ESTIMATION OF THE CARRYING CAPACITY OF GRAZING LAND IN THE BUFFER ZONE OF KATAVI AND RUKWA-LUKWATI CONSERVATION AREA IN MPANDA DISTRICT

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ABSTRACT

This study was conducted in the village land of the buffer zone of South Katavi National Park and the north-western area of the Rukwa-Lukwati Game Reserve, both in Mpimbwe Division, Mpanda District. The study area is characterized by gently undulating hills on the Ufipa plateau between the eastern and western branches of the East African Rift Valley; at an elevation of between 800 and 1000 m above sea level. The area experiences a sub-humid type of climate with medium to high rainfall of between 800 mm in the south and 1200 mm north. Characteristic vegetation is open miombo woodland in most of the area and brash wood, scrubs and tall grass in the rest. In the early 1970's, many immigrant Sukuma from Shinyanga and Tabora regions with their large numbers of cattle and goats moved into the area in search of good pastures and water for their livestock. Being agro-pastoralists, the immigrants also cleared bush and trees for cultivation. This practice triggered soil erosion, land pressure and social conflicts between the immigrants, local people and conservators. The Katavi-Rukwa Conservation and Development Programme (KRCD), was formed in March 1990, to address the problems through "Community Based Conservation" Approach. One of the first step in these approach was to determine the carrying capacity of the grazing land including all potential feed resources in the village land around wildlife protected areas, in order to determine the number of livestock to be retained in the area without negatively affecting conservation efforts. The study revealed that the Dry matter yield (DMY) from natural pastures was 3.54 tones $ha^{-1}yr^{-1}$ and the Potential Dry Matter (PDM) production from crop residues was 33.130 tons ha^{-1} yr^{-1}, the total area under grazing was 49,197ha, the total feed resource potentially available for livestock = 205,320 tons yr^{-1} and the estimated carrying capacity was 1 TLU: 0.63 ha or 1 LU: 1.26 ha. The herbage production potential of 3.54 tones ha^{-1} yr^{-1} obtained in this study is within the range of 0.5-10.0 tons ha^{-1} yr^{-1} reported elsewhere in East Africa bearing in mind the diversity of ecosystems. The inclusion of crop residues in carrying capacity computation has resulted in a relatively higher value of 1 TLU:063 as compared to reported figures. In agro-pastoral systems, crop residues constitute a significant part of the feed resource. Before any decision to remove livestock in conflict areas is made, it is important to estimate the carrying capacity in order to accurately predict the maximum number of livestock to be sustainably maintained in the area.

Key Words: Carrying capacity - feed resources - crop residues agro-pastoralism - community based conservation - buffer zone.

INTRODUCTION

The study area and its background

The study reported on here was conducted in the village land of the buffer zone of southern Katavi National Park and the area bordering the north-western strip of Rukwa-Lukwati Game Reserve both in Mpanda District. The research area covers mostly Mpimbwe Division of South Mpanda District, between Katavi National Part in the

north and north-east, the Ufipa ranges (Lyambalyamfipa) in the south, and Rukwa-Lukwati Game Reserve in the south-east (see annexture I below).

The beautiful landscape of Mpanda is characterized by gently undulating hills of the Ufipa plateau, between the eastern and western branches of the East African Rift Valley (Mascarenhas et al. 1984). Most of Mpanda District lies on the Ufipa plateau between 1000 and 1200 metres above see level. The area covered during this study is found between 800 and 1000 m above see level in the north, while declining below 800 m southwards towards the Rukwa plains (Mascarenhas et al. 1984).

According to climate characterization of Rukwa Region, Mpanda District experiences a sub-humid type of climate with medium to high rainfall which is restricted to a six month rainy season from mid-November to mid-May. Mean annual rainfall ranges between 800 and 1300 mm, with north-western Mpimbwe receiving the highest amount. The lowlands of Rukwa valley fall under relatively drier zone of Mpanda District, receiving only between 800 and 900 mm of rain annually (Mascarenhas et.al 1984). As a consequency of this rainfall pattern, there is only one crop growing season, and abundant pasture forage which supports a relatively higher number of grazing livestock during the rainy season than in the long dry season.

Average maximum temperatures lie around 24^0C and minimum temperatures around 16^0C on average. The hottest month is October with temperatures reaching 26^0C at Usevya (Mpimbwe Division headquarters), while the coolest month is June with temperatures averaging 22^0C.

The vegetation in Mpanda is open miombo woodland in the north; as you move south there is more brushwood, scrub and grassland of medium and tall species dominated by *hyperrhenia species* with scattered trees of different species but mostly of *acacia* types.

The Mpimbwe Land Use plan of 1993 estimates a population density of between 5 and 10 people per square km., most areas having less than 5 persons per square km. Before the influx of agro-pastoralist Sukuma from Tabora and Shinyanga regions in the early 1970's, indigeneous ethnical tribes in Mpanda were the Wabende, Wapimbwe, Wafipa, Warungwa and Wakonongo. At the time of study, the immigrant Sukuma dominated the area both in number and wealth.

In the early 1990's many more Sukuma with their large herds of cattle, some goats and sheep were coming in the area in search for pasture and water for their livestock, and partly looking for fertile arable land for cultivation. This situation caused significant changes in the land use pattern, overburdening the land resources, thus causing remarkable environmental hazards and interfering with conservation efforts in wildlife protected areas.

According to Mpimbwe Division authorities, before 1970 Mpimbwe Division was sparsely inhabited (5-10 inhabitants per km^2) and the indigeneous inhabitants were practicing small-scale arable farming and hunting, owning almost no livestock except a few goats and domestic fowls. Consequently there were limited social conflicts between villagers and conservators, mainly limited to encroachment of villagers in protected areas for hunting on one side, and destruction of crops and other properties of villagers by wildlife on the other. Land scarcity was so far not a problem, mainly because arable farming was kept at minimal level, and the Katavi National Park had not been extended to its present boarders. In addition, the Rukwa-Lukwati Game Reserve had not yet been established. The Mpimbwe division authorities have it on record, that the first agro-pastoral immigrants from Nzega and Igunga Districts of Tabora Region; and Bariadi and Shinyanga Districts of Shinyanga Region started to arrive in Mpimbwe with their large numbers of stock in 1969. Between 1973 and 1975, the

movements into Mpimbwe were intensive, with the greatest influx taking place in 1994. Apart from livestock, the immigrant Sukuma started to clear land for cultivation of maize, paddy sorghum and groundnuts. As good as food production might be, tree felling and bush clearing on large scale for agriculture, decreased the vegetation cover, thus rendering the soil susceptible to erosion. In general, the influx of Sukuma into southern Katavi buffer area with their large herds of cattle and goats triggered competitive land use pressure between grazing, cultivation and wildlife; accelerating environmental damage in terms of soil degradation and loss of vegetation cover; at the same time intensifying social conflicts between conservators and village people living in the buffer zone. In addition, the coming of livestock into the area which traditionally had no cattle (except a few goats), brought new conflicts between the livestock owners and the indigeneous inhabitants who were cultivators. The most serious problem is trespassing of animals into the cultivated areas either pre- or post harvest, damaging crops and crop residues which are potential animal feed as well as damaging top soil of farm land through repeated trampling by animals. This was the major reason of conflict between the two community groups.

Another core problem was the extension of the Katavi National Park towards the south-east in 1997 to reach a total of 4,471 km^2, a size almost twice as much as the original area. During the same period, the Rukwa – Lukwati Game Reserve south of Katavi National Park was established. These developments resulted into 44.3% of the whole land area of Mpimbwe Division to belong to wildlife protected area, in which other land use activities were considered illegal. As a result, all livestock formerly grazing in the now Rukwa – Lukwati Game Reserve were forcibly driven out and pushed either into the already congested south Katavi buffer zone, or further south on the north shore of Lake Rukwa, where already the existing livestock had surpassed the carrying capacity of the vegetation. In this way, the land scarcity problem in the buffer zones was aggravated and thus escalating social problems in the area.

It was in the light of these emerging constraints, the Katavi-Rukwa Conservation and Development Programme (KRCD) was jointly formed by the Division of Wildlife in the Ministry of Natural Resources and Tourism, TANAPA and Mpanda District Council in March 1990. The principle objective of KRCD is to invite the communities in the buffer zones to participate in the wildlife conservation efforts through Community Based Conservation Programme (CBC), in which the communities themselves would identify and utilize resources around conserved areas for their development. The philosophy of CBC is that communities surrounding protected areas will utilize resources more profitably and sustainably and realize social-economic benefits from conservation efforts in which they participate.

As a starting point, The Katavi-Rukwa Conservation and Development Programme (KRCD) wanted first to establish the number of existing livestock in the area, the potential land used for agriculture and livestock keeping, potential forage production in the grazing land, and consequently the carrying capacity of the grazing land in the buffer zone. From the carrying capacity estimation, the optimum number of livestock to be sustainably retained in the area and any other necessary services to be provided to livestock keepers could be determined.

The main objective of this study was to assess the area in the South Katavi and Rukwa-Lukwati buffer zone used for livestock keeping, to estimate the potential forage and other feed resources in livestock keeping areas, and consequently to predict the potential carrying capacity of the grazing land in the buffer zones of South Katavi National Park and Rukwa-Lukwati Game Reserve; the result of which would be the basis of determining the optimum number of

grazing livestock to be sustainably retained in the area.

MATERIALS AND METHODS

General approach

The study reported here was conducted using the participatory approach by first identifying all key players and getting them involved in conducting the study. A combination of the Participatory Rural Appraisal (PRA) methodologies were applied. These included the Rapid Appraisal of Actor Knowledge Systems (RAAKS) and the BENNET's model which includes Knowledge, Attitude, Skills and Awareness Change (KASA). These participatory methodology complexes facilitate innovations and change in situations in which multiple parties or actors have different interests or goals and perceive a given situation differently.

Estimation of potential herbage production

Before estimating the potential herbage production from the village land used for grazing, an estimate of the actual land under grazing was made and compared with estimates made earlier in the Mpimbwe Land use plan of 1993. Because of variations in natural vegetation patterns, the research area was divided into 3 vegetation zones, namely Western Mpimbwe, Central Mpimbwe and Southern Mpimbwe with percentages of land under grazing being 60, 60 and 50 respectively. These figures give an average of 56.7% of the total land which is used for grazing. The total land area under study was 86,767 ha. Therefore the area used for grazing was calculated to be

$$\frac{56.7\,x\,86,767 = 49,197}{100} = 49,197 \text{ ha.}$$

Estimation of crop residues

Crop residues form a significant feed resource for ruminants in agro-pastoral farming systems; and therefore were considered to be part of the potential available feed resource in this study. Potential crop residues usable by animals were calculated from the grain yield to stover yield ratio according to Powell (1985). According to the author, average ratio of grain to vegetative DM is taken as 1:2.8. Stovers included in this study were of maize, sorghum, rice and groundnuts calculated from respective grain yields for the cropping years 1999-2000 and 2000-2001. Only 50% of the so estimated crop residues were included in computing total feed resources available in the area.

Estimation of the potential carrying capacity

The carrying capacity was computed from estimates of the total dry matter yield potential from natural pastures and crop residues on one side, and estimated feed intake of animals as seen in the area on the other. From these figures the number of animals which could sustainably be kept in the area was calculated. Consequently the total area used for grazing divided by the estimated number of animals which could survive on available feed resource gives the estimate of the potential carrying capacity of the grazing land.

RESULTS

Land under grazing, potential feed resources and estimated feed intake

After thorough observations of land use activities in sample villages assisted by data available at Mpimbwe Division Headquarters, the percentage of land used for grazing in the study areas was established to be 56.7% of the total village land; which was 86,767 ha. This implies

that about 49,197 ha were used for grazing animals by the time.

Table 1 shows the herbage production as predicted by sampling of 10 plots of the 3 vegetation zones both during the dry and rainy seasons. It is apparent that the average Dry Matter yield was estimated at 3.54 + 0.55 tones ha^{-1} yr^{-1}. This gives a predictable total DM yield in the whole grazing land of 49,197 x 3.54 = 172,190 tones per annum.

Crop residues (maize, sorghum and rice stovers + groundnut hay) were estimated at 66,259 tones DM per cropping year. Due to quality problems and post-harvest losses, this study assumed that only 50% of this amount could actually be consumed by livestock. This implies that 33,130 tones DM from crop residues are available as animal feed annually. In general the DM available from pasture herbage was 172,190 tones, the DM potentially available from crop residues was 3,130 tones and the total DM feed resources in the area was 205,320 tones annually.

The potential feed intake of animals seen in the study area was judged basing on their live weight, productivity, herd structure and breed/types of animals, complimented by information on the same in Tanzania and else where in the tropics (Colluci et al. 1982; Nasser S.S and Ali, S.O. 1988; McDowell, 1985). Generally, feed intake by grazing animals is estimated at 2% of live body weight. Therefore 1 Tropical Livestock Unit (TLU) is expected to consume roughly 5.0 kg DM day^{-1}. Due to high proportion of shrubs and tall-un-palatable grass and consequently poor nutritive value, a safety margin of 2.0 kg DM per animal and day was allowed in predicting average feed intake in this study. This implies an average feed intake of 7.0 kg DM per animal per day was used to calculate the carrying capacity.

The Potential Land Carrying Capacity

The potential carrying capacity was calculated from the figures of the estimated grazing land, total DM available for animals per year and estimated DM intake per animal and day as explained above. From these figures, DM intake per animal and year is 7.0 kg x 365 days = 2.6 tones.

Since the type of cattle seen in the area is mainly East African Shorthorn Zebu, one head of cattle was rated as 1 Tropical Livestock Unit (TLU) weighing about half (250kg) of one Livestock Unit (LU). The total number of animals to be sustained by the potentially available feed resource in the area was 78,000 TLU. The Dry matter yield (DMY) from natural pastures was 3.54 tones ha^{-1} yr^{-1} and the Potential Dry Matter (PDM) production from crop residues was 33.130 tons ha^{-1} yr^{-1}, the total area under grazing was 49,197ha. This gives the total feed resource potentially available for livestock as 205,320 tons yr^{-1} and the estimated carrying capacity as 1 TLU: 0.63 ha or 1 LU: 1.26 ha

Table 1 Dry Matter Yields in 10 plots during both the dry and rainy seasons (tones/ha).

Plot No.	Dry Matter Yield (tones ha^{-1} yr^{-1})	
	Dry Season	**Rainy Season**
1	4.5	5.2.
2	3.2	4.7
3	2.8	3.5
4	2.7	3.6
5	3.1	4.3
6	4.2	3.4
7	3.0	3.5
8	3.2	4.1
9	2.5	3.8
10	2.7	3.6
$\overline{x}$	3.2	4.0
δ n-1	0.66	0.60
Overall average =	3.5 ± 0.55	

DISCUSSION AND CONCLUSION

This study has revealed that the actual land used for grazing animals in the buffer zone of South Katavi National Park and Rukwa – Lukwati Game Reserve in south Mpimbwe (see also annexure I), was roughly 49,197 ha. In the Mpimbwe Land Use Plan it was found that only 38,693 ha of the said area could be used for grazing. The situation revealed by this study is that the agro-pastoralist Sukuma cultivate crops in good arable land and at the same time keep their livestock in areas not envisaged for grazing in the previous Mpimbwe Land Use Plan. This observation explains the slight difference between the Land Use Plan figure of potential grazing land and estimates obtained in this study. Agro-pastoral land use systems hardly allow land areas to be exclusively used for grazing animals.

Potential herbage production from natural vegetation was determined by sampling from 3 vegetation zones created in the research area. Because of remarkable heterogeneity of flora, and varying proportions of bush to grass ratio, samples were taken from typical grazing land situations. Generalization of the sampling results to the whole area might have thus resulted in overestimation of actual herbage used by animals. Kusekwa and Kidunda (1989) reviewed relevant literature on the carrying capacity of tropical natural pastures, and suggest that DM-yield of natural grasslands varies between 0.5 and 10.0 tons ha^{-1} yr^{-1}. This gives an average of 5.25 tones tons ha^{-1} yr^{-1}. Patil (1981) working in a low mountain, semi humid ecosystem of India, obtained a DM-yield of 4.0 tons ha^{-1} yr^{-1}. The same author obtained an average of 7.3 tons ha^{-1} yr^{-1} while working in dry land ecosystems. The most recently reported data on herbage production in selected grazing natural postures by Kisoza (2007) shows that in the Mkata plains in Kilosa district, herbage production was 2.1 tons ha^{-1} yr^{-1}; and in the Ngorongoro Conservation area 4.1 tons ha^{-1} yr^{-1}. Estimates obtained in the study reported here (3.54 tones) lie within these values. It could, therefore in summary be concluded, that average DM-yield of natural grasslands in the tropics is approximately 5.5 ha tones per ha and year. It must however be noted, that herbage yield is much higher in the rainy season and much lower during the dry season. The value of 3.54 tons ha^{-1} yr^{-1} obtained in this study in a mixed bush-grassland ecosystem is therefore reasonably acceptable.

One of the aims of community based conservation is to determine and utilize sustainably all resources available in the area for development. For this reason, the availability and potential yields of crop residues as potential feed resource was studied. These constituted roughly 16% of the total feed resource used to compute the carrying capacity. There is no reported case in the accessible literature whereby crop residues have been considered in determining the carrying capacity of grazing land. Contrary to theoretical studies on carrying capacity of grazing lands, the ultimate practical goal of determining the carrying capacity in this case, was to determine the optimum number of livestock to be kept in the buffer zones taking into consideration all feed resources available in agro-pastoral systems in the study area; and hence the inclusion of crop residues in the carrying capacity estimation was justified.

However, crop residues especially cereal stovers are of poor nutritive value and limited feed intake from them. They can be of reasonable value if harvested immediately after grain harvest and stored indoors against rain and excessive sunshine. They could be chopped and mixed with grass and/or cereal brans or husks and be fed to young or lactating animals in the kraal.

Available information on carrying capacity potential of tropical grazing lands is varied, mostly showing large ranges both between and within localities. It is assumed that variation of tropical vegetation patterns, soils and rainfall distribution are some of the

reasons for the phenomenon. Mtenga and Kidunda (1989) reviewed the available literature on feed requirements and carrying capacity of Tanzanian pastures. The authors concluded that the carrying capacity of natural pasture lands in Tanzania is 1 LU:4 ha at minimum. The estimates in this study are higher than this figure. Herlocker (1999) reviewed range land ecology and potentials of East Africa, and came up with estimates of carrying capacities according to (a) vegetation region, (b) climate, (c) rainfall pattern and (d) type of soils. According to his classification, the carrying capacity in the region similar in environment as the study area reported here was found to be 1 TLU:0.6 – 5.2 ha. Estimates in this study of 1 TLU:0.63 ha is within this limit but significantly on the upper side. The inclusion of crop residues in the estimation of available feed resources, unlike in reported studies, may be the main reason for the differences. In the earlier Mpimbwe Land Use Plan conducted in 1993, the carrying capacity was estimated to be 1 TLU: 1.6 ha. However, in the Mpimbwe Land Use Plan, there was no estimation of herbage production by sampling according to vegetation zones, and feed intake was not estimated according to animal size and herd structure in the area. In addition, crop residues as potential animal feed were not considered. Therefore carrying capacity figure estimated in this study is more accurate, reliable and practical for determining the maximum number of grazing animals which could be sustainably maintained in the village land bordering South Katavi National Park and Rukwa-Lukwati Game reserve in the south.

Conclusions and Recommendations

After extension of the Katavi National Park to twice as much the previous area, and subsequent creation of the Rukwa-Lukwati Game Reserve south of the park in 1977, the remaining village land is a narrow strip between these conserved areas and the Ufipa ranges known as Lyambalyamfipa. This village land has an average of about 87,000 ha, of which 56.7% is used mainly for grazing, and the remaining 43.3% for arable farming and other uses. The number of livestock present in the area by the time of this study had already surpassed the carrying capacity of the area, therefore it was important to determine the actual carrying capacity and hence the maximum number of livestock to remain in the area. This study suggests that about 78,000 cattle and 30,000 goats per year could sustainably be kept in the area. This means about 30,000 heads of cattle in excess of the carrying capacity should be de-stocked.

In typical rangelands management studies, assessment of carrying capacity does not consider other feed resources such as crop residues available in the area. However, for practical determination of the number of permissible livestock in agro-pastoral systems, consideration of other potential feed resources available in the area is important.

This study suggests further that livestock currently outside this area should not be allowed to re-enter. Influx of agro-pastoralists with their livestock from the north should be prohibited and be directed to settle somewhere else outside Mpimbwe. In order the community based conservation efforts to succeed, a culture of dialogue between pastoralists, conservation authorities, Mpanda district authorities as well as other villagers should be promoted and nurtured. Villagers can only participate in the conservation efforts if their social-economic interests are taken aboard.

Before removing livestock from any area of conflict, it is strongly recommended to carry out carrying capacity studies first, so that only excess stock can be removed. This approach could be applied to solve the environmental problems in livestock congested areas such as the Usangu-plains and some parts of Kilosa district.

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