Economic returns and allocation of resources in the wildlife sector of Botswana

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Wildlife utilization in Botswana was studied to find out (1) whether it generates positive contributions to national income, and (2) which combinations of uses can generate most income. Financial and economic models of different land uses were combined in linear programming and cost–benefit analyses. Results show that the wildlife resource in Botswana can contribute positively to national income, and this justifies government investment in the sector. The sector is economically efficient, and contributes to Botswana's economic development. Wildlife uses need to be fully developed in ways that maximize their economic contributions. Non-consumptive tourism on high-quality wildlife land will give the greatest economic returns, and should get priority. Safari hunting, community-based wildlife use (where viable), and limited intensive ostrich and crocodile production should also be given priority for investment. Other uses should get lower priority, but all should be developed. On about a third of wildlife land, wildlife uses have a clear economic advantage over livestock uses. The remaining two thirds of wildlife land has poor capacity to generate use value. Here, commercial livestock ranching is not an economic threat, but traditional livestock keeping is. A ban on consumptive wildlife uses in Botswana would significantly exacerbate this threat.

Key words: economic efficiency, wildlife sector, wildlife utilization.

INTRODUCTION

Botswana has a substantial and generally healthy wildlife population. The government aims to promote the use of this resource for development while ensuring their good conservation and no loss of biological diversity (Government of Botswana 1986, 1990). A land use and legislative policy framework has been created to this end and, during the 1990s, the Botswana government invested fairly significant resources in the wildlife sector. The challenge facing the government is one of ensuring that these investments achieve the best returns in terms of conservation and development. In this study, wildlife utilization in the country was investigated to find out whether it does or can contribute positively and sustainably to the national income. Also examined was the way in which different wildlife uses can be combined so as to maximize the generation of income, and so justify investments in the sector. Data from around 1991 and 2000 were used. The results were used to assess the sustainability of the wildlife sector in the face of threats from competing land uses. The results were also used to assess the likely effects of policy changes, such as a ban on the consumptive use of wildlife, which might be recommended by some.

Some 227 000 km^2, or 39% of Botswana's surface area, has been allocated to wildlife. Almost half of this is protected as national parks and game reserves, in which wildlife is protected and used through non-consumptive tourism. The remainder is designated, as 'wildlife management areas' in which wildlife utilization is promoted as the predominant form of land use. Outside this formal wildlife land, some private and communal land is also used for wildlife conservation and utilization. Collectively, all the land allocated to wildlife can be referred to as the 'wildlife estate'. Stewardship of the wildlife resource falls to the government through the Department of Wildlife and National Parks, which invests in its preservation, while permitting regulated use of it by individuals, communities and private investors. Centralized management of the resource has not been very successful, so that in recent years there have been moves to entrust communities and private elements with wildlife management and use rights at local level.

Most of the wildlife estate embraces flat Kalahari

sand environments with a paucity of surface water, low soil fertility, and mean annual rainfall ranging from 250 mm in the southwest, to 600 mm in the northeast. *Acacia* spp. dominate tree and shrub savanna in the drier southwest, while towards the north, broad-leaved tree species such as *Terminalia sericea* and *Burkea africana* become more common. Wildlife commonly includes desert-adapted plains game such as gemsbok (*Oryx gazella*), springbok, (*Antidorcas marsupialis*), hartebeest (*Alcelaphus buselaphus*) and blue wildebeest (*Connochaetes taurinus*). A few high-value species such as lion (*Panthera leo*), leopard (*Panthera pardus*), eland (*Taurotragus oryx*) and locally giraffe (*Giraffa camelopardus*) occur, but generally wildlife populations occur in low densities and are widely and opportunistically nomadic. Sparsely distributed pans and fossil river courses provide some scenic variation, but generally the terrain is monotonous. Wilderness is a dominant attribute.

In the north of the wildlife estate, higher rainfall and permanent surface water, in the Okavango Delta and the Kwando, Linyanti, and Chobe Rivers permits a much more diverse and abundant wildlife resource. Here, species such as elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*), hippopotamus (*Hippopotamus amphibius*), giraffe, lion, and leopard occur with many species of plains game, including high-valued sable (*Hippotragus niger*), tsessebe (*Damaliscus lunatus*) and roan (*Hippotragus equinus*) and specialized wetland species such as sitatunga (*Tragelaphus spekei*) and lechwe (*Kobus leche*). Scenic value is relatively high with wetland and riparian habitats interspersed with *Acacia* spp., *Colophospermum mopane, Baikaiea plurijuga* or other-species savanna and woodland. The Makgadikgadi pans system in the central parts of the wildlife estate is characteristically intermediate between the lower quality Kalahari and the biologically richer northern parts.

Aerial surveys showed that in the Kalahari and central pans environments, during the early 1980's, large declines in wildebeest and zebra (*Equus burchelli*) populations occurred, mainly due to severe drought and displacement by livestock. Since 1986, twice a year, almost without a break, Botswana has broadly monitored wildlife numbers throughout the country. Gibson (1995) described results from this aerial monitoring programme. Between 1986 and 1994 there were no significant trends in the populations of most species, but a significant increase in the elephant population and declines in the buffalo, sitatunga, lechwe and hippopotamus populations were detected.

Utilization has involved centrally-managed licensed hunting by citizens, and the lease of safari-hunting and wildlife-viewing lodge/tourism concessions to private sector operators on public land. There has also been some product processing in the form of tanning and crafts production, limited intensive ostrich (*Struthio camelus*) and crocodile (*Crocodylus niloticus*) production, and limited extensive game ranching on private land.

METHODS

During the course of a review of wildlife utilization (FGU-Kronberg 1988), a preliminary list of feasible wildlife use activities for the sector was developed using a screening process. Here, all possible products that could be derived from wildlife in the country were screened for suitability in the context of the natural resource base, the social environment, the business environment, national development policy, land-use policy, and the legislative framework. This process led to a short list of some 10 wildlife use categories, most of which were being practised at the time, and these were studied in more detail, to assess their financial and economic characteristics. Budget and expanded cost–benefit investment models were developed for representative examples of each of these use categories.

The models consist of detailed spreadsheets, based on empirical data gleaned through detailed interview of actual wildlife use operations (n = 11), through examination of business plans for wildlife use enterprises (n = 27), and through examination of financial statements from existing wildlife use enterprises (n = 70). The data were collected between 1988 and 1992, and financial values in models were inflated or deflated to 1991 prices. The models measured *financial* profitability (annual net income, financial rate of return, financial net present value) for each activity from the point of view of the user or investor. They also measured economic efficiency (annual contribution to gross and net national income, *economic* rate of return, economic net present value) for each activity, in economic (or shadow) prices.

Specific uses (sub-sectors) examined included wildlife-viewing tourism, safari-hunting tourism, community-based use of wildlife, game ranching, intensive ostrich and crocodile farming/ranching,

elephant culling and wildlife product processing. Also examined, as a competing form of land use, was livestock ranching. Barnes (1998a) provided detailed descriptions of all these models. They are also described in varying detail elsewhere. Wildlife-viewing tourism and safari-hunting models were described by Barnes (1991, 1992a). Models for community-based wildlife use were described in Barnes (1995). Wildlife and livestock ranching models were described in Barnes & Kalikawe (1994) and Barnes (1994). Crocodile ranching and farming models were described in Barnes (1992b), and those for ostrich production were described in Barnes (1996a). Elephant utilization models were described briefly in Barnes (1996b). Recent enhanced, updated and new versions of these models have been developed by Barnes, Cannon & Morrison (2000) for wildlife-viewing tourism, community-based wildlife use, livestock ranching and traditional livestock production in northern Botswana.

Models were designed to be typical, and representative of the relevant sub-sector, as it occurs or might occur spatially. The price structures used were those considered representative of long-term conditions. For example, the models for intensive production of ostrich and crocodile included slaughter prices rather than the short-term prices for live sale, which were higher but have since collapsed.

The focus of this paper is on *direct use* value, as it fits within the concept of '*total economic value*' as described by Pearce & Turner (1990). Total economic value embraces direct use, indirect use, and non-use (option, bequest and existence) values associated with natural resources. Direct use values are derived from actual *utilization* of the resource. They contribute tangible value in the form of *income,* and make up the main component of formal economic growth, which is the focus of national development efforts. I measured direct use value through the static and dynamic spreadsheet models.

From the static budget models, the primary economic measures of interest are *gross* and *net national income* (GNI and NNI), as defined by Gittinger (1982) and Pearce (1986). These are the returns in gross and net value added to factors of production owned by Botswana nationals. NNI is GNI minus annual capital asset depreciation. In economic analysis the economic cost, or benefit, to society, of using or producing a resource is taken to be its opportunity cost (the value of its best alternative use). The data are based on financial transactions, but where financial prices differ significantly from opportunity cost, then shadow pricing is applied. The gross value added and net value added measures thus represent opportunity cost and gauge *economic efficiency,* unlike the statistical measures of national income presented in national accounts.

The dynamic direct use value models measured financial and economic *internal rates of return* and *net present value* using five- and ten-year net benefit flow (cost–benefit) analysis. Here, interest and inflation were excluded from all calculations and real discount rates are used. All capital expenditures were included and depreciation (or appreciation) was accounted for in the residual value of assets in the final year of analysis.

Shadow pricing, aimed at ensuring that values applied to inputs and outputs reflect their opportunity cost or real scarcity in society (rather than simply market prices), was applied in all economic analyses. The criteria were based on those used in the past by the Ministry of Finance and Development Planning to appraise applications within the Financial Assistance Policy (FAP) grant programme (Ministry of Finance and Development Planning 1986; Matambo 1988). The approach is similar to those described in manuals developed for South Africa (CEAS 1989) and the World Bank (Gittinger 1982).

The Botswana economy has been relatively open, with few price distortions, and in many cases market prices fairly reflect opportunity cost. A few shadow pricing adjustments were necessary. Domestic transfers such as taxes and subsidies, were eliminated as costs or benefits. Taxes included licence and permit fees, Botswana Meat Corporation (BMC) levies, entry fees for protected areas, hunting licences, land rentals, resource royalties (payable to local communities) and sales tax (only present in 2000). Subsidies included those for livestock activities, including certain inputs, and cross-subsidies in transport and in BMC grade prices. The price of slaughter livestock was enhanced through access to the subsidized European Union beef market. Since this was a transfer from outside the country, and was not considered fungible (had no opportunity cost), it was treated as a contribution to national income and not a subsidy in the economic analysis. Projects for the community-based use of wildlife had subsidies provided by donors from outside the country. These, however, were considered fungible, with

opportunity costs, and they were treated as costs in the economic analysis.

A general shadow price for unskilled and semi-skilled labour of 0.5 of the market price was applied in all models to reflect general unemployment and social pressure for higher wages. A foreign exchange premium of 10% was added to the prices of all tradable items in the economic models, to account for general excess demand for traded and tradable goods and services. Cost and benefit flows were discounted over time to reflect the time value of money. The discount rates used for the economic models were 6% in 1991 and 8% in 2000. These accorded with Ministry of Finance and Development Planning recommendations (Matambo 1988). In the economic analyses, inflows from, and outflows to, non-nationals are treated as benefits and costs, respectively. Also in the economic models for basic activities, land opportunity costs were excluded. This allowed direct comparison between model results regarding returns to land. The economic models for basic activities also did not include central government expenditures in the wildlife and agricultural sectors.

In the financial dynamic models, discount rates used in base cases were 12% in 1991 (including a 6% risk premium) and 8% in 2000. In static financial models, interest and amortization costs were included in the calculation of net cash income (financial profitability). Rates for long-term loans of 10% in 1991 and 18% in 2000 were assumed. Rates for short-term loans of 15% in 1991 and 27% in 2000 were used.

All models were tested through sensitivity analysis, by varying key assumptions to determine how robust the models were, and the strength of conclusions that can be drawn from the results. The extent to which financial returns differed from the economic ones was used to provide a measure of the influence of policy and/or market imperfections, as described by Jansen, Bond & Child (1992).

Allocation analysis involved the development of simple linear programming models. These were aimed at maximizing the gross national income and economic net present value generated within the wildlife sector. They were made in the context of the current land use framework for the wildlife estate (parks, wildlife management areas, communal land, private land and state land), and within the broader policy framework prevailing at the time. The model was configured to use different assumptions about the availability of capital, labour and management resources over time. Because the backward and forward linkage effects and multiplier effects (indirect and induced effects) for different wildlife uses were considered to be small, and similar between uses, it was not necessary to include most of them in the model. Only one forward linkage, product processing in the form of tanning enterprises, was included. The basic linear programming model is depicted in Appendix 1.

Linear programming maximizes (or minimizes) a linear function of variables that are subject to linear inequalities which must assume non-negative levels. Commonly the function to be maximized, the objective function, consists of the sum of income or net income from a combination of several activities. The linear inequalities, or constraints, are arranged as an input–output matrix of coefficients, representing the resources or constraints consumed or supplied per unit of activity. The computation begins with a situation where all resources are idle, and involves a logical iterative procedure introducing new activities and changing the levels of activity of previously introduced activities. Each iteration results in a new solution with an increase in total income or net income and this continues until no more positive gains can be made.

Linear programming models have the advantage over non-linear optimization models in that data requirements can be limited to activity/enterprise models such as those applied in this study and a knowledge of the resource constraints for the activities involved. They have been used widely in agricultural planning (Barnard & Nix 1979; Doll & Orazem 1984; Epplin & Stoecker 1989). A limitation of the method is the necessary assumption that production functions are of fixed proportion and do not permit input substitution. Design and interpretation of the model needs to take account of this.

Representative examples of the financial and economic models for wildlife-viewing tourism, safari-hunting tourism, community-based wildlife use, game ranching, cattle ranching, ostrich farming, crocodile farming/ranching, elephant cropping, and wildlife product processing/craft manufacture were used in the model, set up in a Quattro-Pro version 2 computer spreadsheet system. A spatial analysis of the extent of land suitable and available for each activity was made to incorporate the land constraints. The data from the wildlife sector review were used to determine the dimensions of the other constraints to the activities.

The model maximized an objective function with ten activities, within a set of 24 constraints with *capital* as the *numeraire.* The constraints could be divided into those that were relatively rigid and easily delineated, and those that were expandable and less easily determined. Rigid constraints included, for example, availability of factors such as suitable land/habitat, feed, initial stock, stock 'on-the-hoof', raw materials and sustainable off-take quotas. Effectively, the supply of these items in the model was assumed to be perfectly price-inelastic. The expandable and indeterminate constraints were capital, labour and management. Supply of these was, in effect, assumed to be perfectly price-elastic. Since capital, labour and management tend to be linked, they were varied (increased) simultaneously as part of the sensitivity analysis on the model. This sensitivity analysis brought an element of dynamism to the analysis. The framework of constraints was that which would affect expansion of activities over a 15-year period. Because some of the products tend to be price-inelastic (Barnes 1996c), and because price responses were not included in the model, any expansion of activities was assumed to be dependent on growth in *overall* demand. Rates of expansion were adjusted accordingly. The model was run to maximize both annual *gross value added* and economic *net present value.* It was run with combinations of *all* wildlife uses, and combinations including *non-consumptive* uses only.

For *analysis of returns to public investment* in the sector, the projected expansion of capital and recurrent expenditures for the Department of Wildlife and National Parks in the seventh National Development Plan or NDP7 (Ministry of Finance and Development Planning, 1991) were used. Projected expenditures for six years from 1991 were extracted from the plan and extrapolated using various rates and patterns of growth over 15- and 30-year periods. These cost streams were compared with the anticipated *incremental* flow of *net value added* from the use of wildlife (and livestock) on land designated for wildlife use. These different land uses were distributed in combinations found to maximize income (above). They were also distributed spatially in accordance with implementation of land-use allocation plans (N.D. Hunter 1992, pers. comm.) and wildlife and tourism policies (Government of Botswana 1986, 1990). They were expanded over time in accordance with the anticipated growth in *overall* demand for their products (so that expansion did not change prices).

In the case of wildlife viewing, a mean of comparable tourism growth rates recorded by others, including Brown, Turner, Hameed & Bateman *(*1995), Ceballos-Lascuráin (1993), Blaza (1996), J. Scheepers (1996, pers. comm.), Bond (1996) and Ecotourism Society (1995), was used to predict growth. The mean annual growth rate was 12.5%. Rates of growth in demand for the products of other land uses were subjectively determined, based on observed trends. These rates ranged between 3% and 6% per annum.

As stated above, the measure of benefits embraced mostly net value added resulting from *first round* spending. Except for some product processing, value added associated with indirect and induced impacts, was not included. It was assumed that unutilized potential and slack capacity would be fully exploited in 15 years, after which any expansion of land uses would be dependent on new market development and/or intensification.

Because of uncertainty regarding government expenditure patterns, these were subjected to sensitivity analysis. In the base-case model it was assumed that, after year six, annual capital expenditures would not increase while recurrent expenditures would rise by 4% per annum. A 'low-cost' model involved recurrent expenditure growth of 2% per annum after year six, while 'high-cost' models set this growth at 6% and 8% per annum. The 8% high-cost projection represented continued NDP7 growth rates. The analysis was done involving either *all* wildlife use or only *non-consumptive* wildlife use.

RESULTS AND DISCUSSION

The different wildlife use activities, along with cattle ranching, were found to have widely differing characteristics with regard to their financial profitability, economic efficiency, and their efficiencies and requirements for resource use. Some of this variability is depicted in Table 1, which shows base-case financial and economic internal rates of return over ten years for different activities. For land uses which involve tourism in the high-quality northern areas of the country, economic rates of return are consistently much higher than financial ones.

For land uses in the less well endowed parts of the country, rates of return tend to be lower, and economic returns tend to be only slightly higher than financial ones. With cattle ranching and crocodile farming, the financial rates of return are

Table 1. Comparative results from financial and economic cost–benefit models for typical wildlife/rangeland use enterprises in Botswana (1991 prices).

Wildlife/rangeland use	Measure of financial or economic worth			
	Internal rate of return (over 10 years)		Economic net present value (pula, at 6% over 10 years)	
	Financial (%)	Economic (%)	Per square kilometre of land	Per P'000 initial capital
Wildlife viewing	18	28	10177	1551
Safari hunting	16	38	694	2230
Community use, high value[1]	26	67	589	5225
Community use, low value[1]	15	17	22	931
Game ranching	6	7	600	44
Cattle ranching	9	2	<0[2]	<0
Ostrich farming	18	19	2.3 million	950
Crocodile farming	18	11	2.6 million	525

[1]Community-based wildlife use projects in high- and low-quality areas.
[2]Net present value negative.

in fact higher than the economic ones. In the case of crocodile ranching this is due to the heavy reliance on tradable inputs (feed), the economic prices of which carry a foreign exchange premium. In the case of cattle ranching, it is due to the effects of subsidies.

Table 1 also shows economic net present values (over 10 years at 6% discount rate) per unit of land required, and per unit of initial capital for the activities with positive economic net present values). Where wildlife viewing is possible, it shows relatively high economic returns per km^2 of land. Community-based wildlife use projects in the less well endowed Kalahari region have particularly low economic returns per unit area (although higher than commercial cattle ranching which has a negative economic net present value). Intensive animal production systems (for ostrich and crocodile) require very little land. The economic net present value per unit of initial capital is relatively high for the land uses involving tourism in the north. Among the other land uses, game ranching shows up as being inefficient in use of capital.

Table 2 shows the intensity of capital use per unit of land required. As expected, this is very high for the intensive animal farming systems and product processing. It is low for safari hunting and elephant cropping, very low for community-based wildlife use and relatively high for game ranching, cattle ranching and wildlife viewing. Also in Table 2, the return in gross value added per unit of initial capital (efficiency of capital use) is high for community-based wildlife use projects in high-value areas. Capital use efficiency is low for cattle ranching, game ranching and product processing and it is moderate for the other activities.

Column four in Table 2 shows a measure of labour intensity, and this is particularly high for community-based wildlife use projects and product processing. These all represent community projects with a wide participatory base so the finding is to be expected. The last column in the table shows a measure of management intensity. Here, the community-based wildlife use projects and elephant cropping have high values while the wildlife farming and ranching activities have relatively low values.

Table 3 shows results of the base-case linear programming analysis. Here, the allocation of capital on wildlife land, which maximizes gross value added is shown. It is shown for all wildlife uses and cattle ranching, and where levels of capital, labour and management are varied. The availability, in 1991, of capital, labour and management was not known exactly but estimated at around levels '2' or '3' in the table. As the economy expanded over the following 15 years it was expected that levels '7' or '8' would be attained. This represented a rate of growth in availability of these resources of some 8%.

The results suggest that in the early years of expansion, emphasis should be placed on the rapid expansion of wildlife viewing and the intensive wildlife production systems, and that later on additional capital should be applied to safari hunting, better quality community-based wildlife use projects, and then to the other uses. By year 15, at level '8', further development was impossible

Table 2. Comparative resource use efficiencies and requirements for typical wildlife/ rangeland use enterprises in Botswana (1991 prices).

Wildlife/rangeland use	Measure of resource use efficiency and requirements			
	P'000 capital[1]/ square km	Gross value added[2]/ P '000 capital	Labour hours/ P '000 capital	Management hours/ P '000 capital
Wildlife viewing	6.6	462	50	4.2
Safari hunting	0.3	512	42	7.0
Community use, high value[3]	0.1	1066	115	17.2
Community use, low value[3]	0.02	418	235	35.3
Game ranching	13.8	137	7	1.4
Cattle ranching	7.6	95	13	2.6
Ostrich farming	2422.6	265	13	0.8
Crocodile farming	4884.9	378	20	2.4
Elephant cropping	0.6	660	44	10.9
Product processing[4]	2904.8	153	169	6.8

[1]Initial capital requirements in economic prices.
[2]Gross value added to the national income per annum.
[3]Community-based wildlife use projects in high- and low-quality areas.
[4]Medium-scale tanning enterprises.

given the constraints in the model. Any further development in the sector would be dependent on intensification, market development and increased stock or raw material availability. The results of a model developed to maximize economic net present value (not shown) suggested, more or less similarly, that investment priority should go to wildlife viewing, safari hunting, community-based wildlife use in better quality areas, and intensive ostrich production.

Table 4 shows the spread of net value added generated and the spread of land requirements for the different activities when they were allocated to maximize gross value added, as in Table 3. It shows these values with all land uses considered, and also with consumptive wildlife uses excluded (to test the effects of an hypothetical ban on consumptive use). Of interest is the finding that wildlife

Table 3. Optimal allocation of *capital* to maximize gross value added in all wildlife uses and/or livestock production on land allocated to wildlife in Botswana at different levels of availability of capital, labour and management (pula '000 000, 1991).

Constraint or land use	Level of availability of capital, labour and management							
	1	2	3	4	5	6	7	8
Capital (P '000 000)	50	100	150	200	250	300	350	400
Labour (no. '000)	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0
Managers (number)	100	200	300	400	500	600	700	800
Wildlife viewing	43	89	135	181	227	256	256	256
Safari hunting	–	–	–	–	–	6	12	12
Community use, high[1]	–	–	–	–	–	1	1	1
Community use, low[1]	–	–	–	–	–	–	2	3
Game ranching	–	–	–	–	–	–	9	9
Cattle ranching	–	–	–	–	–	–	16	53
Ostrich farming	–	–	8	12	15	29	44	44
Crocodile farming	7	7	7	7	7	7	7	7
Elephant cropping	–	–	–	–	–	–	1	1
Product processing[2]	–	–	–	–	–	–	2	2
Totals	50	96	150	200	249	299	350	388

[1]Community-based wildlife use projects in high- and low-quality areas.
[2]Medium-scale tanning enterprise.

Table 4. Optimal combinations of wildlife uses and/or livestock production, to maximize gross value added, on land allocated to wildlife in Botswana, showing the effect of inclusion or exclusion of consumptive use on values generated and land requirements (1991).

Wildlife/rangeland use	Measure of allocation between activities			
	Net value added[1] (pula '000 000)		Land requirements[2] (ha '000 000)	
	All possible activities included	Non-consumptive activities only	All possible activities included	Non-consumptive activities only
Wildlife viewing	93.5	92.5	3.9	3.9
Safari hunting	5.4	0.0	3.9	0.0
Community use, high[3]	1.3	0.7	1.2	0.6
Community use, low[3]	1.0	0.2	13.3	2.1
Game ranching	0.8	0.8	0.1	0.1
Cattle ranching	3.2	3.2	0.7	0.7
Ostrich farming	10.9	0.0	0.0	0.0
Crocodile farming	2.5	0.0	0.0	0.0
Elephant cropping	0.4	0.0	4.0	0.0
Product processing[4]	0.2	0.0	0.0	0.0
Total: wildlife only	116.0	94.2	26.4	6.7
Total: wildlife + livestock	119.2	97.4	27.1	7.4

[1]Net value added to the national income per annum (net value added is gross value added less depreciation).
[2]Includes very small amounts of land for ostrich/crocodile farming and product processing.
[3]Community-based wildlife use projects in high- and low-quality areas.
[4]Medium-scale tanning enterprises.

viewing would have generated 78% of the total economic value in the sector, but only made use of 14% of the land. Also of interest, is the fact that community-based use of wildlife on low-quality land would take up 49% of the land but would generate less than 1% of the economic value. The picture that emerges is that relatively small parts of the wildlife estate have very high economic value while other, much larger parts have very low value (for both wildlife use and cattle ranching)

The data in the table show that a policy in which consumptive wildlife use activities are excluded would result in a drop of some 19% in the potential economic contribution of the wildlife sector. This is a relatively small loss, due to the overall dominance of wildlife viewing. However, the exclusion of consumptive use would result in a drop of 74% in the amount of land required by the wildlife sector, and an 81% drop in the amount of land required for community-based wildlife use. This means that a large proportion of the wildlife estate would have no wildlife use value in the event of a ban on consumptive wildlife uses. Interestingly, this same proportion of land would also be likely to have low *non-use* values, as suggested by Barnes (1998b). The findings suggest that if all activities were fully expanded, all land on the wildlife estate would be used up, but that only 14 percent of this would generate more than P8/ha in net value added, and some 50% of it would generate less than P0.10/ha.

The results show that commercial livestock ranching has limited potential to compete economically with wildlife use on land allocated to wildlife. In Table 4, cattle ranching contributed less than 3% of the net value added, and occupied less than 3% of the land in the optimally allocated sector. The analysis included only *commercial* livestock production which is capital intensive and requires access to external markets. Unfortunately, traditional livestock keeping systems as land uses were *not* included, and the linear programming model is thus only a partial analysis. The products of traditional livestock keeping are varied and include milk, meat, draft power and 'store of value'. These are mostly non-market, or locally-marketed, products, and the capital requirements are low. Expansion of traditional livestock keeping is more suited to remote areas, and it is likely to be a threat to wildlife in those parts of the wildlife estate with low wildlife values. More recent work, listed in Table 6 below, shows this.

Table 5 shows the results of the 1991 economic cost–benefit analysis of public investment in the wildlife sector. The base-case costs involved planned government expenditure, which was the minimum considered necessary for the sector to be able to expand as anticipated. The other

Table 5. Economic returns[1] to public expenditure in the wildlife sector showing the effect of exclusion of consumptive wildlife uses and varying levels of expenditure (Botswana, 1991).

Case scenario	Measure of return to investment			
	Economic rate of return (%)		Economic net present value (pula '000 000)	
	15 years	30 years	15 years	30 years
All wildlife uses included				
Low cost[2]	6.37	18.43	3.1	434.3
Base case[2]	4.26	16.97	–13.8	348.6
High cost[2]	1.57	14.80	–32.5	234.9
Very high cost[2]	–[3]	10.72	–53.1	83.1
Non-consumptive wildlife uses only	–			
Low cost[2]		12.2	–68.2	205.0
Base case[2]	–	10.13	–85.1	119.3
High cost[2]	–	6.27	–103.8	5.6
Very high cost[2]	–	–	–124.4	–146.2

[1]Measured as first round, private sector, gross value added to national income.

[2]Cost streams follow planned new capital and recurrent costs for first six years of NDP7, thereafter capital expenditures are constant and recurrent costs rise at differing rates: base case = 4%, low-cost = 2%, high-cost = 6%, very high-cost = 8%.

[3]Rate of return is negative.

expenditure streams depicted slower or faster growth rates, which might have resulted if, for example, poaching pressures changed. Economic benefits in the model were the incremental gross value added contribution (i.e. excluding the values existing in the sector at the start of the analysis period). Livestock production was excluded from the model. After 15 years the sector would have expanded to produce incremental gross national income amounting to P117 million per annum. After 30 years, through market development and intensification, the incremental gross value added would have increased to P200 million. The effect that exclusion of consumptive wildlife uses would have had on the results is also shown.

A worthwhile economic return was not possible in 15 years, except marginally with the low-cost scenario, when all wildlife uses were included. In 30 years, acceptable returns were possible with all cost scenarios, except the very high cost one, where consumptive wildlife use was excluded. In the latter case, the return was marginally positive.

The cost–benefit analysis can only give an *idea* as to whether the existing and planned public expenditures on wildlife could result in economically profitable returns in terms of direct use values. The usefulness of the analysis is for comparison with other sectors, to which the public funds could be diverted. The inclusion of multiplier effects (in terms of carefully traced value added resulting from further rounds of spending) would result in higher measured returns, but unless this effect is different in other sectors, there would be no point.

The results suggest that anticipated growth in direct use values from wildlife will be sufficient to justify the public expenditures necessary to maintain the resource over a 30-year period. Only exclusion of consumptive uses and a high or very high costs scenario will preclude this. The sector can be considered *economically efficient,* especially, since likely multiplier effects and other values (indirect use and non-use) have still to be included in the benefits. It behoves Botswana to find ways to capture non-use values, so as to enhance the income earned from its wildlife resource. It also behoves Botswana to carefully plan its public expenditure in the sector, ensuring that development of utilization is optimal and that non-use values are not lost.

Table 6 shows selected results from more recent work on land use values in northern Botswana (Barnes *et al.* 2000). The results in Table 6 give important insights as to whether the allocations and returns indicated with the 1991 data, above, are still likely to be applicable in Botswana. The relative values between different land uses can be compared roughly with those for 1991 in Table 1, and the patterns remain generally the same. Wildlife viewing and community-based wildlife use in high-quality sites continue to have very high economic efficiency, which has been enhanced by international currency exchange rate movements. On the other hand, community-based use of wildlife

Table 6. Comparative results from base-case financial and economic models for wildlife and livestock land uses in Ngamiland, Botswana (pula, 2000).

Land use	Requirements for		Financial measures		Economic measures	
	land (ha)	capital (P/ha)	NCI/ha[1]	FRR[2] (%)	NVA/ha[3]	ERR[2] (%)
Wildlife						
Community use, low[4]	900 000	1.98	0.06	8.0	0.50	24.8
Community use, high[4]	80 100	14	0.76	8.1	9.70	54.1
Wildlife viewing	14 400	139	17.01	9.6	76.33	64.0
Livestock						
Cattle ranching	10 000	157	–4	2.9	–13.20	–[5]
Cattle post production	6 400	78	4	6.8	1.86	2.0
Small-scale cattle keeping	180	225	26	11.5	0.26	10.1

[1]Annual net cash income per hectare (financial profitability).
[2]Financial (FRR) and economic (ERR) internal rates of return over ten years.
[3]Annual net value added to national income per hectare (economic efficiency).
[4]Community-based wildlife use projects in high- and low-quality areas.
[5]Rate of return is negative.

at low-quality sites continues to have low economic efficiency. Livestock production has been analysed in more detail, and the results show that commercial cattle ranching is now likely to have no economic place at all in the relatively remote wildlife estate. However, traditional livestock systems, such as are found in the more settled parts and on cattle posts, although they have generally low economic efficiency, may well be able to compete with wildlife use in the extensive lower quality parts of the wildlife estate. Traditional livestock land uses were not included in the 1991 linear programming analysis.

Barnes *et al.* (2000) suggested that in the medium to long term the comparative advantages of livestock land uses can be expected to decline as international subsidies are phased out. They also pointed out that the comparative advantages of wildlife land uses can be expected to increase over time due to continuing rapid expansion in international tourist markets, increasing scarcity of wildlife elsewhere, and the development of markets to capture international wildlife non-use values as income.

Other evidence, not in Table 6, suggests that capital-intensive commercial game ranching has, and continues to have, low economic efficiency (Barnes & Kalikawe 1994; Barnes & de Jager 1996). Intensive commercial production of crocodiles appears to now have lower economic efficiency than that encountered in 1991, due to global oversupply. There is also evidence that intensive ostrich production is not as economically efficient as it was in 1991, due to looming market saturation.

The evidence above suggests that if the allocation analysis in Table 3, which involved data from 1991, was redone, using 2000 values and including all possible livestock land uses, the results would remain similar. They would show wildlife viewing to have strong comparative advantages in the higher quality parts of the estate. However, from the evidence in Table 6, it is not clear whether the large proportion of low quality wildlife land allocated to community-based use of wildlife (Table 4) would not be better allocated to low-input livestock keeping. Whether this is so or not will depend on future changes in the relative values and efficiencies of wildlife and livestock land uses in the Kalahari sandveld areas. In terms of livelihood generation, there is a tendency for these two land uses to be complementary (Ashley & LaFranchi 1997), although they are spatially mutually exclusive. Continued research into the marginal values at the interface of these land uses is called for.

The results above are based primarily on direct economic values. It is worthy of note that the findings on allocation may have been different if *indirect* and *induced* values, resulting from backward and/or forward linkages and multipliers, were significant and different for the wildlife and land uses. For example, if ostrich production caused the generation of very large amounts of value added in feed production or product processing, then these activities would need to be included with ostrich production in the analysis. As stated above, most indirect effects were found to be small

and similar between uses. Their inclusion would not have affected the findings.

CONCLUSION AND POLICY IMPLICATIONS

The wildlife resource in Botswana can contribute positively to national income, and this justifies government's ongoing investments in the sector. The sector has potential to be economically efficient, and thus to contribute positively to the economic development of the country. To ensure that this happens, wildlife utilization activities need to be fully developed in spatial and temporal patterns that maximize their economic contributions.

In the development of the wildlife sector, non-consumptive tourism on high-quality wildlife land will give by far the greatest economic returns. Investment in this sub-sector should get priority. On adjacent, fairly high-quality wildlife land, safari hunting and community-based wildlife use should be given priority for investment. Emphasis should also be placed on very localized intensive ostrich and crocodile production, within the constraints of feed and markets. Other uses should get lower priority but all economically efficient wildlife use opportunities should ultimately be developed as resources become fully utilized. These findings are fairly robust, and appear to have held throughout the 1990s. They should be subjected to ongoing evaluation.

Only about one sixth of the land allocated to wildlife in Botswana has the ability to generate high economic value from wildlife utilization. This includes land in and around the Okavango Delta, the northern riparian systems, and some pans. It is especially suited to wildlife-viewing tourism development. Another sixth of the land, mostly in wet-season wildlife dispersal areas, has moderately high economic use value for wildlife. Here, safari hunting and community-based use of wildlife, mainly through tourism and joint hunting ventures, have comparative advantages. On what is, thus, about one third of wildlife land, wildlife uses have a clear economic advantage over other land uses. Non-use values for wildlife are also likely to be high here.

The remaining two thirds of the wildlife estate has poor capacity to generate economic use values from wildlife. It is also likely to be associated with low wildlife non-use values. This includes most of the Kalahari sand environment, with its relatively low densities and diversity of wildlife, and featureless terrain. Here, commercial livestock ranching is not an economic threat, but rapidly expanding traditional systems of livestock keeping may well have economic advantage over wildlife-based land uses. Whether they do, or not, will depend on future changes in livestock, wildlife, and tourism markets, and on the non-use economic values associated with the land use options.

Consumptive wildlife uses are relatively unimportant in terms of economic contribution, but they are the only use values possible in the less well endowed two thirds of the wildlife estate. This portion of wildlife land faces an economic threat of conversion to livestock grazing land, and consumptive uses are vitally important to help ensure its future retention under wildlife. Thus a ban on consumptive use, as recommended by some, would seriously jeopardize wildlife conservation, already under threat from livestock expansion, in large parts of Botswana.

More research is required on the current and future marginal economic values of livestock and wildlife uses, especially in the lower quality wildlife areas. In addition, work is required on the current and future *non-use* economic values associated with these areas, and the wildlife estate as a whole. The degree to which wildlife land uses and wildlife non-use values can be harnessed to contribute, as income, to rural livelihoods is critical, and it should be central to future research.

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Appendix 1. The linear programming model of the wildlife sector in Botswana (1991).

Objective function to be maximized:												
[GVA]	Y =	462a +	512b +	1066c +	418d +	137e +	95f +	265g +	378h +	660j +	153k	
[ENPV]	Z =	1551a+	2230b+	5225c+	931d +	44e +	0f +	950g +	525h +	0j +	0k	
Subject to constraints:												
Capital	1a +	1b +	1c +	1d +	1e +	1f +	1g +	1h +	1j +	1k	≤	50 000
Labour[1]	50.2a+	41.8b+	115c+	235d+	7.17e+	12.9f+	12.9g+	20.1h+	43.5j+	169k	≤	2 940 000
Mgmnt[2]	4.18a+	6.96b+	17.2c+	35.3d+	1.43e+	2.58f +	0.81g+	2.41h+	10.9j+	6.75k	≤	196 000
Land a[3]	0.15a+	0b +	0c +	0d +	0e +	0f +	0g +	0h +	0j +	0k +	≤	38 371
Land b	0a +	3.22b+	0c +	0d +	0e +	0f +	0g +	0h +	0j +	0k +	≤	39 122
Land c	0a +	0b +	8.87c +	0d +	0e +	0f +	0g +	0h +	0j +	0k +	≤	11 981
Land d	0a +	0b +	0c +	41.5d+	0e +	0f +	0g +	0h +	0j +	0k +	≤	132 991
Land e	0a +	0b +	0c +	0d +	0.07e +	0f +	0g +	0h +	0j +	0k +	≤	62 800
Land f	0a +	0b +	0c +	0d +	0e +	0.13f +	0g +	0h +	0j +	0k +	≤	62 800
Land g	0a +	0b +	0c +	0d +	0e +	0f +	0.00g+	0h +	0j +	0k +	≤	4 774
Land h	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0.00h+	0j +	0k +	≤	3 000
Land j	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0h +	1.67j +	0k +	≤	1 500
Land k	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0h +	0j +	0.00k +	≤	2 000
Stock e[4]	0a +	0b +	0c +	0d +	1.61e +	0f +	0g +	0h +	0j +	0k +	≤	13 800
Stock f	0a +	0b +	0c +	0d +	0e +	0.95f +	0g +	0h +	0j +	0k +	≤	50 000
Stock g	0a +	0b +	0c +	0d +	0e +	0f +	0.09g+	0h +	0j +	0k +	≤	4 000
Stock h	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0.10h+	0j +	0k +	≤	800
Stock j	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0h +	57.7j +	0k +	≤	52 000
Feed g	0a +	0b +	0c +	0d +	0e +	0f +	442g +	0h +	0j +	0k +	≤	30 000 000
Feed h	0a +	0b +	0c +	0d +	0e +	0f +	0g +	191h +	0j +	0k +	≤	1 398 738
Mater j	0a +	0b +	0c +	0d +	0e +	0f +	0g +	0h +	0j +	13.0k	≤	22 572
Mar c,d[5]	0a +	0b +	87.5c +	25.7d +	0e +	0f +	0g +	0h +	0j +	0k +	≤	328 000
Market e	0a +	0b +	0c +	0d +	4.68e +	0f +	0g +	0h +	0j +	0k +	≤	88 000
Market h	0a +	0b +	0c +	0d +	0e +	0f +	0g +	2.05h+	0j +	0k +	≤	40 000

Where:	X	=	Aggregate gross value added to national income for sector
	Z	=	Aggregate economic net present value for sector
	A	=	Wildlife viewing
	b	=	Safari hunting
	c	=	Community-based wildlife use – high-value area[6]
	d	=	Community-based wildlife use – low-value area[6]
	e	=	Game ranching
	f	=	Cattle ranching
	g	=	Ostrich farming
	h	=	Crocodile farming/ranching
	j	=	Elephant cropping
	k	=	Product processing[7]

[1]Labour, measured in numbers of persons.
[2]Management, measured in numbers of managers.
[3]Land, measured in km^2, reflects the extent of suitable or available land/habitat.
[4]Stock constraint, in terms of limits to existing stock or availability of initial stock.
[5]Market constraint, in terms of limits to size of market.
[6]Community-based wildlife use projects in high-quality and low-quality sites.
[7]Processing, based on medium scale tanning projects.