5-4-2010

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Recommended Citation
Teweldmehidin, Mogos Y. and A. B. Conroy. The Economic Importance of Draught Oxen on Small Farms in Namibia's Eastern Caprivi Region. African Journal of Agricultural Research Vol. 5(9), pp. 928-934, 4 May, 2010

African Journal of Agricultural Research Vol. 5(9), pp. 928-934, 4 May, 2010
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2010 Academic Journals

Full Length Research Paper

The economic importance of draught oxen on small farms in Namibia's Eastern Caprivi Region

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Accepted 15 February, 2010

The main aim of this study was to analyse and document the value of smallholder farmers' use of Draught Animal Power (DAP) systems in the Eastern Caprivi Region and to test the economic viability of DAP usage versus using tractors. This study applied Rapid Rural Appraisal techniques (RRA), including a survey. Semi-structured interviews were conducted with 312 farmers at their farms and data was gathered on the use of and economics related to the draught animal system. Crop enterprise budgets, project reports, expert opinions and group discussions were analysed. The research found that the use of animal power performs better in terms of physical productivity per ha compared to tractor usage. Furthermore, Sibinda production guided by the oxen farming technique outperformed the other systems when it was evaluated with parametric analysis. From a financial perspective, Sibinda and Linyanti oxen farmers ranked above their counterparts using tractors. Further, the exercise indicated that farmers are facing a multitude of challenges such as damage incurred from wild animals and high input costs. It is difficult for a young generation to take up farming in Caprivi within the current cost-price squeeze environment. Therefore, it is crucial to increase the level of potential new farmers' production and management proficiencies through training and skills development programmes.

Key words: Animal drought power, rapid rural appraisal (RRA), participatory rural appraisal (PRA) techniques, oxen economic benefit.

INTRODUCTION

At the turn of this century, more than 300 million cattle were employed as draught animals around the world (Conroy, 2007). Even though the ox continues to grow in numbers and importance in sub-Saharan Africa, it has lost much of its importance in more developed regions of the world. In sub-Saharan Africa, sixty-five percent of the farms' power for cultivation is done by hand, twenty-five percent by draught animals and just ten percent with tractors (Sims and Kienzle, 2006). Tractor schemes have failed in many countries in Africa (Pingali, Bigot and Binswanger, 1987). Namibia is not an exception to this trend, especially in communal areas such as the Caprivi region. Oxen continue to be an important, yet overlooked power source (FAO, 2008 and Bishop-Sambrook, 2005). Communal farmers in Namibia and other countries face challenges such as a shrinking workforce due to HIV-AIDS, competition for cropland, rapidly rising food costs and ever-increasing petroleum prices, which make the use of tractors difficult (Bishop-Sambrook, 2003 and Matundu-Tjiparuro, 2008). All of these factors affect farmers' ability to produce food crops (Bishop-Sambrook, 2003). For the majority of farmers, livestock, particularly cattle, and draught oxen continue to be of great economic and personal value (Ashley and LaFranchi, 1997). Using oxen is appropriate when people are genuinely committed to using them. Without strong educational, moral and technical support, cultures unfamiliar with cattle fail to train and use the animals adequately (Mulanda et al., 2000 and Conroy, 2007). Even with such support, local capacity to maintain this technology must be encouraged from the beginning. People must be motivated to help each other to train, work and use their animals. Namibia has been doing exactly this through their Draught Animal Power Accelerated Programme (DAPAP). The DAPAP-2 programme put together a training manual using the

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same information (Mudamburi and Keib, 2007). All farmer trainers, users and potential users of oxen must understand both the limitations and the potential of draught animal power. Cattle are an economic burden. They require feed, water and security from theft, large predators and weather extremes. Buying an ox represents a substantial investment for a poor farmer. To lose an animal to disease or theft is a tremendous financial loss. Many farmers prefer hand labour to risking their few resources on a technology they do not understand (Conroy, 2007).

Cattle can be a drain on the resources of a small farm, especially when grazing land is limited or money is lacking for veterinary supplies (Conroy, 2007). Oxen are not the answer for all people trying to make improvements in their agricultural systems. However, they are used in great numbers in the Caprivi region and understanding the above challenges and constraints will help the farmers and the Government of Namibia to make appropriate choices and investments in this technology. The importance of oxen in providing power for agricultural development is often forgotten in areas that have adopted more modern forms of agricultural mechanicsation (Pingali et al., 1987 and Ashley and Christopher, 2000). Tractors achieve the greatest savings in time and labour, but at a great initial expense (FAO, 2008 and Sanders et al., 1996). Most farmers would like to benefit from tractor power, but this is often an unrealistic expectation for the rural, resource-poor farmers (Lawrence and Pearson, 2002). Tractors tend to be more appropriate for large-scale commercial farming (Bishop-Sambrook, 2005). Individual tractor ownership is seldom possible for farmers with small areas of cultivation (Ashley and LaFranchi, 1997 and FAO, 2008). The concept of 'modern technology' as the solution to farmers' problems has been vigorously promoted by both Namibia's pre- and post-independence politicians. Government tractor hire services, the subsidised sale of donated tractors and the purchase of tractors by businessmen-farmers, have all tended to reinforce the belief that draught-animal-powered technology is primitive (Ashley and Christopher, 1997). Draught animals are most appropriate for small farms and local transport.

For these reasons, the agricultural use of draught oxen is on the upswing in much of sub-Saharan Africa (FAO, 2008 and Sims and Kienzle, 2006). These important animals continue to assist people in eliminating poverty and creating wealth, by allowing people to more easily and quickly prepare plant and weed crop fields than with hand labour (Graaf, 1994 and FAO, 2008). Food distribution and rural trade are also enhanced through improved transport (Panin and Ellis-Jones, 1994; O'Neill, et al., 1999), while also saving women and children time and effort in moving water and wood for fuel (FAO, 2008). Finally, oxen also have many other values. For many rural people, cattle, especially oxen, are their most significant asset, serving many functions in addition to work-related ones. Oxen represent a renewable resource, well suited to small-scale farming and to local transport (Guthiga et al., 2007). The animals survive on local inputs and contribute to local food production with milk, meat, manure and offspring (FAO, 2008). The use of carts facilitates the marketing of produce and is important for carrying domestic water and fuel, thereby generating additional time that labourers can use for other productive tasks (Ashley and LaFranchi, 1997; Bishop-Sambrook, 2005). In addition, animal power requires little or no foreign exchange. Cash spent on tractors is exported from rural areas and the investment in machinery depreciates over time. In contrast, the money invested in draught animals remains within rural areas (FAO, 2008). While tractors can also bring numerous benefits (Bishop-Sambrook, 2005; FAO/UNIDA, 2008), draught animals are more readily available and affordable to people in rural areas, especially in Namibia's Caprivi region. Many farmers plough with oxen and then leave them idle for the remainder of the year (Bishop - Sambrook, 2005). Employing the animals in labour-saving and profitable ways often requires a new way of thinking, which, if adopted, makes greater harvests possible. The use of draught oxen is profitable when the animals are utilised efficiently. For example, when being used for double-cropping, weeding or for transport in addition to primary tillage, draught animals increase profits (Arriaga-Jordán et al., 2005; Guthiga et al., 2007). However, acquiring the implements needed for ploughing, weeding and transportation may be a larger constraint than acquiring, training and employing the animals (Pingali et al., 1987; Panin and Ellis-Jones, 1994).

The main objective of this research was to quantify the status of smallholder draught power production systems in Namibia, specifically in the Caprivi region, in order to generate information that will assist in designing appropriate draught animal development programmes aimed at poverty alleviation. As such, the research specifically compares the economic situations of resource-poor oxen- and tractor-using farmers in Namibia's Eastern Caprivi.

MATERIALS AND METHODS

Semi-structured interviews were conducted with 312 farmers at their farms in the Caprivi region to evaluate the economics of the draught animal system. A structured questionnaire was used to obtain further information on livestock production characteristics in the smallholder farming systems. The respondents were chosen on the basis that they were involved in animal draught power or used tractors and, further, on the basis that they 'typified' a group or represented diverse perspectives on the issue (Leedy and Armrod, 2000).

Respondents were selected using lists of households sup-plied by either the Agricultural Extension office and/or village heads as the sampling frames, according to the method proposed by Hedrick, Bickman and Rog (1993). Applying financial analysis techniques (mainly NPV, Cost Ratio and IRR) and crop enterprise budget and parametric analysis, the data was processed further to compare the economic differences between the oxen- and tractor- using farmers.

There are numerous factors that need to be considered to determine an economically viable unit. One way gross income

Table 1. Production cost of using oxen and tractor.

		Oxen			Tractor		
Variable cost	**Units**	**Unit price**	**Qty**	**Total**	**Qty**	**Unit price**	**Total**
Ploughing	person/days	52.37	1	52.37	1	52.37	52.37
Planting	person/days	14.24	1	14.24	1	14.24	14.24
Weeding	person/days	14.05	1	14.05	1	14.05	14.05
Seed	kg/ha	14	5	70	14	5	70
Hired labour (threshing, winnowing)	person/days	15	1.5	22.5	1.5	15	22.5
Bags	bags	4	12	48	12	4	48
Repair and maintenance	per head	4.29	2	8.58	1	120.5	120.5
Fuel and oil	per ha	0	0	0	1	461	461
Transport	per bag	20	1	20	1	20	20
Total variable cost				249.74			822.66

should be more than production (variable) costs plus fixed living costs and repayment of medium term. Creditworthiness of a farmer shows that he/she is able to borrow the required capital necessary to generate the expected gross income. Since Caprivi farmers are subsistence farmers, analysis of credit worthiness was not included in the model.

A Crop Enterprise Budget (CEB) is used to depict the economic viability (income minus production costs) of annual and perennial crops at a per hectare level. A sensitivity analysis is provided with a CEB to show the impact of a range of prices and yields on the Gross Margin (GM). A farming unit is financially feasible when: A Cash Flow Analysis (CFA) evaluates the financial viability over time, incorporating the initial investment into its potential earnings. A Financial Costs Benefit Analysis (F-CBA) evaluates financial viability of a farming unit over the long-term, discounting present values. The following indicators and criteria are used for summing up the results of both the financial and economic CBA. - Net Present Value (NPV) > 0 - Benefit Cost Ratio (C:B) > 1 – Internal Rate of Return (IRR) >Inflation (8% for government projects)

Analytical techniques for farm budgeting technique/parametric analysis

Before further analysis, it is very important to highlight the basic assumptions underpinning parametric/sensitivity analysis. The following assumptions apply to parametric analysis: 1. Production variables: the types and number of operations, land area cultivated (per ha) and cost of the operation when using oxen and tractor were based on the ADP manual and Drought Animal Power Acceleration Programme 2 (DAPAP-2) (Table 1). 2. Furthermore, to take inflation into account with respect to the fuel and petrol price, 40% of the price in the DAPAP-2 was added. 3. The parametric budget/ sensitivity analysis test was performed on three different prices: the NAD170 per bag price at farm level, the NAD200 per bag price at the Katima open market and the NAD250 per bag best price scenario (the average mass of the bag was assumed to be 50 kg). 4. Production was based on the average district yield (Table 3). 5. Seed price was based on the Dec 2008 market of Katima and is assumed to be NAD140 per 10 kg.

Farm enterprise budgeting technique/parametric analysis

The budget technique was used to analyse cost revenue and profitability of operations carried out using oxen or tractors. The farm budgeting technique used was the Net profit (Net margin) model. The Net margin is the difference between Total Revenue (TR) and Total Variable Cost (TVC), that is,

$$NM = TR-TC$$

Where:

TR = Total revenue from operation carried
TVC = Total cost of production (variable cost)
NM = Net margin

To evaluate the viability of the project, a 20-years planning horizon based on the estimated life of the tractor was applied. The farming technique viability was evaluated mainly based on NPV, Cost/Benefit ratio and IRR.

Study area and methods of analysis

The study was carried out in the Caprivi District of Namibia. This district is among those known to have the highest draught oxen populations in Namibia and animals are regularly used for transportation and agricultural crop production there. The region is also small and this enabled the study to be completed in the proposed timeframe. The purposive sampling technique was applied in selecting farmers in the district. The selected study areas were chosen with the help of veterinary officers, agricultural extension officers, field attendants, traditional leaders and people involved the DAPAP-2 programme. The main goal was to interview a variety of farmers employing draught animal power, from different representative villages in the region, as well as with varying levels of wealth. In addition to the qualitative analysis and descriptive statistics, an economic evaluation of draught animal power in the region was formulated using farms' production and inputs and outputs data. Farms were divided into tractor-powered and animal-powered farms and prices were gathered and/or assigned based on the cost of using either. The size and estimates of each farm's productivity was recorded. Based on the petroleum price escalation in recent months, cash flow was projected over 20 years. Each cash inflow/outflow is discounted back to its present value (PV) as follows:

$$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+r)^t}$$

Where:
t = the time of the cash flow;
N = the total time of the project;

r = the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk); Ct = the net cash flow (the amount of cash) at time t (for educational purposes, C0 is commonly placed to the left of the sum to emphasise its role as the initial investment). To evaluate further benefits, cost ratio was applied, which is calculated as: BCR = Present value of benefit/cost. This evaluation provided a basic model for the economic efficiency of draught oxen in the area as petroleum prices rise.

Assumptions in analysing financial viability

General assumptions

1. For the purpose of conducting cost benefit analysis, a comparison was drawn between oxen - and tractor- using farmers in the Caprivi region, focusing on the maize crop;
2. The learning curve is projected to be every two years, with a four-bag increment projected over the 20-year period;
3. For the purpose of analysis, the discount rate is assumed to be 6, 8 and 10% respectively, since the inflation rate in Namibia fluctuates from 6 to 10%;
4. Household consumption was assumed to be 1095 kg per year (or 21.9 bags per ha) for a family of six, based on Ashley and Lafranchi's findings (1997).
5. Production costs of the crops were estimated based on the production year 2008 because the animal draught power enterprise budget supplied was constant over 20 years.
6. The price of the maize was based on the 2008 Katima market price, which was NAD200 per bag (a bag being estimated at about 50 kg).

Assumptions for oxen farmers

1. It is assumed that farmers use four oxen for their farming, with a purchase price of NAD2500 per ox (according to information from the Likwama Co-operative Farmers' Union).
2. Farmers use the oxen for five years and sell them at NAD1333 at the end of the fifth year (based on the average data collected).
3. FCB has been done at farm level and at district level and the average has been converted to per ha, for reasons of comparison.
4. This study assumed the soil type in Eastern Caprivi is uniform.
5. Since fertiliser application is not included in this study, the assumption is that none of the farmers apply fertiliser.
6. To make the report more realistic, farms producing /*more than*/ 60 bags per ha are excluded from the analysis (that is, it is treated as irregular data). The analysis is based on information provided by the extension officers as well as on the average yield per hectare.
7. Even though Caprivi farmers produce different crops, for the sake of making comparisons in this report, only maize is taken into account.

Assumptions for tractor farmers

1. It is assumed that the mechanisation cost (tractor) is approximately NAD279 000 based on the Lubbes Auto Centre's tractor retail price as of 26/01/2009.
2. It is assumed that a loan has been secured from Agra Bank at 12.7% to buy a tractor, which will be paid off within a 10-year term, as per information telephonically obtained from Agra Bank (Hoveka, 2009).
3. The estimated life of tractor is 20 years (based on Agra Bank information).

RESULTS AND DISCUSSION

Farmers in this survey were asked about farm profitability, record-keeping and credit. Fifty-two percent (52%) said farm records were not important, with 64% of the farmers reporting that they knew their income and expenses. However, there were very few farmers who could show evidence of this. There are numerous factors which should be considered when determining an economically viable unit. Furthermore, to determine financial feasibility, additional factors need to be taken into consideration. There is also an economic analysis that looks at economic viability of a project as a whole. Creditworthiness of a farmer shows that he/she is able to borrow the required capital necessary to generate the expected gross income. Questions were asked in the survey about credit. Sixty-eight percent of the farmers stated that they would like to have access to credit, yet 47% said credit was not available, with another 47% saying access to credit was limited, largely because they held no title to land and had few other securities that were consi-dered worthy collateral for a loan. Only 6% of the farmers said credit was available to them, but most were reluctant to borrow money as the costs and risks were too high. Due to the limited number of farmers using credit or even having access to it, this was not taken into account in the model.

Parametric/sensitivity analysis

Two types of post hoc sensitivity analysis exist. With traditional threshold-proximity sensitivity analysis, once one has determined the optimal policy corresponding to one's best estimate of parameter values, one then varies parameter values across a reasonable range and observes whether any policy or price changes result. If policy/price changes occur only for parameter values far different from one's best estimates, then one can feel confident in recommending the optimal policy. Otherwise, it may be necessary to improve estimates by collecting more data, or resign oneself to that the optimal policy is a 'close call'. In a probabilistic sensitivity analysis (Doubilet et al., 1985; Critchfield et al., 1986; Hazen and Huang, 2006), the analyst assigns probability distributions to un-certain parameters and can thereby compute or estimate as a measure of robustness the probability of a change in the optimal alternative due to variation in an arbitrary number of parameters, or alternately, the expected value of perfect information regarding any set of parameters (Hazen and Huang, 2006). Table 2 summarises the optimal levels of gross profit (gross margin) of maize in different districts given the 2008 data, assuming the production costs given by DAPAP-2, and fitted it to the data and equated it to the profit formula. With the actual average yield and seed price in the study area, the optimal profit was achieved by Sibinda ox farmers (indicated in bold in Table 2 above), followed by tractor farmers in the Katima

Table 2. Parametric budget/sensitivity analysis for maize gross profit in rural constituencies of East Caprivi.

Parametric budget/sensitivity analysis of different selling price scenarios					
Constituency	Farm system	No. of respondents	Gross profit of different price scenarios		
			NAD170	NAD200	NAD250
Katima rural	Oxen	81	NAD765 ± 18	NAD943 ± 21	NAD1242 ± 26
	Tractor	7	NAD841± 89	NAD1134±10	NAD1624 ± 13
Kabbe	Oxen	79	NAD430 ± 12	NAD547±14	NAD746 ± 17
	Tractor	0	0	0	0
Sibinda	Oxen	55	NAD1503 ± 24	NAD1812 ± 28	NAD2328 ± 35
	Tractor	16	NAD553 ± 25	NAD796 ± 29	NAD1200 ± 37
Linyanti	Oxen	36	467 ± 18	594 ± 21	805 ± 27
	Tractor	1	-593	-552	-485

Rural constituency. However, there was no significant difference between the oxen farmers within the same district. While one Linyanti-based farmer's data regarding farming with a tractor showed a negative gross profit, from these exercises, it can be concluded that profit might depend on the farming area, management and also input/output prices. Furthermore, the damage from wild animals was not taken into account in this calculation, even though the majority of farmers indicated production problems existed because of the wildlife, particularly elephants.

Economic analysis

Table 3 (below) summarises the results of economic analyses. According to this table the most feasible interest rate was 6%. However, taking the current inflation into account, the rational discount rate is around 10%. Using a 10% discount rate as a yardstick to calculate the NPV average, farm sizes were converted to per ha profit and discounted to present value. Sibinda and Linyanti ox farmers were projected to be the most profitable farmers per hectare, showing NPV profits of NAD26 226 and NAD21 192 respectively, followed by Katima Rural (at about NAD15 858) and Kabbe (with NPV NAD8152) when it was discounted over 20 years with a cost ratio of 4.44 and 5.63 respectively. This implied that every NAD1 invested in Sibinda ox farmers is expected to generate a return of NAD4.44 per ha, as in other constituencies. The low performance of Kabbe was due to the fact that both the average yield and farm size were relatively small compared to the other constituencies' (the yield was 3.98 bags per hectare). Considering the economic viability analysis results in Table 1 - this is only done where projects are financially feasible - the Sibinda and Linyanti ox farmers were the most profitable when taking the wildlife threat to crops out of the equation. Taking inflation into consideration, all ox farmers would generate more than 40% IRR (with the exception of Kabbe at 22%), whereas tractor farmers are expected to yield around 17 and 56% at Katima Rural and Sibinda respectively from the long-run gross profit investment. Furthermore, taking a discount factor of 10% and using the whole farm size comparison, the most profitable group was the Linyanti ox farmers (Table 3 and Figure 1). The NPV for the Linyanti analysis of whole farms was calculated to be NAD416 630. Ranking second were the Sibinda tractor farmers, with an expected NPV for the whole farm of NAD249 144. Ranking third was Katima Rural ox farmers with an NPV of NAD85 475. Finally, ranked fourth were the farmers in Kabbe, with an NPV of NAD32 446. The per ha comparison showed that Sibinda and Linyanti farmers were more profitable constituencies, with NPVs of NAD26 226 and NAD20 431, respectively. The smaller farms, especially in Kabbe, did not perform as well. This implied that farmers with the ability to expand their farm size would be able to achieve higher profitability and contribute more toward improved food security for the country (Table 3 and Figure 1).

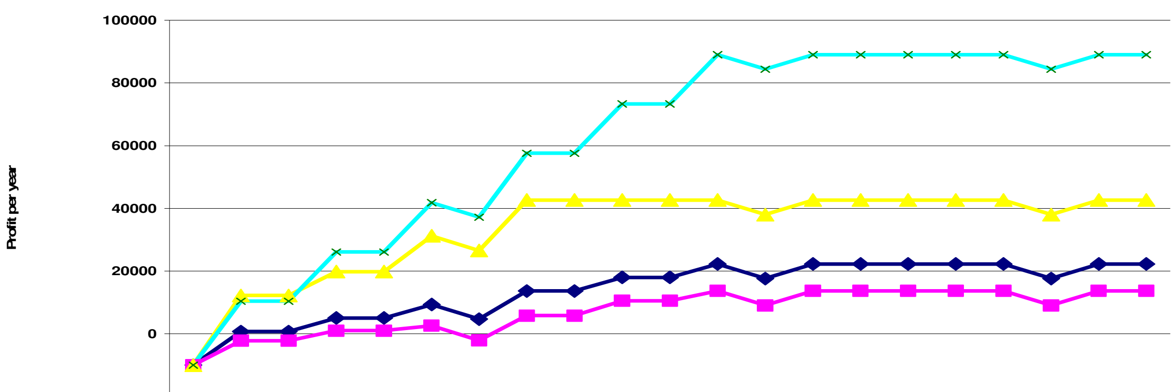
SUMMARY AND CONCLUSIONS

In East Caprivi, ox farmers from the Sibinda constituency outperformed farmers using tractors when using the parametric budget/sensitivity analysis for estimating rural constituencies' gross profit on maize (Table 1). Katima Rural's tractor farmers achieved a gross margin of NAD1624 and oxen farmers about NAD1242, which is not a significant difference. In Sibinda, oxen- and tractor-using farmers' gross margins were estimated at about NAD2328 and NAD1200 respectively, which means ox-using farmers achieved much more than tractor-using farmers. From a financial analysis perspective (Table 2), Sibinda and Linyanti ox farmers ranked first and second

Table 3. Summary of ox and tractor farmers' NPV, cost benefit ratio and IRR at different discount rates in rural constituencies of East Caprivi.

	Ox farmers						
	Net present value at farm size			**Cost benefit ratio**			**IRR**
Constituency	**6%**	**8%**	**10%**		**8%**	**10%**	**(%)**
Katima rural	25 230	19 922	15 858	2.64	2.49	2.34	43.89
Kabbe	15 109	11 145	8 152	1.76	1.65	1.53	22.60
Sibinda	38 150	31 447	26 226	4.83	4.63	4.44	139.45
Linyanti	32 024	25 899	21 192	6.09	5.75	5.43	137.30
			Tractor farmers				
Katima rural	15 670	10 803	7 177	1.51	1.39	1.28	17.33
Sibinda	28 619	22 724	18 214	2.60	2.42	2.27	55.95

Figure 1. Research area - Eastern Caprivi.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Katima rural	-10000	741.9	741.9	5054	5054	9366	4698	13678	13678	17990	17990	22302	17634	22302	22302	22302	22302	22302	17634	22302	22302
Kabbe	-10000	-2190	-2190	994	994	2586	-2082	5770	5770	10546	10546	13730	9062	13730	13730	13730	13730	13730	9062	13730	13730
Sibinda	-10000	12247	12247	19847	19847	31247	26579	42647	42647	42647	42647	42647	37979	42647	42647	42647	42647	42647	37979	42647	42647
Linyanti	-10000	10370	10370	26098	26098	41826	37158	57554	57554	73282	73282	89010	84342	89010	89010	89010	89010	89010	84342	89010	89010

Years

Figure 2. Comparison of potential profit using oxen, by constituency, estimated over 20 years.

based on a per hectare financial analysis. This implies that ox farming is financially feasible and economically viable from both parametric and financial analysis perspectives. This study showed that the best cost ratio performance was in Sibinda and Linyanti, with ox farmers at about 4.44 and 4.68, respectively. For example, the Sibinda cost ratio of 4.44 implied that investing NAD1 in oxen farmers would yield a return of NAD4.44, which was a strong indicator that ox farming was a sustainable farming power source for resource-poor farmers. This again did not take into account the land use conflict and crop risk associated with wild animals in estimating expected household needs. When ox farmers were compared to tractor farmers, the cost ratio of Katima Rural ox farmers and tractor farmers (when it was discounted to the present value) was 2.34 and 1.28, respectively. This showed that an investment of NAD1 would generate a gross margin of NAD1.34 per ha from ox farming whereas it would only generate about NAD0.28 from tractor farming. This was a very small margin with which to cover all the financial commitments of the household. However, this small margin could be due to high petroleum prices during the data collection period. The researcher assumed a constant price and cost and income from renting out a tractor was not included in the analysis. In addition, the benefit of time-saving was not included in the model.

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