

POLYTECHNIC OF NAMIBIA



THE USE, CHALLENGES AND ECONOMIC IMPORTANCE OF DRAUGHT OXEN ON SMALL FARMS IN NAMIBIA'S EASTERN CAPRIVI REGION



By Mogos Teweldmedhin, Lecturer at the Polytechnic of Namibia and Dr. Andrew B. Conroy, Professor of Applied Animal Science, University of New Hampshire (USA) and Fulbright to Polytechnic of Namibia in 2008
Department of Agriculture
School of Natural Resources and Tourism
Polytechnic of Namibia
P/Bag 13388, Windhoek

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TABLE OF CONTENT

Acknowledgements:	i
1.1 Introduction	2
1.2 - REVIEW OF LITERATURE.....	3
1.3 - FIELD RESEARCH METHODS AND MATERIALS	6
1.3.1 - Site selection:	6
1.3.2 - Methods.....	6
1.3.3 - Land use and Tenure	8
1.4 - HOUSEHOLD CHARACTERISTICS	10
2.1 INTRODUCTION	18
2.2 - FARM POWER IN EAST CAPRIVI	19
2.2.1 Tractors.....	19
2.2.2 Draught Ox Power	22
2.2.3 Challenges Facing Draught Animal Power	25
2.2.4 Mixed Farm Power System (Oxen and Tractors).....	28
2.2.5 Hand Hoe Farmers.....	29
3.1 INTRODUCTION	31
3.2 METHODOLOGY AND ECONOMIC DATA ANALYSIS	33
3.2.1 Analytical techniques for farm budgeting technique/parametric analysis.....	33
3.2.2 Model setup and assumptions for Financial Costs Benefit Analysis (F-CBA)	34
3.3 ECONOMIC RESEARCH METHODOLOGY	34
3.4 ASSUMPTIONS IN ANALYZING FINANCIAL VIABILITY	35
3.4.1 General Assumptions:.....	35
3.4.2 Assumptions for ox farmers.....	36
3.4.3 Assumptions for tractor farmers	36
3.5 ECONOMIC RESULTS AND DISCUSSION	36

3.5.1	Parametric/sensitivity analysis.....	36
3.5.2	Economic analysis	37
3.6	ECONOMIC SUMMARY AND CONCLUSIONS.....	39
4.1	. SUMMARY DISCUSSION	43
4.2	HUMAN – WILDLIFE CONFLICT (HWC) - CHALLENGES AND CONCERNS.....	45
4.3	CONCLUSIONS	48

List of Tables

Table 1:	Summary description of the study areas (constituencies) and sample sizes used for this case study in Namibia’s East Caprivi.....	11
Table 2:	Summary descriptions of household characteristics, farm size, yield per ha and educational attainment of ox farmers of constituencies in East Caprivi.....	12
Table 3:	Summary descriptions of household characteristics, farm size, yield per ha and educational attainment of tractor farmers in rural constituencies in East Caprivi.....	13
Table 4:	Summary of household characteristics, farm size, yield per ha and educational attainment of mixed farm power (oxen & tractor) found in rural constituencies in East Caprivi.....	14
Table 5:	Paired Summary of Descriptive statistical among female and male farmers in Eastern Caprivi.....	15
Table 6:	Summary Descriptive mean Statistics comparison between male and female farmers of household characteristics, farm size, yield per ha and educational attainment of ox farmers of constituencies in East Caprivi	16
Table 7:	Summary of oxen ownership by constituencies in East Caprivi	28
Table 8:	Summary average yield per ha and farm power source in rural constituencies of East Caprivi.....	29
Table 9 -	Average Maize Yield (50 kg bags) by Constituency and Farm Power Source	30

Table 10: Production costs of oxen and tractors – Adapted from DAPAP2-2008	33
Table 11: Parametric budget/sensitivity analysis for Maize Gross Profit in Rural Constituencies of East Caprivi.....	37
Table 12 - Summary ox farmer’s NPV, cost benefit ratio and IRR at different discount rates in rural constituencies of East Caprivi	41
Table 13 Summary tractor farmer’s NPV, cost benefit ratio and IRR at different discount rates in rural constituencies of East Caprivi	41

List of Figures

Figure 1 – Research Area – Eastern Caprivi.....	2
Figure 2 - Ox Transport on the Grass Plains near Ilvilivinzi, Namibia	3
Figure 3 - Plowing with oxen near Ngoma, Namibia	5
Figure 4 - Meeting with the Village Headman or Indunas was critical	6
Figure 5 – Interviews were open ended and participatory, with field visits	7
Figure 6 - Key Informants were helpful in seeing the challenges in the district	7
Figure 7 – Eighty-Nine Percent (89%) of the farmers were using oxen in the Eastern Caprivi area .	8
Figure 8 – Farmers in the Chinchimane, Linyanti and Sibinda floodplains had access to large tracts of arable land	10
Figure 9 – Cropland Available and Cropland Utilized by Household.....	10
Figure 10 – Forty-one percent (41%) of the farmers with oxen were women.....	12
Figure 11 – Farmers who owned tractors were few, representing 3.2% of the farmers interviewed.	20
Figure 12 - Farm Power in East Caprivi	21
Figure 13 – Oxen represented an important power source, as well as one of the major investments critical to meeting the cash needs of most farmers interviewed.	23

Figure 14 – Cash Value of Oxen – Namibian Dollars (\$N10 = \$1 USD)	24
Figure 15 – The perceived risks involved with keeping oxen	26
Figure 16 – Most major villages had a crush pen to restrain animals during vaccinations by the staff from Veterinary Services	26
Figures 17 & 18 – Foot and Mouth Disease was the greatest challenge to farmers with oxen	27
Figure 19 – Young oxen often developed wounds from the yoke, during ploughing and were a challenge for some women in training.....	28
Figure 20 – Average Maize Yield (50 kg bags) by Constituency and Farm Power Source	30
Figures 21 and 22 – Very few farmers had actual farm records on inputs, outputs and net profit...	31
Figure 23 - Comparison of potential profit using oxen, by constituency, estimated over 20 years..	42

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SECTION **1*****BACK GROUND, METHOD & HOUSEHOLD CHARACTERISTICS*****1.1 Introduction**

The Eastern Caprivi region in Namibia has the highest adoption rates of draught ox power in Namibia. It is also one of the most well watered areas, with high concentrations of people, crops and livestock. The published research documenting the use of oxen in this region is limited, despite the number of oxen and the interest from the Agronomic Board of Namibia in training people to better utilize these animals. At a time when food and petroleum prices are rising, and Namibia is trying to improve agricultural production, this report helps document the value of these animals.

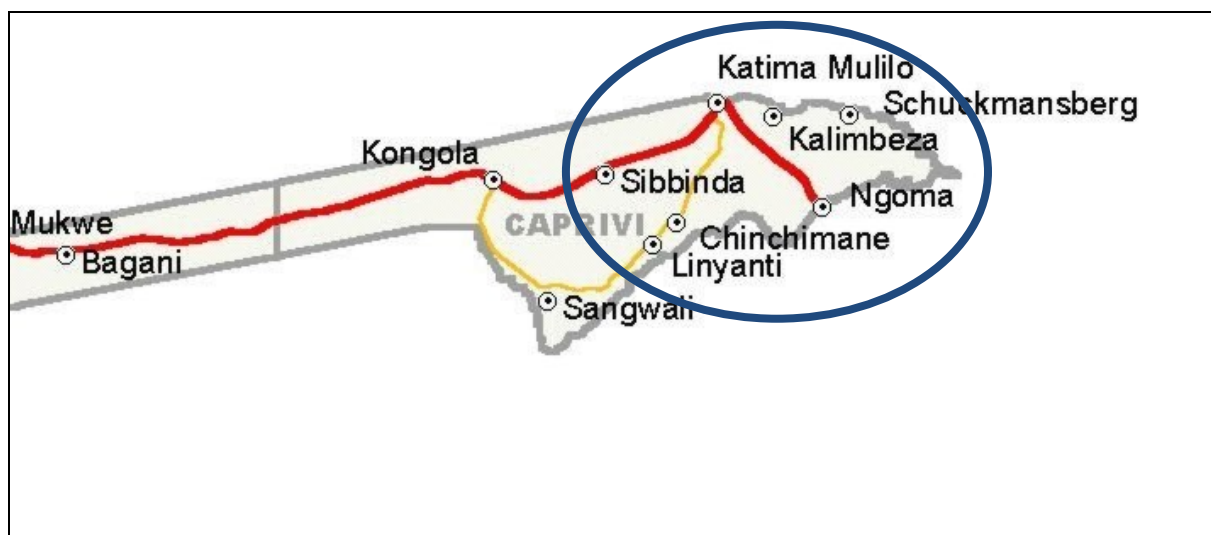


Figure 1 – Research Area – Eastern Caprivi

Evaluating this important agricultural power source in economic terms, compared to hand labour and mechanical power, offers insight into the value and future relevance of this agricultural power source to food production in Namibia. The authors documented the use and value of these animals, using Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) Techniques, with qualitative and economic analysis, during the ploughing season in November and December 2008.



Figure 2 - Ox Transport on the Grass Plains near Ilvilivinzi, Namibia

1.2 - REVIEW OF LITERATURE

The use of oxen is 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 through milk, meat, manure and offspring (FAO 2008). The use of carts or sleds facilitate the marketing of produce, and are important for carrying domestic water and fuel, thereby releasing time that can be used in 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 and FAO/UNIDA 2008), draught animals are more readily available and affordable to people in rural areas, especially in Namibia's Caprivi region.

Throughout Africa 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 fully employed. 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 more serious constraint than acquiring, training and employing the animals (Pingali et al.1987, Panin and Ellis-Jones1994).

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, making the use of tractors difficult (Bishop-Sambrook 2003, Matundu-Tjiparuro, 2008). All of these factors affect the ability of farmers 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).

Oxen are appropriate where people are genuinely committed to using them. Without strong educational, moral and technical support, cultures unfamiliar with cattle fail in training and using the animals (Mulanda et al. 2000, Conroy 2007). Even with such support, local capacity to maintain the technology must be encouraged from the beginning. People must be motivated to help each other train, work and use their animals. Namibia has been doing exactly this through their Draught Animal Power Accelerated Programme (DAPAP). The DAPAP 2 program put together a training manual with the same information (Mudamburi & Keib 2007).



Figure 3 - Plowing with oxen near Ngoma, Namibia

All farmer trainers, users and potential users of oxen must understand both the limitations and the potential of draft 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 where grazing land is limited or money is lacking for veterinary supplies (Conroy 2007). Oxen are not the answer for all people who are 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 in economic terms will help the farmers and the government of Namibia in making appropriate choices and investments in this technology.

1.3 - FIELD RESEARCH METHODS AND MATERIALS

1.3.1 - Site selection:

A purposeful sampling technique was used 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 program. The goals were to interview a variety of farmers employing draught animal power, from different representative villages in the region, as well as varying levels of wealth. Poorer farmers tended to hire oxen when possible, and otherwise used hand-hoes for crop production. Tractor farmers had to be sought out, as they were few in number. Agricultural extension agents and village elders and agricultural business leaders were key informants in finding the tractor owners in the Eastern Caprivi region.

1.3.2 - Methods

The study was based on Rapid Rural Assessment (RRA), including semi-structured interviews. In addition Participatory Rural Appraisal techniques were employed, where groups of farmers and/or key informants were brought together. This applied research was a case study with an economic evaluation to consisting of:



Figure 4 - Meeting with the Village Headman or Indunas was critical

- (1) Semi-structured interviews with 312 farmers conducted at their farms or at predetermined gathering places. Additional key informants, including extension and

veterinary officers, DAPAP2 leaders and trainers, as well as village elders and traditional leaders (indunas) were found to gather data on the use and economics of the draught animal system in the Eastern Caprivi region.



Figure 5 – Interviews were open ended and participatory, with field visits

- (2) Direct and participatory observations of draught animal husbandry, human labour, and tractors use, as well as crop production were used to examine both quantitative and qualitative costs and/or benefits of using oxen.



Figure 6 - Key Informants were helpful in seeing the challenges in the district

312 Interviews with farmers in the Sibinda, Kabbe, Linyanti and Katima Rural constituencies were scheduled using the number of households supplied by either contacts

in the Agricultural Development Centres and or village heads (Indunas) as the sampling frames according to the method proposed by Poate and Daplyn (1993). With the help of the village leaders (Indunas) respondents were also chosen on the basis that they are “typical” of a group or represented the breadth of agriculture in the area (Leedy and Armrod, 2000). The respondents were not randomly selected, but instead were chosen on the basis that they were growing agricultural crops. Individual tractor owners had to be sought out specifically, as they were very few in number.

The economic evaluation of draught animal power in the region was done by gathering production data, including inputs and outputs on the farm. The hectares of crop fields and yields in 2008 were gathered through interviews. For data analyses, farms were divided into those using oxen, tractors or hand hoes, or some combination of the three. Prices paid for plowing and transportation services were gathered directly from farmers, and checked by extension officers for accuracy. Some economic analyses were based on costs assigned to using oxen and/or hand hoes as presented in DADAP2.¹



Figure 7 – Eighty-Nine Percent (89%) of the farmers were using oxen in the Eastern Caprivi area

1.3.3 - Land use and Tenure

¹ Booklet on The Basic Economics of DAP use in Crop Production; includes HIV/AIDS, Gender and Environmental Issues, published by Draught Animal Acceleration Programme 2, March 2008.

Land in the region was communally owned. Farmers were allocated crop growing areas by their village leaders according to traditional tenure. In general, more successful and older farmers, especially those with tractors had larger crop fields available for their use. New farmers started with very small plots, unless a family member allowed them to use part of their unused cropland. The newest and most elderly farmers often required assistance with finding oxen to do their plowing.

Cropping areas available per household varied tremendously from 0.1 ha to over 200 ha. Most of the farmers, with the exception of those with the smallest crop fields did not plant all of their available land to crops. When asked about fallowing or resting fields, there was not one who strategically did this for improving fertility. Fallow fields or unused cropping areas were simply due to a lack of capital or farm power to plough and plant all the available land. All of the farmers said they would have planted more if they had the means to do so. The average available hectares per household was 11.66, and the average actually planted was 5.43 (see Figure 9). However, it should be noted that a few tractor farmers with large plots available to them, raised the average considerably.

Cropland in some areas was contested, particularly near Lake Liambesi. In addition, there was considerable crop damage by elephants with the land adjacent to or located in wildlife corridors. When asked about wildlife damage to crops, 90% of the farmers expressed sincere concern for their crops being damaged by wildlife. Elephants were specifically cited by 78% of the farmers to be the major problem. Many farmers in Kabbe, and Sibinda blamed the many conservancies for bringing more wildlife to the area. They claimed that productive croplands were no longer viable for crop growing, due to wildlife damage rendering the land too risky to plant.² The damage as discussed with farmers varied from slight losses, to complete loss of the fields, with every farmer feeling that any cash investment in the farm crop field is at risk from loss due to wildlife. This risk aversion strategy severely limited crop productivity.

² The wildlife conflict is noteworthy, as the farmers became somber when asked about challenges to crop growing. They expressed concern about compensation, saying there were few benefits the individual could receive that would overcome a complete loss of many hectares of crops. In addition, there were few other livelihood options for the uneducated living in rural areas.



Figure 8 – Farmers in the Chinchimane, Linyanti and Sibinda floodplains had access to large tracts of arable land

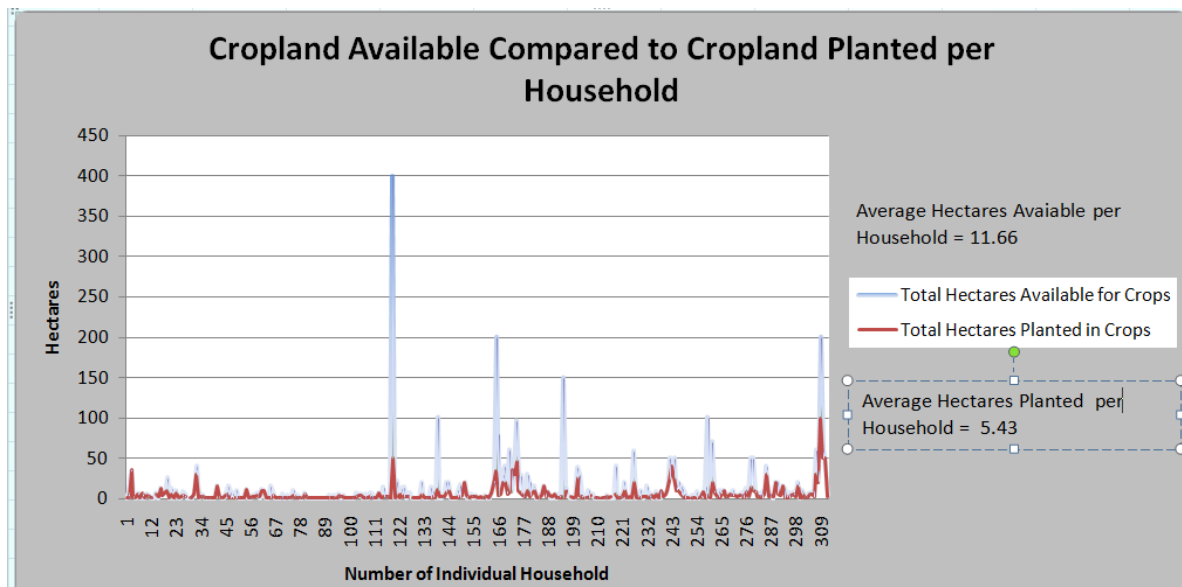


Figure 9 – Cropland Available and Cropland Utilized by Household

1.4 - HOUSEHOLD CHARACTERISTICS

Household characteristics were determined by district, sex; age, level of training/education attained, farming experience, and size of the household, as well as gender of the head of the household. Table 1 summarized the gender distribution in the Caprivi farmers in the survey, Katima Rural women represented 15.1% of the total number of farmers surveyed. Nearly 47% (47/101) of the respondents within the district using in draught power were women. In Sibinda 13% of the farmers interviewed were women, Kabbe was approximately 11%; and in Linyanti only 1.6% of the farmers. Linyanti farmers had larger plots, and access to fertile

floodplains. Access to this land, may have been limited for women with less access to oxen or tractors.

Overall in Eastern Caprivi the female farmers surveyed represented 40.7% of the 312 farmers interviewed. This was encouraging news for household food security and showed that the region was doing well in terms of gender equality in access to land and farm power. This could imply that government and other non government organizations interested in gender equality need to encourage or continue to encourage female farmers in using animal drought power (the DAPAP and DAPAP2 were successful examples).

Table 1: Summary description of the study areas (constituencies) and sample sizes used for this case study in Namibia's East Caprivi

District		Male	%Male	Female	%Female	Irregular	Total
Katima Rural	Oxen	41	13.1%	40	12.8%	2	83
	Tractor	5	1.6%	2	0.6%	0	7
	Mixed	2	0.6%	4	1.3%	1	7
	Handhoe	3	1.0%	1	0.3%	0	4
	Sub total	51	16.3%	47	15.1%	3	101
Kabbe	Oxen	47	15.1%	32	10.3%	0	79
	Tractor	0	0.0%	0	0.0%	0	0
	Mixed	0	0.0%	1	0.3%	0	1
	Handhoe	1	0.3%	1	0.3%	0	2
	Sub total	48	15.4%	34	10.9%	0	82
Sibinda	Oxen	28	9.0%	27	8.7%	1	56
	Tractor	9	2.9%	7	2.2%	0	16
	Mixed	9	2.9%	7	2.2%	1	17
	Handhoe	1	0.3%	0	0.0%	0	1
	Sub total	47	15.1%	41	13.1%	2	90
Linyanti	Oxen	32	10.3%	4	1.3%	0	36
	Tractor	1	0.3%	0	0.0%	0	1
	Mixed	1	0.3%	1	0.3%	0	2
	Handhoe	0	0.0%	0	0.0%	0	0
	Sub total	34	10.9%	5	1.6%	0	39
	Total surveyed	180	57.7%	127	40.7%	5	312

The characteristics of the households using oxen in each district were summarised in Table 2. Most of the respondents were middle aged. There was a relatively larger family size per household in Kabbe, however this district also had the lowest cropping area per household and lowest yield per ha. This could be particularly troublesome for future food security in

that area. Years in farming were similar in all districts, with most of the farmers having more than 23 years experience.



Figure 10 – Forty-one percent (41%) of the farmers with oxen were women

The largest farms using oxen were in Linyanti with an average farm size of 19.66 ha (confidence interval 4.77), followed by Sibinda at 9.5 ha., and Kabbe had the smallest farm size using oxen, with an average of 3.98 ha. However, in terms of yield, the village with the second largest farm size (Sibinda) performed better than the other constituencies, with almost double production quantity per ha (see Table 2).

Table 2: Summary descriptions of household characteristics, farm size, yield per ha and educational attainment of ox farmers of constituencies in East Caprivi

Ox farmer's household characteristics				
	Katima Rural	Kabbe	Sibinda	Linyanti
Age of the household head	55.67±1.60	54.06±1.76	52.93±1.86	47.83±2.31
Family size	6.98±0.47	7.58±0.49	6.78±0.50	6.11±0.40
Years farming experience	23.42±1.71	25.43±2.13	25.34±2.39	22.83±2.44
Ox farmers average farm size and yield per ha				
Farm size	5.39±0.69	3.98±0.69	9.5±2.17	19.66±4.77
Yield per ha	5.97±1.04	3.98±0.7	10.31±1.38	4.21±1.07
Ox farmers average household educational attainment				
Farmer	6.14±0.51	7.5±0.51	5.94±1.38	7.25±0.73
Spouse	4.36±0.59	3.73±0.57	4.38±1.31	4.30±0.79

Ox farmers (see Table 2) in Kabbe and Linyanti had relatively higher educational attainment (with average years of education at 7.5 and 7.25 for men). The remaining

district educational attainment is more or less the same. Spouse educational attainment ranged from 3.73 to 4.38, with higher spouse educational attainment in Sibinda. This does suggest that educational attainment was a main determinant of productivity.

Comparing tractor farmers (Table 3) with ox farmers (Table 2), the tractor farmers, on average, were older than ox farmers, and both tractor owners and spouses had higher educational attainment. However, there were no tractor farmers found in Kabbe and only one farmer interviewed in Linyanti. Out of the 312 farmers interviewed in the East Caprivi, approximately 82% farmers used oxen (see Table 1)).

Using Sibinda's productivity in Table 2 for ox farmers, as example to compare between oxen and tractors, the results confirmed that ox farmers on average in that district were performing better than tractor farmers. However, there are limitations in this comparison due the fact that (i) physical production is not a best way of comparison. Ideally, the comparison should also compare the net profit, time and labour requirements, as well as opportunity cost. However, these results offer a good indicator for further comparison. (ii) This study assumed the soil types of East Caprivi were the same, which in reality was not the case. (iii) Finally, since the fertilizer application is not included in this section this could have also created a deviation.

Table 3: Summary descriptions of household characteristics, farm size, yield per ha and educational attainment of tractor farmers in rural constituencies in East Caprivi

Tractor farmer's average household characteristics				
	Katima rural	Kabbe	Sibinda	Linyanti
Age of the household head	55.28±4.23	0	61.19±4.59	65
Family size	6.28±0.92	0	6.69±0.45	15
Years of farm experience	26.57±6.38	0	29.5±4.6	23
Tractor farmer's average farm size and yield per ha				
Farm size	19.43±6.99	0	44.5±24.16	200
Yield per ha	9.79±5.26	0	8.1±1.46	10
Tractor farmer's average household educational attainment				
Farmer	9.33±3.04	0	9.33±3.04	16
Spouse	7±3.25	0	7±3.25	4

Table 4 (below) summarized the description of household characteristics, farm size, yield per ha and educational attainment of farmers using both oxen and tractors in the constituencies. In terms of household age distribution Katima Rural farmers were higher in age, compared to the other two districts (Sibinda and Linyanti). There was only one mixed

farmer in Kabbe, therefore the farmer was not included in the comparison analysis.

Similar as the above explanation, the yield of Sibinda farmers using both oxen and tractors, performed better than either farm power system used alone.

Table 4: Summary of household characteristics, farm size, yield per ha and educational attainment of mixed farm power (oxen & tractor) found in rural constituencies in East Caprivi

Mixed power farmer's household characteristics				
	Katima Rural	Kabbe	Sibinda	Linyanti
Age of the household head	56.17±4.24	48	60.75±3.07	74±1
Family size	9.67±1.50	8	5.94±0.75	4.5±2.50
farming experiences	23±7.44	28	32±4.36	28±12
Mixed power farmer's average farm size and yield per ha				
Farm size	19.83±16.12	4	28.78±12.57	28±12
Yield per ha	12.76±3.68	5	15.20±3.62	0.75±0.75
Mixed power farmer's average educational attainment				
Farmer	4.83±2.17	7	7.19±1.64	8±8
Spouse	4±2.53	0	4.25±1.53	0

The farmers with the most oxen were the Kabbe female farmers (with average 7.28), followed by Linyanti male farmers with an average farm size of 7 oxen, followed by Kabbe and Katima rural male farmers 6.1 average each, and Linyanti female farmer more or less the same as the male at 6 oxen. However, in terms of yield, the village among the lowest oxen ownership (Sibinda male farmers) and second largest farm size performed better than the other constituencies, with almost double production quantity per ha (11.64 bags/ha - see Table 2). This was followed by female farmers in Sibinda with an average yield of 8.94 bags/ha. This did not necessarily mean that the farmers in Sibinda were more productive than the other constituencies, due to the other factors that affect yield not included in this analysis (such as crop loss to wild animals and soil fertility). However, most important Table 2 shows the female participants in the household security were significant.

Male ox farmers had relatively higher educational attainment (see Table 2) with Katima Rural and Sibinda showing the highest educational attainment (with average years of education at 8.67 and 7.79 for men). The remaining constituencies had educational attainment that was more or less the same in male category. Whereas in female category

educational attainment ranged from 2.89 to 7.28, with higher female farmer educational attainment in Kabbe. This does suggest that educational attainment was a factor in determining crop productivity.

Table 6 shows that the summary statistics of the Caprivi farmers distribution between male and female farmers. The regional average yield was at 4.96 and 7.92 bags (with standard error 1.35 and 1.45) respectively for women and men. However, the average age shows male farmers were relatively younger than the female farmers; this implied that the female farmer's spouse might have passed way. Whereas, family size was bigger for male household, this might also suggest there were male farmers with more than one wife.

Table 5: Paired Summary of Descriptive statistical among female and male farmers in Eastern Caprivi

Paired Samples Statistics					
		Average	N	Std. Deviation	Std. Error Mean
Pair 1	Yield per ha for female farmers	4.96	55	10.02	1.35
	Yield per ha for male farmers	7.92	55	10.78	1.45
Pair 2	Age of the female farmers	56.76	55	14.13	1.91
	Age of the male farmers	49.40	55	13.36	1.80
Pair 3	Family size headed by female	6.20	55	2.89	.39
	Family size headed by male	7.10	55	3.28	.44
Pair 4	Highest education qualification of female farmers	4.49	55	4.54	.61
	Highest education qualification of male farmers	7.80	55	4.08	.55
Pair 5	Years Farming experience of female farmers	26.04	55	16.50	2.22
	Years Farming experience of male farmers	22.40	55	16.46	2.22
Pair 6	Land size owned by females	3.92	55	3.83	.52
	Land size owned by males	15.35	55	25.77	3.48
Pair 7	Area planted last season by females	2.06	52	2.73	.38
	Area planted last season by males	6.49	52	8.06	1.12

Pair 8	Number of oxen owned by females	5.22	54	4.23	.58
	Number of oxen owned by males	5.78	54	5.34	.73

The average educational attainment, was highest among the male farmers, male attainment was 7.8 grade compared to 4.5 average grade attainment among female farmers. This suggested that the female farmers have not an opportunity to go to school, due many possible factors. The Namibian government has been working hard to improve the previously unfair tradition that restricted women from participation in the formal economy. This research shows that there has been progress among the younger generation in terms of gender equality. However, the biggest challenge to bring women on board in communal farming still requires participation of all stakeholders to fight against cultural or tradition restrictions.

Table 6: Summary Descriptive mean Statistics comparison between male and female farmers of household characteristics, farm size, yield per ha and educational attainment of ox farmers of constituencies in East Caprivi

	Gender Group	Kabbe		Kutima Rural		Linyanti		Sibinda	
		Average	Std. Error	Average	Std. Error	Average	Std. Error	Average	Std. Error
Male farmers	Yield ¹	2.67	2.66	6.21	1.28	3.79	0.96	11.64	2.47
	Age	54.72	2.92	49.83	2.12	48.81	2.48	51.86	2.62
	Qualification	6.19	0.33	8.67	0.55	7.53	0.74	7.79	0.77
	F_experience ²	30.25	2.59	20.4	2.30	23.84	2.61	22.11	3.50
	Farm size (ha)	3.02	1.53	6.92	1.22	19.87	5.28	13.94	4.08
	A_planted ³	1.66	2.58	3.73	0.60	7.86	1.58	5.92	1.39
	Number of oxen	6.19	0.86	6.1	0.91	7	1.04	3.86	0.70
	Family size	6.63	1.297	7.875	0.80	6.2813	0.42	7.75	0.72
	Female farmers	Yield	4.88	6.44	5.73	1.66	7.66	6.27	8.94
age		53.62	4.72	57.44	2.27	40	5.64	54.04	2.67
Qualification		7.38	4.57	3.66	0.66	5	2.89	4.67	0.867

F_experience	22.15	3.76	26.37	2.48	14.75	5.76	28.81	3.20
Farm size (ha)	4.64	3.96	3.89	0.61	18	9.38	4.93	0.68
A_planted	2.40	4.4	1.94	0.370	8.1	5.67	3.4	0.68
Number of oxen	7.28	1.83	4.58	0.60	6	2	1.93	0.57
Family size	8.23	1.25	6.12	0.48	4.75	1.31	5.78	0.65

¹ Yield is calculated based on bags (one bag is equal to 50kg)

² indicates farming experience

³ indicates area planted last season of the interview

The average size of crop fields for women was only 3.9 ha compared to 15.4 ha for men, this suggests that the traditional leaders need to work closely with the policy makers on the issue of land distribution among the female and male farmers.

Cropping area planted showed that on average male farmers only planted 42% of the land available through traditional means, where as female farmers planted 53% of the land available. This could imply that female farmers were willing to take more risk, in order to achieve higher yields on the allocated cropland.

When a statistical comparison was made on important household characteristics (such as yield per ha, age, educational attainment, land ownership, area planted and oxen ownership), specifically to examine the gender equality, the results showed there was no significant difference between male and female farmers in an important variables (the paired samples t-test even fail to reject the hypothesis at 30% significance level). Statistically male and female farmers have the same productive capacity. This implied that there was no significant difference among female and male farmers in terms of production and productive capital in the Eastern Caprivi. Further, this demonstrated that there was a high level participation of women in draught ox power. In addition, this research showed that women are in position to contribute more significantly to poverty reduction. Therefore, government strategies, expenditures, and NGO efforts should continue to focus on the promotion of ox power amongst smallholder farmers, as a method of poverty reduction and food security.

SECTION 2

FARM POWER IN THE EASTERN CAPRIVI

2.1 INTRODUCTION

Efforts to promote draught animal powered technology for cultivation in Namibia have two major objectives. Firstly, using an animal drawn mould board plough or dry planting using a small ripper generally enable more timely cultivation than by hand hoe or hired tractor. Therefore expansion of the already widespread use of draught animal powered technology, and improvements in its efficiency, are desirable. Secondly, row planting by hand and weeding using an interrow cultivator is more efficient than traditional methods that is ploughing or discing to destroy initial weed growth, and, weeding by hoe after crop emergence. Promotion of these technologies is currently a major objective of the extension service (Vigne and Martim, 1997).

The concept of ‘modern technology’ as the solution to farmers’ problems has been vigorously promoted by both 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(Vigne and Martim, 1997).

The importance of oxen in providing power for agricultural development is often forgotten in nations and even regions of Namibia that have adopted more modern forms agricultural mechanization (Pingali et al.1987, Ashley, C and Christopher, 2000). Tractors achieve the greatest savings in time and labour, but at a great initial expense (FAO 2008, Sanders et al. 1996). Most farmers would like to benefit from tractor power, but these are often unrealistic expectations for the rural poor (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 LaFanchi 1997, FAO 2008).

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, Sims and Kienzle 2006). These important animals continue to assist people in eliminating poverty, and creating wealth, by allowing people to prepare, plant and weed crop fields in a more timely manner, compared to hand labour (Graaf 1994, 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 fuel wood (FAO 2008). Finally, oxen also have many other values. For many rural people cattle and especially oxen are their most significant asset, serving many functions in addition to work

2.2 - FARM POWER IN EAST CAPRIVI

There were five forms of agricultural power found in this area:

- 1) Tractor owners
- 2) Hired Tractors (both private, and government subsidized)
- 3) Ox owners
- 4) Hired Oxen (used by farmers in all categories)
- 5) Hand Hoe

2.2.1 Tractors

Most of the farmers did not own a tractor, but expressed an interest in at least being able to hire one, when they needed it. However, even when available, many were unable to afford or risk spending the cash cost of hiring them. There was also a frequent complaint that farmers had to wait for tractors to plough their fields, often resulting in planting late. Many farmers wished the subsidized tractors were once again available, as they had been in the 1990's. However, the Namibian government had sold its tractors, and tractor hiring has been privatized. The government negotiated the prices farmers could charge for ploughing. Tractors were sought out for breaking new land or for cultivating a larger area in a short time, in order to capitalize on the soil moisture generated by early rains.



Figure 11 – Farmers who owned tractors were few, representing 3.2% of the farmers interviewed.

The prices for hiring tractors was negotiated by the government, and in 2008, as petroleum prices escalated, the price of N\$500/ha created a particularly difficult situation for tractor farmers.³ Tractor farmers stated they could not cover their costs, and some were reluctant to plow for others. A number of tractor farmers stated they had hoped to get at least N\$700/ha in these negotiations. In contrast, some tractor farmers needed the cash flow generated by plowing in order to purchase petroleum for their own fields. In either case, the price controls negotiated by the government could not seem to keep up with the rapid increases in petroleum prices during 2008. This rapid increase in petroleum prices was in part an inspiration to conduct this research.

Farmers who hired tractors felt the 2008 prices were too high, compared to the N\$350/ha price used in 2007. Nine percent (9%) of the farmers interviewed hired a tractor in 2008, but 12% hired a tractor in 2007. This decrease seemed to be due to the increase in price for ploughing per hectare. This cash price increase was significant for farmers hiring services. It increased their financial risk, especially if the crop failed due to insufficient rains or wildlife damage to the crop.

³ At the time of this study the exchange from N\$ to US\$ was approximately 10:1. N\$10 = US\$1

It should be noted however, that the government did subsidize tractor services. Farmers could register with the Agricultural Development Centre, and for the first 3 ha they plowed, they could receive N\$150 for each of the hectares plowed by tractors as N\$500.

Ten of the farmers interviewed owned tractors, representing 3.2% of the total. These farmers all had substantial off farm income, with full time jobs in education or government and/or were retired with a pension from the same. This income seemed to be essential to the purchase and maintenance of a tractor. The tractor owners were also located in areas near large floodplains where ample arable land was available for crop production. In addition to ploughing their own fields, the tractor owners also viewed hiring their services to others essential for generating cash (primarily for fuel), although they all stated that the government price ceiling on tractor hiring was too low and limited their willingness to plow when fuel prices rose substantially in 2008.

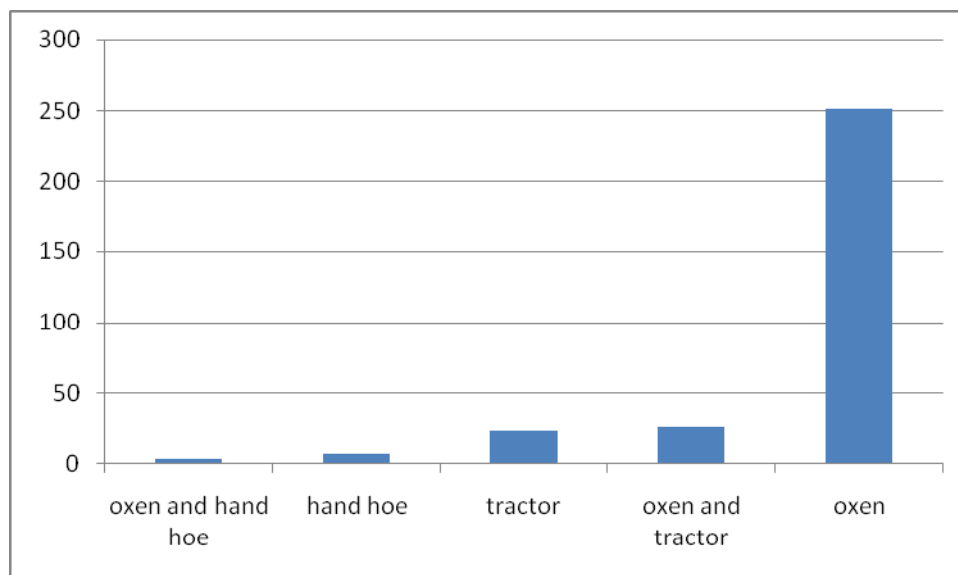


Figure 12 - Farm Power in East Caprivi

The price for hiring tractors also influenced the price that farmers who hired out their oxen charged for these services, as many farmers were charged the same price for ox hiring as they were for tractor hiring. However, farmers also stated that there was more room for negotiation and bartering with ox ploughing. The average price for ox ploughing after taking into consideration these other options was N\$478/ha. It should be noted that many

people who hired oxen, did this without any cash cost. If farmers without a cash cost were included in the average price for ploughing with oxen, the average dropped to N\$286.46/ha. This lower average reflected farmers who had friends and relatives who helped them plough their fields for free or in trade for labor. The farmers with no cash cost (who borrowed oxen) represented 13.5% of the farmers interviewed.

Those without oxen sometimes hired oxen, but many farmers used various barter schemes in order to get their fields ploughed by oxen with no cash cost. The disadvantage of hiring or bartering for either oxen or tractors was that the farmer had to wait for the ox or tractor owner to finish their own fields first. This in turn led to planting the crops days or weeks after the early rains. This put the crop at considerable risk of failure, depending on the rainfall in any given year.

2.2.2 Draught Ox Power

The vast majority of farmers used draught animal power in this study (see Figure 13). Eighty-one percent (81%) of the farmers used oxen exclusively, with an additional 8% using oxen and also either using their own tractor, or hiring a tractor to supplement the ploughing with oxen.

Cattle were owned by all but a few farmers, and even those without cattle had owned cattle in the past, or hoped to own cattle in the future. Oxen were viewed as a farm power source that will continue in the future. Sixty-six percent (66%) of the farmers thought that young people would continue to use oxen. While many young people in the Caprivi region hoped to use a tractor, many adults stated this was unrealistic, as tractors were too expensive. Twelve percent (12%) of the farmers said young people would not use oxen in the future, and 5% said that maybe young people would use oxen, but it depended on their education, the economy and tractor availability. However, when asked about the economic and environmental sustainability of using oxen 83% stated that oxen were an essential and sustainable farm power resource in the region.

Those without oxen sometimes hired oxen. In this study, 13.5% of the farmers used various barter schemes in order to get their fields ploughed by oxen with no cash cost. Such barter

schemes included weeding in exchange for ploughing with oxen. Others, provided labor by driving oxen for farmers with large plots, in exchange for getting their fields ploughed. Still others combined a small team of their oxen, unable to plough on their own, with farmers who had more oxen, in exchange for ploughing fields.

The average ox was trained and began work at 3.4 years of age, and worked until they were sold at 8.18 years of age. The age at which oxen were sold, was higher than what it has been in years past, because the Meatco market in Katima Mulilo had not been available for all of 2008.



Figure 13 – Oxen represented an important power source, as well as one of the major investments critical to meeting the cash needs of most farmers interviewed.

The average price for a young ox, if purchased in the local village was N\$1175.19. The average sale price for oxen, when including the Meatco market, after the oxen worked a number of years was N\$1682. This represented an increase in value, at little cash cost to the owner, while at the same time getting valuable work from the animal.

One of the factors that seemed to be unique to this study was the marketing of oxen through MeatCo which offered prices roughly 32% higher than selling animals locally, when the export market was open. The availability of this market was largely dictated by the incidence of Foot and Mouth Disease in the region. Meatco Katima started in 1992, and

peak capacity could process about 55 cattle per day (Subrinal 2009). For the year prior to the study, the Meatco Katima abattoir, which primarily exports to South Africa had been closed down, due to FMD. The temporary closing of the processing plant has occurred in the past, and had in the past, resumed operations once FMD was under control. Operations would only resume when confirmed by Namibia's Veterinary Services with an official go ahead from international inspectors.

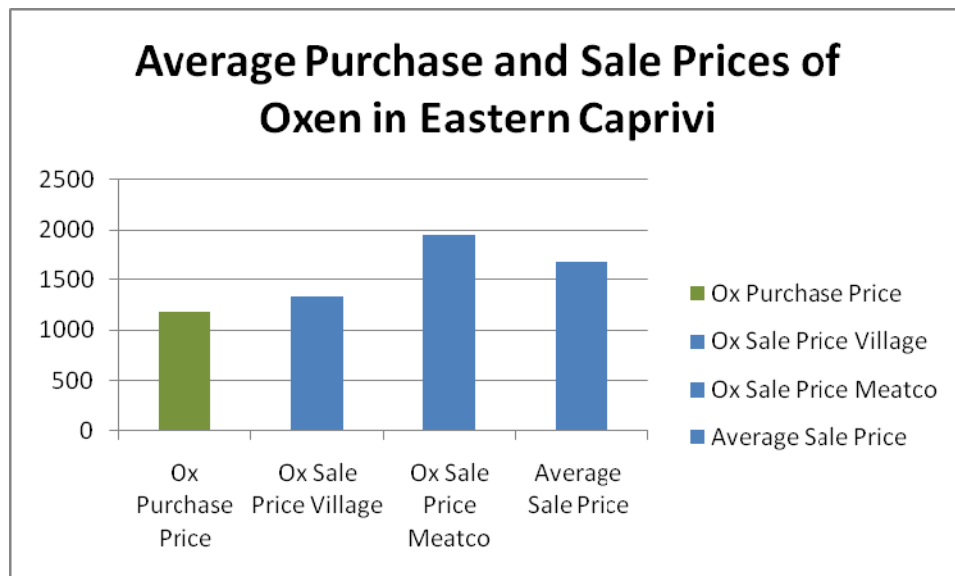


Figure 14 – Cash Value of Oxen – Namibian Dollars (\$N10 = \$1 USD)

A few farmers mentioned specifically that “*MeatCo was depleting their supply of oxen.*” Selling oxen were certainly within their control. However, the cash price offered was lucrative and seen as a critical part of family strategies to meet financial obligations. Fifty-nine percent (59%) of the farmers admitted having seen people use cows for work, and attributed this to the frequent sale of oxen. The use of cows seemed to have been a cultural shift that may be attributed to the value of younger oxen sold to Meatco. One additional benefit of working cows mentioned by many farmers was that cows that did not give birth were providing a useful service, and often became pregnant after working one ploughing season.

This shift toward cows for work, seemed somewhat unique compared to what is typically found in other African agropastoral societies in Southern and Eastern Africa (Conroy 2001). In other cultures this shift is often the result of severely limited grazing and limited

animal numbers. However, the farmers interviewed, who were using cows, often had relatively large numbers of cattle, but sold oxen when the prices were highest, and were willing to utilize other smaller oxen and cows that they had available for farm work. A challenge they admitted was the requirement of more time training animals and fewer hectares plowed, by the smaller working cattle.

Despite the drawbacks of having younger and fewer oxen, most farmers preferred to have the MeatCo market available, even if it meant fewer oxen, and more cows being worked. This was a significant issue, and discussed at length, as farmers typically worked the oxen for a few years and preferred to sell them as young oxen, receiving a higher price per kg. compared to old worn out oxen. For ploughing purposes farmers admitted the larger older oxen were better work animals. However the higher and fair cash value of the animals, based on classification and weight at the abattoir was preferred to having larger oxen. According to Bishi and Kamwi (2008) The off-take through the formal marketing system remains low at about 2%. The two abattoirs of Katima Mulilo and Oshakati operate at less than 45% (17,000 units per year) of capacity (Bishi and Kamwi 2008).

2.2.3 Challenges Facing Draught Animal Power

There were many risks involved with keeping oxen. Specifically mentioned by farmers in order of importance were disease, delays in planting, a lack of grazing and adequate body condition at the beginning of the grazing season, injuries to oxen (see Figure 18), and training young oxen. Theft, a lack of labour, death, ticks, the availability of oxen, and equipment were considered lower risks by the farmers in general. However for the farmers who had lost oxen to theft or death, had a lack of labour or no oxen available, there were very serious concerns.

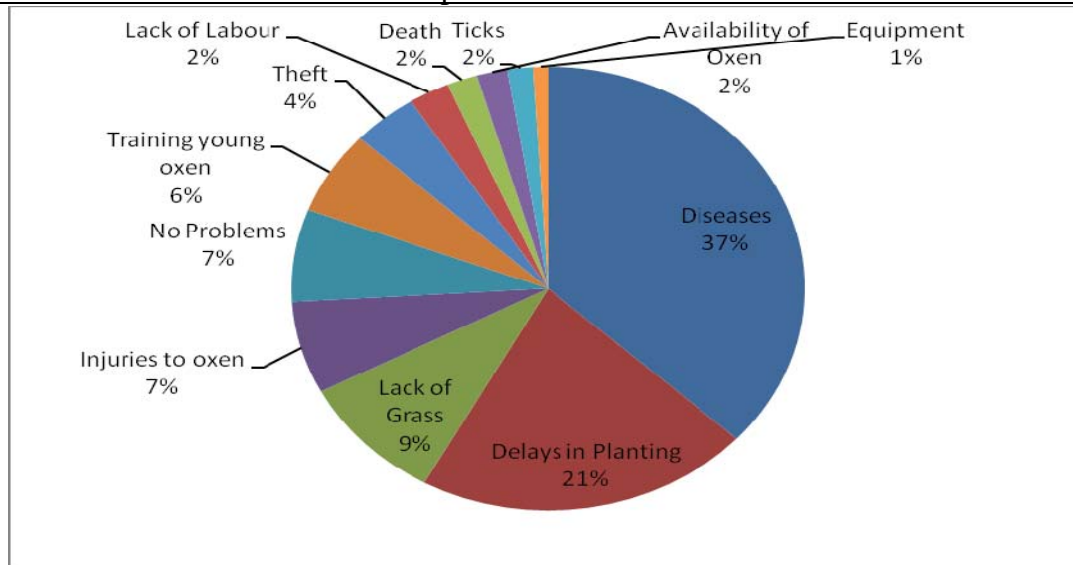


Figure 15 – The perceived risks involved with keeping oxen

There were numerous diseases affecting cattle in the region. The government, through its Veterinary Services provided vaccines for rabies, anthrax and Foot and Mouth Disease, which are administered two times per year by the Veterinary staff in the village crush pens. Approximately 20-30% of the farmers buy drugs or vaccine in addition to the vaccine supplied by the government. The recommended vaccines include Lumpy Skin Disease, Contagious Bovine Plueropneumonia, (CBPP) and Brucellosis. Some farmers also treat for parasites, including Liver Flukes, but internal parasites were more of a problem in the Eastern floodplains, such as the Kabbe constituency (Chitate 2008).



Figure 16 – Most major villages had a crush pen to restrain animals during vaccinations by the staff from Veterinary Services

East Caprivi had an outbreak of Foot and Mouth Disease in November 2007, (DVS Quarterly Report 2007). According to one source, “For the animals to access the EU market, the farmers will have to abandon the traditional animal husbandry practices for high input high output market-orientated production systems that require the application of contemporary technologies such as suitable breeds, feeding, veld management, animal health care, etc.” (Bishi and Kamwi 2008). However, the cultural practices of raising cattle, and the intermingling on the rangeland with wildlife in the conservancies, and often originating in Chobe National Park in nearby Botswana, will likely continue into the future.



Figures 17 & 18 –

Foot and Mouth Disease was the greatest challenge to farmers with oxen

In terms of draught oxen ownership per district, it was highest in Kabbe, where mixed farmers who used both oxen and a hired tractor (had an average of 8 oxen). Ox ownership was second highest with mixed farm power farmers in Linyanti (with an average of 7.5 oxen). Ranking third in were the mixed farmers in Sibinda. Ranking fourth in the number of oxen owned were the tractor farmers in both Katima Rural and Linyanti with 5.3 oxen. Ranking fifth were the mixed power farmers in Katima Rural and Kabbe each with 5.23 oxen (see Table 7 below). What these numbers suggest were that the farmers in Kabbe with adequate grazing tended to have more oxen, and being mixed farmers, they also had more financial means. The mixed power farmers in Linyanti and Sibinda also had better access to tractor hiring and adequate grazing, and as the economic data will show, higher profits over time. Finally, the tractor farmers had more oxen than some groups, largely due to the financial position of the individuals.



Figure 19 – Young oxen often developed wounds from the yoke, during ploughing and were a challenge for some women in training.

Table 7: Summary of oxen ownership by constituencies in East Caprivi

Farming System	Katima Rural	Kabbe	Linyanti	Sibinda
Oxen	5.23±0.53	5.23±0.53	6.89±0.94	2.98±0.53
Tractor	5.33±1.83	0	5.33±1.83	2.05±0.42
Hand hoe	0.5±0.5	0.5±0.5	0	0
Mixed Oxen and Tractor	4.8±2.94	8	7.5±0.50	6.4±1.33

2.2.4 Mixed Farm Power System (Oxen and Tractors)

Comparisons of the different farm power systems, showed that farmers using mixed farm power (tractors and oxen) performed better in terms of productivity (at about 8.4 bags average yield per ha), followed more or less the same for ox and tractor farmers (average yield at about 6.12 and 6.97 bags per ha respectively), and at the lowest productivity was 2.23 bags by hand hoe farmers. Looking the yields, specifically in Sibinda farmers using both tractors and oxen had the highest yields. As mentioned above further analysis is important for cost comparison.

Table 8: Summary average yield per ha and farm power source in rural constituencies of East Caprivi

	Oxen	Tractor	Mixed	Handhoe	Average
Kabbe	3.98	0	5	3.35	3.08
Linyanti	4.21	10	0.75	0	3.74
Katima rural	5.97	9.79	12.76	3.35	7.97
Sibinda	10.31	8.1	15.2		11.20
Average	6.12	6.97	8.43	2.23	5.94

When yields were compared by district (see Table 8), the Katima Rural and Sibinda farmers using both oxen and tractors (Mixed Farm Power) had highest average yields per ha (12.76 and 15.2 bags per ha). The highest yields per farm were found in Linyanti and Sibinda, but was largely due to farm size, as a few of the farmers had hundreds of ha and used tractors (see Figure 16 and Table). However, as mentioned above, these did not necessarily prove to be more profitable. Comparisons in terms of profitability, required further analyses of the data (such as performing other statistical tests and enterprise budget comparisons). These tests can be seen in the economic analysis section, below.

2.2.5 Hand Hoe Farmers

Farmers using only a hand hoe represented the farmers in the least favourable economic situation. They did not produce enough maize to sustain their households and struggled to meet their basic needs (see Table 9 and Figure 16). Hand hoe farmers tended to be older farmers with few assets, and fewer family members. They often had the least number of options for both bartering and hiring oxen. The hand hoe farmers represented only 2.2% of the farmers interviewed, and were also the most impoverished. Of the ten farmers using only a hand hoe for their primary means of cultivation, 7 were women and 3 were men. These farmers, as seen in Table 8 (above) also had the lowest yield per hectare.

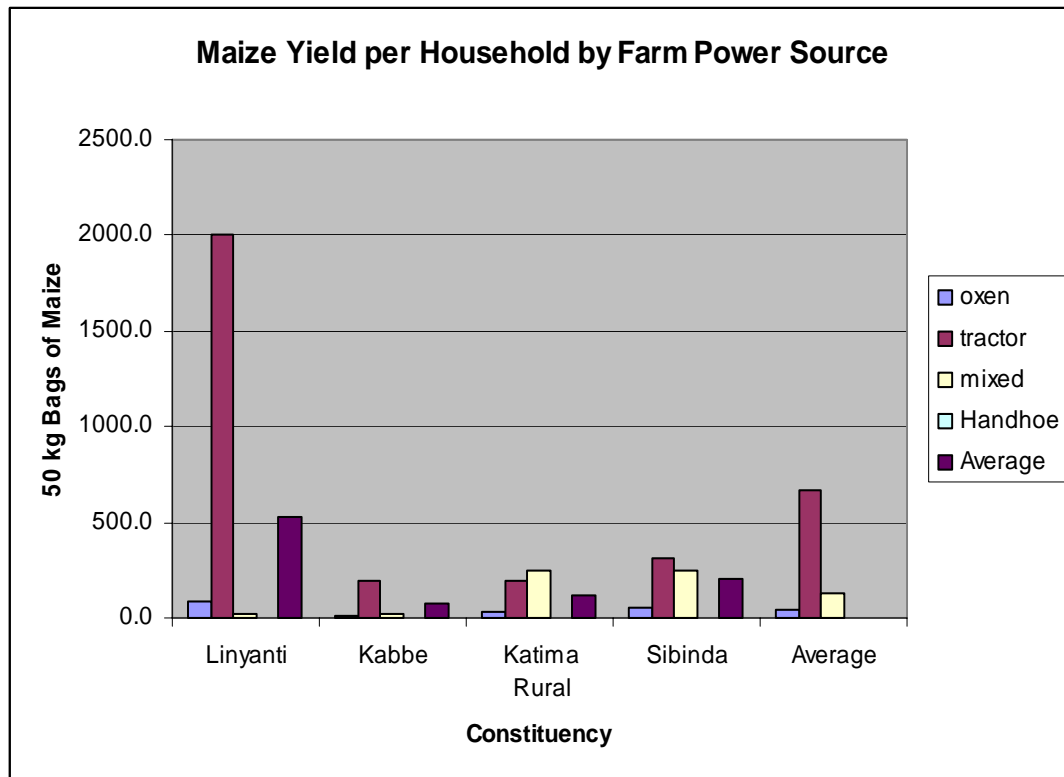


Figure 20 – Average Maize Yield (50 kg bags) by Constituency and Farm Power Source

The hand-hoe farmers expressed an interest in using both oxen and tractors, as a way to increase production and food security. However, their financial situation and lack of cattle often precluded them from doing so. Many farmers had cattle in the past, but due to age or a loss of family members or greater support from the community no longer had access to oxen.

Table 9 - Average Maize Yield (50 kg bags) by Constituency and Farm Power Source

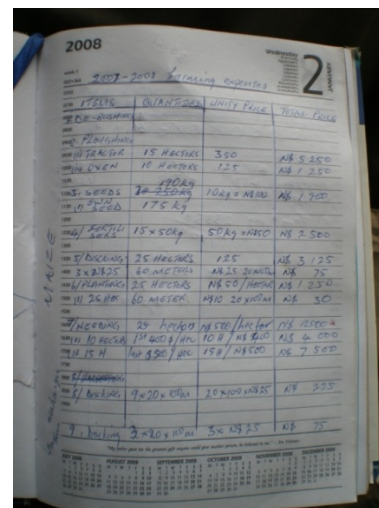
	Oxen	Tractor	Mixed Power	Handhoe	Average
Linyanti	82.8	2000.0	21.0	3.4	526.8
Kabbe	15.8	190.2	20.0		75.4
Katima Rural	32.2	190.0	253.0	3.4	119.6
Sibinda	58.0	310.0	242.8		203.6
Average	47.2	672.6	134.2	3.4	

SECTION 3

ECONOMIC COMPARISON BETWEEN TRACTOR AND OX FARMING IN EASTERN CAPRIVI

3.1 INTRODUCTION

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.



Figures 21 and 22 – Very few farmers had actual farm records on inputs, outputs and net profit.

There are numerous factors needed to be considered and taken into consideration 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.

A farming unit is economically viable when: Gross Income was greater than the Production (variable) Costs

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 Gross Margin (GM).

A farming unit is financially feasible when: Gross income is greater than Production (variable) Costs + Fixed living costs and repayment of medium term loans.

Credit worthiness of a farmer shows that he/she is able to loan the required capital necessary to generate the expected gross income. Questions were asked in the survey about credit. Sixty-eight percent (68%) of the farmers stated that they would like to have access to credit, yet 47% said credit was not available, with another 47% who said access to credit was limited, largely because they held no title to land, and had few other securities that were considered worthy collateral for a loan. Only 6% of the farmers said credit was available to them, and even of this group, 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.

A Cash Flow Analysis (CFA) evaluates the financial viability over time, incorporating the initial investment with its life expectation to serve. A Financial Costs Benefit Analysis (F-CBA) evaluates financial viability of a farming unit over the long term, discounting to 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).

3.2 METHODOLOGY AND ECONOMIC DATA ANALYSIS

For this study parametric analysis and Net Present Value (NPV) evaluation were used to compare the economic usage between oxen and tractor farming

3.2.1 Analytical techniques for farm budgeting technique/parametric analysis

Before further analysis it was important to consider the basic assumptions that have been used made to make parametric/sensitivity analysis. The following assumptions apply to parametric analysis adoption:

- Production variables: the types and number of operations, land area cultivated (ha), cost of operation, when using oxen and tractor were used based on the Chigariro et al. 2008 (DAPAP-2 - manual) as follows (Table 10).
- Furthermore, to take into account the inflation of fuel and petrol price, the model has added 40% on the prices that the DAPAP-2 manual provided.
- To calculate parametric budget/sensitivity analysis for maize production at the different district of Caprivi the prices tested was N\$170 per bag price at the farm, N\$200 per bag price in Katima market and N\$250 per bag best price scenario
- Production was based on the average district yield (see table 1.2 on the previous section)
- Seed price up dated to the current market of Katima Mulilo was N\$140 per 10kg

Table 10: Production costs of oxen and tractors – Adapted from DAPAP2-2008

Variable Cost	Units	Oxen			Tractor		
		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 & 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

Farm budgeting technique/parametric analysis

The budget technique was used to analyze cost revenue and profitability of operations carried out using oxen or tractor. 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 $NP = TR - TC$

TR= Total revenue from operation carried

TVC = Total cost of production (variable cost)

3.2.2 Model setup and assumptions for Financial Costs Benefit Analysis (F-CBA)

A comprehensive financial analysis based on maize crop yield, costs and prices was necessary and a series of crop simulations were performed. To come up with acceptable results in analyzing financial viability and economic feasibility for comparison of oxen and tractors to the recent enterprise budget for prices and costs, and expert opinion were utilised to obtain data of different management systems.

Various Benefit-Cost models were developed to evaluate the viability of the project with a 20 year planning horizon for financial analysis. Based on the petroleum price escalation in recent months, cash flow was projected over 20 years, assuming the tractor life and discounted to present value to evaluate the cost effectiveness of the two farming techniques.

3.3 ECONOMIC RESEARCH METHODOLOGY

The farming power source viability was evaluated mainly based on: NPV, Cost/Benefit ratio and IRR. The results are seen in the tables and figures below. However, again numerous assumptions had to be used, as there were many variables that could not be fully accounted for.

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.)

C_t - 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 emphasize its role as the initial investment.).

To evaluate further benefit cost ratio was done as follows: BCR = Present value of benefit/cost

This evaluation provided a basic model as to the economic efficiency of draught oxen in this area, as petroleum prices rise.

3.4 ASSUMPTIONS IN ANALYZING FINANCIAL VIABILITY

3.4.1 General Assumptions:

- For the purpose of conducting cost benefit analysis comparison between oxen and tractor farmers in the Caprivi region major crop maize selected,
- The learning curve projected to be every two year with four bags increment over the 20 years projected;
- For the propose of analysis discount rate to be 6, 8 and 10% respectively were assumed, since inflation rate in Namibia fluctuate from 6 to 10%
- The farm size was based on current the average usage at the district (see above)
- House hold consumption is assumed to be 1095kg per year or (21.9 bags per ha) of six family size based on the Ashley and Lafranchi, 1997).
- Production costs of the crops were estimated based on the production year 2008 based on animal drought power enterprise budget supplied constant over 20 years
- Price of the maize is based on the 2008 of Katima, which is N\$200 per bag (bag is estimated at about 50kg)

3.4.2 Assumptions for ox farmers

- It was assumed farmers use four oxen for ploughing with a purchase price of N\$2500 each, based on information from Likuwama farmers union and the farmers themselves.
- Farmers use the oxen for five years and sold at N\$1333 at the end of the fifth year, based on the average data collected information
- FCB done on the farm level to district average and converted to per ha, for the seek of comparison

3.4.3 Assumptions for tractor farmers

- It is assumed that mmechanisation cost (tractor) is estimated to be R279 000 based on the Lubbe's Auto centre tractor retail price as of 26/01/2009 prices,
- Loan secured from agra bank at 12.7% to buy tractor paid with in 10 years term, as per agra information telephonically inquiry (Hoveka, 2009).
- Estimated life of tractor to be 20 years, based on agra bank information
- Since the method uses partial cash flow method to reach to NPV. Depreciation expenses is excluded from the analysis (because of non cash item cash transactions)

3.5 ECONOMIC RESULTS AND DISCUSSION

3.5.1 Parametric/sensitivity analysis

Two types of post hoc sensitivity analysis are practiced in the decision analysis community. In a 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 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 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 uncertain 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 11: Parametric budget/sensitivity analysis for Maize Gross Profit in Rural Constituencies of East Caprivi

Parametric budget/sensitivity analysis at different selling price Scenarios					
Constituency	Farm system	No of respondents	Gross profit at different price scenarios		
			N\$170	N\$200	N\$250
Katima Rural	Oxen	81	N\$765±18	N\$943±21	N\$1242±26
	Tractor	7	N\$841±89	N\$1134±10	N\$1624±13
Kabbe	Oxen	79	N\$430±12	N\$547±14	N\$746±17
	Tractor	0	0	0	0
Sibinda	Oxen	55	N\$1503±24	N\$1812±28	N\$2328±35
	Tractor	16	N\$553±25	N\$796±29	N\$1200±37
Linyanti	Oxen	36	467±18	594±21	805±27
	Tractor	1	-593	-552	-485

Table 11 summarized the optimal levels of gross profit (gross margin) of maize in different districts given the 2008 data. Assuming the production costs as given from DAPAP 2 and fitted to the data and equating it to the profit formula. With the actual average yield and seed price in the study area the optimal profit was achieved in Sibinda ox farmers (indicated by bold in Table 11 above), followed by tractor farmers in Katima Rural constituency, however, there was not significant difference with the oxen farmers within the same district. Whereas, one farmer's data from farming with a tractor at Linyanti shows a negative Gross profit, from these exercises, it can be concluded that profit might be depend on the farming area, management and also input/out prices. Furthermore, the damage from the wild animals was not taken into account in this calculation, even though the majority farmers indicated conflicts with crop production and wildlife, particularly elephants.

3.5.2 Economic analysis

Table 12 (below) summarized 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 to calculate the NPV with average yield of district and farm size, Linyanti ox farmers were projected to achieve a highest profit performance when the gross profit was discounted to NPV (N\$ 416,630) followed by Sibinda tractor farmers, who were expected to perform at about N\$249,144 of NPV with cost ratio of 4.68 and 4.4 respectively. This implied that every N\$1 invested in Linyanti in by ox farmers per ha expected to generate return of N\$4.68, the same explanation applied to other constituencies. The low performance of Kabbe was due to the fact that both average yield and farm size was relatively small compared to the other constituencies (yield was 3.98bag per ha) and average farm size (3.98ha).

Net present value (NPV) is defined as the total present value (PV) of a time series of cash flows. It is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met (Wikipedia, 2009).

However, it was not fair to compare different farm sizes by discounting to NPV, therefore the average farm sizes were converted to per ha profit and discounted to present value, with 10% discount rate as a yard stick. Sibinda and Linyani ox farmers were projected to be the most profitable farmers per ha, showing NPV profits of N\$26,226 and N\$20,431 respectively, followed by Katima Rural (at about N\$15 858) and Kabbe (with NPV N\$8,152) when it was discounted over 20 years.

Looking at the tractor farmers, the farmers surveyed in Sibinda and Katima Rural were expected to obtain NPV of N\$18,214 and N\$7,177 per ha respectively with a 10% discount rate.

Considering the economic viability analysis results in Table 11, (this is only done where projects are financially feasible), the Sibinda and Linyanti ox farmers were the most profitable without taking the wildlife threat to crops into consideration.

The IRR Internal rate of return (IRR) is the rate of return produced by each dollar for the amount of times that dollar is in the investment. Given a collection of pairs (time, cash flow) involved in a project, the internal rate of return follows from the net present value as a function of the rate of return. A rate of return for which this function is zero is an internal rate of return (Wikipedia, 2009). Taking inflation into consideration all ox farmers would generate more than 40% IRR (with 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.

3.6 ECONOMIC SUMMARY AND CONCLUSIONS

In East Caprivi, ox farmers from the Sibinda constituency outperformed all other systems when using the parametric budget/sensitivity analysis for Maize Gross Profit in Rural Constituencies of East Caprivi (see Table 11). Using oxen was financially feasible and economically viable from both parametric analysis and financial analysis perspectives. Linyanti, ox farmers ranked second on a per ha financial analysis.

This study showed that 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 N\$1 in oxen farmers will yield a return of N\$4.44, 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 the wild animals, to generate expected household needs.

When ox farmers were compared to the tractor farmers, the cost ratio of Katima Rural ox farmers and tractor farmers (when it discounted to present value) was 2.34 and 1.28 respectively. This showed that an investment of N\$1 would generate a gross margin of N\$1.34 per ha from ox farming, where in contrast it would only generate about N\$0.28 from tractor farming. This was a very small margin with which to cover all the financial commitments of the household. However, this could be due to high petroleum prices during data collection period. The assumption of a constant price and cost; and also income from

renting of tractor was not included in the analysis. In addition, the benefit of time saving was not included in the model.

Table 12 - Summary ox farmer's NPV, cost benefit ratio and IRR at different discount rates in rural constituencies of East Caprivi

Constituency	Farm size	Yield per ha	Net Present value at farm size			Cost Benefit ratio			IRR	Net Present Value per ha		
			6%	8%	10%	6%	8%	10%		6%	8%	10%
Katima Rural	5.39	8.97	135,991	107,381	85,475	2.64	2.49	2.34	43.89%	25,230	19,922	15,858
Kabbe	3.98	3.98	60,133	44,359	32,446	1.76	1.65	1.53	22.60%	15,109	11,145	8,152
Sibinda	9.5	10.31	362,424	298,744	249,144	4.83	4.63	4.44	139.45%	38,150	31,447	26,226
Linyanti	19.66	4.21	629,591	509,183	416,630	6.09	5.75	5.43	137.30%	32,024	25,899	21,192

Table 13 Summary tractor farmer's NPV, cost benefit ratio and IRR at different discount rates in rural constituencies of East Caprivi

Constituency	Farm size	Yield per ha	Net Present value at farm size			Cost Benefit ratio			IRR	Net Present Value per ha		
			6%	8%	10%	6%	8%	10%		6%	8%	10%
Katima Rural	19.43	9.79	304,471	209,898	139,445	1.51	1.39	1.28	17.33%	15,670	10,803	7,177
Sibinda	44.5	8.1	1,273,530	1,011,230	810,522	2.60	2.42	2.27	55.95%	28,619	22,724	18,214

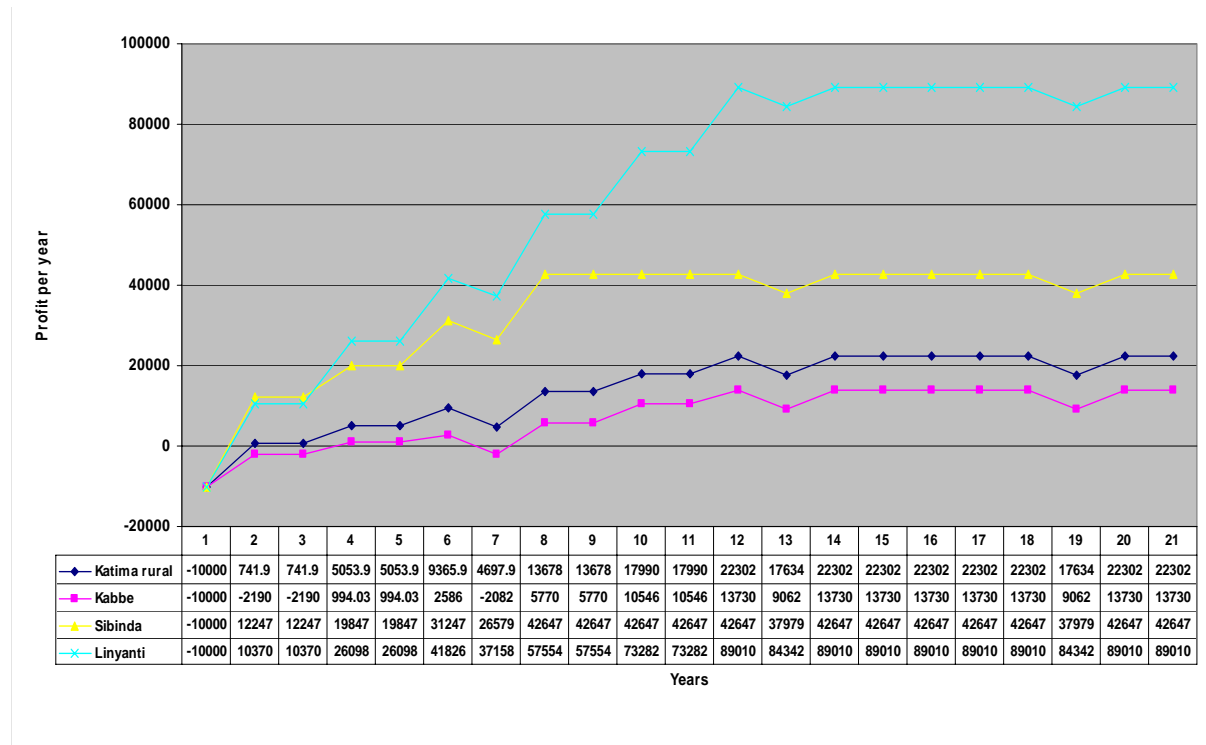


Figure 23 - Comparison of potential profit using oxen, by constituency, estimated over 20 years

Furthermore, taking a discount factor at 10%, and using the whole farm size comparison, the most profitable group was found to be the Linyanti ox farmers (see Table 12 and Figure 23). The NPV for the Linyanti analysis of whole farms was calculated to be N\$416,630.00. Ranking second were the Sibinda tractor farmers, with an expected NPV for the whole farm of N\$249144. Ranking third was Katima Rural ox farmers with an NPV of N\$85,475. Finally, ranked fourth were the farmers in Kabbe with an NPV of N\$32,446. Whereas, the per ha comparison showed that Sibinda and Linyanti farmers were found to be the more profitable constituencies with NPV’s of N\$26,226 and N\$20,431 respectively. The smaller farms, especially in Kabbe, did not perform as well. This implied that farmers who had the ability to expand their farm size, would be able to achieve higher profitability and contribute more toward improved food security for the country (see Table 12 & Figure 23).

SECTION 4***SUMMARY AND CONCLUSIONS***

4.1 . SUMMARY DISCUSSION

This research focused on the economics and challenges related to the adoption of specific farm power sources used to grow crops in the Eastern Caprivi. While it was recognized that farmers in the Eastern Caprivi grew a number of field crops, such as sorghum, millet, and beans, the primary crop grown was maize. It was a culturally preferred food, and had a much more readily available market, when there was a surplus to sell. The productivity of the cropland, the size of the fields and other factors affecting the yields were largely based on farmer recall. However, there was substantial field checks and discussion with family members to get the most accurate figures. Factors such as the loss of crops to wildlife were noted, but not accounted for, as this study looked at what was harvested, not what was lost.

This study found many similar results to Ashley and LaFranchi (1997) where their research categorized farms into three categories of farms less than 1 ha, 1-2 ha, and over 2 ha, with farmers in Caprivi numbering approximately 1/3 in each category (see Figure 12) . They found draught oxen to be used by approximate 80% of the farmers, and similarly found that the typical approach by the majority of small farmers was to make sure family land was protected by using it, and relying largely on low input and low output systems of management to reduce financial risk of crop failure or loss.

Similar to Ashley and LaFranchi (1997) the use of tractors and commercial inputs, such as fertilizer continues to be low, largely because of the farmers using low-risk approach to crop production. Small farmers, in particular minimized financial risk of crop loss due to drought or wildlife and other pests, by minimizing cash costs and using local seeds, oxen, and family labour. This 2008 study found similar results, with the majority of ox farmers adopting least cost strategies of crop production as a way to minimize financial risk.

Ashley and LaFranchi (1997) also reported that the typical yield per ha was 30-700 kg/ha. In comparison, this study found that average yields per ha were 297 kg/ha with yield averages ranging from 150-560 kg/ha. Farmers using tractors had the highest yields, but as this study showed the most productive system per ha was the mixed farm power system (see Table 8), where farmers used oxen, but had access to hiring tractors for plowing additional land.

An additional challenge mentioned in many villages was the cost of transporting crops to points of sale, there was also the desire to have crop harvests picked up in major villages, which would save considerably on transport costs for the farmers. However, the cost would likely be simply passed along to farmers, and may not result in true savings.

Disease, delays in planting due to problems with oxen, a lack of grazing and adequate body condition at the beginning of the grazing season, injuries to oxen, and the loss of the Meatco Market were major issues with the oxen. The government veterinary service was well respected, and their vaccination programs were taken advantage of by the vast majority of farmers. However, optional vaccines which had to be purchased, and would be administered by veterinary field staff, had far fewer adopters. Theft and illegally moving animals across the borders with Zambia, Angola and Botswana were often cited by farmers as an ongoing problem, and the Veterinary Service acknowledged this, both through personal communication, and Namibia television at the time of the study.

Finally, Ashley and LaFranchi (1997) estimated there were 10,000 farming households in Eastern Caprivi, with the average household size to be approximately 6 people, and that a typical Caprivi household of 6 needs approximately 20-28 bags of maize required per year. On average, the

households we saw were larger, and the above mentioned maize requirement on average was met in our study. However, the data were skewed by the high production levels of the tractor farmers, and in fact, most of the households in Kabbe, and many of the households with smaller plots and using the hand-hoe were not able to meet this basic food requirement.

4.2 HUMAN – WILDLIFE CONFLICT (HWC) - CHALLENGES AND CONCERNS

The authors were not in the field to conduct research on human-wildlife conflicts. However, when farmers were simply asked what problems they were facing with growing crops, the answer was almost always wildlife or elephants. The majority of the farmers never mentioned weed control, seed or fertilizer prices, nor army worms, until were issues brought up by the researchers. The major concern farmers expressed during the question about problems they were having, were that the wild animals (Particularly elephants, but also buffalo) created a land use conflict. This discouraged farmers from expanding their farm size. The risk of loss to cash investments was often too great to encourage crop expansion, especially for small farms with little cash and locations near known elephant corridors. Similar results were reported by the Ministry of Agriculture, Water and Forestry in 2008 (MAWF 2008). Finding ways to minimize crop loss from wildlife, particularly elephants, needs to be apriority if crop production is expected to increase for farmers in East Caprivi.

This study indicated that farmers in much of East Caprivi are facing challenges to improving crop production. Many of the most successful farmers have considerable off farm income, and a greater tolerance to risk, from weather, wildlife, rising fuel prices, as well as disease and feed shortages for livestock. Small farmers with little off farm income have more to lose from wildlife damaging crops, high cash input costs, and great risk to any cash investment in tractor purchase, or hire, improved seeds, and fertilizer. Given current trends in expanding conservancies and increases in elephant numbers, it will remain difficult for future generations to grow crops and improve food production in East Caprivi, without some change in the financial risks involved. East Caprivi has great potential, geographically, as a crop Namibia's most productive rain fed, crop growing area. However, without continued technical, management and financial support, particularly compensation for crop damage, the possibility for greater crop production from the

area will be limited. The need to increase the level of potential new farmers' production and management proficiency through training and skill development programmes is crucial.

Ashley and LaFranchi (1997) stated with regard to, wildlife damage to crops and livestock;

“Once wildlife management and use by conservancies increases, wildlife damage can be expected to increase. Although “average” cash earnings per household can significantly outweigh losses, some households may in fact lose more than they gain. Losses are not just cash losses, but undermine household strategies of food security (for crops) and building up of reserves, production inputs and intangible assets (livestock), so may have greater significance to households than market prices indicate.”

Ashley and LaFranchi (1997) also stated;

“It is as important to reduce the costs of wildlife damage to crops and livestock as to increase the cash benefits from wildlife and tourism enterprises.”

Eleven years later, the predictions in the first statement have largely come true, with regard to increased wildlife conflict, and the loss by many poorer households being more than they gain through food security and personal wealth. Furthermore the people expressed their frustration with reporting wildlife damage and nothing seeming to be done to directly compensate them for their tolerance of wildlife. Below are a few typical responses to our question about wildlife damage.

Farmers in Kabbe, especially Eastern areas were the most affected by wildlife damaging crops.

One farmer, a 51 year old man, with a large family stated his discontent with elephants like this, *“they ate all the fields that’s why I am planning to stop plowing.”*

Other farmers in some of the regions most productive floodplains, expressed their frustration with wildlife like this:

A 54 year old woman from Linyanti-Kipani stated, *“when you are about to harvest, the elephants come in and in one hour destroy everything, and there is no control, you cannot chase an elephant out.”*

A 65 year old farmer with a tractor and 35 hectares of crops in Linyanti said, *“they are damaging the whole crop if you do not look after them day and night.”*

A 43 year old farmer from Linyanti’s Batubaja village, who was a DAPAP trainer with 3 ha explained, *“sometimes they eat all the crops, like they did in 2008.”*

A 64 year old, award winning maize grower, with 25 hectares became quite animated when asked about wildlife problems, *“This is the biggest problem, because of this idea of conservation, we have elephants in our lappa. This idea of a conservancy is not good for farmers who grow crops, 2-3 elephants can come in and eat your whole crop.”*

An articulate, and educated 64 year old retired businessman pointed out, *“elephants sometimes destroy everything. Half the field was destroyed last year, I lost 50 bags.”*

Finally, another highly educated 73 retired principal summed up the statements of many by saying, *“Out of my 10 hectares, 2 ha were lost. I reported this to MET, but nothing ever happens.”*

According to NASCO (2008), there were over 2000 incidents of wildlife conflict in the Caprivi Region in 2007, with the majority of these being caused by elephants. This number is lower than the reported incidences in 2006. However, it should be noted that many of the farmers growing crops do not even report damage, such as the farmers mentioned above, as they feel as though nothing will be done anyway, especially farmers who are not part of a conservancy. NASCO (2008) recognizes these challenges, and supports the idea of reporting wildlife conflict, as a way to build a case for compensation within the conservancy, and documenting to donors and the government the seriousness of this issue, and its threat to food security.

Even the Ministry of Agriculture, Water and Forestry expressed the seriousness of the risk and crop damage to elephants in 2008, in its widely read, Agricultural Inputs and Household Food Security Situation Report – from December 2008. This risk of growing crops in close proximity to wildlife, especially elephants, somehow must be offset with compensation or mitigated with additional support for farmers, as conservancies continue to promote wildlife in areas that are known to be some of Namibia’s most watered cropping areas. While the authors recognize the value of wildlife for hunting and tourism, this elephant conflict will continue to grow in the future as more and more villages register new conservancies.

4.3 CONCLUSIONS

One of the research questions driving this study was “do draught oxen make a significant contribution to the viability of crop farming in Namibia’s Caprivi Region.” The results showed that draught animals are and continue to be an important resource for Namibian farmers. Draught oxen are known to be compatible with farmers who grow crops and own cattle. Eastern Caprivi farmers, in Namibia’s most well watered area, have both cattle and grow crops and will continue to do so. Furthermore, ox power in Namibia is a farm power source that can be and has been adopted successfully by women. Women in this study had similar success on average compared to men in producing crops with oxen and even tractors. Given the losses due to HIV-AIDS in the region, this was particularly encouraging for household food security.

Another driving force behind this study were the rapidly rising petroleum prices in 2008. Given the cost of operating tractors is directly related to petroleum prices, the authors wanted to explore the economics of using oxen compared to tractors. Ultimately the results showed that one system was not better than the other in all situations. Over time, ox power could yield the greatest return on the cash investment. Yet, the tractor and ox were different, and required different levels of investment and management expertise. Most small farmers would not be able to buy a tractor. Yet most interesting of all, combining draught animal power with tractors seemed to be an excellent combination. This result showed that significant increases in crop production could be made by making sure tractor plowing and hiring are available in the future, to farmers who use oxen, especially those who have unused land available for crop growing and cash for hiring the tractors.

In part this result has to do with the expense of tractor ownership vs. hiring tractors, similar to trends seen in other countries. Tractors and other equipment that are not used regularly are an expense most small farmers cannot take on. Tractor hire prices are expected to increase in the future, as petroleum prices climb. When this happens the financial risk in East Caprivi of making any cash investment in crop growing, using tractors, will likely become prohibitive for small farmers. Add to this the risk of crop loss, as wildlife numbers increase, and again the small farmers suffer most. Weather and rainfall already offer a level of risk, which many farmers

struggle to adjust to. The early rains limit the planting season, and without tractors, most farmers cannot plant the land they have available for their crops. If subsidized tractors were to once again become the norm, this might minimize personal risk, but it would increase costs dramatically for the government. More tractors would also likely lead to larger areas simply be destroyed by wildlife (elephants in particular), and this would then be at the expense of the government.

Oxen are not only a cost effective animal power source, they also provide many other benefits, including an investment that grows over time. They minimize the financial risk of growing crops for farmers, especially small farmers. Yet, tractors offer the ultimate flexibility for farmers with some extra cash to add a few extra hectares or plant their crop fields in a more timely manner.

The higher actual yields seen in this study for mixed farmers compared to ox farmers were likely due to farmers being able to maximize the land ploughed during critical planting times by using both draught animals (a readily available farm power resource) and tractors. Tractor owners also had oxen, and in some villages, as many if not more oxen than farmers that used oxen exclusively. However, this combination of farm power was not available to all. While draught oxen reduce the amount of physical labour and makes farming additional hectares possible, the ownership or access to oxen is directly related to education, wealth, and availability of land for crop growing. The yields (positive economic returns) attained by ox farmers shown in this study may encourage farmers to stay on the farm and not to migrate to the towns. Yet, tractors also requires a larger investment, and the farmers using tractors and mixed power had to take the production of maize and other crops more seriously than farmers using a hand-hoe or oxen.

Government policies should promote equity, promote efficient resource use, and promote sustainable natural resource use. Considering the Namibian Government's four major development objectives as stated in its First National Development Plan (NPC. 1995), the promotion of growth and employment, and the reduction poverty and inequality. The high level of participation of women in animal draught power in Namibia, specifically in the Eastern Caprivi region showed that women in this communal area are in a position to contribute to Namibia's food security, as draught oxen use by women is culturally accepted and encouraged. However, the HIV Epidemic is rising in Namibia, and at its highest level in the Caprivi region.

Government strategies and expenditures should continue to promote this form of sustainable agriculture amongst smallholder farmers, as a way toward poverty reduction. However additional policies may be necessary that continue to encourage that some form of tractor hire subsidy be available and also reduce the risk of draught oxen ownership and crop loss to wildlife.

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