliefs and may be related to sorcery. These traditions are unlikely to be changed, at least during the project's timeline, but may have quite a large impact on the interventions' success. Hence, so it would be very valuable to better understand local beliefs, traditions and knowledge related to grazing areas and goat keeping practices.

4.4. Main constraints for communal grazing lands' implementation success

Collecting views and ideas of the communities on their communal pastures and the management of their goat herds was essential to get a better understanding of the pasture areas' future perspectives. Moreover, different topics were brought up and it allowed to identify some sensitive topics, which would need to be further discussed within the ImGoats' project. The three main constraints are the water supply, the labour availability and the herd mobility, all related with each other.

Water availability is a critical criterion for making the systems a success or a failure. Communities with natural water streams (C1CCHI, C3ICVU and C5CMA) can rely on them and manage the grazing distribution of their herds in order to have water at a reachable distance from the corrals. However, one community which has 3 different grazing areas (C3ICVU), has one of them far from the water stream (see detailed map in Appendix 2). This grazing area, that is the most grass productive with available shrubs and trees, could be a substantial fodder source for the goat herd(s). The community's male respondents were thinking that the goats could go to this area and still go back to the water point before reaching for their corral in a day. However, this pasture area is situated at 3-4 km from the water stream, which would mean *at least* 6-8 km in a day (independently of the corral's position). Moreover, this pasture area is separated with the other one by the EN1 (national road), making the crossing of a herd very dangerous. If the community wants to use this pasture area, they would have to provide water from their borehole, situated next to the households (that are next to this pasture).

For the communities without natural water stream (all situated in the interior agroecological zone), this water supply from households' borehole would be the unique solution. Having a water tank/ storage unit next to the corral(s) was an answer given by one community (C6IRUM). This method would allow to bring more water in once and then to repeat the task less frequently. The community mentioned that all producers could help in the task, the water borehole being at 1h (walking time) from the pasture area.

The future communal grazing lands' management perspectives brought along interventions that would require extra labour compared to what is currently allocated to the goat production (e.g. for fencing or harvesting grass for making hay). Goat keeping is not the first activity of the project's participants and this additional work could be perceived as demanding or even overload. Another concern would be about child labour. The project is trying to re-introduce the tradition of herders to manage the goats. However, before the civil war this task was assigned to children, who were then not going to school. People who would not be willing or able to share the cost of a herder and who would not have time for doing the herding themselves could be tempted by having their children doing it. For this, discussion with the community in order to find alternatives to child labour would be highly recommended.

As the idea of communal pasture was still not concrete, the topic of how many herders would be needed was not clear, as one community put it: "it needs to be seen in reality before taking any decision" (C3ICVU, men). A consultant for the ImGoats' project gave the advice of one herder on 30-40 animals, meaning 6-8 herders for 250 animals. It would also depend on how the animals are divided among the corrals, as separating a collective herd in different corrals could be a complicated and tiresome task.

Interventions like "permanent" housing and hay making (that would have to be stored next to the corral) bring a new challenge: the herd mobility. As stated before, the herd could have a seasonally moving pattern, meaning that in some situations the goat corrals would need to be moved or that new housing units would have to be built across the pastures. Hence, this would entail necessary collective labour. During the growing season (wet season), people would be too busy working in their crops for these tasks. Either the community could plan the tasks related to the goat production during a period with less work needed in the crops (if possible), either it could require extra paid labour, thus increasing the production costs.

4.5. Recommendations for the project

The pasture management's plans should be individual for each community, taking into account, among others, their pasture's layout (e.g. one or more areas, distance from households, tree/shrub coverage), their herding type, their housing preferences and their water supply's form. All the topics presented in this thesis should be discussed again with the communities, but with more concrete concerns e.g. if you want your goats to graze in this area and that the water stream is located in this zone and the corral in this other zone, do you think that the goats will be able to travel all that distance in a day? Is it worth/profitable to take a goat over such a distance as the energy the animal will spend would be more than what the goat would gain from the plants eaten? Could the goats graze all over the pasture area and stay in a corral at the same spot all year round? Thanks to the GPS coordinates obtained during the field work, maps of each pasture could be printed in big format and used in farmer groups discussions as support. Furthermore, this new discussion could also identify the communities that are not ready to use their communal pasture in a tangible way. For example, from the group interviews, the male respondents of one community (C2ICA) stated that if ImGoats would not bring them a borehole on their pasture, the project would be a complete failure. The fact that, in Mozambique and for more than two decades of governmental and international aid organisations, communities often received material assets e.g. clothes, food, livestock, etc... (*personal communication*), so participants are expecting to get something and thus easily ask material input from development projects. Hence, imGoats project should clearly state and explain to the participants what are its core principles (providing knowledge and training, not material assets) and how it operates to avoid such discourse. However, water availability remains a critical factor for the communal pastures' success. The implementation of boreholes being supported by the Mozambican government, it is the one who should then take into account livestock and communal grazing area for the future boreholes' installations in villages.

5. Conclusion

This thesis brought a unique opportunity in investigating the initiation of communal pastures in African savannahs. Literature can be found concerning already in-use African communal grazing lands, their use and/or degradation as well as their management by the neighbouring communities, but the study of "intact" areas was a novelty. This special situation allowed to measure the grass production's potentials of 6 communal pastures in the Inhassoro district, in Mozambique but also to explore the ideas of the selected communities' goat producers on how they would manage these grazing lands. The results show the incredible opportunity that these grazing territories represent for the communities, but they also bring concerns e.g. how wide areas could be managed by a small group of people? In addition, critical topics need to be further discussed with the communities, such as the water supply (especially for the communities relying on a borehole), the fire management and the implementation of a maximum stocking rate or number of animals allowed to graze. This latter is highly important as the ImGoats project aims at increasing the goat production (higher number of goats per farmer) so farmers need to know how many animals their grazing lands can carry. Furthermore, this would be even strengthened if the goat keepers decide to use only a part of their entire communal grazing area. Recommendations concerning topics to be discussed with the communities were favoured over giving direct use rules that should be blindly followed. The pastures' organisational charts should come from communities' brainstorming with the help of experts, as one of the ImGoats project's core principle is to adopt a bottom-up approach.

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Appendices

I. Questionnaire

1. Interviews with focus group

We will now talk to a group of goat producers (max. 10 people), in order to obtain information on their perceptions and views of the new communal pasture area for goats. Questions on the current and future situation will be asked, mainly related to the management of the newly defined area.

Needed tools: beans, flip charts

Name of respondent(s)	Status/ Position in the community	Age	Sex (F/M)	Number of goats

Questions:

Current situation

Q1.1: What is currently the average way of keeping goats?

All tethered	
Non tethered or "free range"	
Only dominant animals tethered	
Mixed of free and tethered in the time	

Q1.2: Do you have herder(s) for the goats?

If **yes** -> Q1.2.1: Who is/are it/they?

Q1.2.2: How many animals a herder looks after?

Q1.2.3: Are the herders paid (how much)?

Q1.3: In case of shortage of pasture during the dry season, what do you feed the goats?

If "**collecting leaves**" -> Q1.3.1: Who is in charge of collecting it?

Q.1.4: Did you already discuss about the communal grazing area within the community or producer group?

If **no** -> Q1.4.1: Why not?

Q.1.4.2: Who is aware of it?

Now, let's talk about this communal grazing area.

Q1.5: Mapping of the pasture area:

Q1.5.1: Which types of vegetation are present? (I.e. grasses, bushes, trees)

Q1.5.2: Can you show where the different types of vegetation are?

Q1.5.3: Which species are the ones favoured by the goats?

Q1.5.4: Is there any water point in the pasture area?

Q1.5.5: Is there an area without vegetation?

Q1.5.6: Which vegetation is not suitable for goats in that area?

Q1.6: Are there already goats grazing it? Is the pasture area already in use?

If **yes** -> Continue questions below

If **no** -> Future scenarios

Q.1.6: YES:

Q.1.6.1: How many producers are bringing their goats to the area? How many of these producers are female?

Q1.6.2: how many goats?

Q1.6.3: How many hours per day do the goats spend grazing?

Q1.6.4: What is the distance of the communal grazing area from your house? (Walking time)

Minimum	
Average	
Maximum	

Q1.6.5: Which period of the year are you planning to let the goats grazing the communal pasture? (Beans/month)

Q1.6.6: What is the most difficult time to herd the goats, in term of labour availability?

Q1.6.7: Did you already or are you thinking of setting up a maximum number of goats?

Future scenarios

The next questions will concern how the goat owners think about the future management of the communal pasture. During this meeting we will not get decisions. The objective of this part is to do a brainstorming to gather ideas about the possible management options for the pasture area.

Q1.7: Who would like to bring his goats to the new pasture area?

Q1.8: What are the different ways to manage the communal grazing area?

Note: If no ideas come up*: for example: how would take the goats there? Would they have water? Would you fence the area? How many hours per day? Which period of the year?*

After the discussion, the main scenarios should be summarised for the participants to confirm their ideas:

Q1.9: What do you think are the benefits of each scenario you mentioned?

Q1.10: Which are the challenges of each scenario?

Note: i.e. fencing, watering, herding, labour availability, theft, conflicts with other goat owners

Q1.11: How could you overcome these challenges?

2. On-pasture's measurements

Following a mapping of the pasture area (identification of the different vegetation zones, water point (if any)), an on-field visit with 1 or 2 goat smallholder(s) as well as an extension officer will permit to define which plant species are eaten by the goats (and which one are not) as well as to obtain their local names.

Needed tools: precise weighing scale, sickle (scissors), 1m² quadrat and paper bags.

Name of respondent(s)	status/ position in the community	Age	Sex (F/M)	Cell phone number

a. Plants found:

Local names (Xitswa)	Portuguese (English)names

Q3.1: Which plants are eaten by the goats?

Q3.2: Which plants are favoured over the others?

Q3.3: Which plants stay green during the dry season?

Q3.4: Is there any toxic species for goats in the area?

b. Visual cover (%) *with 1m² quadrat*

Plant	% cover

Q.3.5: What are the different trees used as goat fodder during the dry season?

Local names (Xitswa)	Portuguese (English)names

Q.3.6: Which ones are the dominant?

For each plant collected, this question should be asked:

Q3.7: Which parts of each plant are eaten by the goats?

Concerning the grasses' species, their biomass will be calculated, in fresh in dry matter. A 1m² quadrat will be applied on randomly-selected locations (or locations characterised by different herbaceous vegetation cover within the pasture area). The grasses into the 1m² will be collected, being cut at 2.5cm from the ground. It will be weighed and then air-dried for 15 days, in order to get the dry matter weight.

II. Communal pastures' sketches and pictures

All the sketches were made by the focus groups (men and women mixed) that had been interviewed for each community.

Community 1 (C1CCHI):

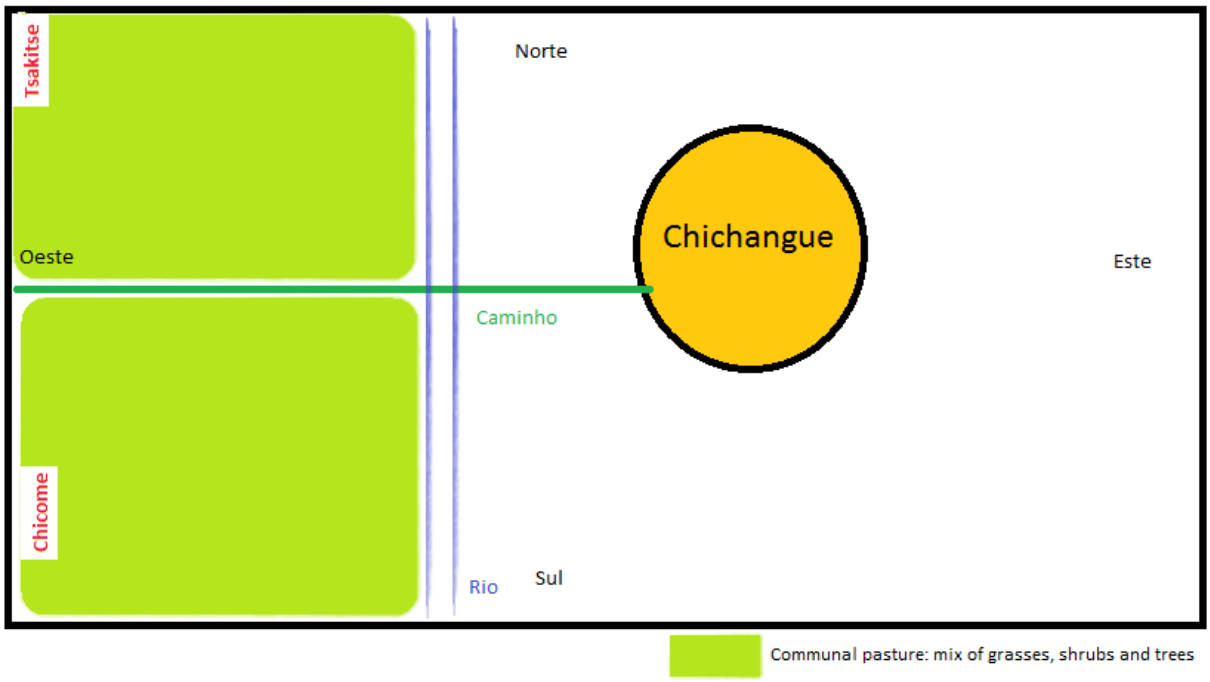


Figure 6: Sketch of the communal pasture within the community of Chichangue (C1CCHI)

Community 2 (C2ICA):

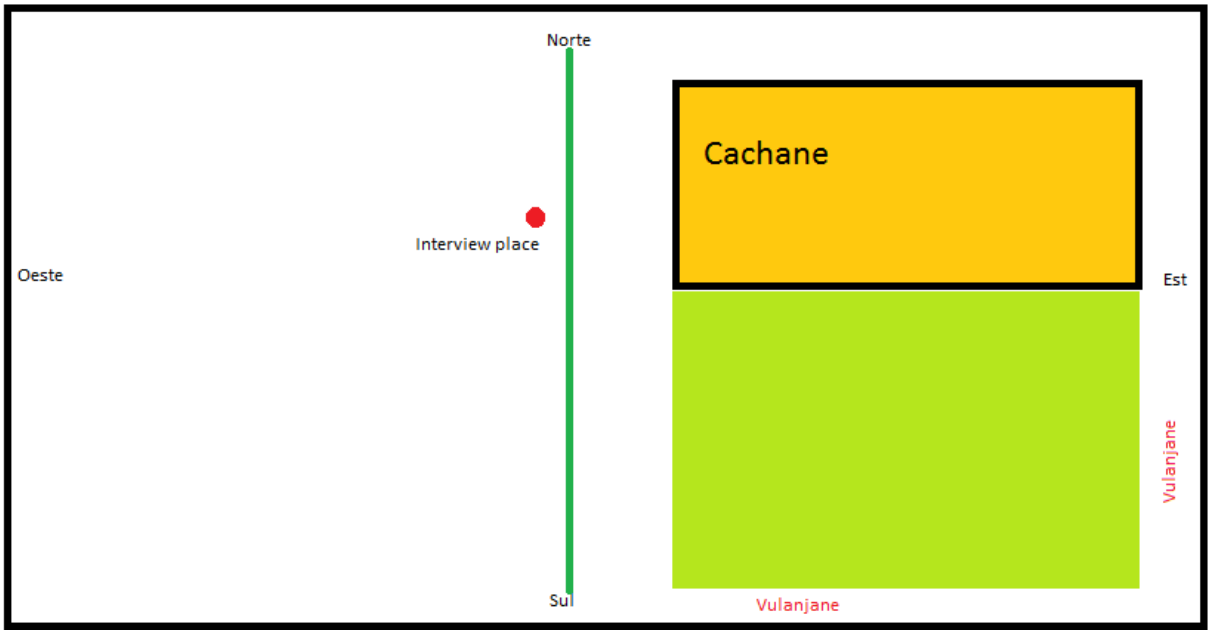


Figure 7: Sketch of the communal pasture within the community of Cachane (C2ICA)

Community 3 (C3ICVU):

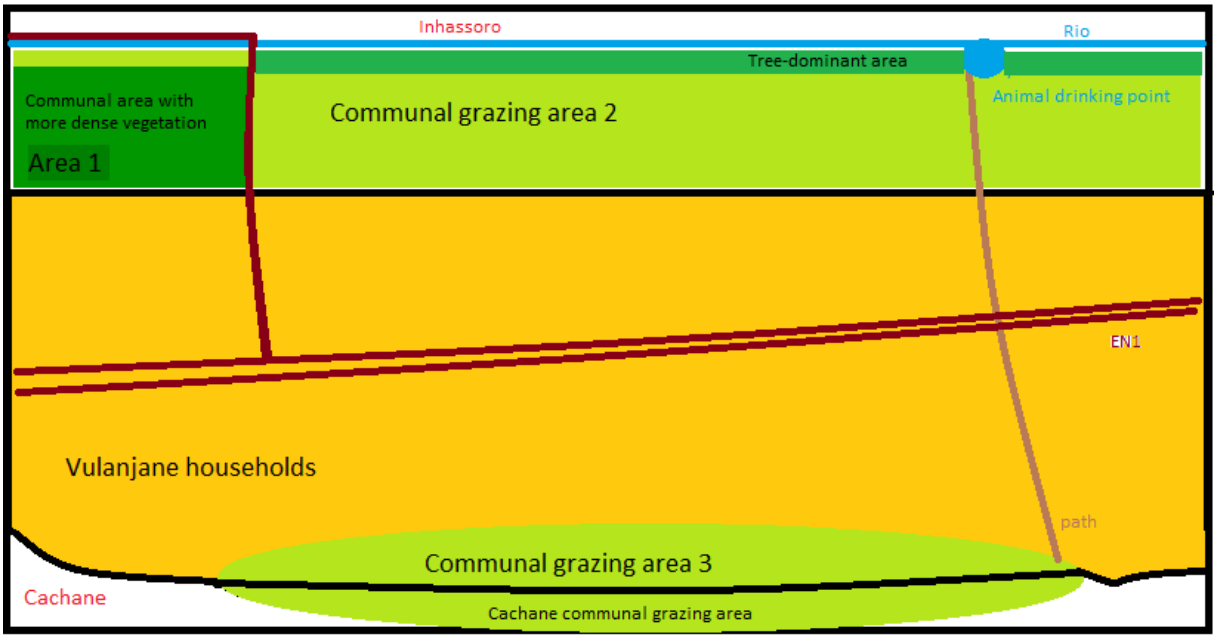


Figure 8: Sketch of the communal pasture within the community of Vulanjane (C3ICVU)

Grazing area 1

Grazing area 2

Animal drinking point

Grazing area 3

Community 4 (C4INHA):

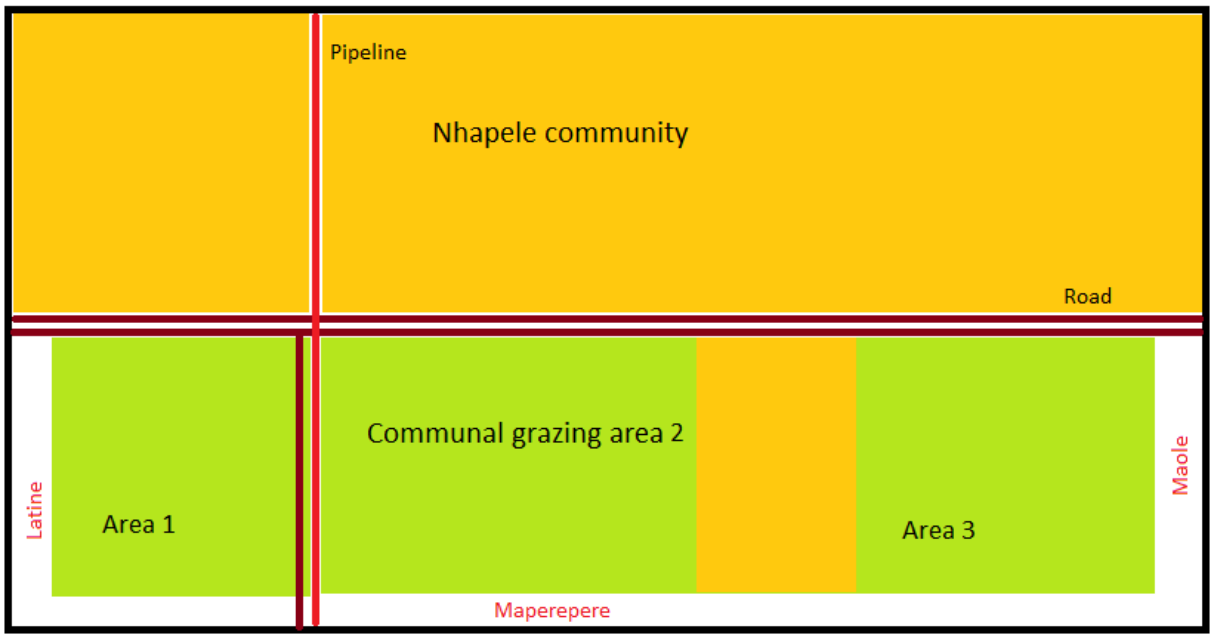


Figure 9: Sketch of the communal pasture within the community of Nhapele (C4INHA)

Grazing area 1

Grazing area 2

Grazing area 3

Community 5 (C5CMA):

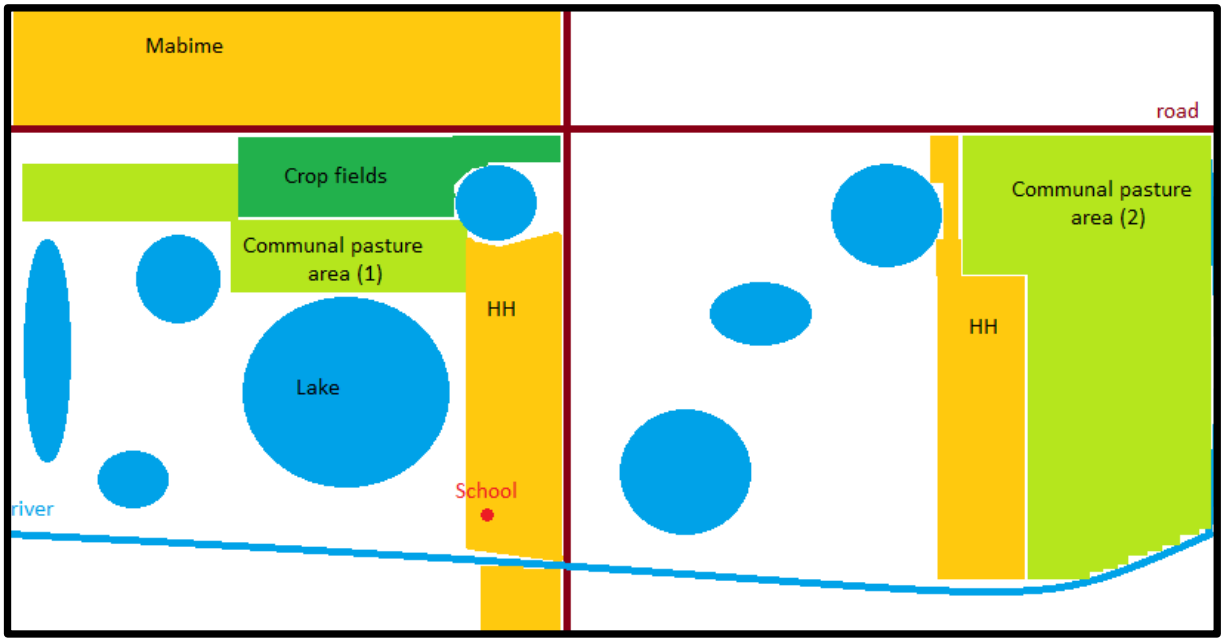


Figure 10: Sketch of the communal pasture within the community of Mabime (C5CMA)

Grazing area 1

1m2 taken in grazing area 1

Grazing area 2

Sampling in grazing area 2

Community 6 (C6IRUM):

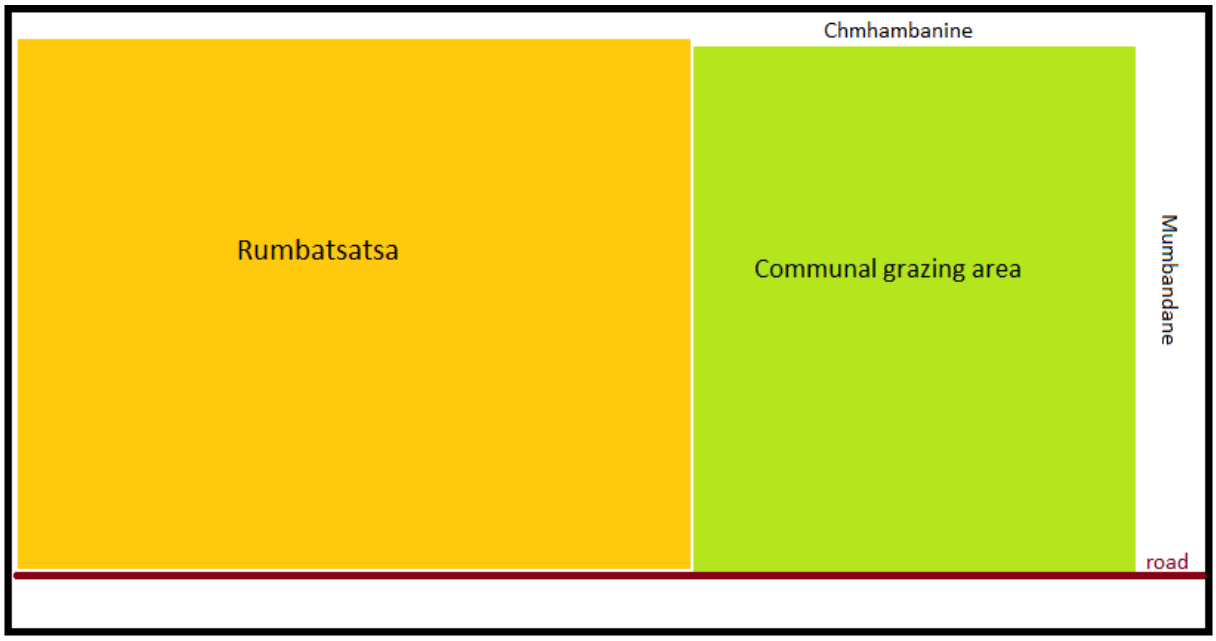


Figure 11: Sketch of the communal pasture within the community of Rumbatsatsa (C6IRUM)

III. Herbarium


Collection place: Cachane
Collection date: 17/05/2012
Family: Poaceae
Latin name: Heteropogon contortus
Local name: Chilongua

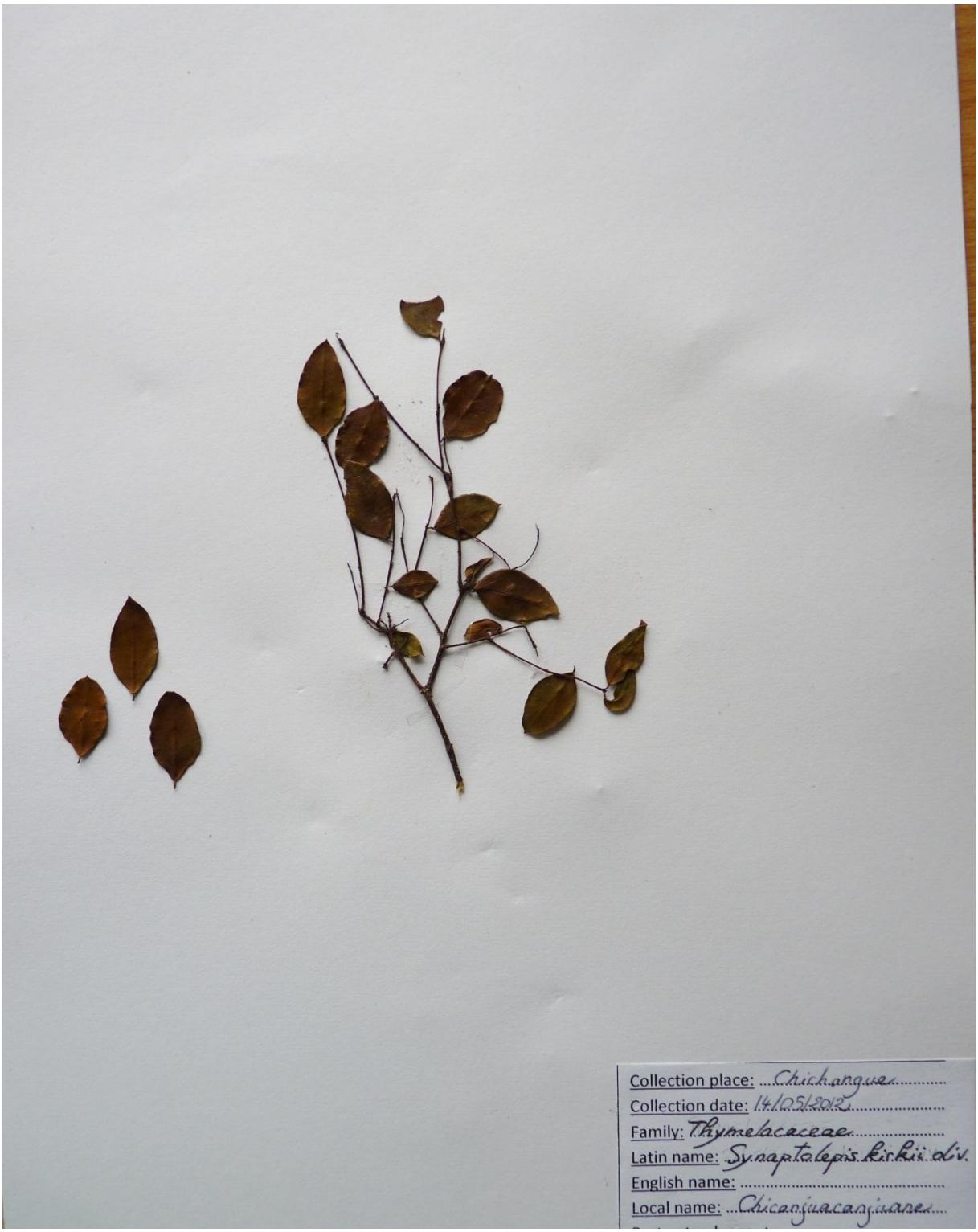

Collection place: Cachaner
Collection date: 17/05/2012
Family: Poaceae
Latin name: Hyparrhenia rufa (Nees)
English name:
Local name: Tsongua
Part eaten by goats:
Sample size: 175cm


Collection place: Cachare
Collection date: 17/05/2012
Family: Poaceae
Latin name: Rhynchelytrum sp.
English name:
Local name: Chilusa cha Funja
Part eaten by goats:
sample size: 53 cm


Collection place: Cachane
Collection date: 17/05/2012
Family: Menispermaceae
Latin name: Cocculus hirsutus L.D.
English name:
Local name: Litamba
Part eaten by goats:


Collection place: Nkapeke
Collection date: 22/05/2012
Family: Menispermaceae
Latin name: Cocculus hirsutus L. Diels
English name:
Local name: Tsamba
Part eaten by goats:

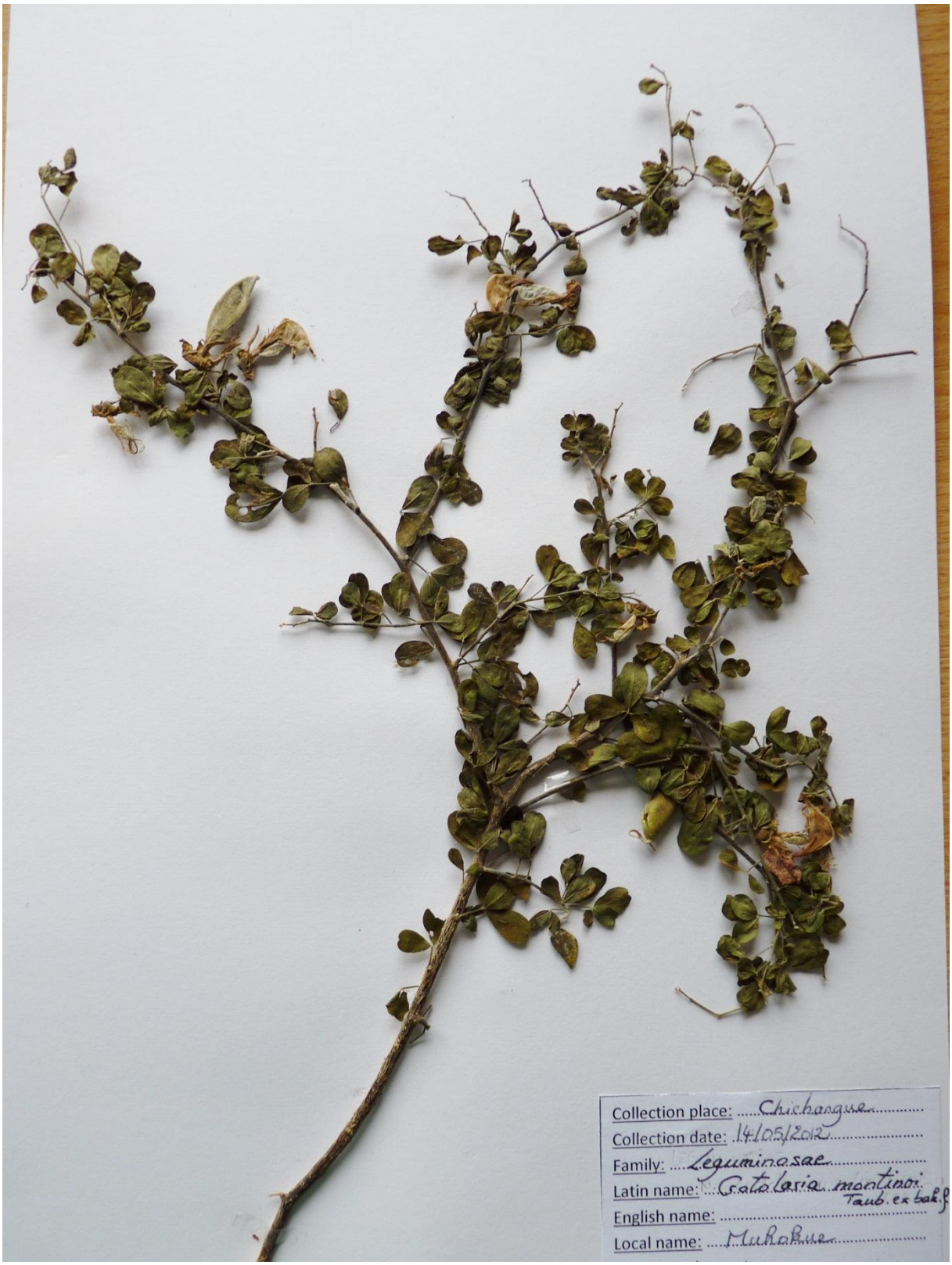

Collection place: Chichangue
Collection date: 15/05/2012
Family: Loganiaceae
Latin name: Strychnos spinosa Lam.
Local name: Chala / Massala


Collection place: Chichanguer
Collection date: 14/05/2012
Family: Thymelacaceae
Latin name: Synaptolepis kirkii dlv.
English name:
Local name: Chicanjuacanjuanes


Collection place: Cachane
Collection date: 17/05/2012
Family: Meliaceae
Latin name: Trichilia emetica vahl.
Local name: Kushu


Collection place: Vulanjaree
Collection date: 13/05/2012
Family: Clusiaceae
Latin name: Garcinia livingstonei
English name:
Local name: Mbimbi
Part eaten by goats:


Collection place: Vulanjane
Collection date: 19/05/2012
Family: Leguminosae
Latin name: Crotalaria capensis jacq.
English name:
Local name: Mubalwa
Part eaten by goats: Leaves


Collection place: Chichaoua
Collection date: 14/05/2012
Family: Leguminosae
Latin name: Crotalaria montinoi
Taub. ex bak.f
English name:
Local name: Muhabue


Collection place: Chichaaqua
Collection date: 14/05/2012
Family: Verbenaceae
Latin name: Clerodendum glabrum E. Hey.
English name:
Local name: Muushitambeva


Collection place: Chichangue
Collection date: 14/05/2012
Family: Burseraceae
Latin name: Commiphora africana
Local name: Titi


Collection place: Chickaagues
Collection date: 15/05/2017
Family: Annonaceae
Latin name: Actabotrys brachypetalus Benth.
English name:
Local name: Titi