vrije Universiteit amsterdam

iied
International Institute for Environment and Development

Economic Valuation of Communal Rangelands in Botswana: A Case Study

Jaap Arntzen

CREED Working Paper Series No. 17

Economic Valuation Of Communal Rangelands In Botswana: A Case Study

Jaap Arntzen

CREED Working paper No 17

February 1998

The author

Jaap W Arntzen is senior lecturer at the Department of Environmental Science, University of Botswana. He may be contacted at:

Dept. of Environmental Science
University of Botswana
Private Bag 0022
Gaborone
BOTSWANA

Phone: 267 3552524
Fax: 267 356591
E-mail: arntzenj@noka.ub.bw

The programme of Collaborative Research in the Economics of Environment and Development (CREED) was established in 1993 as a joint initiative of the International Institute for Environment and Development (IIED), London, and the Institute for Environmental Studies (IVM), Amsterdam. The Secretariat for CREED is based at IIED in London. A Steering Committee is responsible for overall management and coordination of the CREED Programme.

Environmental Economics Programme, IIED

IIED is an independent, non-profit organisation which seeks to promote sustainable patterns of world development through research, training, policy studies, consensus building and public information. The Environmental Economics Programme is one of seven major programmes of IIED; it conducts economic research and policy analysis for improved management of natural resources and sustainable economic growth in the developing world.

Environmental Economics Programme
IIED, 3 Endsleigh Street
London WC1H 0DD, UK
Tel (44 171) 388 2117; Fax (44 171) 388 2826
e-mail: Jacqueline.Saunders@iied.org

Institute for Environmental Studies, (IVM)

IVM is a non-profit research institute, based at Vrije Universiteit, Amsterdam. The Institute's primary objective is to carry out multi- and interdisciplinary research on environmental issues, based on cross-fertilisation of monodisciplinary sciences. Environment and the Third World is one of eight major IVM research programmes.

IVM, Vrije Universiteit
De Boelelaan 1115
1081 HV Amsterdam
The Netherlands
Tel: (31 20) 444 9555; Fax: (31 20) 444 9553
e-mail:secr@ivm.vu.nl

CREED Steering Committee members include:

Abstracts of CREED publications and details of all CREED projects are now available on the Internet. Visit the CREED Web site at:

http://www.iied.org/creed

Acknowledgments

Sennye Masike, then research assistant and currently staff development fellow in the dept. of Environmental Science, has assisted with data collection and preliminary analysis. Happy Fidzani and Jeremy Perkins provided useful comments on an earlier draft. Newman Kahiya (Farm Management Survey), Bonake Tsimako and Yvonne Merafe (Monitoring and Evaluation Unit) of the Ministry of Agriculture kindly assisted with the collection of key agricultural data. Poppy Monyatse and Jan Broekhuis assisted with data on wildlife. Dave Parry and Mike Murray-Hudson (Ecosurv) assisted with historical data on hunting quota and with the conversion of old and new controlled hunting areas. Mark Murray and Richard White offered valuable help by digging relevant documents out of their personal libraries. Without this assistance the study would not have been possible. Any errors remain the responsibility of the author.

Abstract

The literature on rangelands is extensive but very little includes an examination of rangeland valuation. Where it does appear, rangelands tend to be undervalued, mainly due to the fact that most analyses are a) restricted to a specific sector, most commonly livestock production; b) biased towards one marketed product, frequently beef sales or slaughter; and c) limited to use values. Undervaluation of rangelands may contribute to their mismanagement or their transformation to monoculture, such as for livestock or wildlife. Similarly, this may lead to inappropriate policy recommendations and prescriptions, for example that vegetation changes in rangelands are not a problem as long as they do not affect livestock productivity.

This paper undertakes a valuation exercise in an effort to address the first two causes of undervaluation mentioned above. The objective is to estimate the annual direct use value of an average hectare of communal rangeland in Botswana, based on an analysis of secondary data. The exercise incorporates the three major direct uses, both marketed and non-marketed, of rangelands - livestock, wildlife and gathering.

The valuation clearly shows that each use makes a significant contribution to the direct use value: in the case of hunting and gathering amounts to around one third of the total direct use value during the period under study. Another conclusion is that non-marketed products are very important; milk production and processing represent a considerable, although partly potential, use value which requires further investigation. Considerable discrepancies were found between private and social use values for livestock, mostly as a result of government subsidies to that sector. The use values for wildlife based on hunting quota has dropped significantly. This suggests a trade-off between livestock and wildlife use values. With the observed decline in wildlife numbers, a switch towards game viewing offers opportunities to boost the use values. alternatively hunting values should be raised to net market values. It is critical to ensure that any benefits from wildlife should accrue to the local population.

These conclusions raise important policy questions as to the future use of rangelands in Botswana. Total land productivity per hectare should be the key variable in assessing the significance of eg, vegetation changes or erosion, as well as the merits of different single or multiple use options, such as livestock expansion, wildlife utilisation and/or gathering. The growing resource scarcity not only raises concerns about efficiency and sustainability but also about the distribution of current and future use values.

Resumen

Evaluación económica de pastizales comunales en Botswana: un estudio de caso

Existe una gran cantidad de literatura sobre pastizales pero muy poca se refiere a su evaluación económica. Cuando se toca este tema, sin embargo, hay una tendencia a subestimar su valor económico. Esto se debe a que la mayoría de los análisis: a) se concentra en un solo sector, por lo general la ganadería; b) se sesga hacia un producto comercial, con frecuencia la venta de carne de res o los mataderos, y c) se limita al valor de uso. Subestimar el valor económico de los pastizales puede contribuir a una mala gestión o a su transformación en monocultivos destinados a la ganadería y a la fauna silvestre. Este enfoque puede conducir también a un diseño de políticas y recomendaciones inadecuadas como es la de afirmar que los cambios de vegetación en los pastizales no representan un problema mientras no afecten la productividad ganadera.

En esta monografía se elabora un ejercicio de evaluación de las dos causas, antes mencionadas, de la deficiente valoración económica. El objetivo de este trabajo es el de calcular el valor de uso directo por año de una hectárea promedio de pastizal comunal en Botswana. Este análisis se ha efectuado con base en información secundaria. El ejercicio incluye los tres usos directos principales de los pastizales, sean o no comerciales, como son la ganadería, la fauna y la recolección.

Los resultados de la evaluación muestran con claridad que cada uso contribuye de manera importante al valor de uso directo. En el período cubierto por el estudio se encontró que la recolección y la caza representan una tercera parte de la totalidad del valor de uso directo . Otra conclusión es que los productos no comerciales son muy importantes; la producción y procesamiento de leche representan un valor de uso importante que merece la pena investigarse un poco más aunque tenga aún un valor potencial. También se encontraron discrepancias significativas entre los valores de uso privados y públicos de la ganadería, debido principalmente a los subsidios estatales a dicho sector. Los valores de uso de la fauna basados en la cuota de caza han bajado considerablemente, lo cual sugiere una sustitución de ésta por la ganadería. Debido a la reducción numérica de la fauna, existe la oportunidad de aumentar los valores de uso mediante la explotación del turismo de observación de animales salvajes. Al mismo tiempo se deben aumentar los valores de caza para alcanzar valores de mercado. Es esencial asegurarse de que los beneficios procedentes de la fauna redunden en beneficios para la población local.

Estas conclusiones hacen resaltar aspectos importantes de política acerca del uso futuro de los pastizales en Botswana. Es fundamental que la productividad total por hectárea sea la variable clave en la evaluación de, por ejemplo, cambios en la vegetación o la erosión, así como en el examen de las ventajas relativas de opciones únicas o múltiples como son la expansión de la ganadería, la utilización de la fauna y/o la recolección. La creciente escasez de recursos no sólo conlleva interrogantes acerca de la eficacia y la sustentabilidad sino también acerca de la distribución de los valores de uso presentes y futuros.

Abrégé

Évaluation économique des terres de parcours communes du Botswana: Étude de cas.

On ne compte guère, parmi les très nombreux travaux consacrés aux terres de parcours, d'estimations de la valeur de celles-ci. Et les quelques unes dont on dispose tendent à sous-évaluer les terres de parcours, surtout parce que la majeure partie des analyses (a) se limitent à un secteur particulier, à savoir, le plus fréquemment, la production d'élevage; (b) sont biaisées en direction d'un produit commercialisé -il s'agit souvent des ventes ou de l'abattage de bovins; et (c) ne portent que sur les valeurs d'usage. Il se peut que cette sous-évaluation des terres de parcours contribue à leur mauvaise gestion ou à leur passage à la monoculture, comme c'est le cas pour le bétail et la faune. Elle peut aussi aboutir à des recommandations et à des instructions inappropriées en matière de politique à suivre, lorsque l'on considère, par exemple, que les modifications de la végétation des terres de parcours ne posent aucun problème tant qu'elles n'affectent pas la productivit’e de

On mène dans ce texte un exercice d'évaluation afin de traiter les deux premières des causes de sous-évaluation susmentionnées, avec pour objectif l'estimation (effectuée en partant d'une analyse de données secondaires) de la valeur d'usage annuelle directe d'un hectare moyen de terres de parcours communes, au Botswana. On y intègre les trois principaux usages directs des terres de parcours, que leurs produits soient ou non commercialisés - l'élevage, l'exploitation de la faune et la cueillette.

L'évaluation montre clairement que chaque usage contribue de manière significative à la valeur d'usage directe, ce qui équivaut, dans le cas de la chasse et de la cueillette, à approximativement un tiers de la valeur

d'usage directe totale réalisée durant la période étudiée. Selon une autre conclusion, les produits non commercialisés ont une grande importance: la production et la transformation du lait représentent une valeur d'usage considérable (bien qu'elle demeure pour partie au stade potentiel) qui devrait faire l'objet d'investigations plus approfondies. On a relevé des ‘ecarts considérables entre les valeurs d'usage privées et sociales de l'élevage, dus surtout aux subventions gouvernementales accordées à ce secteur. La valeur d'usage de la faune, estimée à partir des quotas de chasse, a diminué de manière significative, ce qui suggère un transfert de valeur d'usage entre l'élevage et l'exploitation de la faune. Avec le déclin constaté du nombre d'animaux sauvages, une évolution vers la contemplation touristique du gros gibier offre des occasions d'en relever la valeur d'usage. Une alternative consisterait à augmenter la valeur d'usage de la chasse pour l'amener au niveau de sa valeur de marché nette. Il est crucial d'assurer aux populations locales le bénéfice de toutes

Ces conclusions soulèvent d'importantes questions d'ordre politique quant à l'emploi futur des terres de parcours du Botswana. La productivité totale des terres, mesurée à l'hectare, doit constituer la variable-clé pour l'estimation de l'importance, par exemple, des modifications de la végétation ou de l'érosion, ainsi que des avantages de différentes options d'usage simples ou multiples, telles que l'expansion de l'élevage, l'exploitation de la faune et/ou la cueillette. La rareté croissance des ressources n'est pas seulement source de préoccupation pour l'efficacité et la durabilité mais aussi pour la répartition des valeurs d'usage actuelles et futures

Contents

List of Tables and Figures

ACRONYMS

ALDEP	Arable Land Development Programme
ARAP	Accelerated Rainfed Agricultural Production Programme
AS	Agricultural Statistics
BAMB	Botswana Agricultural Marketing Board
BMC	Botswana Meat Commission
CSO	Central Statistical Office
DWNP	Department of Wildlife and National Parks
EU	European Union
FMS	Farm Management Survey
ILCA	International Livestock Centre for Africa
LSU	Livestock Unit
UNEP	United Nations Environmental Programme
TCM	Travel cost method
TGLP	Tribal Grazing Land Policy
WMA	Wildlife Management Area
WTP	Willingness to Pay

Introduction

The literature on rangelands is extensive but very little includes an examination of rangeland valuation. A few studies have attempted to estimate the costs of rangeland degradation. For example, UNEP (1992) estimates global and continental degradation and the associated losses in income[1]. Globally, income losses due to rangeland degradation are estimated to be in the region of US$7/ha. This figure is a "global average of at least moderately degraded rangelands"; thus this figure is indicative[2] and should not be applied to local sites without detailed field checks. Africa is most adversely affected by degradation with income losses amounting to 2.7% of the continent's GNP (calculated from UNEP and World Bank data). Australia is the second most affected continentk, with 1.1% of its GNP, followed at a distance by Asia (0.5%), South America (0.3%), North America (0.1%) and Europe (negligible). For Namibia, Quan et al. (1994) estimate rangeland degradation in communal areas at N$ 96.7 mln/annum (see Box 1). The major income losses are attributed to poorer conditions of animals, reduced milk production and manure losses. Using the extra costs of supplementary feeding, Convery (1995) estimates the costs of rangeland degradation in Ghana at US$ 8.4 mln in 1988. The above income losses per ha of communal rangelands in Namibia and Ghana convert to around Pula 2.50/ha. and Pula 4.50/ha. respectively. Both the Namibian and Ghanaian figures underestimate the costs as they only incorporate part of the uses and exclude externalities.

The literature study further revealed that where no costing studies are available, rangeland values are usually underestimated, mainly due to the following three factors:

they are limitated to a sectoral approach, most commonly livestock production;
they are biased towards one marketed product, frequently beef/cattle sales;
they are limited to use values.

Undervaluation may contribute to the mismanagement of rangelands or transforming them for a single use, such as livestock or wildlife. But there is growing evidence that valuable resources and development opportunities are being lost in the process. Therefore, this valuation exercise explores a data gap. The objective is to estimate the annual direct use value of an average hectare of communal rangeland in Botswana, based initially on secondary data. It is envisaged that, at a later stage, primary data would be collected and linked either to ecological baseline data or to the modelling exercise[3]. The exercise incorporates the three major direct uses of rangelands - livestock, wildlife utilisation and gathering[4]. The following specific uses are considered here:

[1] UNEP uses a broad definition of degradation, which includes vegetation changes, erosion and productivity losses. Results of the degradation inventory demonstrate that vegetation changes are much more common than erosion (UNEP, 1992).

[2] The estimate is based on "anecdotal accounts, personal opinions and local experience".

[3] This has not materialised because of inadequate ecological data collection. Moreover, there was no longer a need to collect primary valuation data as part of the modelling exercise.

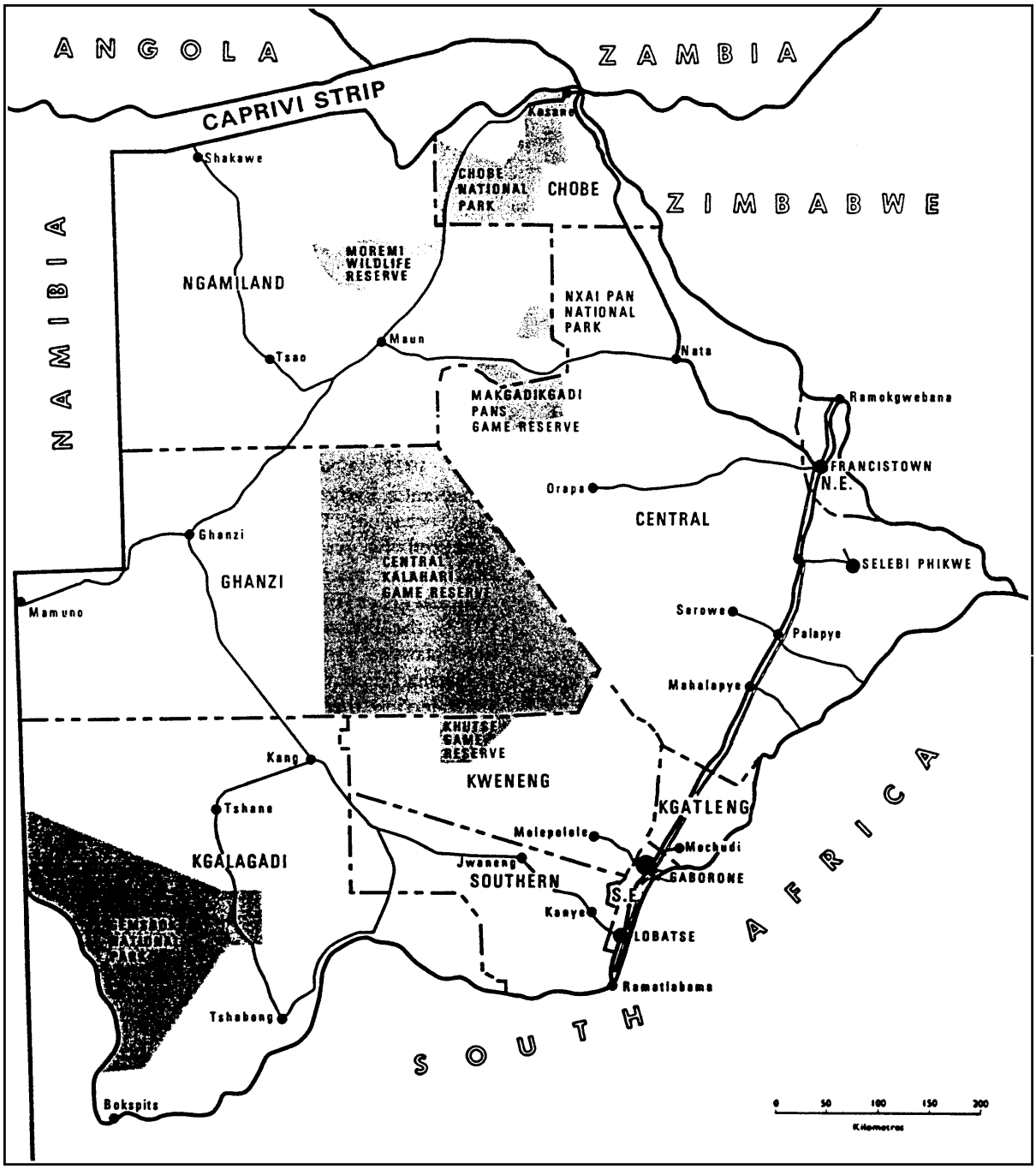
[4] There are inadequate physical data to estimate the value of indirect uses such as ground water recharge, green house source/sequestration and biodiversity.

* livestock: meat, draught power, milk, manure
* wildlife: current wildlife utilisation, mostly hunting but increasingly tourism in the north
* useful plants: current utilisation, mostly wood and gathering of food, building material and medicinal plants

Generally, gathering is the most common use of rangeland use in the country, followed by livestock production and wildlife utilisation; this order may differ by region.

The paper is structured as follows. First, the methodology will be briefly discussed together with the details of the value calculations for livestock. Subsequently, details of the methods used to estimate value components of livestock, wildlife and gathering are discussed. This is followed by a discussion of the comprehensive results. Conclusions and policy and research recommendations are presented in the final section.

Botswana's land use



Methodology

The methodological issues have been discussed in more detail elsewhere (Arntzen, 1995). The following criteria influenced the selection of the valuation method:

* the need to estimate individual value components related to different rangeland uses, ie, livestock, wildlife and gathering.
* the need to estimate market and non-marketed use values, and where possible non-use values. Use values would provide an essential input into the modelling exercise. Incorporation of non-use values would lead to more comprehensive estimations.
* using secondary data as a first step towards valuation, with fieldwork to be carried out when necessary.

Turner et al. (1994) distinguish two broad valuation approaches, ie, *demand curve approaches* and *non-demand curve approaches*. The former attempt to incorporate the consumer surplus while the latter do not. The former are, in principle, a better measure of welfare, but they are more difficult to implement; the latter are easier to use and provide useful policy relevant information. Since the demand curve approaches do not provide a breakdown in values, this study cannot rely solely on these method. The general advantages and disadvantages of each method are well documented (Pearce et al., 1994; Goodstein, 1995; Turner et al., 1994), and below, the merits of each method are briefly discussed.

Demand-curve valuation approaches include willingness to pay (WTP), the travel cost method (TCM) and hedonic pricing. The travel costs method could, in principle, be applied to livestock where the travel costs to cattle posts could serve as a reflection of the rangeland value. The distance to boreholes, however, is primarily determined by family and cultural factors, and hence, travel costs would be misleading. For example, most people originating from the north and living in Gaborone will have boreholes in the north through inheritance or allocation by the Land Board. Their travel costs are high in comparison to people living and originating in southern Botswana. Clearly, differences in travel costs reflect family and cultural affiliation rather than the resource value. The hedonic pricing method is difficult to use in communal areas, where no market exists. It could be used to value rangelands surrounding boreholes as an informal borehole market is currently emerging. Because of the scarcity of borehole sites, the price includes an element of speculation and does not reflect the true value of rangelands[5]. An additional problem is the lack of official data.

[5] This is similar to the commercial ranches in Zimbabwe. Kreutman and Workman (1994a) show that the market price of ranches is not a good indicator of range conditions because: a) the impact of overstocking on rangelands is often time-lagged and difficult to quantify; b) range conditions are insignificant compared to land speculation.

Non-demand curve approaches include substitution costs, replacement costs, mitigation and opportunity costs etc. Although most rangeland-based resources are free, their products or substitutes can be priced through genuine or surrogate markets. For example, there are prices for products such as mophane worms and grapple plant. Moreover, wild berries, thatching grass and wood are priced around large settlements. Alternatively, substitute values may be used such as the costs of hiring tractors in lieu of animal draught power, and corrugated iron instead of thatching grass. The value of manure could be measured in terms of equivalence to fertiliser to a unit of fuelwood. This method is attractive because of the ease of data collection, although it usually leads to an undervaluation as it assumes perfect substitutability and excludes the consumers' surplus.

In view of the requirements, the conditions prevailing in communal areas and the merits of the valuation methods, non-demand valuation approaches are used, focusing on the most important actual and potential uses and with replacement or substitution costs, opportunity costs, etc. The estimation technique has been simple. For the outputs considered, first the net use value (revenues minus costs) has been calculated. For revenues, market prices (eg. beef, crops) and substitutes (draught power, milk) have been used. Cost calculations proved most difficult because of the scarcity of statistics and research. Cost estimates have been based on the limited empirical data available and assumptions. Second, the average use value per hectare has been calculated by dividing the net use value by the total size of communal rangelands. A distinction has been made between net private and social use value, the former reflecting the use value to individual users, and the latter the use value to society. In order to estimate comprehensive social use values, the following changes to the private value should be made:

* deduction for subsidies and addition of tax values;
* use of opportunity costs of capital, labour etc.
* deduction of negative environmental externalities (such as resource depletion, pollution)

In this study, livestock subsidies have been deducted and opportunity costs of land, water and land have been considered. Within the scope of this study, environmental externalities and taxation could not be comprehensively quantified because of the lack of data., but have been inlcuded where possible. Environmental externalities of the livestock sector are considered to be substantial and include the following: increased run-off and reduced ground water recharge; changes in vegetation, soil erosion and disappearance of wildlife from livestock areas. The tax system significantly favours livestock in several ways through eg, allowances for writing off livestock losses against profits of other business ventures, and undervaluing of capital gains through increases in livestock numbers. Tax is payable on herds of over 300 animals only but the collection is very poor. The main livestock tax is on the throughput of BMC, ie. cattle for export purposes mostly (Fidzani et al, 1996). Given the extent of environmental externalities and tax favours, the discrepancy between private and social values related to livestock must be substantial.

The estimatation of communal rangelands is not as simple exercise due to data inadequacies and the overlap between land tenure and land use categories. Communal rangelands are understood to comprise *land available as pastures for domesticated animals and/or wildlife and accessible for the local population*. Communal rangelands are earmarked either for livestock and/or for wildlife. It largely overlaps with "Tribal Land" but excludes cultivated

areas and leasehold ranches. Wildlife management areas on tribal land are included; those on State land are excluded. Although some Game Reserves are located on tribal land, all reserves have been excluded as they currently have little direct use value to people living in communal areas. Ten percent has been deducted to correct for the built-up environment such as infrastructure and settlements. Communal rangelands then cover 34 mln. hectares or around 60% of the country. The main subcategories of communal rangelands are:

a. *Open access, communal rangelands* used primarily for livestock and gathering without permanent groundwater. Their size is diminishing because of settlement and arable encroachment on the one hand and borehole expansion on the other. They are the domain of the small cattle herds and smallstock; low income groups primarily depend on them.

b. *Communal, but de-facto private rangelands* used for borehole centred livestock production. Such areas have rapidly increased in the last fifty years, and are probably covering some 25 mln. hectares (Arntzen et al. 1996). These areas are found in eastern Botswana and increasingly in western and northern parts of the country. Because of the costs of groundwater and the remoteness of such areas, high income groups dominate these areas.

c. *Wildlife management areas* in tribal land. These areas are located in the western and northern parts of the country. Wildlife utilisation is declared to be the primary form of land use; other uses such as for livestock and smallstock should play a secondary role.

Temporal variations in values have been included by analysing the average use value over the period 1980 to 1993. Where possible, data have been collected for the period 1980-1993. Unfortunately agricultural statistics are not available after 1990, although more recent data for wildlife are available. At this stage use values mostly relate to the period 1980-1987[6]. Time series have been used to obtain an average annual value as well as insight into the interannual fluctuations in direct uses; for example, use values are likely to vary with rainfall, which is an important determinant of primary biomass. An estimate of the average annual use value of a hectare of communal rangeland has several limitations:

* it does not account for the substantial spatial variations in use values. Generally livestock is mostly kept in the eastern part of the country, but encroaching into western and northern Botswana. Wildlife has largely disappeared from the east, and the main potential remains in western and northern Botswana. The distribution of veldproducts varies by species. For example, mophane worms are confined to the northern half of the Botswana.

[6] An up-date will be made once more recent agricultural statistics are available.

Box 1: Example of a monetary valuation of rangeland degradation in Namibia

The study covered 2 communal areas and 2 commercial areas in Namibia.

Desertification: "combination of processes of land degradation occurring in arid and semi arid environments, whereby the productive potential of the land and its ability to support populations is severely impaired or destroyed" (p.i)

Degradation is mostly associated with vegetation changes

Communal Areas:
* 1 in the north: 500 mm of rain per year and mixed farming;
* 1 in the south: 100-150 mm of rain per annum and mostly small ruminants.

Valuation methods: market prices, replacement costs and opportunity costs

Costs considered for rangeland degradation in communal areas:
* lost capital value of animals (market price of re-stocking)
* lost milk production (market price of substitute)
* lost fertilising impact of dung (market price/substitute)

Costs considered for commercial areas:
* lower stocking rates (and carrying capacity?)

Estimated costs of rangeland degradation in communal areas per household:

*	capital losses:	$ 480
*	milk losses;	$ 300- 600
*	manure losses	$ 165
		$ 945-1 245

Assumption: 50% of losses due to drought; 50% due to rangeland degradation
Total cost estimate of rangeland degradation in communal areas: $ 96.7 m/yr plus approximately $98 mln in asset losses. Poor and vulnerable groups are most adversely affected by degradation because of their limited coping strategies and their dependence on the most degraded land.

Estimated costs of rangeland degradation in commercial areas:
* 30% reduction in stocking rates has led to average income losses of $ 100 m per annum over the past 40 to 50 years (present loss probably substantially higher)

Comments:
* cost estimate only covers part of the use value
* study assumes that land degradation has adversely affected secondary production (livestock). There is, however, no empirical quantitative evidence (other than survey findings that farmers report poorer livestock conditions and milk losses)
* communal area estimate based on results of 1 case (mixed farming case) only despite the large variations in conditions and use).
* difficulties to separate the impacts of *temporary* droughts and *more permanent* rangeland degradation resolved by making assumptions (50:50)
* analysis remains sectoral; impacts on wildlife and gathering have not been considered.
* demonstrates the applicability of non-demand curve valuation/cost estimates
* the study does not value rangeland per hectare; such a estimate is more difficult because of animal mobility

Source: derived from Quan et al., 1994.

* it does not reveal differences in dependence on particular use values by income category or gender. In general, wildlife and veldproducts are critical for low income subsistence. For example, mophane worms are mostly collected by the poor (Moruakgomo, 1994). Although high income groups also engage in gathering and hunting, it is more for leisure purposes and livestock is the most important rangeland use.

Spatial variations have been partly incorporated either in quantitative (eg. manure) or in qualitative terms (wildlife and gathering). Spatial variation and differences in dependency on particular uses are revisited in the section on the findings.

Sensitivity analyses have been carried out to see the impact of alternative assumptions on the results. All values are given in constant terms (1990 Pula)[7]. The year 1990 is taken as a reference point as more recent 1993 agricultural data appear less reliable and are currently being re-analysed.

The study has several limitations. Costs estimates are mostly based on simple averages. It would have been better to estimate the marginal opportunity costs, which include for example external costs, and to incorporate increasing resource scarcity (eg, through higher resource supply costs as seen for water). Therefore, the costs are underestimated and the productivity or net use values are overestimated from an environmental perspective. Furthermore, the production costs of livestock have been fully attributed to sales and slaughter. Obviously, this reduces the use value of these outputs and favours secondary products. The study only covered the drought period 1980-87. A post drought assessment will only be possible once more recent agricultural statistics become available. The study does not consider the natural growth of herds as an output. As livestock tend to be considered as assets, natural growth may be a primary livestock output and an important reason to keep animals.

[7] In 1990 the following exchange rates applied :1 Pula = US$ 0.5364 or UK£ 0.3085. Since then the Pula has effectively devalued by around 100% against the US$ and UK£.

Livestock

Animals considered here are cattle, goats, sheep and donkeys (as draught power only). All domesticated animals are assumed to be dependent on rangelands. Out of the almost 90,000 communal farms in 1990, 62.3% held cattle; 76.8% held goats; 20% held sheep and 32.7% held donkeys. During the 1980s, a substantial shift took place in favour of small stock, particularly goats whose numbers more than tripled. Whilst in the past this has been observed as a drought adaptation, small stock numbers have continued to increase after the end of the drought in 1987. This suggests that a structural change may be occurring in the herd composition, possibly reflecting social and environmental considerations: small stock is cheaper and easier to keep and goats perform better than cattle on degraded land. Table 1 summarises livestock numbers for 1980 and 1990 respectively.

Table 1: Number of domesticated animals in communal areas

Animal	**1980 (million)**	**1990 (million)**	**% Change**
Cattle	2.5	2.2	-12.0
Goats	0.6	2.0	+233.3
Sheep	0.1	0.3	+200.0
Donkeys	0.1	0.2	+100.0
LSU			

Source: Agricultural Statistics

According to the Population Census 1991, 51.3% of households owned cattle and 60.3% owned goats. Animals perform different functions as shown in Table 2, with differences between and within countries. In Zimbabwe, crop production is important in communal areas and therefore draught power and manure constitute a substantial value. Dankwerts (quoted in Blaikie,1982, p.7) found during the 1970s that in the then Victoria Province, Zimbabwe, sales of cattle represented only 17% of the output value of livestock production. Home consumption of meat and milk (33%) and draught power and manure (49%) were considerably more important. In Kwazulu/Natal, Tapson (1991) found that social functions of cattle were of great importance. In Botswana, livestock is the major attractive rural activity, and therefore livestock tend to be kept for accumulation and to provide a flow of outputs such as meat and milk. Large farmers benefit from economies of scale and are less susceptible to droughts. There is therefore reluctance to sell animals from smaller herds (Fidzani, 1993).

Smallstock provide important additional and alternative outputs. Goats and sheep are mainly kept for meat and sales but, as the poor man's cattle, perform comparable social and savings functions. Donkeys are primarily kept for draught power purposes, but are useful for transport too and their meat may be consumed even though it is traditionally shunned. Wildlife in communal rangeland areas is an important source of meat for low-income groups and offers recreational opportunities for other population groups. Presently, the main wildlife utilisation in communal areas is consumptive. However, in areas with substantial wildlife resources emphasis is broadened to photo safaris etc.

Table 2: Use functions of animals in communal areas

Animal	Primary Output	Secondary Output
cattle	sales/cash, meat	draught power, manure, milk, *savings/capital accumulation, social functions*
goats	sales/cash, meat	*milk, savings/capital accumulation, social functions*
sheep	sales/cash, meat	*wool, pelts, savings/capital accumulation, social functions*
donkeys	draught power	*transport, meat*
wildlife	meat, hunting, recreation	skins, skulls, trophies

Note: output in italics have not been captured in this valuation

Below, we review and estimate the value/ha. of the most important outputs of domesticated animals.

Home slaughter and sales

Cattle

The sale of animals and slaughtering for meat are the primary outputs from cattle. In 1990, 159,200 animals were sold and 42,000 were slaughtered at home. Cattle are sold through a variety of marketing outlets, including the Botswana Meat Commission (BMC), which holds the monopoly for beef exports (1990: 69.7%), local butchers (8.2%), traders (7%), auction (6.7%) or other farmers (8.2%). Prices and marketing costs depend on the marketing outlet. Selling animals to BMC fetches the highest prices, but it entails uncertainties as to the grading of the animal and the exact weight (losses may occur during transport) and involves higher transport costs for the farmers. Local sales usually imply lower prices but also lower costs and fewer uncertainties. To estimate the annual value of sales and home slaughter, the following equation has been used:

$$SMV_C = ((OT_C + HS_C) \times (P_C - PC_C))/ SCA$$

where:
Ot_C = number of cattle sold
Hs_C = home slaughter of cattle
P_C = price of cattle
Pc_C = production and marketing costs
SCA = size of communal rangelands
SMV_C = sales and meat value/ha rangeland

Data sources used included Agricultural Statistics (off-take, home slaughter and price), Farm Management Surveys (labour costs), Waterpoint Survey and Motsomi (1983) for watering costs. The size of communal rangelands has been derived from CSO (27.5 mln ha). Selling prices differ from one source to another (BMC, CSO, Agricultural Statistics and FMS).

With regard to prices, the average price paid by communal farmers was used, as given in the Agricultural Statistics and the Farm Management Surveys)[8]. This price reflects the actual revenues for farmers and also can also be considered as the replacement value of home slaughter (price to be paid to locally purchase an animal). This price is substantially lower than the average producer BMC price, which is determined by high-priced export markets such as the EU, Reunion and South Africa and the BMC operational costs. The latter are relatively high, and make it difficult to compete in the global market (Metroeconomica, 1996). During the period 1985-1994, the average beef market price fetched by BMC was 25.6% above the global beef export price[9]; during the same period the producer price was 24.8% of the price fetched by BMC. It is expected that the relatively high BMC producer prices have at least partly pushed up domestic beef prices, but the extent is unknown. Metroeconomica (1996) assumes that the price advantages are fully transferred to domestic beef prices. This is unlikely for producer prices as part of the price advantage is used to cover BMC's high operational costs[10]. We found that the average FMS and AS producer prices are slightly below the world market price at around 70% of BMC prices. Following the likely phasing out of preferential EU-access in future, the producers price is expected to decline by 50% (Metroeconomica, 1996) or by 5 to 45% (Fidzani et al., 1996). The degree of price fall will depend on the degree of global market penetration, farmers' adaptability in terms of producer costs and the efficiency of BMC's operation. Because of the existing market distortions and the expected changes in future beef prices, beef prices will be subject to detailed sensitivity analysis later.

The estimation of the production costs is more difficult. A distinction has been made between private and social production costs (PPC and SPC; Tables 3 and 4). PPC comprises labour costs, watering costs and other costs such as supplementary feeding and marketing costs. Labour costs have been calculated from the FMS data. Watering costs comprise fixed and recurrent costs. For council boreholes in Kgatleng, Motsomi (1983) calculates that the recurrent costs/animal are P0.36/month and that the fixed costs/animal are P0.88/month. The Waterpoint Survey of 1980 showed costs in the same range as Motsomi's. We have assumed that Motsomi's costs represent the average costs of a borehole in Botswana and that the costs have not changed in real terms. In practice, borehole costs differ considerably as they are determined by the distance from major servicing centres, the depth of the groundwater, the

[8] Livestock prices differ significantly. Price determinants include the animals conditions, the season of selling and the marketing outlet. BMC overvalues high grade animals at the expense of lower grades. The high grades (Super and grade 1) are 19% and 9% over paid while the lower grades (3 and 4) are underpaid by 8 and 10% respectively. This pricing policy is an attempt to improve the beef quality but constitutes a cross-subsidisation of large farmers by smaller ones (Fidzani et al., 1996).

[9] Market prices for BMC are estimated to be 30 to 50% above the world market (Fidzani et al., 1996). Hubbard (1986) found that for the 1970s the gross benefits of access to the EU-market were 17.7% of the total payment to producers; the benefits for the South African market were on average only 1%.

[10] This is supported by the fact that BMC's beef producer prices are lower than those in South Africa and Namibia. This is likely to be caused by a combination of abattoir costs and poorer grade animals.

chance of drilling blanks and finally the yields. There is an emerging borehole market reflecting resource scarcity. The associated increase in resource rent is likely to considerably increase the costs of watering. Therefore our assumption is probably on the low side. Farm Management Survey data show that other producer costs are low because of limited management and government subsidies (eg, supplementary feeding). Marketing costs are most important, particularly when animals are sold to BMC (McDonald, 1980). Marketing costs vary substantially by destination (high for BMC; low for local butchers), location (distance to selling point) and by season (to encourage a constant supply of slaughter animals), and are difficult to estimate. Using fragmented data (FMS, McDonald, 1980), we have assumed that "other production" costs amount on average for communal rangelands to 10% of the labour and water costs. In order to calculate the total production costs per animal, the average age of animals sold needs to be determined. To estimate the total production costs, the annual costs have to be multiplied by the selling/slaughtering age. No comprehensive data exist on the age of animals sold, but available BMC data suggest that animals sold are mostly in the age group of 4 to 8 years with an average of around 5 years. Even though cattle generate a variety of outputs (manure, draught power, milk), all animal production costs are charged to the primary product, ie. sales and meat.

Table 3: Net private value of a head of cattle (current prices)

Year	Price (Agric.Stat)	Labour Cost	Watering Costs	Marketing Costs	Total Private Costs	Net value/ Animal
1980	139	5.45	74.40	7.99	87.84	51.16
1981	142	5.06	86.53	9.16	100.75	41.25
1982	150	4.53	96.16	10.07	110.81	39.19
1983	162	5.00	106.32	11.13	122.45	39.55
1984	170	9.68	115.46	12.51	137.65	32.35
1985	179		124.82		(149.10)	29.90
1986	210		137.30		(160.55)	49.45
1987	252		150.76		(171.99)	80.01
1988	(318)	3.35	163.41	16.68	183.44	134.56

Note: figures in brackets are estimates.

Subsequently, social production costs were calculated. There are several sources of difference between the social and private production costs. First, Fidzani (1993) states that 55% of the production costs are subsidised by the government, particularly subsidies of many veterinary services. To gain some insight into the impact on the rangeland value, the annual costs of the Department of Veterinary Services have been allocated to cattle, goats and smallstock in proportion to their total number of livestock units (LSU[11]). Second, although the sector fully pays the water supply costs (and therefore watering costs are high), the costs are not related to the actual amount consumed nor do they take into account environmental externalities. From a social perspective, the opportunity costs of water or the marginal water supply costs are more relevant. This is particularly realistic with the anticipated growing water scarcity, growing supply costs and demand conflicts. With an average water consumption of 1.5

[11] 1 head of cattle is 0.7 LSU; 1 goat or sheep is 0.1 LSU.

M^3month/animal and taking the average of the long run marginal costs of Gaborone and North East (P3.15/M^3; SMEC, 1990), watering costs per animal over five years would be P283.50 (1990 prices). Not surprisingly, the opportunity cost estimate is higher than the one using the earlier described method (1990: P203.16). Thirdly, government charges leasehold farmers in Tribal Land a P0.04 land rent per annum per hectare (ie. opportunity costs of communal land[12]). As this figure has been constant since 1975, it causes only a minor difference between private and social value. Fourthly, the opportunity costs of labour were used instead of the actual labour costs. The Ministry of Finance and Development Planning recommends taking 50% of the minimum wage as the opportunity costs of labour (MFDP, 1996). Assuming an eight hour working days for herdsmen and taking the lowest minimum wage (ie. nightwatchman), the opportunity costs of labour were three times the actual labour costs. Finally, the tax system favours the livestock sector. Tax concessions reduce the production costs, and only the tax on BMC throughput lowers the producer prices. However, in some instance BMC has been refunded in the past to cushion livestock producers from adverse drought impacts.

Table 4: Net social value of a head of cattle (current prices)

Year	Price	Labour Costs	Watering Costs	Marketing Costs	Veterinary Costs	Total Social Costs	Net Social Value/Animal
1980	139	16.35	102.8	7.99	13.62	140.76	-1.76
1981	142	15.18	115.65	9.16	14.17	154.16	-12.16
1982	150	13.59	134.5	10.07	15.83	173.99	-23.99
1983	162	15.00	149.57	11.13	20.36	196.06	-34.06
1984	170	14.01	165.27	12.51	26.67	218.46	-48.46
1985	179	13.02	179.49	(13.55)	29.60	235.66	-56.66
1986	210	12.03	194.03	(14.60)	41.96	262.62	-52.62
1987	252	11.04	213.43	(15.64)	51.30	291.41	-39.41
1988	(318)	10.05	234.35	16.68	62.92	324.00	-6.00

Note: Social costs of land are not included; these are minimal given the low land rentals.

[12] This rate is the lowest possible opportunity cost of land. opportunity costs for leasehold land on State land (average of P0.19/ha) and land rentals for wildlife areas (see section 3.1) are much higher. The P0.04/ha charge has not increased since its inception in the mid 1970s (despite the intention stated in the TGLP White paper to achieve economic rents). To remain constant in real terms, the charge should have risen to P0.27 to date. The decline of the rate in real terms has diluted whatever incentive for better land management may have been generated by the initial charge.

Tables 3 and 4 summarise the net social and private values (price minus costs) of a cow. A number of conclusions may be drawn. Clearly, beef production alone has limited a social use value. Furthermore, the gap between private and social values of an animal is growing, mostly due to subsidies and water costs. The net private price per animal was adversely affected by the drought of 1981-87 but bounced back after the drought; in real terms the use value remains stable. The net social use value also decreased during the drought, and only recovered slightly following the drought. The social use value has decreased substantially in absolute and real terms. Private production costs were on average 35% lower than the social ones for the period 1980-1988 with annual differences ranging from 26 to 42%. The growing difference can be attributed to rising costs of veterinary services and higher water costs. Third, watering is the critical cost component of livestock production. The labour costs, both in terms of person days[13] and wages, are low and are declining in real terms due to the high level of rural unemployment and the absence of government regulations to protect the purchasing power of herdsmen. Clearly, herding practices and remuneration are minimal.

The net price per animal (P-PC) directly influences the use value for sales and meat. Obviously, lower net prices lead to lower annual use value per hectare of rangeland. There are considerable interannual fluctuations in results. This is due to changes in sales and slaughter (eg. restocking after the drought) and in prices. In addition, the value is sensitive to the reported prices. If the net social price is used, the net value per hectare is often negative, especially in the latter part of the period 1980-1988 (Tables 11 and 12). Using the FMS cattle prices, private use values range from a low of P0.17 in 1987 to a maximum of P1.04 in 1980; social use values range from as low as P -0.82 in 1986 to P0.09 in 1980. Using AS-prices, private use values vary from P0.34/ha in 1984 to P0.94 in 1982; social use values range from P -0.83 in 1985 to P 0.06 in 1981. The average annual use value for 1980-87 is P0.55/ha (private) and P-0.31/ha (social).

Goats

Goats play a different role in the rural economy than cattle. They are kept more frequently than cattle, and home slaughter (1990: 152 300 head) is more important than sales (1990: 144 200). Goats are mostly sold locally; BMC's market share is small at 14% (1990: 20 670). The equation of the goat sales and meat value (SMV_g) is similar to that of cattle:

$$SMV_g = ((OT_g + HS_g) \times (P_g - PC_g)) / SCA$$

where:
Ot_g = number of goats sold
Hs_g = home slaughter of goats
P_g = goat price
Pc_g = production costs of goats
SCA = size of communal rangelands

[13] Possibly labour has been underestimated (e.g. amount of family labour involved).

Data have been obtained from Agricultural Statistics (prices, off-take and slaughter), Farm Management Survey (production costs and prices) and BMC (prices). No detailed data exist on the slaughtering age of goats. The average life of a goat is assumed to be three years. Unlike cattle, the sensitivity analysis will later show that the results are not very sensitive for alternative assumptions. As with cattle, the Agricultural Statistics and FMS offered the most relevant prices (actual revenues and replacement value).

The estimation of PC_g proved more difficult. Again, a distinction was made between private and social production costs. Private labour costs were taken from the Farm Management Surveys which records labour inputs and costs, and the social labour costs were estimated based on the opportunity costs of labour. The water costs of goats were estimated as proportional to water consumption of cattle, ie 10% of cattle. Marketing costs are assumed to be negligible as most goats are either slaughtered at home or sold locally. The resulting net private and social value of a goat (price minus costs) have been summarised in tables 5 and 6.

Table 5: Net private value of a goat (current prices)

Year	Price (As)	Labour Costs	Watering Costs	Private Production Costs	Net Private Value/Animal
1980	14	0.37	7.74	8.11	5.89
1981	14	2.87	8.65	11.52	2.42
1982	16	3.62	9.63	13.25	2.75
1983	24	1.49	10.63	12.12	11.88
1984	29	2.76	11.55	14.31	14.69
1985	33		(12.49)	15.12	(17.88)
1986	44		(13.73)	15.92	(28.08)
1987	49		(15.08)	16.73	(32.27)
1988	54	1.19	16.34	17.53	36.47

Note: figures in brackets are calculated as constant annual increases.

Table 6: Net social value of a goat (current prices)

Year	Price (As)	Labour Costs	Watering Costs	Veterinary Costs	Social Production Costs	Net Social Value/Animal
1980	14	1.11	5.54	1.47	8.12	5.88
1981	14	8.61	6.23	1.47	16.31	- 7.07
1982	16	10.86	7.24	1.47	19.57	- 3.57
1983	24	4.47	8.06	1.78	14.31	9.69
1984	29	8.28	8.90	0.65	17.83	11.17
1985	33		9.67	0.68		(17.03)
1986	44		10.45	2.10		(22.88)
1987	49		11.50	2.65		(28.74)
1988	54	3.57	12.62	3.22	19.41	34.59

Note: figures in brackets are calculated as constant annual increases.

The following conclusions emerge. First, unlike cattle, there has been a rapid increase in the net price, both in social and private terms. In real terms, the net private (constant prices 1990) price has increased from P16.24 in 1980 to P44.14 in 1988; the increase in the net social value increase has been similar. This explains the rapid expansion of the national goat herd in the 1980s. Second, the distinction between private and social costs results in less dramatic differences than in the case of cattle. The difference between private and social production costs are much smaller than for cattle, and interestingly in most cases private production costs exceed social production costs because of higher private water costs (private production costs range from 98% to 116% of the social production costs; on average private costs are 7% higher).

In terms of output/ ha. of rangelands the contribution of goats is limited, but rapidly growing (from P0.03 in 1980 to around P0.22 in 1988; see Tables 11 and 12). The difference between social and private value is minimal (1980-87 average of P0.05 and P0.06/ha/yr), reflecting minimal subsidies to goat production.

Sheep

Sales of sheep (1990: 21 900 head) are slightly higher than home slaughter (1990: 17 000). Sheep are treated in a similar way to goats, ie. a similar equation was used to estimate the use value. The lifetime and production costs of sheep were assumed to be the same as those of goats. The use value of sheep/ha (slaughter/sales) is low (private P0.01/ha on average), and unlike goats, it does not increase (ranges from P0.01 to P0.04/ha). As for goats, the difference between social and private use value is limited.

Draught power

Draught power, together with labour and capital, is one of the key constraints to arable development (Litschauer and Kelly, 1980; Odell, 1980). The main grains grown are sorghum, maize and millet; in addition, most farmers grow beans, water melons etc. In good years, Botswana produces half of its domestic needs; in bad years less than 5%. Less than ten percent of the rural households produce enough to meet their own needs. In recognition of the unfavourable climate and the high production costs, the government has shifted the emphasis under the Agricultural Development Policy 1990, from food self reliance to food security. Animal draught power is mostly provided by cattle and donkeys (Table 7). The contribution of cattle has rapidly decreased, leading to a loss of actual use value of cattle. Tractor ploughing and, to a lesser extent, donkeys have greatly increased in the last two decades aided by government subsidies under the ARAP and ALDEP programmes. In this section, the (potential) draught power value of cattle and donkeys has been calculated. The use of animal draught power also has costs, mostly in the form of labour and a deteriorating quality of the animals. Labour costs could be easily assessed. The decline in animal quality is incorporated in the producer price at sale.

Ideally, farmers use a span of six to eight strong oxen as a draught power team. This requires a herd of at least 40 animals. Herds of 20 to 40 head can generate an animal draught power team, but it is less strong, and may not consist of oxen only (Carl Bro, 1982; Arntzen, 1989). The actual picture of draught power use is more complicated than the draught power availability described above. In practice, farmers with small herds may put together a smaller draught power team with non-oxen at greater costs in terms of animal quality, or different

farmers may pool their animals. Owners of large herds may give priority to livestock production and may prefer to hire a tractor or donkeys even though they have their own oxen team available. Unfortunately, *actual* draught power use in relation to herd size is poorly documented in statistics. Therefore, we used the following assumptions mostly reflecting potential use for *cattle*:

* in herds of less than 20 head, own animal draught power is not used;
* in herds of 21 to 40 head, 50% use their own animal draught power;
* in herds of over 40 head, use own draught power.

Table 7: Draught power used in Botswana (% of use; 1990)

Type	**1980**	**1990**
Cattle	66.0	33.4
Tractors	17.3	39.3
Donkeys	10.3	17.4
Combination	6.4	9.9

Source: Agricultural Statistics.

Unlike cattle, donkeys are primarily kept for draught power and transport. Therefore, it is safe to assume that donkeys are more frequently used for draught power than cattle. The following assumptions have been made for *donkeys*. :

* 75% of the herds of less than 5 donkeys use donkey draught power
* 100% of the herds of over 5 donkeys use donkey draught power

Because of generous government assistance since the early 1980s, many farmers have resorted to hiring tractors (Table 7). The calculated draught power value therefore has an actual and potential use element. Given the low returns for crop production, it is unlikely that tractor ploughing is sustainable without government subsidies.

The draught power value is a step-by-step calculation. First, the maximum potential area ploughed by cattle and donkeys has been estimated. Subsequently, the maximum potential area ploughed by cattle and donkeys has been compared with the annually ploughed area. If the former would exceed the latter, the latter is assumed to be the actual area ploughed by animals. If the former was less than the latter, it is assumed that the calculated potential areas ploughed equal the actually ploughed area. Throughout the period 1980-1993, the potentially ploughed area was less than the area ploughed and it was therefore concluded that all ploughing could be done by animals. The costs of animal draught power were difficult to collect. Therefore, the costs of tractor ploughing have been used. ARAP subsidies for tractor ploughing/ha. have been used for the period 1983 up to 1996. Tractor charges are gross, ie. costs of labour, diesel etc. have to be deducted. In the absence of detailed cost data, such input costs have been estimated to be 20% of the tractor charges per hectare.

The results (Tables 11 and 12) indicate an average use value of P0.22/ha for the period 1980-1987 with a minimum of P0.17 during the drought (1984) and a maximum of P0.32 in 1980 prior to the drought.

Manure

Botswana's arable sector is characterised by extremely low average yields, mostly around 250kg/ha. This may be attributed to a combination of low and unreliable rainfall, poor soils and inadequate crop husbandry and management. Manure could contribute to improved yields. Fertiliser is hardly used, and although manure has been traditionally applied, it is becoming less common (Odell, 1980; Mmopelwa, 1995). In other words, the calculated value is to a large extent a potential value. Documented constraints for the collection and application of manure include (FMS, 1980; Herbert, 1992):

* it is a scattered resource; only kraal manure is usable for manure;
* it implies high labour and transport costs, depending on the distance between kraal and field. The average distance found by the FMS was 0.8 km; 70% of the farmers had their kraal within 1 km distance of the field (FMS, 1980);
* application encourages weeds (germination rates of seeds in manure are high) and requires more (labour-intensive) weeding;
* manure appears to produce positive results in wet years only.

Given the large number of animals and declining use, manure is generally not a scarce resource. Locally, mostly around large settlements, kraal manure has become a valuable resource. For example, Herbert (1992) mentions a horticultural project, which pays P1.50/ton of manure.

Based on the limited literature (Herbert, 1992; FMS, 1980), the following assumptions have been made:

* manure from cattle in western and northern Botswana is not used: in these areas, there is very limited cultivation and the distance between the cattleposts and fields is large
* only manure of kraaled animals is used
* one kraaled cow produces 10 ton dry matter manure/pa
* 33% of the cattle are kraaled at night; no animals are kraaled during the day.
* the recommended application rate is 12.5 tons/ha (Herbert, 1992).

The manure value/ha of rangeland has been calculated as follows:

Step 1: calculation of the potentially manured area (PMA):

$$PMA = (a \times CE \times AMP) / AR$$

where:
CE = total number of cattle in eastern Botswana
AMP = annual manure production/ animal
a = proportion of kraaled animals
AR = recommended application rate/ha

Step 2: calculation of the yield increase (in kg and Pulas)

If PMA is larger than AAP (as is this case), then PMA = AAP.

MV = ((AAP x (1 + b) x Y x CP) - CM) / SCA

where: b = yield increase due to manure
Y = average yield
CP = average crop price/kg
CM = costs of manure (labour/transport)

A number of assumptions have been made:

* the average yields (Y) increase by 25%. The literature shows an enormous range of yield increase from almost 0% (in dry years) to over 300% (eg. dry parts of India; Herbert, 1992). For Botswana, a yield increase of 50% in good years appears reasonable. With a 50:50 chance of a good year, the average annual yield increase would be 25%.

* farmers perceive the labour and transport costs (CM) to be high. However, no empirical figures are available. High labour and transport efforts may mean 7 days work per hectare. The costs of labour are taken from the FMS.

* the vast majority of households do not meet their own food needs; higher yields reduce the purchasing requirements and therefore the rural retail price of grain is used (an average for maize and sorghum has been calculated proportional to the contribution of each to the country's production in a particular year; see table A.5).

The calculated use values are summarised in Tables 11 and 12. Annual use values vary by a factor of 4 to 5 due to the large variation in animal area ploughed and yield fluctuations, which both vary with rainfall.

Milk

The common perception is that cattle are primarily kept for meat etc. and milking cows is not systematically undertaken, as with dairy cows. Milk and milk based products such as sour milk (madila) are generally considered as a secondary output; milk is a seasonal product, which is confined to the wet season. However, milk is more important than commonly believed. There is evidence to indicate the existence of a dairy sector in the past. Some surveys show the importance of milk in the Mathete area (Abel et al., 1987) and the sandveld west of Serowe (Perkins, 1991). In the Mathete region, milk represented 65% of the energy output and 35% of the cash output of livestock;, and was more important than meat (Abel et al., 1987). There have also been some attempts to establish a dairy sector in communal areas close to urban areas (Boitumelo, 1993).

Milk is considered particularly beneficial for children, who are given most of it, and is extremely important for the diet of cattlepost dwellers. According to ILCA, an average head of cattle produces 43 kg of milk per annum (1987; ILCA, 1991). Using this figure, communal rangelands would have produced around 95 metric tonnes in 1990[14]. Carl Bro (1982) mentions that a good cow produces 360 lt. of milk in a good rainfall year. The origin of these

[14] ILCA (1991) further estimates a total goat milk production of 3 MT in 1987 (or 2 kg/goat/annum). Goat milk has not been incorporated in the use value.

production figures is unclear, and therefore they can only be used indicatively. The growth of urban areas has created a limited market for dairy operations. The Department of Agricultural Research is starting a milk production and consumption survey. For cattleposts in the sandveld west of Serowe, Perkins (1991) calculates an average milk consumption of 25 lt/day/ cattlepost (for a good year at the beginning of the rainy season). In practice, almost all milk is locally consumed, ie, an important dietary component at the cattleposts. A cautious generalisation of Perkins' findings suggests that:

* each herd of over 40 head produces on average 20lt/day during 4 months of the rainy season
* herds of less than 40 head produce on average 5lt/day during the rainy season

Consumption patterns and prices for milk are not well documented; nor are the production costs. The price has been estimated through the replacement value, ie. the average rural long life milk price. Production costs mostly involve labour and transport. Labour costs are expected to be low; transport costs depend on the distance to the market, but are very high for remote cattleposts. However, no empirical data are available. It is therefore initially assumed that production costs are high and represent 40% of the retail price of long life milk. This key assumption is later subjected to sensitivity analysis (Table 13). Not surprisingly, the milk use value proves to be very sensitive for this assumption.

The milk value/ha of rangeland was found to be high with an average annual value of P1.45 (in constant 1990 prices) during the period 1980 to 1990, and a range from P1.14 (1987) to P1.85 (1981). It must be noted that this figure is an overestimate as the production costs of livestock are fully attributed to meat production and sales. Furthermore, it is unclear which value part represents *actual* milk production/value and which part is *potential* production/value. In the latter case, the high costs of meat losses due to milking should be deducted. De Ridder and Wagenaar (undated) quote Roy (1980) that 1kg of milk is equivalent to 0.28 kg additional live weight of animals. If this figure is applied to communal rangelands in Botswana, the use value of milk would drop to 36% of the estimate over the period 1980-1990. Another way of comparing cost and benefits is that the benefit of producing 1 litre of milk valued at P2.02 would have very high cost of P1.61 in terms of meat losses. This may explain why little milk is actually sold; possibly only a specialised dairy industry would warrant the beef losses.

Clearly, milk deserves further investigation[15]. Collection of data on actual milk production and the identification of opportunities for agricultural diversification would be necessary first steps. It is also important to evaluate the impact of rainfall on milk production and costs in terms of meat losses.

[15] The importance of milk is recognised in the National Accounts, where milk is considered to be the most important product for own use in the traditional agricultural sector (more important than crops and meat).

Wildlife and Veldproducts

Compared to livestock, statistics on wildlife and, in particular, veldproducts are poor and fragmented. This reflects the neglect by planners and researchers which both resources suffered until recently. Consequently, there are few variables for which time series can be constructed, and the net pricing method used for most livestock outputs cannot be applied. Through necessity therefore, this section contains quantitative and qualitative data. It is important to realise that wildlife and veldproduct resources are very unevenly distributed over the country. Generally, the availability of wildlife and vegetation species is determined by physical conditions (rainfall, temperature, soils) and land-use patterns.

Wildlife

While Botswana has traditionally been endowed with one of the richest wildlife resources, mostly concentrated in the north and west (Map 2), drastic resource changes have occurred in the last decades. First, a reduction and fragmentation of the wildlife habitat has occurred. Livestock encroachmenth has reduced the remaining wildlife areas. Furthermore, the original country-wide wildlife system is now subdivided in a northern (with the Okavango/Chobe as its centre) and southern system (with the Schwelle and Central Kalahari as the centres), with very limited mobility between both systems. Secondly and related, wildlife numbers have rapidly declined since the late 1970s, although some stabilisation has occurred in the mid 1990s.

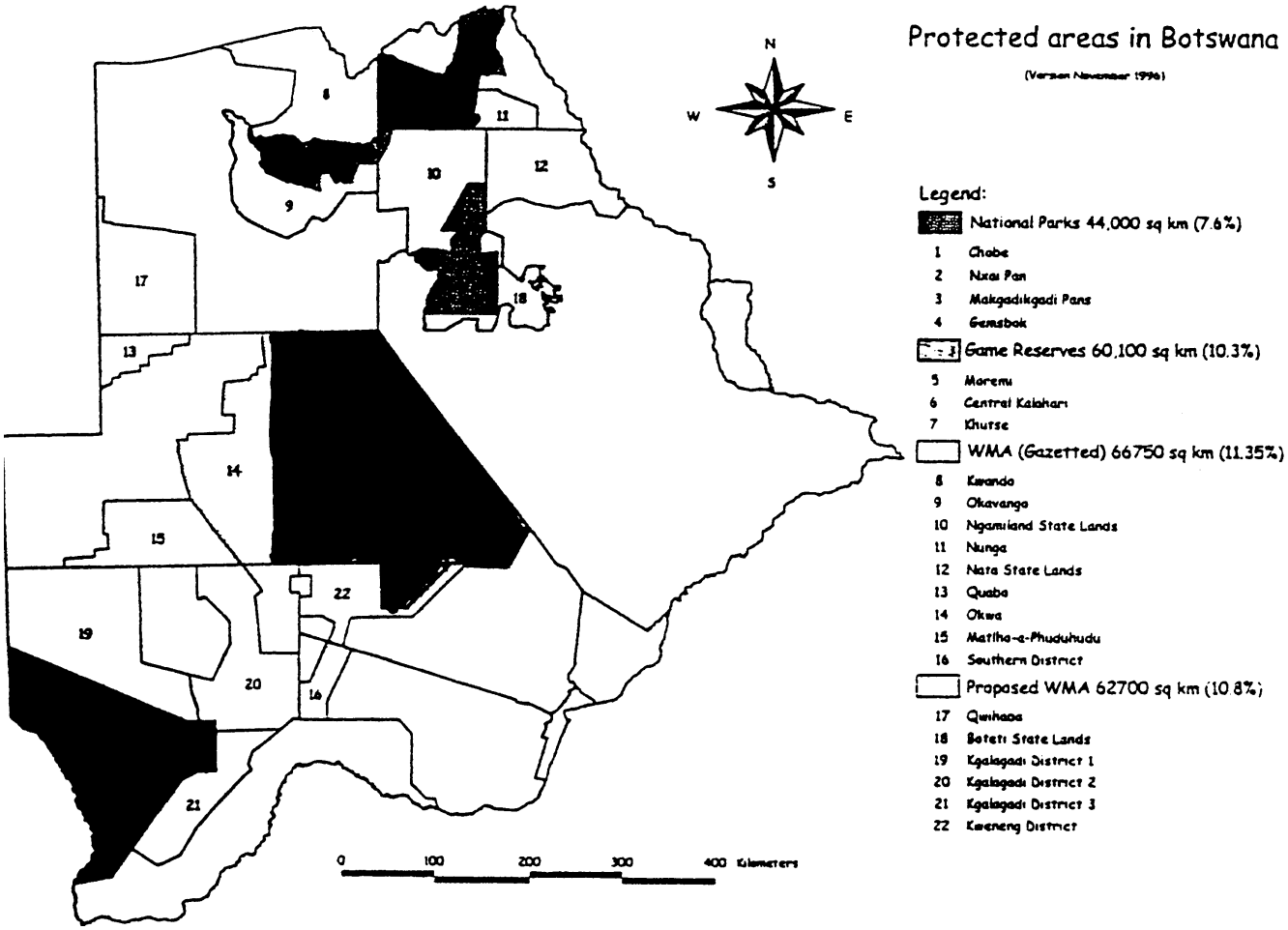
Hunting is regulated through a system of annual quotas determined by aerial counts for each *controlled hunting area* (the CHAs cover the entire country). In addition, *wildlife management areas* have been designated countrywide. In WMAs, wildlife utilisation takes priority over other forms of rangeland uses. Forms of land use in WMAs are:

* community based wildlife utilisation
* commercial wildlife utilisation
* multiple use areas
* non-hunting photographic areas

Hunting is traditionally the most common form of wildlife use in communal rangelands, but there is a marked increase in multi-purpose use and photo safaris, especially in the north. This switch has probably resulted from the lower numbers and hence lower hunting quota but may also reflect an increase in the market for non-consumptive wildlife use. It is often asserted that diversification into non-consumptive use offers higher returns, certainly with declining wildlife numbers[16]. Barnes (1995) argues that wildlife viewing can be economically more important than hunting, particularly in wildlife rich areas in the north. Potential economic benefits may vary depending on the wildlife resource - from P0.12/ha (poor wildlife area) to P0.79 in moderate and P1.20 in good wildlife areas. Potential economic net present values may vary from P0.22/ha in Ngwaketse to P6.33 in Chobe (Barnes, 1995).

[16] The economic arguments underlying the switch towards game ranching which rapidly occurs in freehold areas and on state land in principal also apply to communal areas (cf. Ashley, 1996 for Namibia).

Map 2 Protected areas in Botswana



Interestingly, small scale game farming was found to be more profitable than medium scale. Returns strongly depend on resource numbers. Losses are likely when numbers drop below 150 ha/lsu equivalent, and therefore restocking and cropping moratorium are worthwhile investment strategies in areas which experience resource depletion. While these figures show some of the potential wildlife benefits, it must be emphasised that many community-based projects have not met the expectations. Where a high potential has been realised, the distribution of benefits has been highly skewed. The main beneficiaries in the past have been safari companies with few benefits trickling down to communities. Therefore the issue is not just a matter of *value maximisation* and comparison as shown in the following quotation: ".....estimated value to the economy of each animal killed by a safari hunter in Northern Kgalagadi district to be P2182, as compared to P76 for an animal killed by a citizen recreational hunter" (Cumming and Taylor 1989 quoted in Adams et al., 1990, p.53). Equally important is the *value distribution*, ie. who benefits?

Enormous spatial variations in wildlife use and potential exist. Wildlife (use) in the eastern part of the country has become minimal, and only common species remain. The largest actual and potential use of wildlife are in the north and in the southwestern parts of the country. The use value depends on the variety and numbers of animals, which is determined by the following factors (pers. comm. Bond and Department of Wildlife and National Parks):

a. population density: Zimbabwe's CAMPFIRE projects only provide reasonable wildlife returns in areas of low population density (less than 5 persons/km^2)
b. cattle density: DWNP found a strong inverse relationship between cattle and livestock densities. In other words, wildlife disappears from livestock invaded areas.
c. rainfall and primary production. Primary biomass production and subsequent animal species and numbers are positively correlated to rainfall. Therefore the rainfall gradient from low rainfall in the south west (250 mm) to relatively high rainfall in the north (700mm) also indicates the possible biomass densities in these areas.
d. protection of the migration routes for migratory species. The country's wildlife resource is now subdivided into a southern and northern system. This limits the opportunities for species traditionally dependent on south-north migration.

Factors a and b indicate a trade-off in use values between crops/livestock on the one hand and wildlife revenues on the other hand. Factors c and d refer to the total potential productivity of the ecosystem given different physical conditions and different degrees of land use planning (and conflict resolution).

Three types of variables were considered to estimate economic use values for the period 1980-1993: value added from the National Accounts, trends in single game licenses and finally data on household income derived from wildlife use.

The first estimate used data on traditional hunting from the National Accounts. Wildlife output is restricted to subsistence hunting, assumed to be fully confined to communal rangelands. Annual data are available. The annual figures are indirect estimates derives from the annual population growth rate and the most recent income and expenditure surveys. The figures show a persistent increase which is incompatible with the decline in wildlife numbers and hunting quotas. World-wide National Accounts tend to underestimate subsistence activities. However, Tyler (1996) found that some commercial activities have been included in traditional hunting. Botswana's National Accounts provide figures on: gross output,

intermediate costs and value added. There is no information on the costs of hunting (and gathering). Costs probably vary substantially, depending on the area, and are likely to have increased because of regulations (license fees plus related travel costs[17]) and scarcity. Hunting fees are private costs and currently only intended to cover government expenditures on wildlife and therefore also represent a social cost (FGU/Kronberg, 1998). Scarcity causes both private and social costs, and should therefore be included. The following equation has been used to estimate the hunting value of wildlife:

$$HV_w = (VA_w - PC_w)/ SCA$$

where: HV_w = hunting value of wildlife (subsistence)
PC = production costs
VA_w = value added
SCA = size of communal rangelands

No information is available on hunting costs. We assume that on average such costs were 10% of value added in 1980, and have annually increased by 0.5% per annum because of growing resource scarcity. The results indicate that the wildlife use values range from a low of P0.33 in 1987 to a high P0.65 in 1992. During the 1980s the use value decreased slightly, but the values in 1991 and 1992 are much higher. The value is generally below the private use values of milk and sales/meat of cattle, but similar or higher than that of draught power and manure. Despite the increase in smallstock and the decline in wildlife, wildlife has a much higher use value than smallstock. The trend in wildlife use value from the National Accounts is suspect. The decrease in the 1980s is very small given the dramatic decline in wildlife numbers and hunting quota. There is no logical explanation for the sudden increase in the 1991/92 values, and this increase must be attributed to changes in coverage or calculation.

The use trend can be assessed more accurately through an analysis of single game hunting licenses (second estimate). Hunting quotas are set annually to allow for resource regeneration and may therefore reflect the sustainable harvest level. The largest category of licenses concern single game licences, with differential fees for species and residence status. For remote area dwellers, special game licenses are issues free of charge, but unfortunately it is not known how many animals are shot under such licenses. Table 8 summarises the trend in product use value as well as hunting fee revenues (FGU, 1988)[18]. The table presents values of hunting quota measured in two different ways:

[17] Such costs can be substantial for the local population, and prohibitive for low income groups (for who the free special licenses are meant).

[18] Hunting quota do not accurately reflect the real off-take. Some quota remain unused; some are repeatedly used (instead of once) and hunting without licenses also occurs. It is impossible to accurately estimate the real off-take. After a thorough literature review, FGU (1988) assumes that the illegal off-take is 165% of the legal (licensed one).

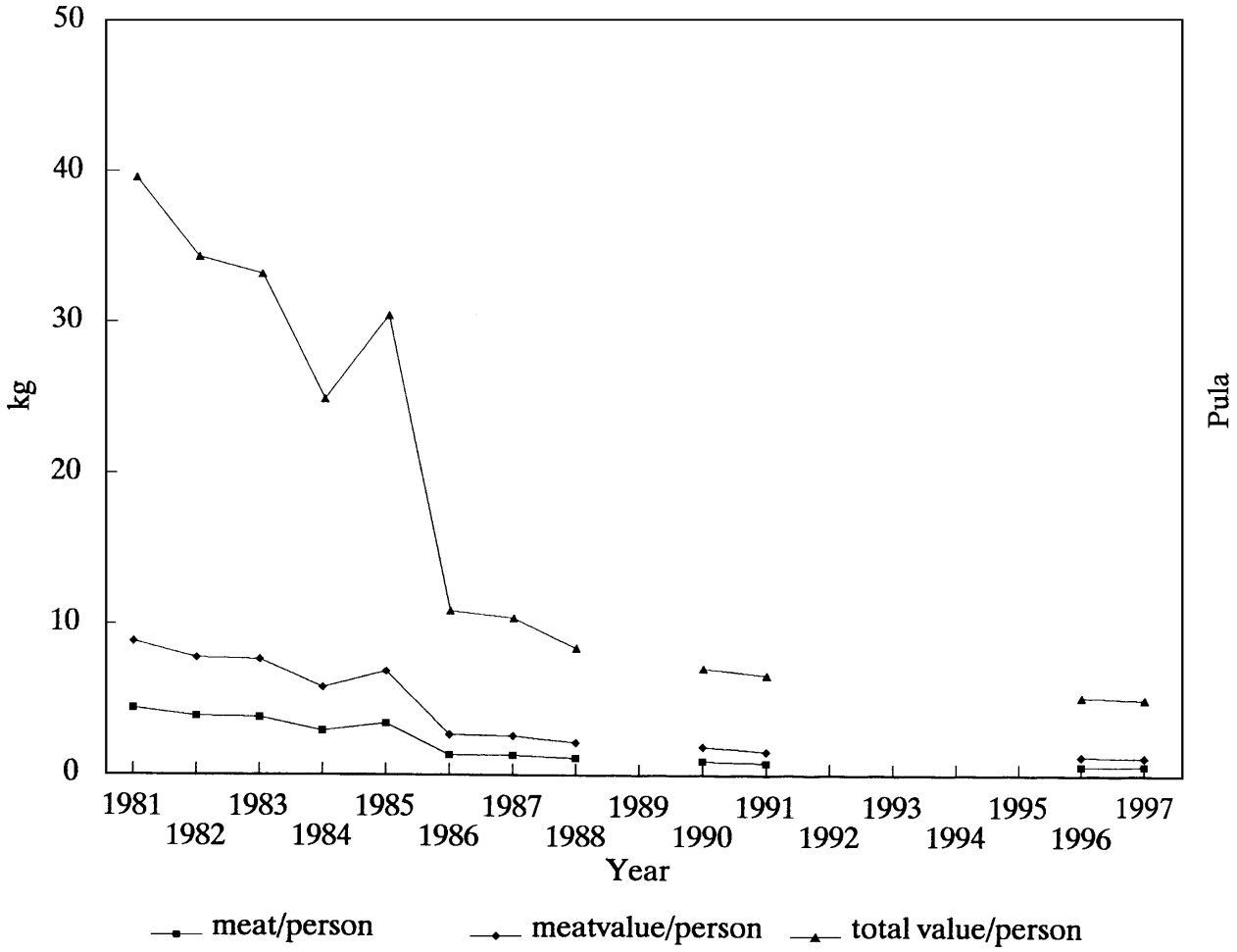
* product use value in terms of meat, trophies, skins, skulls and hides
* in terms of hunting fees, using non-resident rates (citizen rates are much lower)

The product use value shows an enormous decline from P0.83/ha to P0.23/ha in 1990 with a modest recovery in the 1990s (1996: P0.34/ha). The use value is generally somewhat lower than the estimate based on the National Accounts. This may be due to illegal hunting, which may be partly included in the National Accounts. The hunting fee value/ha is around 15% of the product use value, and after an initial decline in the 1980s appears to stabilise at P0.05/ha. Value losses are due to a general reduction in wildlife numbers and a switch from hunting of luxury, high-value species to common, low-value, species such as steenbok and duiker.

At this stage, no changes in product values have been incorporated. The reason is simply that the few product values used all refer to "around 1990" (Parry, 1989; Coneybeare and Rozemeijer, 1991; for values used see footnote below Table 8). Hunting fees have been constant at least since 1988, but are currently under review. They are now far below the product or market value (Table 9), representing a substantial implicit subsidy to hunters. This is difficult to justify for leisure hunters at a time when the viability of community wildlife utilisation projects is being eroded by declining stocking rates. However, there are plans to increase hunting fees to a more economic level.

The third estimation method is to assess changes in household income from wildlife. Unfortunately, data are fragmented and no time series could established. The available evidence suggests, however, a clear decline in subsistence income from wildlife. In eastern Botswana, wildlife use has become an insignificant source of subsistence unlike gathering (Mars, 1996), while in western Botswana, the importance of wildlife has also reduced. Adam et al. (1990) estimate for the Kgalagadi and Ghanzi districts that wildlife revenues have declined from P 920 000 in 1980 to P 291 000 in 1987 (both in 1987 prices). The number of beneficiaries has declined from 2 000 to 1 000 households in the same period. The total off take in both districts declined from 460 to 255 tonnes, of which only 85 tonnes benefitted subsistence households (the same amount of meat went to leisure hunters from outside the district). Adams et al. (1990) attributed the decline almost entirely to the drought. Wildlife losses have had major impacts on subsistence activities as well as the development potential of region. Arntzen et al. (1993) calculate that wildlife depletion constitutes a capital loss of around P25 - 30 million in the Boteti area between the central Kalahari game reserve and the Makgadikgadi Game Reserve. This is a substantial loss of development opportunities in this area. Coneybeare and Rozemeijer (1991) and Barnes (1995) conclude that the decline in wildlife resources has affected the viability of game ranching in many parts of the country. Based on single game license quota, there has been a considerable reduction in wildlife benefits. The amount of game meat available per person in communal areas has declined from 4.4 kg. in 1981 to 0.6 kg. in 1997. This represents a loss in total use value per person of just under P40 in 1981 to just under P5 in 1997 (Figure 1).

Figure 1: The trend in average wildlife benefits in communal areas (1981-1997)



Note: figures exclude special are based on special game licenses (no data available).
Source: calculated from DWNP data on single game licenses.

Table 8: Values of hunted animals in communal rangelands (1984-1997; current prices)

	1984	1988	1990	1996	1997
Product[a] value (mln Pula)	28.4	11.7	7.9	11.6	11.5
Value based on hunting fees (mln Pula)	3.1	1.8	1.9	1.7	1.8
Hunting value as % of product value	12	15.0	2.4	15.0	16%
Main species (numbers)	1. wildebeest 11017 2. hartebeest 10802 3. gemsbok 3244 4. springbok 2867 5. ostrich 2449	1. springbok 3375 2. gemsbok 2826 3. ostrich 2022 4. impala 1900 5. kudu 1878	1. steenbok 8950 2. springbok 8465 3. duiker 5316 4. impala 1699 5. gemsbok 2218	1. steenbok 7275 2. duiker 5535 3. lechwe 3467 4. impala 2475 5. kudu 1460	1. steenbok 7320 2. duiker 5499 3. lechwe 3397 4. springbok 2780 5. impala 2502
Main species in value (mln. Pula)	1. hartebeest 8.2 2. wildebeest 7.6 3. gemsbok 3.1 4. eland, ostrich, buffalo 1.3 each	1. gemsbok 2.3 2. kudu 1.7 3. buffalo 1.5 4. ostrich 1.0 5. zebra 0.9	1. springbok 1.5 2. buffalo 1.1 3/4. zebra/lechwe 0.6 each 5. tsessebe/lion/ gemsbok 0.5 each	1. lechwe 3.6 2. tsessebe 1.6 3. kudu 1.4 4. gemsbok 0.8 5. springbok/ duiker 0.5	1. lechwe 3.5 2. tsessebe 1.6 3. kudu 1.4 4. gemsbok 0.9 5. steenbok/springbok 0.6 each
Value/ha (Pula)	0.83	0.34	0.23	0.34	0.34
Hunting value[b]/ha (Pula)	0.09	0.05	0.06	0.05	0.05

Note: [a] products include meat, skins, hides and skulls. [b] based on resident hunting fees (citizen fees are lower; non-resident fees are higher)

Sources: hunting quota from DWNP; meat prices estimated at the "magic" P2/kg CDM used by Kay, 1981; FGU, 1988 and Parry, 1989. Trophy fees from FGU, 1988 and Coneybeare and Rozemeijer, 1991; skin and skull and hide values from FGU, 1988; Parry, 1989).

Table 9: Hunting fees, market value and estimated meat value of wild animals

Animal	Hunting Fee Citizens	Hunting Fee Non-Residents	Market Value	Meat Value
Eland	50	300	1901	700
Gemsbok	5	200	1154	220
Hartebeest	3	150	1335	190
Impala	1	100	255	70
Kudu	5	150	986	260
Lion	100	1000	3141	?
Ostrich	10	75	636	250
Reedbuck	1	200	1086	?
Springbok	1	200	248	?
Wildebeest	3	200	1110	260
Zebra	20	200	1171	400

Note: hunting fees have been constant since 1988. Plans are under way to substantially increase the fees, and bring them closer to the market value (pers. comm. DWNP). Market values are the 1995 average for South Africa (Farmers Weekly, 1996). Botswana does not have a wildlife market because of veterinary marketing constraints. Meat values have been taken from Conybeare and Rozemeijer, 1991.

The following conclusions emerge from the discussion on wildlife use values. First, the dominant form of wildlife utilisation in communal rangelands, i.e. hunting, has an important use value/ha exceeding that of smallstock and manure and in the same order of magnitude as draught power. Due to low hunting fees benefits mostly accrue to the hunters and the opportunity costs of hunting are very high. Assuming a 50:50 distribution of hunting licenses between citizen and non-citizens, the market value is nine times the average hunting license value. The average meat value is more than double the average license fee. In other words, license-based values are a considerable underestimation of the true resource value. Second, data of single game licenses reveal a substantial decline in the product value of hunted animals. In 1996/97, the value was less than half of the 1984 value (in absolute terms). In this respect, the National Accounts data, which show an increase in use value, seem suspect. The decline in use value is due to smaller numbers of hunted animals and a switch towards hunting of low value species. Third, currently only a small portion of the actual wildlife use value is realised. This value can be enhanced by encouraging wildlife viewing instead of hunting, particularly through community projects. It may also be worthwhile to consider export of life animals to countries with higher land pressure. Another way is to increase the low hunting fees, which constitute only a small portion of the animal's product value, leaving the hunters with a large share of the resource rent[19]. The drop in wildlife numbers has reduced wildlife utilisation options in many areas. Nonetheless, in wildlife rich areas wildlife remains a valuable source. This is clear from the recent tendering of wildlife management areas (Table 10). These rentals exclude the 4% royalties to be paid over the gross income, and clearly show the profitability of wildlife operations. It must be pointed out, however, that enormous spatial fluctuations in the wildlife use value occur. Restocking and bans on cropping may be helpful for resource regeneration and revitalising wildlife based projects (Barnes, 1995).

[19] Hunting fees have remained constant since 1988; significant increases are now being considered.

Table 10: Current land rentals[a] of tourism concessions in northern Botswana (P/ha)

Type	Annual Rent Per Ha.	Comment
Controlled hunting areas (Tribal)	average: P0.51 range: P0.16-1.55 (Land Boards)	tendering
Controlled hunting areas (State)	average: P0.24; range: P0.16-0.34 (Dep. of Lands)	tendering
Commercial Photographic Areas	average: P0.40; range P0.04-1.13	tendering

[a] excludes royalties paid over gross earnings.
Source: calculated from data from DWNP.

Veldproducts

As stated in the introduction, gathering is the most common form of rangeland use in Botswana. It is also the most undervalued activity although it is of critical importance for low-income groups. Commercial use of veldproducts is also increasing, and poses a larger threat to resource regeneration than subsistence use (pers. comm. Mr. Dipholo, Agricultural Resources Board). Examples include the grapple plant, mophane worm and fuelwood. Some veldproducts are found throughout the country (eg, fuelwood, thatching); others are area-specific (eg. grapple plant[20], mophane worm[21]). Important veldproducts include:

* thatching grass for roofing
* wood for energy, building and kraaling purposes;
* wild plants for food (morogo, berries, monkey orange), beer brewing and medicinal purposes
* palms for baskets etc.
* morula, mophane worms

Commercially exploited veldproducts include sengaparile (devil's claw), mophane worm, palms (for basket weaving) and certain trees (eg, morukuru, morula). A general inventory of veldproducts identified several species with a viable commercial use: mophane worm, marula fruits, sengaparile or grapple, papyrus, wood for carving and berries (moretlwa and mogwana) (Taylor and Moss, 1982). Millar (undated) further identified species such as the morama bean, mmilo fruits, various types of indigenous species, leaves for medicines and/or teas and dried flowers.

The impact of livestock expansion on veldproducts is unclear. Some indications are that associated changes in vegetation reduce the diversity of veldproducts. However, the availability of veldproducts is most frequently linked to rainfall patterns (Rampete, 1996).

[20] Thusano Lefatsheng bought 20,000 tonnes in 1988 valued at P80,000 (Adams et al., 1990).

[21] Tins of mophane worms (400 grs) are sold for P5.50 (in water and brine) and P6.00 (in tomato and onions). These are mophane worms collected in Botswana and canned in Zimbabwe). During droughts, mophane worms sometimes serve as cattle fodder (eg, export to South Africa).

Veldproducts have long been neglected by planners and researchers. The Agricultural Resources Board regulates the use of some veldproducts such as the grapple plant. However, there is presently no policy on their utilisation and management. The new National Development Plan mentions the preparation of a veldproducts policy, which reflects the growing awareness of their development potential for subsistence activities (Brothers et al., 1993). For veldproducts such as mophane worm and marula fruits sufficient demand exists but in order to exploit the potential value supply constraints need to be removed (Arntzen and Fidzani, 1997).

There are two data sources. First, the National Accounts (SNA) are the only source of time series data. Second is the information about the actual and potential use values of individual veldproducts. According to the SNA, gathering comprises the collection of wood (the most important), phane and other veldproducts. The use value of gathering exceeds that of wildlife. The same formula has been applied as for wildlife estimates taken from the SNA. In the absence of detailed production cost data, they were assumed to be 10% of value added in 1980, with an annual increase of 0.5% per annum, reflecting growing resource scarcity. The results demonstrate the importance of gathering which ranges from P0.68 to P0.86/ha in the 1980s and an average of P0.65 for the period 1980-87. Gathering is more important than Dahl's re-analysis of the 1974/75 RIDS data suggests. Dahl (quoted in Adams et al., 1990) estimates the total use value of veldproducts at P5.2 (1987 prices) or P0.17/ha (1990 prices). Drought has an adverse impact on gathering; this finding is supported by Kgathi (1988) for grapple harvesting in south western Botswana and for veldproducts in general by studies in the Boteti area (Arntzen et.al., 1993) and Shoshong area (Rampete, 1996). Gathering is second only to the use value of milk. It is more important than most other livestock and wildlife outputs. As with wildlife, SNA data of gathering show a sudden increase in 1991/92, probably due to technical reasons rather than changes in real value.

Detailed studies demonstrate the potential or actual use value of certain veldproducts. Mophane worm is probably the most valuable resource after firewood. Moruakgomo's study shows that mophane worm represented an actual use value of P0.13/ha, P0.07/ha, P0.22/ha and P0.16/ha for the years 1991 to 1994 respectively. Mature marula trees could easily yield 1ton/year valued at P96/annum (pers. comm. Hartley, NRMP). For 100,000 mature trees in Botswana, the potential harvest value would be P0.28/ha. These are significant use values bearing in mind that they relate to a single veldproduct. During the Botswana Society Symposium on "Botswana in the 21st Century" it was observed that monkey orange trees could produce 300 to 400 fruits valued at P1 each (Brothers et al., 1993). The general discussion concluded that veldproducts have an important role to play in Botswana’s economy.

It is clear that veldproducts are economically valuable resources whose commercial potential has hardly been tapped, mainly because of the substantial government support schemes which offer higher returns than basket weaving, for example (see eg, Bishop et al., 1994).

Discussion Of Findings

The estimated figures for sectoral and aggregate use value are summarised in Tables 11 (private) and 12 (social). The calculated average value is expected to be an underestimate of the average long-term use value as it includes a drought period when primary biomass production is down. The average for wildlife and gathering may be correct but the upward trend is clearly suspect, and probably the result of the estimation techniques used as part of the National Accounts.

Sensitivity analyses

Sensitivity analyses have been carried out for selected key variables. The results are summarised in Table 13 and some details are presented in appendix A. The changes in key variables are given in column 2 of Table 13. Their impact on the average use value are summarised in columns 3 (partial use value such as milk) and 4 (aggregate use value). Only the results for wildlife are discussed in the text. The largest changes in sectoral and aggregate output value occur with respect to cattle sales, meat and milk. Different assumptions for manure influence the sectoral output substantially, but have a limited impact on the aggregate output value. Different assumptions for goats and sheep (and for kraaling with respect to manure) have a minimal impact on sectoral and aggregate values.

With respect to cattle, sensitivity analyses were carried out for price and age (the latter greatly influences the production costs). Regarding the livestock prices, it has been assumed that the high BMC prices apply. Botswana has access to the lucrative European market, which offers prices well beyond the world market (Fidzani, 1993). Therefore, BMC prices tend to be higher than the average price received by communal farmers. During the period 1980-1988, the average annual price received by farmers as recorded in the Agricultural Statistics was 70.1% of the BMC price while the FMS price was 68.7%. Using the average BMC price as the value of an animal would lead to a substantially higher sales/slaughter value per ha. of communal rangeland (Table 3). The use value would almost triple to P1.44/ha (private) and to P0.25/ha (social; see also Table A3). It would even lead to a positive average social use value of P0.54 for the period 1980-1988 (Table A3). It should be noted, however, that BMC prices are artificially high and therefore are not the most appropriate prices, certainly from a social perspective. There is limited information about the average age at which animals are slaughtered or sold. Let us assume that the average age of animals sold or slaughtered is 3 instead of 5 years. This leads to lower production costs, hence increasing the value of the annual output. This would lead to an increase of meat/slaughter use value to P1.26 (private) and to P0.58 (social). The age reduction of 40% leads to an increase in average output value (Table 3). From a social perspective, the age reduction would lead to positive output values for both AS and BMC prices. The tables A.3-5 demonstrate the sensitivity of the results for prices and selling/slaughter age. The use value is highest using BMC prices plus an age reduction to 4 years leading to positive private and social use values (P1.89/ha -private- and P1.12 -social- in the period 1980-1988).

For manure, sensitivity analyses were carried out for the kraaling rate, crop prices and expected yield increase. First, the impacts of different kraaling rates were examined. An increase in kraaling rate would not increase the use value because there would be more manure than needed for the ploughed area. In fact, the kraaling rate could drop to around 20% before the usable amount of manure (ie. kraaled) would become inadequate to manure the entire annually ploughed area. Clearly, the results are robust for kraaling. Second, different crop prices were used. The FMS records average crop prices paid to farmers per kg. These prices are 35% below the retail prices in the period 1980-1988. The Botswana Marketing Board (BAMB) purchases grain throughout the country, but its producer prices are below the rural retail prices and the FMS prices. Using BAMB prices, therefore, leads to a considerably lower manure value/ha than the other two prices. The average manure value/ha for 1980-87 was P0.35/ha (rural retail), P0.22/ha (FMS) and P0.19/ha (BAMB[22]). Finally, the use value was tested for different yield assumptions. Yield increases considered ranged from 0 to 100% increase. As to be expected, the partial value is quite sensitive to different assumptions; it makes relatively little difference on the aggregate use value. Obviously a 0% increase would reduce the manure use value to 0. In the case of yield doubling, the value would increase to P0.58 (rural retail) or P0.36 (FMS prices). The combined impact of different yield increases plus different prices is shown in Table A.5. Use values range from P0.20 to P0.61/ha.

For milk, different assumptions were made for the milking period and production costs. First, the impact of a shorter (90 days) and longer (150 days) milking period were examined. The milk value decreases and increases proportionately to the change in milking period, ie. a reduction to P1.09/ha in the case of 90 days and an increase to P1.81 in the case of 150 days. Second, an increase in production costs from 40% to 60% of the milk price would lead to a significant reduction in milk value to P0.96. Finally, entirely new calculations have been made using yield figures from ILCA/FAO for Botswana of 43 milk production in 1987 (kg/head/annum; ILCA, 1991). This leads to an even higher value/ha (eg. P2.52 for 1980-1990 assuming a net price of 50% of the retail price). The conclusion is that *unless the costs approximate the price or milk consumption is reduced to a few days only, the annual milk value remains substantial as compared to other outputs*. The net milk price or the yields would have to decrease to a third to have values comparable to the sale and slaughter value/ha of cattle.

[22] It is not surprising that crop producers are hesitant to sell to BAMB as local outlets offer much better opportunities.

Table 11: Private use value of communal rangeland (constant 1990 prices: Pula/ha)

Year	Total Value/Ha (As Prices)	Sales/Slaughter Beef		Sale/Slaughter Goat		Sales/Slaughter Sheep (Fms)	Draught Power	Manure	Milk[b]	Hunting[a]	Gathering
		Fms	As	Fms	As						
1980	3.87	1.04	0.85	0.02	0.03	0.03	0.32	0.71	1.57	0.37	0.70
1981	4.16	0.85	0.94	0.00	0.1	0.01	0.29	0.89	1.85	0.37	0.69
1982	3.37	0.90	0.57	0.06	0.02	0.00	0.19	0.16	1.41	0.36	0.66
1983	3.47	0.63	0.51	0.044	0.04	0.02	0.25	0.20	1.45	0.35	0.65
1984	3.15	0.58	0.34	0.046	0.06	0.01	0.17	0.13	1.47	0.34	0.63
1985	3.34	0.44	0.35	0.098	0.08	0.04	0.25	0.28	1.34	0.34	0.66
1986	3.43	0.22	0.45	0.072	0.12	0.01	0.25	0.26	1.33	0.35	0.66
1987	2.99	0.17	0.42	0.16	0.14	0.01	0.22	0.18	1.14	0.33	0.55
1988		0.59	0.81	0.14	0.22	0.02	0.26	0.50	1.38		
average 80-87 (AS)	3.65	0.55 or 15.1%		0.06 or 1.6%		0.02 or 0.5%	0.22 or 6.0%	0.37 or 10.0%	1.45 or 39.7%	0.35 or 9.6%	0.65 or 17.8%

[a] based on the National Accounts

[b] this excludes the costs of animal weight loss (see section on milk).

Table 12: Social use value of communal rangeland (constant 1990 prices: Pula/ha)

Year	Total Value/Ha (As Prices)	Sales/Slaughter-Beef		Sale/Slaughter Goat		Sales/Slaughter Sheep (Fms)	Draught Power	Manure	Milk[c]	Hunting[a]	Gathering
		Fms	As	Fms	As						
1980	3.63	0.09	-0.10	0.03	0.03	0.03	0.32	0.71	1.57	0.37	0.70
1981	4.15	-0.03	0.06	-0.01	-0.01	0.01	0.29	0.89	1.85	0.37	0.69
1982	2.35	-0.06	-0.40	0.04	-0.02	-0.01	0.19	0.16	1.41	0.36	0.66
1983	2.45	-0.37	-0.50	0.04	0.03	0.02	0.25	0.20	1.45	0.35	0.65
1984	2.08	-0.47	-0.71	0.02	0.04	0.01	0.17	0.13	1.47	0.34	0.63
1985	2.21	-0.74	-0.83	0.08	0.06	0.03	0.25	0.28	1.34	0.42	0.66
1986	2.38	-0.82	-0.59	0.06	0.11	0.01	0.25	0.26	1.33	0.35	0.66
1987	2.29	-0.52	-0.27	0.15	0.13	0.01	0.22	0.18	1.14	0.33	0.55
1988		-0.29	-0.07	0.13	0.21	0.02	0.26	0.50	1.38		
average 80-87 (AS)	2.77[b]	-0.31 or 11.1%		0.05 or 1.8%		0.01 or 0.4%	0.22 or 7.9%	0.35 or 12.6%	1.45 or 52.4%	0.35 or 12.6%	0.65 or 23.5%

[a] based on the National Accounts

[b] average calculated over the column averages. The average of the second column is P2.69

[c] this excludes the costs of animal weight loss.

Table 13: Results of sensitivity analyses for outputs of domesticated animals

Output	Change In Assumption	Change In Particular Use Value (Average 80-87)	Change In Total Use Value/ Ha. (Average 80-87)
Cattle: sales and meat	1. *price* (BMC price instead of AS price)	up from P0.55 to P1.44 (private); up from P-0.31 to P0.25 (social)	up from P3.65 to P4.54 (private); up from P2.77 to P3.33 (social)
	2. *age of animals sold* (3 instead of 5 years)	up from P0.55 to P1.26 (private) and from P-0.31 to P0.58 (social)	up from P3.65 to P4.36 (private) and from P2.77 to P3.66 (social)
Goats: sales and meat	1. price (BMC price instead of AS price)	up from P0.06 to P0.10 (private)	up from 3.65 to P3.69
	2. age (2 instead of 3 years)	up from P0.06 to P0.08	up from P3.65 to P3.67
Sheep: sales and meat	1. price (BMC price instead of FMS price)	no change	no change
	2. age (2 instead of 3 years)	no change	no change
Draught power	cost of draught power (10% and 30% of draught power charges resp.; instead of 20%)	10% costs: up from P0.22 to P0.24 30% costs: down from P0.22 to P0.21	up from P3.65 to P3.67 down from P3.65 to P3.64
Manure	1. kraaling rate	insensitive up to a drop to 20% of animals kraaled	no change up as long as kraaling rate exceeds 20%
	2. grain prices (BAMB prices instead of rural retail prices)	down from P0.35 to P0.19 (BAMB prices) or P0.22 (FMS prices)	down from P3.65 to P3.49 (BAMB prices) and P3.52 (FMS prices)
	3. yield impacts of manure	up from P0.35 to P0.43 (50% increase), to P0.51 (75%) and P0.58 100% yield increase)	up from P3.65 to P3.73 (50%), P3.81 (75%) and P3.88 (100% yield increase)
Milk	1. *milking frequency* (90 and 150 days instead of assumed 120 days)	90 milking days: P1.09 120 milking days: P1.45 150 milking days: P1.81	value down to P3.29 same value value up to P4.01
	2. *cost increase/lower milk price (prod. costs rise to 60% of milk price)*	down from P1.45 to P0.96	value down to P3.16 (private)

Italics in column 2 indicate a large sensitivity.

With respect to *wildlife*, we considered the impacts of special game licenses, illegal hunting and different meat prices. The figures in Table 11 and 12 may include special game licenses but probably seriously underestimate illegal hunting; both are entirely excluded from Table 8. No reliable data exist to estimate the amount of special game license hunting and poaching. Poaching has been estimated at 65% of legal hunting (FGU, 1988). Assuming that poaching affects all species proportionally[23], the use value of wildlife would increase. The use value would increase considerably. However, the species sustainability as official hunting quota are set at regeneration level. A sensitivity analysis was also carried out for the price of bush meat. Retail prices of game meat vary in Gaborone from P20/kg (impala and kudu) to P40/kg (ostrich). Doubling of the game meat price to P4/kg only had a minor impact on the results. The use value is much more sensitive for trophy prices as they represent the bulk of the product value. Trophy prices are determined by local supply conditions and the international demand/willingness to pay.

Based on tables 11-13, the following may be concluded:

Total land productivity

The aggregate annual land productivity fluctuates considerably. The average private use value of one hectare of communal rangeland in the period 1980-1987 was P3.65; the social use value/ha over the same period was P2.77. Taking into account data uncertainties, it appears reasonable to assume that the total land productivity during this period was in the range of P3.00 to P5/ha (private) and P2 to 3.50/ha (social).

These figures are low compared with the few international data available mentioned in the introduction. For example, the estimate is less than half of the income *losses* due to rangeland degradation estimated by UNEP (1992). As pointed out earlier, the latter figure is a very rough global average, which cannot be easily applied to individual countries. Our estimate is in the same range as the crude cost estimate of rangeland degradation for Namibia (P2.50/ha) and Ghana (P4.50/ha). The apparent low estimate may be due to the drought period, and is therefore below the long term average. A post-drought assessment is necessary to determine productivity recovery and resilience after droughts.

Assuming that the total productivity of Botswana's rangelands is not less than that of Namibia's rangelands and that rangeland degradation poses similar problems in both countries, it may be inferred that the "potential" rangeland productivity could be in the range of P6-8.50. Productivity losses due to rangeland degradation and drought would be substantial (20 to 40%). It is likely that current land use patterns have altered the total productivity and that of individual components. Because of the brief period covered in the study and the impacts of drought, it has not been possible to assess the long-term trend in land productivity. However, we found evidence of a clear trade-off between wildlife use values and livestock values. Looking at the wildlife use values derived from hunting quota, it appears that a rapid decline occurred, which was not matched by a proportional increase in livestock use values.

Although the total productivity estimate is primarily based on actual uses, it may contain some elements of potential use values. Sales and slaughter are actual use values, but draught power,

[23] It is probable that the incidence of poaching is higher among high value species.

manure and milk contain a component of potential use value. While it has been demonstrated that there is potential draught power to plough the entire country, in reality roughly half the area is ploughed by animals; the other half represents the potential draught power value. This implies that out of the estimated use value of P0.22/ha for draught power, P0.17/ha is actual use value with the balance potential use value. Given the data paucity for manure and milk it is impossible to indicate the magnitude of actual and potential parts. Wildlife and gathering use values are based on actual, mostly subsistence, use values, but the figures are probably underestimates because of poaching and unrecorded uses. It is important to note that the estimates hardly include the substantial potential for commercial use of both resources, which is only beginning to be tapped. Therefore, the use value of wildlife and gathering can be substantially increased. This implies that *the potential total land productivity may be raised if the increase in wildlife/gathering use values outweighs any resulting decline in livestock productivity*. This question should be pursued at the national level, but is probably most relevant in the western and northern parts of the country. Judging from land rentals, wildlife utilisation could yield substantially higher yields than livestock.

Composition of use values

Livestock represents the bulk of the use value (around 70%), whilst wildlife and gathering account for roughly 30%. Cattle represents high use value primarily through milk and to a lesser extent sales and meat. It must be recognised that as the costs of livestock production are entirely deducted from meat and sales, the use value of meat and slaughter is underestimated, and that of other livestock uses overestimated. Nonetheless, it becomes clear that milk should be up-graded to a primary product, and its potential should be better exploited, particularly in the proximity of large villages/towns. Manure and draught power are less important but nonetheless significant sources of output. Gathering has a higher use value than sales and slaughter of cattle. Goats remain of limited value, but there has been a rapid increase during the 1980s. Sheep have a minimal use value/ha (P0.02 in 1987). The value of draught power and manure is significant but subject to substantial interannual fluctuations due to rainfall (through the area ploughed and the yields).

The decline in wildlife numbers is not reflected in the use values derived from the National Accounts, but the process is evident from the analysis of hunting quota, which reveals substantial loss of use value (Table 8). The modest increase in use value after the 1980s drought is encouraging. The use value based on opportunity costs (eg. market prices, meat value) would yield double to nine times the use value calculated using license fees.

Trade-offs between value components

Within the livestock sector, trade-offs exist between meat production and sales on the one hand and milking and draught power on the other hand. Increased use of animal draught power and milking adversely affects the animal quality and price. There is also a trade-off between livestock values, wildlife -and probably veldproduct- values. The inverse relationship which exists between livestock and wildlife density implies that wildlife values rapidly decrease with livestock encroachment.

Options to enhance rangeland use values

Several options have emerged to increase the rangeland use values. The point of departure should be the available resources in rangelands. There is considerable variation especially with respect to wildlife, veldproducts and water availability. In areas with abundant wildlife, expansion of human activities could lead to substantial capital losses, which adversely affect future use values. Therefore, options to improve rangeland use values include emphasis on wildlife utilisation and increasing exploitation of non-consumptive wildlife utilisation. The potential could be increased by temporary hunting bans, restocking and proper land use planning. In livestock dominated areas, rangeland values could be increased by diversification of livestock products, in particular development of a dairy sector, and the exploitation of the remaining wildlife and veldproduct opportunities.

Interannual changes/drought impact

The temporal fluctuations in estimated use value reveal a significant drought impact. Drought adversely affects total land productivity/ha, which declined from P4.16 in 1981 (start of the drought) to P2.99 at the end of the drought in 1987 (private). The most drought susceptible livestock uses appear to be: cattle meat and sales, draught power, manure and to a lesser extent milk. Using a conservative estimate of P1.5/ha productivity losses due to drought, private use losses due to drought could be at least in the range of P35 to 50 million per annum; cf. an increase in value added of the traditional livestock/crop production from P106.4 mln in 1986/87 (last year of a drought period) to P213.5 mln in 1987/88 (after drought; source: National Accounts). Wildlife is also affected by drought as evidenced by the modest recovery of the product value in the 1990s.

Difference between private and social use values

Private use values exceed the social ones on average by 32% during the period 1980-1987. The discrepancy between the two is largest in the livestock sector for cattle sales and meat. The causes of diverging private and social use values are: veterinary services, water costs, labour and land rent. Data were too limited to differentiate between private and social wildlife and gathering use. Given the absence (gathering) or lower (wildlife) subsidies, the difference between private and social values is expected to be small for wildlife and gathering.

Spatial variation in use values

Substantial spatial differences exist in total productivity and productivity composition. Generally, primary biomass production and also secondary biomass production is positively correlated with rainfall. Therefore, one would expect use values to increase along the rainfall gradient running from southwestern Botswana (250 mm) to the northeastern parts (up to 650 mm). The rainfall gradient is also relevant for the use value of draught power and manure (which has been restricted to eastern Botswana in this study because other regions are hardly suitable for staple food crops).

The following physical and socioeconomic factors may lead to variations in this general trend.

1. livestock diseases in northern Botswana have restricted livestock production. For example, around three hundred thousand cattle were recently killed in Ngamiland district in an effort to eradicate cattle lung disease. Livestock values are dominant in the eastern part, but spreading into the west and the northern parts.

2. population and cattle densities in eastern Botswana have reduced the remaining habitat for wildlife. As a result, larger species have virtually disappeared. Valuable wildlife resources are mostly found in western and northern Botswana.

3. some valuable wild plants/trees only occur in certain parts of the country. The most important ones are:
   a. the mophane worm in the north
   b. the grapple plant in the western sandveld
   c. the mokola palm found around the Okavango

   Therefore, it is expected that these areas would have a higher use value for gathering.

Different importance of use value components

For half the households which do not own cattle, "their" value of rangelands must be much lower, ie, confined to smallstock, wildlife and gathering. The break down in value components provides some insights into the value differences between population groups. The average private use value for the low-income groups (ie, those without cattle) appears to be at maximum P2.03 (private use value average for 1980-87) or roughly a third of the value for livestock holders (medium and high income groups). Equity concerns also relate to wildlife use and gathering. It is argued that safari hunting represents a larger use value than citizen hunting, but this does not take the distribution of benefits into account. The value of rangeland differs by income category. The value of an average hectare of communal rangeland is different for a subsistence hunter, a small cattle owner and a large cattle owner.

Conclusions And Recommendations

The estimates presented in this report must be interpreted with caution. They are at best indicative of the rough value of each component. At the same time, the sensitivity analyses showed fairly robust results in terms of order of magnitude. Therefore, the figures presented are believed to provide a reasonable indication of the total and sectoral use value/ha of rangelands.

There is a considerable "hidden harvest" from rangelands, both within the livestock sector as well as in wildlife and gathering. Rangelands derive their value from livestock, wildlife use and gathering, each of which generate marketed and non-marketed outputs. Research and policy should pay much more attention to these multiple uses and outputs. The discrepancy between private and social use value of livestock products indicates that government subsidies have made the livestock sector artificially attractive, leading to its expansion. This has adversely affected wildlife numbers and use value, but this study was unable to clearly assess whether the total land productivity has increased or decreased (the drop in wildlife use value is also drought related).

Priority areas emerging from this study include milk production and processing and balancing wildlife, livestock and wild plants. With regard to development planning and economic diversification, the key policy question is how to increase total land productivity in a sustainable way. It appears that rangeland degradation may have substantial productivity losses (compare Namibia and Botswana); drought also causes substantial temporary productivity losses.

Although it is not the primary goal of this study to make policy recommendations, a number of recommendations emerge:

1. Rangeland policies must cut across traditional sectoral lines and incorporate the main uses (livestock, wildlife and vegetation) and outputs. This requires frequent inter-ministerial collaboration. In addition to livestock and wildlife policies, there is an immediate need for a ‘gathering policy’.

2. It is important to assess the comparative advantages of each usage in the different parts of the country. Without such an analysis it appears very difficult to justify the substantial livestock subsidies in view of the other important uses and outputs. In particular, the trade-off between wildlife and livestock must be studied carefully. Livestock expansion may have led to a drop in total use value of land, in areas where wildlife use values have become marginal. The trade-offs probably apply mostly to the north and western parts of the country.

3. Government efforts to promote the outputs should reflect the relative importance of each output and activity. There appears to be a clear need to increase the efforts of the Ministry of Agriculture with respect to milk production (given the potential use value), and smallstock (given the growing numbers). Another area for attention is the intensification of linkages between livestock and crop production, particularly in Eastern Botswana (manure, draught power). For the department of Wildlife and National Parks, it is important to explore the

implications of changes in species composition (eg. steenbok and duiker instead of wildebeest and hartebeest) for use options.

4. Resource charges and fees appear inconsistent and confusing. The study found that the land rents were lowest for TGLP ranches (P0.04/ha) followed by hunting fees (P0.05/ha) and the much higher land rentals by safari operators in the north. If charges reflect the ability to pay, one must conclude that wildlife has comparative advantages in large parts of the communal areas (hunting and safari operators). It is more likely, however, that TGLP land rents are artificially low, leaving a larger part of the resource rent for the companies or individual farmer. However, the enormous difference between the TGLP rent and the rentals paid by safari operators in the north strongly suggest that wildlife has a comparative advantage over cattle. There is need for a systematic approach towards resource charges based on the general principle of the "user-pays" but balancing equity, efficiency and sustainability.

5. There appears to considerable scope to increase the use value of wildlife and gathering through safari hunting, multiple wildlife use etc. In such cases, it is critical to ensure that direct and/or indirect benefits accrue to the local population.

6. Growing resource scarcity does not only raise efficiency and sustainability concerns. Increasing scarcity is also likely to lead to a more skewed distribution of the remaining use value. Examples include the domination of livestock related use values and the increasingly skewed distribution of the remaining wildlife resource in western Botswana (the benefits to outside leisure hunters equal those of the 1,000 local subsistence hunters). The on-going review of the hunting fees is very important in this respect. It is probably time to raise hunting fees to a level where leisure hunting is limited to small numbers (with much larger benefits through tendering or auctioning). Obviously, special consideration should be given to the low income groups.

Four major research issues emerge from the study. The study needs to be up-dated as soon as post drought agricultural data become available. This would provide valuable information about productivity recovery and economic resilience of rangelands. There is a need for production cost data on livestock, wildlife and gathering. Proper cost-benefit studies need to be carried out distinguishing private and social costs. Examples relate to livestock and wildlife production costs and specific issues such as the costs to the herd of using cattle for draught power or of diverting milk for human consumption. More research is needed into the external costs of each rangeland use and the compatibilities between different uses (at different levels of use intensity). At present, these can be pointed out, but hardly be incorporated. Finally, it is imperative to repeat this exercise for the major ecological regions (eg. the north, the east and the west). This would provide further insights into the comparative advantages of each use.

Appendices

Table A.1: The impacts of different prices on the annual use value (slaughter + sales) per ha of communal rangeland (constant prices 1990)

Year	Annual Private Output/Ha (As Prices)	Annual Private Output/Ha Fms Prices	Annual Private Output/ Ha Bmc Prices	Annual Social Output/ Ha As Prices	Annual Social Output/ Ha Fms Prices	Annual Social Output/ Ha BMC Prices
1980	0.85	1.04	1.82	-0.06	0.13	0.91
1981	0.93	0.85	2.00	0.10	0.01	1.16
1982	0.56	0.90	1.77	-0.36	-0.02	0.85
1983	0.51	0.63	1.58	-0.46	-0.03	0.62
1984	0.34	0.58	1.46	-0.67	-0.44	0.13
1985	0.35	0454	1.30	-0.79	-0.70	0.17
1986	0.45	0.22		-0.55	-0.78	
1987	0.42	0.16	1.16	-0.23	-0.48	0.52
1988	0.81	0.59	1.94	-0.03	-0.25	1.10
averag e	0.58	0.62	1.63	-0.34	-0.29	0.54

Table A.2: The impact of cattle age on private use value (sales + slaughter) using AS and BMC prices (constant 1990 prices)

Year	Annual Output/Ha As Prices + 5 Year Old Animals	Same But 4 Year Old Animals	Annual Output/A Bmc Prices + 5 Year Old Animals	Same + 4 Year Old Animals
1980	0.85	1.44	1.82	2.11
1981	0.93	1.24	2.00	2.31
1982	0.56	0.87	1.77	2.08
1983	0.51	0.83	1.58	1.90
1984	0.34	0.63	1.46	1.44
1985	0.35	0.80	1.30	1.75
1986	0.45	0.81		
1987	0.42	0.62	1.16	1.37
1988	0.81	1.03	1.94	2.16
average	0.58	0.92	1.63	1.89

Table A.3: Impact of cattle age on social use value (sales + slaughter) using AS and BMC prices (constant 1990 prices)

Year	Annual Private Output /Ha As Prices + 5 Year Old Animals	Same + 4 Year Old Animals	Annual Private Output/Ha Bmc Prices + 5 Year Old Animals	Same + 4 Year Old Animals
1980	-0.06	0.39	0.91	1.36
1981	0.10	0.54	1.16	1.61
1982	-0.36	0.11	0.85	1.32
1983	-0.46	0.02	0.62	1.09
1984	-0.67	-0.21	0.13	0.60
1985	-0.79	-0.25	-0.17	0.71
1986	-0.55			
1987	-0.23	0.06	0.52	0.81
1988	-0.03	0.33	1.10	1.47
average	-0.34	0.12	0.54	1.12

Table A.4: Impact of yield increase variations on manure value/ha. of rangeland (average for 1980-1988; in Pula/ha constant 1990 prices)

Yield Increase	Manure Value/ Ha. Retail Prices	Manure Value/Ha Fms Prices
no increase	0	0
12.5% increase	0.33	0.20
25% increase (standard scenario)	0.39	0.24
50% increase	0.45	0.28
75% increase	0.53	0.33
100% increase	0.61	0.38

Table A.5: Estimated retail price of grain (Pula/kg; actual prices)

Year	Average Rural Maize Price (P/Kg)	Average Rural Sorghum Price (P/Kg)	Sorghum/Maize Production (Metric Tonnes)	Average Weighed Rural Grain Retail Price (P/Kg)
1980			27170 / 885	
1981			26500 / 16415	
1982			3700 / 3500	
1983			4445 / 4005	
1984			5170 / 100	
1985	0.51	0.66	11785 / 735	
1986	0.54	0.67	11330 / 1910	0.57
1987	0.59	0.68	11135 / 215	0.68
1988	0.59	0.70	69340 / 4840	0.69
1989	0.62	0.71	34930 / 9765	0.69
1990	0.65	0.79	19180 / 4280	0.75
1991	0.59	0.81		
1992	0.86	1.07		
1993	0.97	1.23	10797 / 2976	1.17

Sources: compiled from Statistical Abstracts and Agricultural Statistics.

References

Abel, N., Flint, M., Hunter, N., Chandler, D. and Maka, G. 1987. *Cattle Keeping, Ecological Change and Communal Management in Ngwaketse*. Ministry of Agriculture, ILCA, Ethiopia.

Adams,M., Devitt, P., Gibbs, D., Purcell, R. and White, R. 1990. *Botswana Western Region Study. A Review of the Development Potential of Kgalagadi and Ghanzi Districts*. Mokoro Ltd, Oxford, UK.

Arntzen, J.W. 1989. *Environmental Pressure and Adaptation in Rural Botswana*. Ph.D Thesis, Centrale Huisdrukkerij, Vrije Universiteit, Amsterdam.

Arntzen, J.W., Chanda, R., Musisi-Nkambwe, Ringrose, S., Sefe, F.T.K. and Van der Post, C. 1994. *Desertification and Possible Solutions in the Mid Boteti River Area*. Report prepared for the INCD and the Ministry of Agriculture.

Arntzen, J.W. 1995. *Economic Valuation of Rangelands in Botswana: an Exploration of the Options and Requirements*. Paper presented at the CREED workshop on Valuation Methods, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.

Arntzen, J.W., Fidzani, H. and Tacheba, G. 1996. "Communal Rangelands in Botswana: Less Subsistence, More Commerce and Fewer Beneficaries." In E.Odada et al (eds). *Global Change and Subsistence Rangelands in Southern Africa: the Impact of Climatic Variability and Resource Access on Rural Livelihoods.* pp. 85-99. CGTE Working Document No.20.

Arntzen, J.W. and Fidzani, N.H. 1997. "Incentives for Sustainable Natural Resource Management and Economic Diversification in Botswana." Draft report to the Botswana Nat.Conservation Strategy Agency. Botswana University.

Ashley, C. 1996. *Wildlife, Tourism, Communities and Resource Economics: Experiences in Namibia*. Directorate of Environmental Affairs, Ministry of Environment and Tourism, Namibia.

Ashley, C. 1996. *Incentives Affecting Biodiversity Conservation and Sustainable Use: the Case of Land Use Options in Namibia*. Research Discussion Paper No 13. Directorate of Environmental Affairs, Ministry of Environment and Tourism, Namibia.

Barnes, J. 1993. "Alternative Uses for Natural Resources in Botswana: Wildlife Utilisation." In Brothers et al. *ibid., pp.323-336*.

Barnes, J. 1995. "Economic Analysis of Community-based Wildlife Utilisation Initiatives in *Development of Southern Africa* 12(6): 783-803.

Bishop, J. et al. 1994. *Beer and Baskets: the Economics of Women's Livelihoods in Ngamiland, Botswana*. Sustainable Agriculture Proramme Research Series 3(1). International Institute for Environment and Development, London.

Blaikie, M.J. 1982. *Improved Productivity from Livestock Production in the Communal Areas of Zimbabwe*. Working Paper 82/2. Department of Land Management, University of Zimbabwe.

Boitumelo, W.S. 1993. “Peri-urban Smallscale Dairy Research Programme in Botswana.” In J.A. Kategile and S.Mubi (eds). *Future of Livestock Industries in East and Southern Africa*. ILCA, Ethiopia.

Brothers, S., Hermans, J. and Nteta, D. (eds.) 1993. *Botswana in the 21st Century*. Botswana Society.

Carl Bro Int. 1982. *An Evaluation of Livestock Management and Production in Botswana with Special Reference to Communal Areas*. Ministry of Agriculture, Gaborone.

Coneybeare, A. and Rozemeijer, N. 1992. *Game Ranching in Botswana: an Assessment of the Game Ranching Potential of Eight Controlled Hunting Areas*. Department of Wildlife and National Parks, Gaborone.

Convery, F. 1995. *Applying Environmental Economics in Africa*. World Bank Technical Paper No 277. The World Bank, Washington, DC.

Fidzani, N.H. 1993. *Understanding Cattle Offtake Rates in Botswana*. Ph.D thesis, Boston University, USA.

Fidzani, N.H.,.Makepe, P. and Tlhalefang, J. 1996. *The Impact of Trade Liberalisation on Botswana's Beef and Maize Sectors*. Report prepared for BIDPA, Gaborone.

FGU/Kronberg. 1988. *The Contribution of Wildlife to the Economy of Botswana*. Special Report No 7 to the Department of Wildlife and National Parks, Gaborone.

FGU/Kronberg. 1988. *Review of Wildlife Utilisation in Botswana and Proposals for the Development of Projects and Programmes in this Field*. Special Report to Department of Wildlife and National Parks, Gaborone.

FGU/Kronberg. 1988. *Wildlife Industry Support in Botswana in the Context of Selected Production Economics Studies. Special Report No 8* to Department of Wildlife and National Parks, Gaborone.

Goodstein, E.B. 1995. *Economics and the Environment*. Prentice Hall, London..

Herbert, 1992. *Kraal Manure*. Agricultural Research Bulletin, Ministry of Agriculture.

Hubbard, M. 1986. *Agricultural Exports and Economic Growth: a Study of Botswana's Beef Industry*. KPI, London/New York.

ILCA. 1991. *A Handbook of African Livestock Statistics*. Working Document No 15. ILCA, Addis Ababa.

Kay, L., 1981. *Wildlife Market Survey report on the Present and Potential markets for Botswana's Rurally Produced and Potentially Produced Game Products*. New World Consultants, Gaborone.

Kgathi,D.L., 1988. The Grapple Plant Trade in Botswana. *Botswana Notes and Records, 20, 119-124*.

Kreuter,U.P. and J.P.Workman, 1994a. Costs of Overstocking on Cattle and Wildlife Ranches in Zimbabwe. *Ecological Economics 11, 237-248*.

Kreuter,U.P. and J.P.Workman, 1994b. Government Policy Effects on Cattle and Wildlife Ranching profts in Zimbabwe. *Journal of Range Management* 47, 264-269.

Litschauer, J.G. and Kelly, W.F., 1981. *Traditional Arable Practices*. Ministry of Agriculture.

Mars, G.C.H., 1996. *The Value of the Veld*. Ministry of Agriculture, Division of Land Utilisation, Gaborone.

McDonald,I., 1980. *Handbook of Livestock Statistics 1980*. Ministry of Agriculture. ILCA, Ethiopia.

Mmopelwa, G. 1995. *The Role of Farming Practices in Soil Conservation: the Case of Mogobane, Botswana*. MSc thesis, Agricultural University of Norway.

Millar, C. undated. *Environmental Impact Assessment of Increased Sustained Harvestnbg of Botswana's Veldproducts.* Report prepared for Veldproducts Research, Botswana.

Moruakgomo, M.B.W. 1994. *Commercial Utilisation of Botswana's Veldproducts: the Economics of Phane Trade*. Thusano Lefatsheng.

Motsomi, A.M. 1983. *An Analysis of Council Livestock Boreholes in Kgatleng District*. NIR Research Notes No 12. University of Botswana.

Odell, M. 1980. *Planning for Agriculture in Botswana: a report of the Arable Land Survey*. IDM/ Ministry of Agriculture, Gaborone.

Parry, D.C. 1989. *The Wildlife Management Areas of Botswana*. MSc thesis, Dept. of Biology, University of Zimbabwe.

Pearce, D., Whittington, D., Georgiou, S. and Moran, D. 1994. *Economic Values and the Environment in the Developing World*. Report to UNEP, Nairobi.

Perkins, J. 1991. *The Impact of Borehole Dependent Cattle Grazing on the Environment and Society of the Eastern Kalahari Sandveld*. Ph.D dissertation, University of Sheffield.

Rampete, P. 1996. *Livestock Expansion and Changes in Multiple Use of Communal Rangelands in Botswana: the Case of Mosolotshane Communal Areas*. MSc dissertation, Dept. of Environmental Science, University of Botswana.

de Ridder, N. and Wagenaar, K.T. undated. *A Comparison of the Productivity of Traditional Livestock Systems and Ranching in Eastern Botswana*. ILCA, Addis Ababa.

Quan, J., Barton, D. and Conroy, D. 1994. *A Preliminary Assessment of the Economic Impact of Desertification in Namibia*. DEA Research Discussion Paper No 3. Windhoek.

SMEC/Knight Piesold. 1992. *Botswana National Water Master Plan Study*. Department of Water Affairs, Gaborone.

Tailor, F. and Moss, H. 1982. *Final Report on the Potential for Commercial Utilisation of Veldproducts.* Ministry of Commerce and Industry.

Turner, R.K., Pearce, D. and Bateman, I. 1994. *Environmental Economics: an Elementary Introduction*. Harvester/Wheatsheaf, London.

Tyler, G.J. 1996. *The Contribution of Community-Based Wildlife Tourism to Botswana*. Report prepared for IFAD.

PUBLICATIONS AND ORDER FORM

Beginning with No. 17, full copies of CREED papers may be downloaded from the CREED Web site free of charge. Please visit the english abstracts page to connect to the full paper at:

http://www.iied.org/creed

The following papers are available from the CREED Programme. Please check the publications you wish to obtain and return the order form to Jacqueline Saunders, Environmental Economics Programme, IIED, 3 Endsleigh Street, London WC1H 0DD, or email your requests to Jacqueline.Saunders@iied.org.

Paper Nos. 1-16 may be obtained free of charge. Starting from No 17 onwards, **a charge of £5 plus postage, will be levied for northern readers only**. Copies may be downloaded free as Adobe Portable Document Files (PDF) from our Website as indicated above.

***CREED* Working Paper Series**.

- ☐ **No 1. Adjustment Policies and the Environment: A Critical Review of the Literature.** Carlos E.F. Young and Joshua Bishop. July 1995.
- ☐ **No 2. Environmental Regulations as Trade Barriers for Developing Countries: Eco-labelling and the Dutch Cut Flower Industry.** Harmen Verbruggen, Onno Kuik and Martijn Bennis. July 1995.
- ☐ **No 3. Economic Incentives for Watershed Protection: A Report on an Ongoing Study of Arenal, Costa Rica.** Bruce Aylward, Jaime Echeverría and Edward B. Barbier. September 1995.
- ☐ **No 4. Economic Policies for Sustainable Water Use in Thailand.** Ritu Kumar and Carlos Young. June 1996.
- ☐ **No 5. The Informal Sector and Waste Paper Recovery in Bombay**. Pieter van Beukering, Edwin Schoon and Ajit Mani. June 1996.
- ☐ **No 6. Economic Trends in the Timber Industry of the Brazilian Amazon: Evidence from Paragominas.** Steven Stone. July 1996.
- ☐ **No 7. Input Substitution in the Indian Paper Industry: A Variable Cost Function Approach**. K.V. Ramaswamy, R.R. Vaidya, M.J. Bennis and J.G.M. Hoogeveen. July 1996.
- ☐ **No 8. Poverty and Environmental Degradation: A Literature Review and Analysis.** Anantha Duraiappah. October 1996.
- ☐ **No 9. Valuation and Evaluation of Management Alternatives for the Pagbilao Mangrove Forest.** Ron Janssen and Jose E Padilla. October 1996.
- ☐ **No 10. The Economic and Environmental Impacts of the Waste Paper Trade and Recycling in India: A Material Balance Approach.** Pieter van Beukering and Anantha Duraiappah. November 1996.
- ☐ **No 11. Incentives for Eco-efficiency: Lessons from an Evaluation of Policy Alternatives; A Case Study of the Steel Sector in India.** Ritu Kumar, Nick Robins, A.K. Chaturvedi, R. Srinivasan and J. Gupta. December 1996.

☐ **No 12. Poverty and Environment Linkages in Mountains and Uplands: Reflections on the 'Poverty Trap' Thesis.** Sanjeev Prakash. February 1997.

☐ **No 13. The Economic Importance of Wild Resources in the Hadejia-Nguru Wetlands, Nigeria.** Derek Eaton and Marie-Thérèse Sarch. May 1997.

☐ **No 14. Economic Valuation of Mangrove Ecosystems: Potential and Limitations.** Frank Spaninks and Pieter van Beukering. July 1997.

☐ **No 15. The Use of Environmental Functions to Evaluate Management Strategies for the Pagbilao Mangrove Forest.** A.J. Gilbert and R. Janssen. August 1997.

☐ **No 16. Trends and Issues in the Plastics Cycle in China, with Special Emphasis on Trade and Recycling.** Pieter van Beukering, Li Yongjiang, Zhao Yumin and Zhou Xin. December 1997.

☐ **No 17. Economic Valuation of Communal Rangelands in Botswana: A Case Study**. Jaap Arntzen. February 1998.

☐ **No 18. Environmental Product Measures: Barriers for South-North Trade?** Harmen Verbruggen, Onno Kuik, Martijn Bennis, Hans Hoogeveen, Roland Mollerus. March 1998.

Please check the papers you wish to obtain and use this form to provide details for delivery/to indicate a change of address/to be added to the mailing list to receive information about future CREED Working Papers (please tick as appropriate).

Name

.....

Organisation

.....

.

Address

.....

.....

.....

.....

For Northern based readers only: if paying for papers (No 17 onwards):

I enclose a cheque for *£.....made payable to **IIED**/I authorise you to debit my credit card for £..... My Access/Visa/Mastercard number (please tick as applicable) is:

□□□□□□□□□□□□□□□□

Expiry date..... Name of cardholder.....

Cardholder address.....

* For postage within the UK please add 80p per paper
For postage to Europe please add £1.40 per paper
For postage to the rest of the world, please add £2.00 per paper

A programme of Collaborative Research in the Economics of Environment and Development (CREED) was established in 1993 as a joint initiative of the International Institute for Environmentand Development (IIED), London, and the Institute for Environmental Studies (IVM), Vrije Universiteit, Amsterdam.

The ultimate goal of CREED is to enrich the knowledge base and widen the debate on sustainable development by strengthening research capacity in environmental economics and policy analysis in developing countries. This is achieved primarily through collaboration on research projects, information exchange and dissemination involving initially IIED, IVM and counterparts in developing countries.

The CREED working paper series provides a new channel to disseminate the results of research projects, as well as other articles relevant to CREED themes. A particular aim of the series is to enable rapid diffusion of research results, including work in progress, to a worldwide audience. All articles have been reviewed by leading experts in the economics of environment and development. Any comments from readers would be welcomed.