PERFORMANCE EVALUATION OF NEAZDP ANIMAL TRACTION PROGRAMME

BY

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DECLARATION

I declare that this dissertation "PERFORMANCE EVALUATION OF NEAZDP ANIMAL TRACTION PROGRAMME" is written by me under the guidance of my supervisors. It has not been accepted in any previous application for a higher degree. Sources of information are acknowledged by means of references.

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CERTIFICATION

We certify that this dissertation "PERFORMANCE EVALUATION OF NEAZDP ANIMAL TRACTION PROGRAMME" has been duly presented by HUSSAINI K. HASSAN meets the regulations governing the award of Doctor of Philosophy (Agricultural Engineering), Ahmadu Bello University, Zaria and is approved for its contribution to knowledge.

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DEDICATION

This piece of work is dedicated to my parents Mal. Hassan and Hajiya Titi who gave me initial home training and discipline to resist/face all kinds of human endeavour. To my beloved wife Salamatu and children (KK, NN, DD and AD) who simultaneously with me under went educational development as part of live and a means of survival.To my uncle beloved Alhaji A.B. Galadima who supported my educational propagation and wishes me to be the greatest Scientist in the African Sub-content and the world at large.

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ABSTRACT

The North East Arid Zone Development Programme (NEAZDP) has a high population of draught animals. A number of activities were undertaken which have not been properly documented for possible improvements of the entire NEAZDP programme. This study was to provide detailed information on the technical performance of the traction programme.

A baseline survey was carried out to determine the initial status of animal traction in the State. This was followed by acquisition of various types of animal-drawn equipment which were tested, modified and re-tested. For sustainability, artisans were trained on the newly introduced equipment. The modified equipment were field tested and any faults corrected. Large quantities of the modified and artisans fabricated/constructed equipment were procured and distributed. Final evaluation was carried out after three years of project operation.

Baseline survey showed that, there were 2,358 workbulls, 302 donkeys, 400 camels, 1,573 horses, 2,358 ridgers, 2,358 ox-carts, 1 ARARA cultivator and 4-5-tine blacksmith make cultivators owned by farmers. There were 34 carpenters and 44 blacksmiths with poor skills initially and were trained in appropriate fabrication/construction methods using modern tools. About 39,513 pairs of workbulls, 44,402 pairs of donkeys, 19,756 single camels and 9,878 single horses were estimated to cover the cultivable land area of NEAZDP.

The study showed that on the basis of estimated body weights of draught animals evaluated, their tractive efforts ranged between 98N and 1247N. The working speeds ranged between 1.3km/h and 3.8km/h, implements draft requirements ranged between 647N and 2481N, field coverage ranged between 4 to 18h/ha for different field operations and soil types. On average, draught animals evaluated pulled between 502 to 825kg of load over a distance of 1 to 45km at a speed between 3 - 5km/h.

The average efficiency ranged between 79 to 99%, depth of work between 12 to 23cm, ridge height between 12 to 20cm and effective width of work between 42 to 186cm for different implements and field operations.

Of the technologies introduced the ridging and ox-carting, were the most adopted, while ox-ploughing and ox-harrowing were least adopted field operations.

Study revealed that incorporation of artisans and animal handles to sustain the NEAZDP animal traction programme is a necessity.

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ABBREVIATIONS/SYMBOLS

A.B.U.	-	Ahmadu Bello University, Zaria
AETC	-	Agricultural Engineering Training Centre Harare
APC	-	Agricultural Production Component
ASST. ATS	-	Assistant Appropriate Technology Specialist
ATC	-	Appropriate Technology Component
ATS	-	Appropriate Technology Specialist
DA	-	Development Area
DAP	-	Development Area Promoter
EEC	-	European Economic Community
FAO	-	Food and Agriculture Organization of United Nations
FT	-	Field Technician
M & E	-	Monitoring and Evaluation
MC	-	Marketing and Credit Unit
MDT	-	Manpower Development and Training
NEAZDP	-	North East Arid Zone Development Programme
RAMCAT	-	Ramat Polytechnic Centre for Appropriate Technology
UNCHS	-	United Nation Centre for Human Settlements
VDP	-	Village Development Promoter
VWS	-	Village Water Supply
WM	-	Workshop and Mechanical Unit

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CHAPTER ONE

INTRODUCTION

1.1 General Introduction:

The North East Arid Zone Development Programme (NEAZDP) is an integrated rural development project jointly initiated and owned by the Borno State Government, Federal Government of Nigeria and the European Economic Community (EEC). The general objective of NEAZDP is to promote and motivate the rural people of the area in the proper use and management of their natural resources through provision of financial and technical support. With creation of Yobe State, the programme area now falls entirely in Yobe State covering nine out of the seventeen Local Government areas of the State.

Due to inadequacy and high cost of tractors, NEAZDP in its solution to ease the burden of human labour in terms of tillage and transportation of agricultural produce, packaged a programme loan to prospective farmers consisting a pair of workbulls, a cart and a ridger (animal-drawn equipment already known to farmers). Other alien animal-drawn equipment such as mouldboard ploughs, cultivators, spike tooth harrows and bund formers were introduced on an experimental level for probable adoption. Similarly, harnessing techniques for single animals to pull implements and carts were also introduced.

To ascertain the success of this programme and possibly improve on it entails that, a continuous evaluation of its impact be carried out. This study therefore focussed on an initial

evaluation to introduce methods of sustaining the programme by incorporation of artisans (blacksmiths and carpenters) in the modification, fabrication, maintenance and repairs of the introduced technologies. Likewise, animal handlers were incorporated in the programme to train farmers in the techniques of handling or operating the newly introduced technologies.

Finally, to evaluate the performance of the introduced technologies, skills provided in sustaining the programme and its impact after 3 years of operation.

1.2 Statement of the Problem:

Due to environmental factors i.e. soil type and topography, breeds of the animals in the area and level of existing technology, promotion of animal traction technology in NEAZDP area could face some likely problems as enumerated below.

1. Environmental Factors:

NEAZDP area is arid in nature with prevalence of sand dunes and oasis. Some areas are relatively flat consisting of sand loan or loamy sand, whereas others are Fadama (clay) areas. Therefore, introducing various animal-drawn equipment may require initial testing and evaluation to suit a particular soil type in terms of tillage operations and carting.

2. Breeds of the Animals:

Most animal-drawn equipment introduced were developed elsewhere based on the capabilities of the draught animals in

those regions so, the introduction of such equipment without prior knowledge of arid zone animal capabilities is a likely problem.

3. **Training Skills of the Introduced Technologies:**

Provision of newly introduced animal-drawn equipment such as cultivators, ploughs, harrows and bund formers as well as application of other animal power sources such as donkeys and camels without proper training of artisans (blacksmiths and carpenters) and animal handlers on the introduced technologies could also be a problem area. This underscores the need for provision of adequate maintenance and repair services and implement operational techniques for an effective and sustainable programme.

1.3 Objective of the Study:

The general objective of this study was to evaluate and improve the technical performance of NEAZDP animal traction programme.

Specific Objectives:

The specific objectives of the study were:-

(i) To carry out a base-line survey of the available draught animals and related technologies so as to establish their statistical distribution and utilization within NEAZDP area.

(ii) To have initial test of the introduced animal-drawn equipment for sustainability and make modification where necessary before issuing to farmers.

iii) To improve NEAZDP animal traction programme by incorporation of artisans in the modification, fabrication, maintenance and repairs of the introduced technologies and animal handlers in the training of the techniques of the newly introduced technologies.

(iv) To evaluate the performance of the animal-drawn implements, carts and technologies introduced (artisans and animal handlers).

(v) To determine the level of adoption of the animal-drawn equipment introduced and to assess the economic benefits of animal traction.

CHAPTER: TWO

LITERATURE REVIEW:

2.1 Previous Research On Animal Traction:

Acccording to Starky (1988) both research and evaluation studies relating to animal traction require a general approach which consist of farming system, animal husbandry, veterinary services, repair and maintenance services, extension, training and economic benefits assessment. This implies that animal draught power technology for sustainable development require an integrated programme which involves different activities as mentioned above.

2.1.1 History of Animal Traction Technology:

According to Charles et al. (1956) animals were used as pack for transportation, communication, etc since the neilotic ages before the advent of technological inventions.

Jean (1992) reported that though animal traction technology has existed for about 4,000 years, it has hardly changed since then across the world.

Kaul (1989) reported that some 400 million horses, oxen, cows, water buffaloes, donkeys and even elephants work for man at a global level, providing about half the energy used by the third world countries in agriculture. He further reported that some developing countries for example Zambia, Mali, Gambia and Senegal depend on animals for over 90% of their agricultural

power.

In Ethiopia and North Africa, draft animals have been used for centuries, sustained by traditional services (Starkey, 1986). He further stated that in much of sub-saharan Africa, systematic attempts to introduce animal traction to increase the production of export crops started about 1905 and by 1945, almost all countries in Africa were actively encouraging the use of animal power. He also reported that in Africa about ten to seventeen million draft animals are employed, but within West Africa about one million draft cattle and 800,000 donkeys and horses are used for work. According to him most are found in sahelian and savannah zones with highest concentration in Senegal and central southern Mali. He further reported that in the Gambia an extension programme, based on training centres started in 1955 and by 1995 it had introduced work bulls into most villages, but not untill between 1965 and 1985 did donkeys become increasingly important. In Africa, primary soil cultivation accounts for 90% of animal power usage, while less than 5% of farmers who plough with animals use seeders or weeding tines, but carts are used all year round, making them to be more important (Starkey, 1986).

2.1.1.1 History of Animal Traction In Nigeria:

Musa (1989) reported that animal drought power technology was introduced to Nigeria by British colonial administrators in the early 1920's and was first tried in Daura in 1922. In 1928, three farmers were trained to adopt mixed farming principles. Each of the farmers was given a pair of bulls with ox-plough, ox-

cart, cultivator and a cow for milk production at Shika (near Samaru). By 1955, the number of workbulls owners (successful ones) rose from 3 to 15,452 and at present there are over 300,000 bulls in northern Nigeria. The highest concentration is found in Katsina, Kano, Sokoto, Bauchi and Borno/Yobe States. According to Bako and Ingawa (1990) in Kashere, a small village of the Pindiga district (Bauchi), it is reported that most households have at least one pair of work oxen and many have up to four pairs. They (Bako and Ingawa, 1990) further stated that Ox-drawn ploughs are the most common land preparation tools and can last for up to 20-40 years with the share being replaced every three years.

According to Saror (1995) the 1990 National Livestock Survey showed that Nigeria possesses about 14 million cattle, 936,000 donkeys, 208,000 horses and 88,000 camels. If only 10% of these figures are devoted to farm operation, an additional 5.6 million kilowatts power would have been made available for farm use. NEAZDP socio-economic survey of 1990 revealed that there were 205,373 cattle, 20,011 donkeys, 7,333 horses and 4,166 camels in the 370 cluster villages within the Programme Area excluding villages that are not directly assisted by the Programme (NEAZDP, 1990).

2.1.1.2. History of Animal Traction Programme in North Eastern Nigeria:

According to Badawi (1989) animal traction technology for cultivation was introduced in 1928 in the then Borno Province (now Borno/Yobe States) under the then British Government. He

further observed that the technology proved to be beneficial to the farmers in both Borno/Yobe States of Nigeria. Farm institutes which were established in the colonial period trained young farmers on mixed farming and on graduation each was issued with a pair of bulls, a ridger, fertilizer and some cash to assist them start farming.

Badawi (1989) further indicated that following the success of this Programme, succeeding National and State Governments after the colonial rule, made various efforts to promote workbull ownership among farmers in the two States. He also explained that at one time in 1965, the animal traction programme was used to provide employment to both standard four and primary school leavers under a programme called "mixed farming scheme" through Farm Institutes (Farm Centres) were established in various parts of the then Borno State.

Badawi (1989) described the history of the programme ant its subsequent situation as follows:-

These new farm institutions provided training on improved crop production and animal traction technology. The training which last for nine months has course contents designed to provide 80% practical and 20% theoretical instructions, with English and Hausa as language of communication. On graduation a loan consisting of a pair of bulls, a ridger, some bags of fertilizer and cash for veterinary costs and land clearing was given. Each participant was expected to clear 5ha of farmland in their respective villages. The loan was scheduled to be paid in 5

years of equal instalment. As observed by Badawi (1989), this scheme became politicised after the military handover in 1979 which led to its total collapse.

Although animal traction has been introduced into Northern Nigeria since 1920s, it is currently employed on less than 15% of the total sown area (Spencer, 1985). Sustained adoption has occurred only in relatively limited areas in Kano, Katsina, Bauchi, Jigawa and Adamawa States of Nigeria (Orsar, 1987). Elsewhere, initial adoption rates were not only low, but early adopters have often abandoned the technique within a few years of adoption (Jaeger and Malton, 1990). Although animal traction was shown to be labour augmenting, the rate of adoption is still very low. The reasons given for the low rate according to Ochi and Kushawa, (1994) include poorly functioning financial credit scheme, low propensity to save and low marginal productivity of capital (under small holding) and infrequent practice of line planting.

Kline (1970) stated that broad-adoption of animal traction was blocked by equipment inappropriately designed for African conditions, inadequate extension, and the absence of support services. However, Kaul (1989) stated that lots of implements developed world wide can be adopted in Nigeria with appropriate modification and new innovations may emerge during the development adaptation stage. Hassan (1991) on the other hand concluded that modernization and improvement should remain the ever lasting solution in order to attain perfection, in that, the

pattern of development of both traditional and modern tillage implements remains the same.

However, it should be noted that improvement can sometimes be rejected by farmers as pointed out by Abubakar (1989) who indicated that an attempt to modify the Emcot ridger has been made but rejected by farmers. However, he stated that improvement and modernization of implements should go hand in hand with extension training and adaptive research.

Starkey (1988) pointed out that 1000 units of wheeled tool carriers were imported into Africa but were not to be adopted by farmers due to several problems, namely: that the implement is too expansive, insufficiently manoeuvrable, and very heavy for most African animals. Other reasons identified by farmers is that stumps prevented its proper use and it is used for single operation other than multipurpose.

Ndanusa (1989) has recommended that if draught animal utilization is to be properly integrated into Nigeria's farming system, there must be a programme to ensure adequate supply of draught animals; the development of a wide range of appropriate implements; and the training of blacksmiths, carpenters and other village level artisans, so that the manufacture of the simple tools and components in draught animal utilization, can be permanently entrenched in the rural economy.

2.1.2 Workbulls Traction Technology:

General:

Both Workbulls traction programme and performance evaluation are treated within this context. According to Reddy et al. (1986) the impact of animal traction technology can be measured in terms of level of technology adoption and that little emphasis should be placed on economic issues at the expense of social effects. This implies that programme evaluation is basically based on its performance, that is, whether the programme is technically and economically viable, and beneficial to the people it is intended to serve.

Barnes (1960), as reported by Mohammed (1990), stated that there are four types of machine performance that must be evaluated if true knowledge of an agricultural machine is to be secured. They include functional, mechanical, capacitive and economic performance. The first three can be regarded as technical performance. It is imperative to report here that Draught Animal Technology (DAT) means the implement and the animal are considered as machine using animal muscle (FAO, 1990).

The U.S. Agency for International Development (USAID) as reported by Dennis and Kumar, (1987) that apart from daily report, project staff and technical assistance are expected to carry out annual assessment that examine reasons for success or failure of each programme activity and are to recommend modification/improvements.

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It is generally estimated that draught animals require 30% extra feed to cover their nutrient needs to work (Hrabovsky 1983 in Alhassan, 1989). Similarly, work is reported to increase feed intake of draft animal by 30% (Leng 1985, Weston 1985 in Alhassan, 1989). Alhassan (1989) reported energy requirement by cattle for maintenance and percentage extra energy requirement for work (Table: 2.1).

World Bank as reported in Dennis and Kumar, (1987) classified the rate of adoption as follows:- two third acceptance or application of technology is said to be adopted, one third is said to be partial adoption and none is said to be non adopter.

TABLE: 2.1 **Energy Requirement by Cattle for Maintenance and % Extra Energy Requirement for Work:**

ENERGY REQUIREMENT:	BODY WEIGHT (KG)			
	200	300	400	500
Maintenance MJ ME/day extra energy requirement above maintenance (%)	27	37	46	54
2 hours work	18	20	22	23
4 hours work	37	41	44	47
8 hours work	74	82	88	94

Source: Kearly (1982) cited in Bamualim and Kartiarso (1985) all contained in Alhassan (1989).

2.1.2.1 Evaluation of Workbulls Traction Programmes:

An es-post evaluation was conducted in Latin American irrigation and settlement project. Initially, the project was considered a failure due to several constraints faced by the programme. Later, after five years, the es-post evaluation revealed that lasting progress was being made, in that, farmers progressively and successfully took over the project responsibilities and even began to function administratively as substitutes for government institutions (World Bank as reported in Dennis and Kumar (1987a). Conversely, Reddy et-al (1986) explained that slow initial uptake of a technology does not necessarily mean that technology is inappropriate. Njei (1988) evaluated the impact of animal traction programme of Promotion of Adopted Farming Systems base on Animal Traction (PAFSAT) in the north-west Cameroon, and found that the (PAFSAT) provided alternative farming system suitable to the ecology, resources and know how of the local farmers.

Dennis and Kumar (1987a) further reported that between 1985 and 1987, PAFSAT organized 26 training sessions in which a total of 699 target farmers (652 farmer families and 47 women groups) were trained and settled in 110 villages. They also reported that most tools were locally manufactured and assembled, such that by 1986, a local production company "Catmi" manufactured 500 animal-drawn ridgers, 200 bullock carts and 40 planters. Animal traction was found to be suitable to various farming activities e.g.

- clearing of land with roller cutter;
- ploughing;
- harrowing and raking with harrow;
- puddling in irrigated rice plots;
- sowing of rice and wheat seeds with seeders;
- ridging with adjustable ridger;
- weeding and covering fertilizer;
- incorporation of farm residues;
- transportation of farm products such as firewood and organic manure with ox-carts.

Anthony (1988) conducted a profitability assessment of animal traction investment in north eastern Ghana. Financial analysis based on farm management data revealed that animal traction investment over short (5 years) and medium (10 years) term periods was profitable. The analysis produced internal rates of return (IRR) with equity financing of 46% and 54% for short and medium term periods, respectively with debt financing (credit) the figures were 79% and 90 % respectively. Further, it provided moderate increases in average annual income over hoe farming of 10% for short and 17% for the medium term period. However, sensitivity analysis showed that the investment, particularly over the short term period, was highly vulnerable to variations in the value of production.

Ndiame (1986) analyzed the role played by animal traction in lower Casamance, Senegal. The results of both technical and socio-economic aspects showed that 79% of the farmers used animal

traction for ploughing because it was easier and faster than manual operation. Fifty nine percent use carts for transportation, fifty nine percent did not use weeding equipment even though its use offers benefits, 42% used ox-drawn seeders. It is further observed that farmers using oxen generate N761 against N551 for farmers without oxen, N774 verse N634 were also obtained the following year. It is also observed that farm implement acquisition were mainly from credit programme. Technical and oxen performance was not taken into consideration during the study. Instead the significance and the intensity of utilization were considered.

On the basis of Indian and West African experience Bansal et al. (1986) revealed that the use of animal traction without other intensified production practices will not have an appreciable impact on productivity. Yield increasing synergistic effects are the greatest when other improved management techniques are used with a high-yield potential variety and adequate fertility. A distinction is made between tool bars with depth gauge wheels or skids and wheeled tool carrier (WTC). With a WTC the working depth, weight transfer and rake angle can be precisely regulated.

A case study of ox-traction programme was conducted by Corbel in 1986 in Koinnadugu district, Seirra-leon. The results obtained showed that there were 167 loans to purchase oxen and/or plough. The loan was below the cost of suitable animals. Average annual use of oxen was 41 days. Seventy eight percent

of the farmers hire their oxen for an average of 11 days a year. The terrain of the land is poor for animal cultivation unless levelled, farming is risky and yields erratic due to pest.

Corbel concluded that, inspite of all these constraints, the appreciating value of oxen made animal traction potentially attractive, it can be combined with increased farm size, diversified operations (ridging for tuber crops and hiring out animals. Similarly, an assessment of some aspects of work oxen use in Sierra-leone was conducted by Bell and Kemp in 1986, and results showed that farmers using oxens grow double the area compared to hand cultivation. They also found that it is typical to use oxen for 30-40 days per year of which 20-30 days are in hire service to other farmers. The risk of loss or death of oxen has been determined to be about 10% over 5 years or 2% average value per year.

Mathew (1994) identified social, economic and cultural factors of ox-traction at the small farm level in Gambia. The Data were collected from 47 oxen owners and 41 non-oxen owners. The results showed that although there were marked cultural differences between oxen owners and non-oxen owners, these are not so in socio-economic characteristics and adoption behaviour. Irrespective of ethnic or cultural differences, farmers are likely to adopt whatever technology introduced to them provided it proves to be profitable.

2.1.2.2. **Performance Evaluation of Workbulls Traction:**

Musa (1989) reported that the power of performance of horses are rated 0.76kw, cattle 0.38-0.62kw and donkeys 0.23-45kw. He further observed that economic analysis of animal power utilization and management indicates an increase in yield and net income of up to 255% per hectare when more efficient equipment and management techniques are employed. He finally presented a comparative rate of coverage for some field operations (Table 2.2).

Bolaji (1989) reported that a team of oxen can cultivate up to 1 hectare of land per day. He further explained that research has shown that bulls are 50-100kg heavier than cows of the same breed and age. Age of animal is a factor associated with power utilization. for example, oxen are best trained at the age of 2 or 3 years but become difficult thereafter. They perform best at age 7 or 8 years and can work until they are 12 or more years

Abiye and Mohammed-Salem (1992) explained that the power developed by a single local Zebu animal using a modified 'Maresha' and V-yoke was 0.3kw under field conditions and varied between 0.15kw and 0.19kw on test track.

TABLE: 2.2 **Comparative Rate of Coverage for Some Field Operations in h/ha:**

OPERATION	MAN	DONKEY	OXEN	TRACTOR
1. LAND PREPARATION:-				
a) Ploughing	-	-	17-25	1.7-2.5
b) Harrowing	-	5.2	6-7	0.8-1.5
c) Ridging	80-250	20-34	6-8	1.0-1.4
2. FERTILIZER APPLICATION:-	2/70	-	-	0/4/1.0
3. SPRAYING:-	2-3	-	-	0.4-0.5
4. PLANTING:-	50-100	8-13	6.8	1-1.5
5. WEEDING:-				
a) 1st Weeding	40-50	7-11	4.8	0.8-1.2
b) 2nd Weeding	40-120	8-12	6.8	0.8-1.2
c) 3rd Weeding	50-90	12-17	8-11	1.0-1.4

Source Musa (1989).

INCRISAT (1983) reported that though the speed of operation depends upon many factors, the walking speed of oxen is about 2.5 to 3.5km/h and horses and mules will usually work a little faster. Depending upon the breed and physical conditions, oxen can usually pull 7.5 to 20% of their weight. A pair of oxen weighing 350kg each will normally be able to pull at least 100kg and can provide 0.76kw of tractive effort. A pair of oxen weighing 300kg each has no difficulty in pulling a sustained load of 150kg or more.

Kwiligwa et al (1992) narrated that the use of animal-drawn cultivators alone reduced labour inputs for weeding by up to 80%, and the use of cultivators combined with hand weeding reduced labour inputs by 40% compared to manual weeding alone. Manual weeding, and combination of manual and cultivator weeding, gave the best control of weeds and similar yields (5t/ha. of maize compared to 2t/ha with no weeding). The use of cultivator alone gave significantly poor weed control and reduced yield advantages (3.3t/ha).

Kaul (1989) indicated that 10% increase in tractive power, and 15% rise in speed of workbulls would produce a 25% decrease in daily working time. He further stressed that some yokes may impose as much as 40kg of weight on some animals' neck resulting in wasted effort and fatigue. However, studies with water buffaloes have shown a 50% increase in available power as compared to workbulls.

Tillers (1987) observed average speeds of 4.4km/hr in the mobile mode compared to 2.8km/hr for stationary sweep. This increase in ground speed increases shaft speed and power. A minimum of 0.76kw is needed to run a small mill (NASCO, 1987) and an average oxen can be expected to generate .00039N-.00076N on an extended basis (Geo, 1980), but African workbulls are smaller and are frequently under-nourished and can be expected to perform near bottom of this scale (Tillers, 1987).

United Nations (1975) explained that gear powers used historically in Europe and America are in most cases impractical for contemporary third wold applications. Because, they require large, heavy cast gears, now manufactured only in Poland.

Goe and Mcdowel (1980) presented the estimates of tractive efforts produced by different animals at low and high speed as indicated in the Table 2.3.

Even though there is considerable variation in the data from different sources, the following figures are suggested as reasonable guidelines for draught work; horses 6-8 h/day; donkeys 3-4 h/day; mules 6-8 h/day; camels 6-8 h/day.

Geo (1980) reported in ILO and UNCHS, 1986 provided a flow diagram Fix. 1 showing factors affecting tracvtive efforts of draught animals as indicated in figure 2.1.

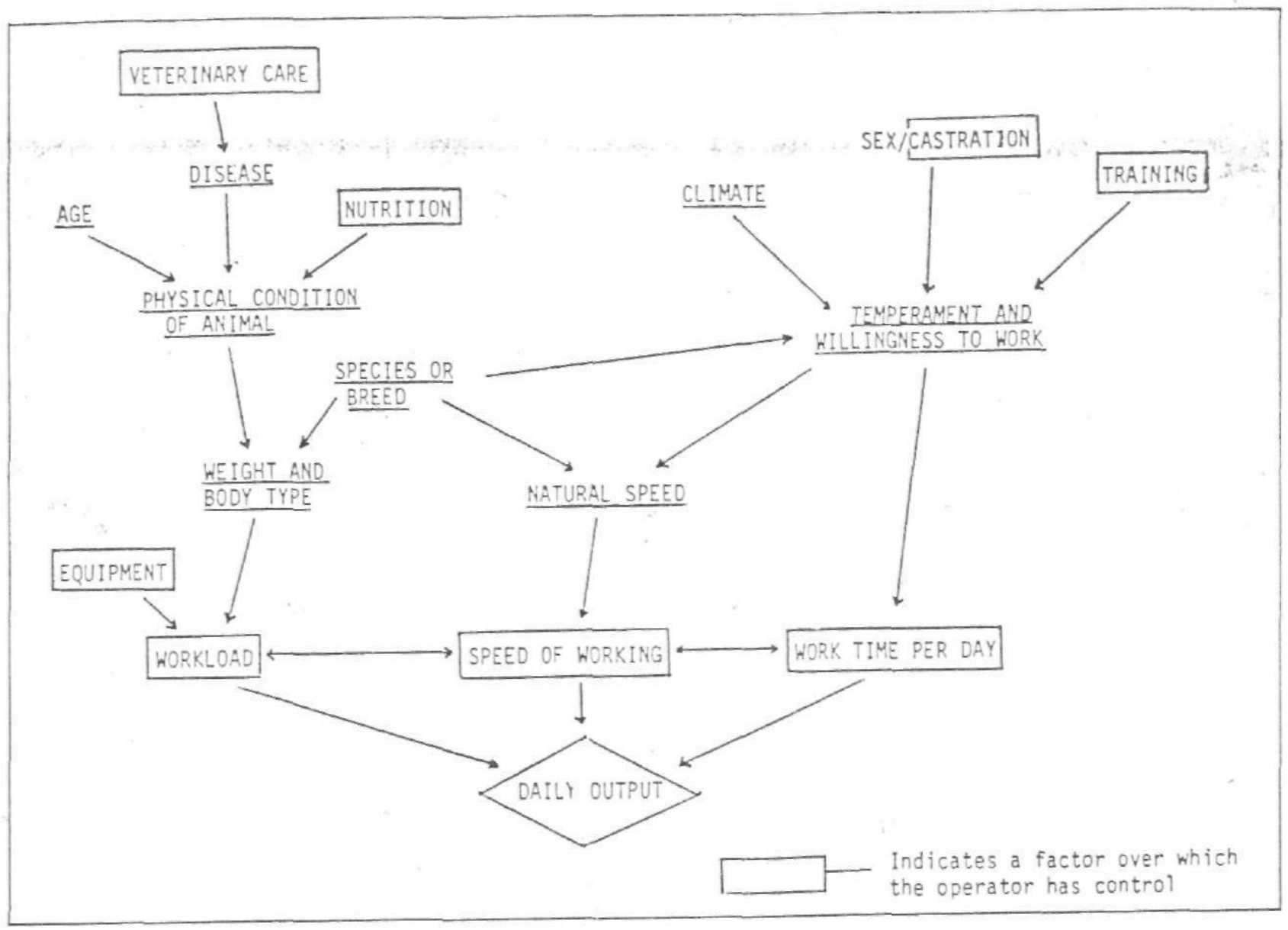
TABLE: 2.3

Tractive Efforts Produced by Different Animals

ESTIMATES OF TRACTIVE EFFORT PRODUCED BY DIFFERENT ANIMALS AT LOW AND HIGH SPEEDS

Type of Animal	Mature Weight (kg)	Low Speed		High Speed	
		Speed (km/h	Draught N	Speed (km/h)	Draught N
HORSE					
Light:	385	2.4	471	4.0	383
Medium:	500	2.4	618	4.0	490
Heavy:	850	2.4	1040	4.0	834
MULE					
Light:	200	2.4	314	4.0	196
Heavy:	600	2.4	941	4.0	588
DONKEY					
Light:	190	2.4	294	4.0	186
Heavy:	300	2.4	471	4.0	294
OX					
Light:	210	2.4	294	4.0	206
Medium:	450	2.4	628	4.0	441
Heavy:	900	2.4	1265	4.0	885
COW					
Light:	200	2.4	196	3.5	157
Heavy:	575	2.4	569	3.5	471
BUFFALO					
Light:	400	2.4	549	3.2	392
Medium:	650	2.4	892	3.2	637
Heavy:	900	2.4	1236	3.2	883
CAMEL (Dromedary)					
Light:	370	3.5	50	4.0	37

Source Geo and Mcdowel (1980).



Source: Geo (1980)

Fig: 2.1 Factors Affecting Tractive Effort of Animals.

Musa (1989) listed different types of workbulls in Nigeria with their relative body weights. The popular white fulani found in Zaria and Kano weighed between 300 to 500kg. The Sokoto Gudali found in Sokoto-Gusau areas had a body weight of over 500kg. The Bororo (Zebu) cattle found around Gombe, Potiskum, Maiduguri and Mubi areas weighed between 300 to 400kg. The Shuwa cattle breed around Lake Chad have the largest horns and look big but their performance and body weight is not yet known. He concluded that from wide spread use, the white fulani (Bunaji) are the most amenable to training and have acceptable temperament.

FAO (1990) documented various draft animals across the continent of the world with their relative weights, types, sustainable tractive effort, relative sustainable tractive effort, daily work hours, working speeds and maximum tractive efforts as seen in table 2.4a and 2.4b.

TABLE: 2.4a Types of Draught Animals and their Tractive Efforts

RACE TYPE & /SOURCE/	AVERAGE WEIGHT (KG) M	F	RELATIVE SUSTAINABLE TRACTIVE EFFORT (% OF WEIGHT)	SUSTAINABLE TRACTIVE EFFORT (N) M	F	MAXIMUM TRACTIVE EFFORT (N)	APTITUDE AT WORK	DAILY WORKING HOURS (hrs)	WORKING SPEED (km/hr)
BOVINES:									
Zebu/1/	375	300	10-14	375-525	300-420		good	4-6	2.4
Zebu X Taurin /1/	375	300	10-14	375-525	300-420		excellent	4-6	2.4
Zebu X Sanga /1/	375	300	10-14	375-525	300-420		good	4-6	2.4
Taurin /1/	250	210	10-14	250-350	210-290		excellent	4-6	2.4
Sanga /1/	530	375	10-14	530-740	375-525		good	4-6	2.4
Ox /2/	350		14	500		4500		4-6	2.4
Bull /7/	200		12.5	245					
Bull /7/	225		12.5	276					
Bull /7/	250		12.5	307					
Bull /7/	275		12.5	337					
Bull /7/	300		12.5	368					
Bull /7/	325		12.5	398					
Bull /7/	350		12.5	432					
Bull /7/	375		12.5	461					
Bull /7/	400		12.5	491					
HORSES:									
/1/	300		12	360				5-6	2.7
/2/	300		12	350		4500		5-6	2.7
DONKEYS:									
/1/	125		20	250				3-3.5	2.0
/2/	125		20	250		3000		3-3.5	2.0
/7/	80		20	160					
/7/	90		20	180					
/7/	100		20	200					
/7/	110		20	220					
/7/	120		20	240					
/7/	130		20	260					
/7/	140		20	280					
/7/	150		20	300					
MULES:									
/2/	200-600		14-18	280-1080				4-6	3.2
BUFFALOES:									
/2/	400-900		10-14	400-1250				5-4	2.9
CAMELS:									
/2/	300-600		10-14	300-840				3.5	2.5-3.2

Source: FAO, 1994.

TABLE: 2.4b Animal Draught Operations and Draught Requirements for Implements:

OPERATION:	WIDTH (cm)	DEPTH OF TILLAGE (cm)	DRAUGHT (N)	SPECIFIC DRAUGHT (N/cm²)	SPEED (km/hr)	POWER REQUIREMENT
Ploughing fallow with single mouldboard plough on medium loam soils /7/	11.4	12.7	873	6.0N/cm²		
/7/	14.0	12.7	922	5.2N/cm²		
/7/	16.5	15.2	1187	4.7N/cm²		
/7/	25.0	18.0	1660	3.7N/cm²		
Ploughing fallow with double on medium loam soils /7/	30.0	5.5	1138	6.9N/cm²		
Harrowing ploughed medium loam soils /7/			451			
18 tine peg tooth harrow	11.4	6.3	1158			
5 spring tines	165-320	11.4	785-981	4.2N/cm²		
heavy harrowing	320		883	2.8N/cm²		
Light harrowing						
Levelling ploughed medium loam soil with board + 50kg weight /7/	180		883	4.9N/cm²		
Cultivator, 3-tines on medium loam soils /7/		9.0	520			
Seed drilling, 11-13 opener on medium loam soils /7/	175-299		883	4.0N/cm²		
Wheeled Transport, 1 ton (on farm roads) /7/			883-1177			
Breaking old cotton ridges with plough in dry, 2% argilous (sandy) soil /7/	15.0	12.0	1099-1472	6.1-8.2N/cm²		
Breaking old cotton ridges with plough in dry, 8% argilous (sandy) soil /7/	15.0	12.0	2060-2158	11.4-12.0N/cm²		
Single mouldboard plough during rainy season on: /7/						
2-5% argilous soils	15.0	15.0	697	3.1N/cm²		
4-8% argilous soils	15.0	15.0	785	3.5N/cm²		
Ridging; 12cm high, 15cm wide on 4-8% argilous soil /7/			1079			
Weeding (cultivator) with 4 shovels a 200mm on 2-5% argilous soil /7/		3-4	500			

Lifting peanuts, on medium (6-8% argilous) soil with /7/ 350mm blade 500 mm blade			 392-441 785-884			
Plough, indigous /6/ Mouldboard /6/ Disc /6/			1.4- 6.9N/cm² 2.1- 11.0N/cm² 1.0- 9.8N/cm²			
Disc Harrow, single action /6/ double action /6/				4.4-14.7N/cm² 11.8-26.5Ncm²	1.6-4.0 1.6-4.0	7.4W/cm 14.9W/cm
Rotary tiller /6/				6.9- 26.5N/peg	0.8-2.4	7.4W/cm
Harrow, spike or peg /6/ Spring tine /6/				17.7- 26.5N/peg 98.1- 147.2N/tine	1.6-4.8 1.6-4.8	19.6W/peg 109W/tine
Roller or puddler /6/				1.5-8.8N/cm²	0.8-4.8	3.4W/cm
Leveller, float /6/				2.9-6.9N/cm²	1.6-4.8	4.2N/cm
Row-crop planter /6/				294.3- 686.7N/row	1.6-4.8	436W/row
Grain drill /6/				58.8- 215.8N/row	1.6-4.8	142W/row
Transplanter /6/				98.1- 196.2N/row	0.8-2.4	65.4W/row

Source: FAO, 1994.

2.1.2.3 Performance Evaluation of Workbulls-drawn Implements:

Donnel (1983) stated that agricultural machine performance are the rate and quality at which the operations are accomplished. He further mentioned that rate of machine performance is reported in terms of quantity per time. For example for field operation it is reported as area per hour. He noted that field speeds may be limited by overloading the machine functional unit, inability of the operator to control the machine accurately and loss of function and structural damage to the machine due to rough ground surface.

Kepner et al. (1978) reported that quantitative assessment of machine performance is difficult because no method has been developed for adequately describing soil conditions or for specifying conditions needed for intended use. However, to evaluate a tillage operation in terms of energy utilization, the actual tillage energy input per unit volume is calculated from measured draft, width of cut and depth of cut. They further observed that increased forward speed increases the draft with most tillage implements, mainly because of the more rapid acceleration of any soil that is moved appreciably. They also observed that specific draught of a plough generally decreases as the depth is increased to some optimum depth/width ratio and then increases as the depth is increased further.

AETC (1986) explained that under rough working conditions the frog can be squashed, the distance between the rear points of the base of the frog will measure less than 20cm and the width of cut will be reduced. Hence soil inversion and burial of organic matter will be poor, because the position of the mouldboard is distorted. It is therefore recommended to hammer the frog back to 20cm. Rumpstand Bulletin 1(year not printed) specified various implements made by the company for example ox-drawn plough "sandy III" weigh 32kg, cultivator 22kg, harrow 37kg, scraper 53kg, and precision seed drill 60kg and their respective working width are 22cm, 15-80cm, 130cm, 74cm and nil.

Muhammed and Haq (1989) designed, fabricated and tested animal-driven water pump at the Bangladesh Rice Research Institute. The results obtained showed that the pump delivered 213, 231, 249 l/min when a bullock, a buffalo, and a horse were employed at a speed of 3.43, 3.90 and 4.28 km/h, respectively. Similar harness as employed for sugar-cane crusher was used. The range of total draught, recorded between 157-196N, is very low compared to the potential draught capability of an average bullock (588N). The pump can irrigate about 0.92ha of boro rice land or 1.8ha of wheat or a very sizeable area of irrigated winter vegetables.

David (1988) reported that in Zambia an average of 6.7 ha per year is being ploughed by a pair of oxen well beyond the target of 5 ha. About 370 oxen-packages were disbursed by 1987. As a result about 2500 farmers had therefore obtained access to

ploughing services, which represents 54% of the Lima farmers so far covered by the project. Assessment revealed that 1.5 ha is ploughed for the owner, 1.6 ha for free of charge or operator and 3.6 ha for hiring to others and this is regarded as satisfying results.

David (1988) further reported that roughly, 1750 ha (43% of the total cultivated area in all three districts) of Zambia were ploughed by oxen drawing 260 ox-ploughs.

Gabon et al. (1992a) identified five different types of animal drawn ridgers in the north eastern Nigeria whose weights varied between 22kg and 44kg. The variation therefore is expected to influence the capability of draft animals in arid zone of Nigeria.

For mouldboard ploughs, approximately 25% of the draught is required for cutting the soil, 25% for turning and 50% to overcome friction and these could be affected by poor adjustment of the plough. Similarly, working width, depth of work could also be affected due to poor setting/adjustment of the implement (Dibbits, 1987).

Sharma et al. (1991) conducted a three year performance evaluation of different bullock-drawn puddling equipment, i.e., rotary blade puddler, disc harrow and harrow-cum-puddler in comparison with the desi (indigenous plough). Performance results showed that rotary blade puddler performed very

satisfactorily when operated twice in the field before transplanting the crop. It was found to be very effective in reducing percolation loss and it provided good 'puddle' with puddling index of 49.10-59.02% in clay loam soil. The average depth of puddling was 110-150mm under different conditions. Its average draught was 478N, 509N and 586N at three different locations as compared to 1167N, 1132N and 873N in bullock-drawn disc harrow and 333N with desi plough. It required about 18 hours per ha for puddling operation. Where as bullock drawn harrow required 23.5 hours to do the puddling in 3 operations and desi required 55.6 hours for similar work. The energy required and cost of operation of bullock-drawn disc harrow and desi plough was 1.35 and 4.64 times the requirements of bullock-drawn rotary blade puddler.

Jadhav and Turbatmath (1991) presented the development and performance evaluation of bullock-drawn multipurpose hoe. The test results showed that a bullock pair can operate 2 to 4 hoes at a time. The weight of a hoe is 16kg and the average draft required for a pair of hoes varies from 255N to 314N. The actual field capacity of a pair of hoes varies from 0.15 to 0.25 ha per hour. The hoe gives 35mm maximum mulching depth, 75mm maximum tillage depth and 50 to 80mm earthling height (ridging crop rows).

Senapati and Satpathy (1989) tested bullock-drawn ploughs in lateritic soils. Results obtained indicated that the draft experienced by a pair of bullocks in Fidu-I plough was maximum of 1031N as it was difficult to drag this plough on the field.

The Bishu plough II developed by the Orissa College of Agricultural Engineering at Bhubaneswar inverts and pulverizes the soil better than any other plough under test. Performance index values of the plough are summarized in the Table 2.5 be precisely regulated.

TABLE: 2.5 Efficiency of Mouldboard Ploughs

TREATMENT	EFFECTIVE FIELD CAPACITY (A) ha/8h	DEPTH OF FURROW (CM)[4]	INVERSION (I) %	PULVERIZATION (P) (CM)	UNIT DRAFT (D) kgf/cm²	PERFORMANCE INDEX = AdIP/D
T1	01745	8.0	72.32	10.41	0.9158	1147.4
T2	0.192	8.0	87.23	10.78	0.8534	1692.5
T3	0.192	7.5	70.64	8.91	0.7240	1251.9
T4	0.192	8.5	57.84	7.55	0.6018	1184.3
T5	0.192	9.5	69.33	10.46	1.13560	1164.8
T6	0.1846	7.5	8.012	9.79	1.0860	999.9
T7	0.1811	8.5	79.52	9.89	0.9413	1284.1
T8	1.3333	6.0	57.149	9.89	0.7262	211.9

Source Senapati and Satpathy (1989)

Brain et al. (1996) evaluated technical and economic performance of animal drawn chisel plough developed in Honduras. Field performance results showed an effective field capacity of 0.08ha/h at an inter-furrow spacing of 60cm was obtained. This is compared with 80 man/hours to do the job by hand. At a working depth of 11cm the draft force was about 450N which, at a forward speed of 0.8m/s. gives a power requirement of some 360W which is within the capability of a healthy horse or mule. Economic evaluation showed that with chisel plough 1.75ha of summer maize and 1.75ha of winter beans can be cultivated. The plough cost N72 and is used for 50h/year over life span of six years.

2.1.2.4 **Draught Animals Transportation:**

Rumstad (year not printed) of Holland within their 50 years experience in the manufacture of animal-drawn equipment have designed and constructed ox-cart and donkey cart whose loading capacity ranged between 100kg to 800kg respectively. The weight of ADV cart (Indian) is 400-500kg, donkey cart (Senegal) is 190kg, bullock cart (Vietnam) is 300kg and their pay load or loading capacity are 2,500-3,000kg, 500kg, 800kg-900kg, 1,000kg and 1,200kg, respectively (ILO and UNCHS, 1986).

Adeoti (1989) reported that the use of animal carts is less widespread in Africa even in areas where animals are used for cultivation. Recently, there has been renewed interest in animal transport, especially in efforts to develop improved animal carts, notably in India and on a limited scale in Malawi, Nigeria

and Senegal. He presented characteristics of alternative transport systems as depicted in Table 2.6.

David (1988) studied the impact of oxenization programme in the north-west province of Zambia. The study showed that roughly 4,000 tonnes of crops were carried to marketing depots by 470 ox-carts. This represented about 80% of the 5,000 tonnes of marketed produce of Zambezi and Kabompo districts. One pair of oxen has a capacity to transport about 100 tonnes during the two months marketing session; thus 400 pairs were sufficient to transport 900 tonnes of maize over an average distance of 5km.

Table: 2.6 **Characteristics of Transport Devices:**

TRANSPORT SYSTEM/VEHICLE	CHARACTERISTICS			
	LOAD CAPACITY (kg)	SPEED (km/h)	DISTANCE (km)	EFFECTIVE WIDTH OF TRACK
A: MANUAL SYSTEM				
Human portrage	40-50	4-6	5	unlimited
Wheelbarrow	100-120	3-4	3-5	wide/limited
Hand cart	400-700	3-4	3-5	wide/limited
Bicycle with carriers	60-100	10-15	40	unlimited
Bicycle with trailer	100-120	8-12	40	limited
B: ANIMAL SYSTEM				
Pack animal	80-150	3-5	20	unlimited
Animal cart	400-2000	3-5	20	limited
C: MOTORIZED SYSTEM				
Motor cycle	150-200	30-80	100	unlimited
Motor cycle with trailer	100-250	30-50	100	limited
Cars	100-200	40-100	100	limited
Pick-Ups	1000	40-80	100	limited
Tractor-trailer	2000-3000	28-40	50-100	limited

Source: Adeoti, 1989.

2.1.3 Donkey Traction Technology:

The predominant donkey colour is grey, height at withers varies from 90 to 110cm, girth measurement immediately behind the shoulder average 109.8 ± 4.66cm for Sudan donkeys, while average weight is 125 ± 12.8kg. It is imperative to note that the Mossi donkeys in Burkina Faso and those of Kano in northern Nigeria are said to be bigger than the average of other African types, though not of noticeable difference (Payne, 1990).

Musa (1978) as reported by Adeoti (1989) showed that most donkeys can carry about 80-150kg of load and up to a maximum of 200kg of grains (2bags) per trip, they can pull 5 times the load they carry on their backs but require light carts and access roads. Further research work revealed that donkeys could pull light tillage implement for cultivation, harrowing, ridging, planting and weeding, with an average draft of 450N at an average walking speed of 2.34km/h giving an average power output of about 0.29kw (Musa, 1989)

Geo and Mcdowell (1980) presented mature weights and estimated tractive efforts produced by different animals for light and heavy work at low and high speeds as indicated in Table 2.4. For donkeys, the weight ranged between 190 to 300kg and the draught ranged between 294 to 471N. The working speed ranged between 2.4 to 4km/h.

Sim and Maldonado (1991) and Betker and Kutzlach (1991) concluded that donkey power should be limited to transport

purposes (already widely practised). However, Musa (1989) explained that donkeys are valuable sources of power in draught work especially in planting, inter-row cultivation (weeding). Load carried in the middle of oxen and buffalo backs was nearly twice as great as when the load was carried over a donkey's hind-leg a favoured location when ridging with a donkey (Lawrence and Stibbards, 1990). He further explained that donkeys are amenable to training from one day to over two weeks to get them used to draft work and that they are docile and respond to command as against the notion of their stubbornness. Musa (1989) also found that for donkeys, the draft speed is relatively higher than that of oxen provided they are not overloaded or over worked.

FAO (1990) listed types of draught animals and their tractive efforts. For donkeys of average weight 125kg, the sustainable tractive effort was 250N at a working speed of 2.0km/h as indicated in Table 2.5(a).

2.1.4 Camel Traction Technology:

William and Payne (1989) reported that when camel were used in the British army, the maximum load normally permitted was 204kg for 32km a day over prolonged, periods, with one day rest each week. They further reported that Bacterian camels used for transport can pull loads of up to 1,500kg. A good riding camel can move at the rate of 15 to 19km for an hour or so and can travel 80km a day for two weeks.

Payne (1990) reported that mature camel weights are between 350-550kg of most breeds and up to 660kg of heavy Indian breeds. It was stated that the Sudan riding camels could attain a speed of 8km, and 16 to 32km per hour when trotting and running, respectively. He further noted that, the small compact, muscular, heavy-boned hill type, bred in rough upland regions, is very different from the more rangy, long-legged, more loosely coupled plain camel. The former is only some 1.8-2.0m high at the withers, while the later may be up to 2.14m.

Geo and Mcdowel (1980) presented mature weights and estimated tractive efforts produced by different animals for light and heavy work at low and high speeds as indicated in Table 2.4. Similarly, FAO (1990) listed the types of draught animals and their tractive efforts as indicated in Table 2.5(a)

2.1.5 Horse Traction Technology:

Geo and Macdowel (1980) presented mature weights and estimated tractive efforts produced by different animals for light and heavy work at low and high speeds as indicated in Table 2.4. Similarly, FAO (1990) listed the types of draught animals and their tractive efforts as indicated in Table 2.5a.

Roosenberg (1987) stated that some historical gear powers that drove threshing machines were only 60% efficient but used 14 horses and that increasing available power requires either harnessing more animals or improving efficiency by smooth gear arrangements or simpler harnessing techniques that will reduce

fatique and increase efficiency by smooth gear arrangements or simpler harnessing techniques that will reduce fatique and increase efficiency.

Horses are used in Nigeria but limited only to small scale sugar-cane crushing and processing with output as high as 300kg/h which is quite good compared to the outputof 700kg/h from 7.3kw engine power crusher (Kalkat and Kaul, 1983). It is however, still not clear why horses are not used for tillage operation in Nigeria (Gwani,1990).

2.1.6 Harnessing and Hitching Technologies:

Harnessing and hitching techniques of draught animals could be said to have started when the idea of traction came into being along with implement development. Globally the yoke made from tree or timber can be said to be the early design and the most predominantly used even today world wide. After several decades of utilization, researchers confirmed the weakness of using yoke harness. Later, on the course to improve effectiveness, efficiency and ease the burden of fatigue on draught animals, the idea of improved harnessing and hitching arrangement came into existence.

Since the introduction of draught animal power technology to Nigeria in the 1920s yoke harnessing of a pair of workbulls is the only existing technique in Nigeria. In some areas of Africa workbulls with the short neck are harnessed through the horns. However, these methods of harnessing are found

inefficient as reported by researchers. Kaul (1989) explained that some yokes may impose as much as 40kg of weight on some animals' necks resulting in wasted effort and fatigue. However, studies with water buffaloes have shown a 50% increase in available power using collar harnessing techniques.

When animals are harnessed in teams the useful effort available per animal is rather less than that produced by the animal on its own. The reduction in effort produced per animal amounts to 7.5% for a team of two, 15% for three, 22% for four, 30% for five and 37% for six. With more than two, the time and cost of caring for animals increase, the hitching and harnessing arrangements become more complex, control becomes more difficult, efficiency decreases significantly (Geo and Mcdowell, 1980). Many researchers have pin-pointed the use of improved harnessing techniques to achieve maximum performance apart from the traditional yokes which are very significant in reducing both the productive work output of the animal and their useful working live.

The mosc common traditional yokes are shoulder yoke, forehead, neck and head yokes used for short-necked oxen. Simple improvement is to add padding to the traditional type of shoulder yoke. Other improved techniques are three pad collars, breast bands, saddle and breach straps harnessing techniques for oxen,s donkeys, horses and camels (FAO, 1994, Tillers, 1987, AERLS, 1983, Starkey 1986, FAO, 1972 and ILO & UNCHR, 1986).

Traditional equipment is not always well designed either. A draught animal work best at slow speed with a steady load and comfortable harness (Francis & Mansell, 1988).

When an animal is worked by itself a single forehead, head, neck or shoulder yoke may be used. According to FAO, (1972) single forehead and neck yokes have been successfully used in Zaire.

A simple and effective head yoke equipment was designed by Read 1942 in at Hissar in India William & Payne (1989) consists of the head yoke proper, a surcingle, a pair of traces and a drawbar. Leather harness, either in the form of a breast strap or a shoulder collar are used with horses, and can be employed when cattle work by themselves. However, this type of harness are unsatisfactory as it appears to cause discomfort and to discourage traction. This is presumably because the shoulder muscles of cattle are not so well developed as those of horses and neither protect the joint nor cushion the skin. Two types of double yokes are normally used, - the double neck yoke and double shoulder yoke, the former widely used in African sub-region. (FAO, 1972, reported by Williams & Payne, 1989). The yoke is 142cm long, and 9cm diameter smooth round pole. Distance between pegs are 25cm on either side of the pole.

Evely (1964, 1965, 1966, 1967) enumerated yoke sizes in Nigeria. Yoke for making new ridge, splitting ridgers, moulding old ridger and cult furrows is 2.5m long, yoke for splitting

ridge, carting and drawing single planter is 1.6m long, yoke for ploughing with a victory plough is 1.4m long.

The Yoke dimensions are given below:-

- size of holes for neck pegs = 0.6m
- distance between holes for neck peg = 0.3m
- extension of poles beyond outside neck peg hole on each neck = 0.2m
- Length of neck pegs = 0.4-0.5m

Gifford (1986) reported that many attempts over past twenty years to introduce improved harness and implements have failed because either appropriate models were not consistently available in the market, or the cost was beyond the means of the farmer.

Comparison of collar harness showed that a pair of oxen using the collar harness could do the same work as two pairs using traditional yoke. A pair of donkeys working with the collar harness could do the same work faster than physically heavier oxen with collar harness or traditional yoke (unpublished data of Onyango, 1987 reported by Samuel, 1990).

AETC (1988) narrated that depending upon the type of job for better performance efficiency, yoke dimension may differ e.g. ploughing yoke approximately 150cm, carting yoke is approximately 170cm and cultivating yoke approximately 240cm long.

Hassan (1996) tested and evaluated single harnessing of workbulls, donkey and camel in NEAZDP. The results obtained showed that using collar harnessing techniques, single draught animal is capable of performing the same job as paired and is faster as well as easy to control. With light implement, single animal works for a longer period as compared to paired animals.

However, economically new harnessing techniques should comply with the ability of the farmer to pay for extra charges based on the benefits he derives. Similarly, adopting new harnessing techniques with mature animals is difficult, therefore, new harnessing techniques should be adopted to young animal during training programme (Dibbit, 1987).

Starkey (1992) reported recent improvement in harnessing techniques in Morocco. He mentioned that different species of animals are harnessed together using traditional belly yokes, such as a cow with a donkey, a camel with mules and a horse with a donkey as teams for ploughing operations.

2.2 Performance Evaluation Methods of Animal Traction Technologies:

Starkey (1988) stated that the methodology should be flexible and open-ended, being designed to seek solutions, rather than prove points. The studies should be highly development - orientated with any data collection being merely a means to an end, rather than an end in itself, and measurements or assessments should clearly reflect those parameters important to the farmer, representative local farms, using resources that are

available to, and affordable by the farmer. Finally, research should be undertaken in close liaison with similar programmes elsewhere, to ensure that researchers do not duplicate studies unnecessarily and that they build on each other's experience.

FAO (1994) further expressed that it is the responsibility of the test Engineer to decide which measurements should be made to best judge the work output and suitability of the implement.

Evaluation of a programme's effect on people, structure and organization and programme activities can simply be determined from (1) physical measurements, like height, weight etc., (2) verbal questions, such as thosed asked in questionnnaires, interviews, tests of knowledge and skill, tape recordings, meetings, discussion, (3) written questions such as those asked in questionnaires, tests of knowledge and skills, attitudes, (4) analysis of existing information, such as records, reports, diaries and autobiographies, (5) observations, photographs and drawing of customs, practice and procedures. Others include budgets, plans, past evaluations, registers, minutes, check lists, records of personnel work or work diaries and surveys (Marie, 1986, Dennis and Kumar, 1988 & Ndiame, 1986).

2.2.1 Evaluation of Animal-drawn Equipment:

Thiec et al. (1986) listed methodological stages for testing, evaluating and promoting animal-drawn equipment: -

1] Identification of needs: study of the farming system in

which equipment will be used and context of work for which it will be selected or developed.

2] Operational requirements: definition of exactly what the equipment is required to do.

3] Specification: clear listing of weight, draft, size and working width, affordable costs, technical level of users, maintenance requirement and working life.

4] Study of option: review of available equipment (locally or from other countries) that meets specified requirements. If non available development of new prototype or adaptation.

5] On-station testing and evaluation of selected equipment.

6] On-farm testing and evaluation with farmers.

7] Standardization of appropriate design with formal drawings.

8] Small batch production and distribution to farmers.

9] Further on-farm evaluation with farmers to establish durability and suitability.

10] Economic studies and assessment

11] Large scale production and extension.

2.2.2 Procedure for Measuring Performance:

FAO (1994) compiled and reported procedures for measuring animal and equipment performance as follows:-

2.2.2.1 Animal Performance:

i) Working Speed (km/h)

To measure working speed, a plot of 40m square in strips of 10m wide should be marked on the test field. The speed in m/s is to be recorded after every 20m travel until the test plot is completed. The average of the working speed is then calculated and converted to km/h, i.e. $S_1 = S_2 \times 3.6$. ---------1

where,

S_1 = speed(km/h)

S_2 = speed (m/s)

(ii) Working Time (h/ha)

The working time in h/ha is deduced from (i) above i.e. WT

$$(h/ha) = \frac{10,000 \times t}{1,600} \quad \text{----------2}$$

where,

WT = working time (h/ha)

t = time taken to cover $40m^2$

(iii) Estimated Body Weight & Tractive Effort:

In order to estimate the load required to be pulled by animals, it was reportedin previous research that animals will be able to pull between 10-20% of

their body weights. In the absence of weighing scale for animals, it is recommended that body weight can be estimated from the following formula:- Estimate body weight (kg) = G^2 x L x 92.46, ---------- 3

where,

G = The heart girth in metres
L = Body length from front shoulder to the base of the trail in metres.

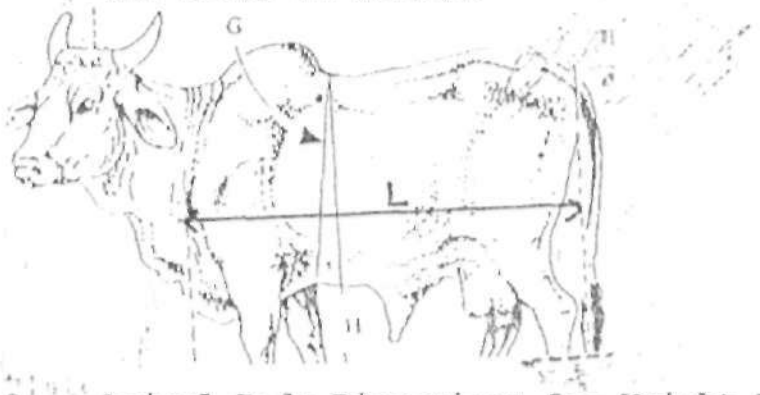


Figure: 2.2 **Animal Body Dimensions for Weight Estimation:**

2.2.2.2 **Implement Performance**

(i) **Depth & Width of Cut (cm)**

Generally, the measurement of depth and width of cut are the same as reported by many researchers. FAO (1994) explained that to measure width of cut, the implement should be run several times in the test plot. The width of cut therefore is calculated as follows:-

$$\text{Width of cut (cm)} = \frac{\text{Total width of travels}}{\text{No. of travels.}} \quad \text{-----4}$$

The depth of cut is measured by inserting a graduate steel rule into the tilled plot at several points and the average is taken.

(ii) **Height of ridge, top & bottom furrow (cm)**

FAO (1994) reported that, to measure height of a ridger, top and bottom furrow, a graduated measuring device should be inserted into the furrow between two ridges. The device which is similar to a divider should be opened at the bottom of furrow as well as at the top and the reading is recorded on the scale. The scale has a vertical reading on which the height of the ridge can be read. In the absence of this graduated device, a steel rule can be used to measure these parameters.

(iii) **Inversion/cutting Efficiency (%)**

FAO (1994) reported that to measure efficiency of an implement, a one metre frame is dropped on uncultivated land and the number of weeds and stubble roots in the one meter square is counted and recorded. In a plot 40 x 10m, only 3 readings are necessary. Later, after cultivation, the same count is taken usually to record the number of uncovered roots of the weed or stubble in the one metre frame.

Inversion is expressed as:-

$$F = \frac{W_p - W_g}{W_p} \times 100 \qquad \text{---------- 5}$$

Where,

F = Indicator for soil inversion, ration of weeds or crop stubble being covered (%).

W_P = No of weeds or crop stubble before operation per unit area

W_E = No of weeds or stubble exposed on the surface after operation.

(iv) **Implement Draught Requirement (N)**

To measure draught, a dynamometer is to be fitted between the implement and the towing arrangement. The draught is to be recorded after every 20m distance travel (FAO, 1994). During this process, it is only pull force which is recorded by the dynamometer. The draught therefore is calculated as follows:-

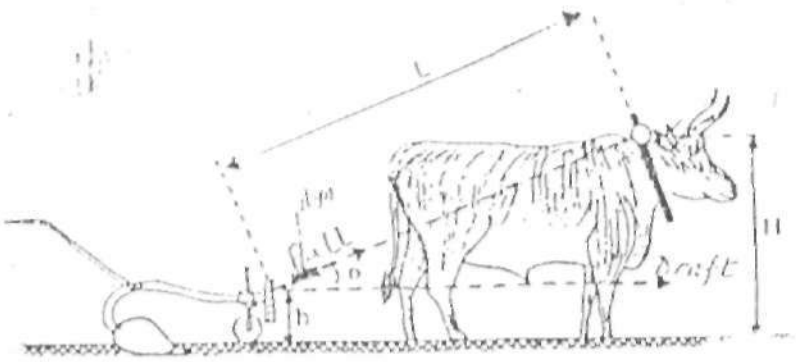


Figure: 2.3 **Dimensions for Draught Calculations:**

a) Draught = Pull force x Sin O

$$\text{Sin O} = \frac{\sqrt{[L^2 - (H - h)^2]}}{L}$$

or

b) Find O from: $\frac{\text{Sin O}}{} = \frac{H - h}{L}$ ---------- 6

Where,

H = height of yoke (cm) from ground level.

h = height of implement from hitching point (cm)

L = length of chain from hitching point to the centre of the yoke on which it is attached.

v) **Implement durability:**

Implements can be evaluated for durability in the laboratory or on the field for number of hours or on the field through several years of utilization. FAO (1994) reported that durability through several years of utilization can be done through constant checks, supervisions and inquiries from users annually.

vi) **Implements comparative performance:**

Sharma et al (1991) in their study of comparative field performance of bullock-drawn puller gave the following procedure. A plot size of 60 x 15m was chosen for each treatment with three replicates for determing yield data and puddling indix. Alternatively, Senapati & Satpathy (1989) tested different types of bullock-drawn ploughs.

The field trials were conducted on a 20 x 10cm laid in a randomized block design with the three replicates.

Similarly, Shetto and Kwillgwa (1990) compared the efficiency of weeding cultivator. The treatments included nine different weeding regimes, replicated three times in a randomized block design. The plot

size was 30m x 3m with five rows each.

FAO (1994) reported that for convinience, animal and equipment can be measured by laying out a field 40 x 40cm divided into 4 strips and data be collected from each strip.

2.2.2.3 Cart Performance

i) Cart durability

Like implement, carts are tested in the laboratory on standard track for haulage or durability. For field testing, the evaluator has to make constant visits to the users and make frequent checks on wearing components, joints, axles bearing, tyres, rims and hubs for a period of years (2-3) before reporting (Dennis and Kumar, 1987b and FAO, 1994). FAO (1994) further mentioned that during such checks, types of carts, hitching and harnessing techniques employed, number of animals and types should be noted. Similarly, the loading capacity, distance travelled and time taken should be recorded.

2.2.2.4 Artisans Performance

Bai (1990) stated that in Sierra-Leone, by using scrap metal, home-made tools and local charcoal, blacksmiths contribute 80% of the final value of the production themselves. He went ahead to assess the

products in terms of various skills such as cutting, bending, forging, measurements, costing etc. For each skill, he scored 10 points and the overall quality of the product was based on the average percentage of the skills scored. He therefore concluded that research and development should emphasize on producing low cost equipment that can be made and maintained locally. From this findings it can be said that all artisans (blacksmiths, carpenters, fabricators and ox-handlers) need to be assessed once they are trained on certain basic skills so as to confirm their degree of perfection.

2.3 Justification for the Study:

From the above review in the literature, there are various reasons that warranted this study. They are summarized as follows:-

i) **Limited Research Work on Animal Traction Technology of the Arid Zone of Yobe State.**

Most of the research works in Nigeria on animal traction technology have been undertaken at Zaria, Bauchi, Kano and Sokoto States. There is limited or no research work done on the arid zone particularly north eastern part of the country where NEAZDP lies. It is therefore imperative to come up with data from this agroclimatology for comparison with others obtained elsewhere.

ii) **Needs for Confirmation of the Previous Research Findings:**

Previous researchers concluded that broad adoption of animal traction technology was blocked due to implement inappropriately designed for African conditions. Secondly, African animals are underfed and smaller, and are expected to perform below thresholds of animal power obtained elsewhere. Since NEAZDP is introducing animal drawn equipment from other regions, it is necessary to test and evaluate them with arid animal ability before they could be disbursed to farmers in large quantity if found suitable to the animals as well as the soil conditions. If not, then modifications or improvements would have to be done and re-tested before disbursement to farmers.

ii) **Needs for Sustainability of NEAZDP Animal Traction Programme through Artisan Training**

Since the introduction of animal traction technology in Nigeria in the 1920s, ox-ridger and ox-cart were the only technologies fully promoted using workbulls. When NEAZDP came in to being in 1990, various animal-drawn equipment as listed earlier were introduced. Similarly, other animal power sources such as donkeys and camels were equally introduced.

To sustain this programme, there is the need to train blacksmiths and carpenters for the fabrication,

CHAPTER THREE

MATERIALS AND METHODS

3.1 Base-Line Survey:

This chapter describes the experimental work conducted as part of the research. It first describes in detail a base-line survey conducted to establish preliminary information on the study area, selection and modifications made to existing NEAZDP Animal Traction (AT) Programme and technical evaluation of the modified components of the AT Programme. It ends with an assessment of the level of technology adoption and economic evaluation.

3.1.1 Drought Animals and Existing Equipment:

The number of available draught animals and existing animal-drawn equipment were established in NEAZDP area through the base-line survey. The survey carried out by visiting and counting the number of draught animals in all the 355 selected villages under the Programme area. Information on existing implements, carts and animal utilization were obtained from draught animal users as well as Borno State Agricultural Development Programme (BOSADP) and Ministry of Agriculture and Natural Resources. Research institutions such as NAPPRI, AERLS, Zaria and Ramat Polytechnic Centre for Appropriate Technology (RAMCAT) were also visited to find out technologies in draught animal utilization.

3.1.2 Artisenal Skill Availability and Assessment:

A base-line survey of blacksmith, carpenters, fabricators and draught animal handlers was carried out to establish the availability of related technologies for the maintenance and repairs of animal drawn equipment and their skills in equipment fabrication/construction.

3.2 Primary Field Evaluation of the Existing Draught Animals and Equipment:

In order to establish preliminary information on the Arid Zone draught animals and existing equipment in terms of capability and operational suitability, a primary field evaluation was conducted. This initial evaluation provided necessary step for modification and improvements of NEAZDP Appropriate Technology (AT) Programme.

3.1.1 Location, Characteristics and Selection of the Study Area:

The NEAZDP area falls within the northern part of Yobe State and covers an area of 22,860sq kilometres, lying between latitude 10^{0}N and longitude 9^{0}E of the equator. It shares border in the north with Borno State, south with Jigawa State, east with Fune and Tarmawa Local Government areas of Yobe State and West with Niger Republic.

The area is generally loamy sand and sand loam. Garin Alkali which falls within this area and close to the Programme Headquarters was selected for primary testing of equipment. The field is located opposite to programme headquarter about 6km away

from Gashua - along Gashua to Potiskum road. Azam village was selected for plough primary testing due to Fadama (clay) nature of the area. Azam is located 8km away from Bukarti village which is 18km along Gashua-Nguru road.

3.2.2 Programme Evaluation of the Introduced Equipment:

The introduced equipment initially by the Programme were:-

1. Emcot Ridgers
2. Indian Make Ridgers
3. Locally Constructed Carts

The ridgers were initially tested to find out their suitability in terms of weed cutting, inversion and soil penetration to make better ridges and identify if any, mechanical components faults. The Emcot ridger which was earlier known to farmers was procured and distributed without primary testing. As a result of increase in cost of the Emcot ridger, Indian ridgers which were a bit cheaper were imported by the then Borno State Ministry of Agriculture but initially rejected by farmers due to poor performance in terms of soil penetration, weed cutting and inversion to make proper ridges was procured. Only one sample was purchased at the beginning and tested. Operational and mechanical problems were identified. Using a blacksmith, amendments were made and the ridger was re-tested again. Been satisfied with the operation, large quantities were purchased and amendments were made using blacksmiths, and were later distributed to farmers. Locally constructed carts were already known to farmers and only

its initial design and mode of disbursement to farmers was studied.

3.3 Modification to the NEAZDP Appropriate Technology (A.T.) Programme:

Modification of AT Programme was carried out in terms of modifying imported Indian make ridgers and locally constructed carts for better performance.

3.1.1 Modification of the Existing Indian Ridgers:

Primary testing showed that, the beam curve was too wide i.e. more than 90° which affected the share rake angle and consequently prevented it from getting into the soil at different depth settings. The curve was hammered to Emcot beam curve angle of approximately 90°. This was done by heating the beam curve to hot red colour until the beam curve became softened, and then hammered using slash hammer on an anvil. After bending the beam to the correct curve angle, they were hardened by quenching in water. The bolts and nuts that connect the wings to the frog got loosen due to vibration while at work. These were replaced with a 6mm diameter steel rod and bent at two ends to avoid wings from collapsing.

3.3.2 Modification of the Existing Locally Constructed Carts:

The body frame work of the locally constructed cats were made of nails. These were replaced with bolts and nuts at all the corners and joints of the frame for rigidity. The volume of the carts were increased to accommodate more loads instead of heaping more loads above the frame work as traditionally practised.

Heaping usually affected the stability of the carts. The scrap axles used from Nissan and Landrover vehicles were replaced with the 25mm diameter steel shaft mounted on stab axle bearing purchased from John Holt. This was done by welding the stab axle bearing at the two ends of the steel shaft. The scrap axles from Nissan and Landrover were replaced because of heavy weight and bearings worned out. Alternatively, Peugeot transmission shafts purchased as scrap and mounted on stab axle bearings were lighter in weight and used to replace scrap axles from Nissan and Landrover rear axle.

3.4 Incorporation of Artisans and Animal Handlers into NEAZDP A.T. Programme:

To sustain NEAZDP A.T. Programme, artisans and animal handlers were incorporated to provide services such as fabrication, construction, maintenance, repairs and training technigues of the newly introduced technologies.

3.4.1 Blacksmiths and Welders:

Due to increase in the cost of Emcot ridgers and importation stoppage of Indian ridgers, a new ridger was designed based on operational and mechanical advantages of the Emcot and Indian ridger. The Emcot has a better share body assembly for soil penetration, weed cutting, soil inversion and appropriate beam. While, the Indian make has better steering wheel and depth adjustment possibilities under field condition manually without the use of a spanner. The beam and the shares of the new ridgers were copyright of the Emcot design, while the steering wheel and hitching points were adopted from Indian design. All other

assessories such as handle frame work, breast plate, wings and the frog were same with that of Indian and Emcot ridgers. Templates of all the components were traced and cut from the existing Emcot and Indian ridgers. Scraps were selected and blacksmiths fabricated the modified ridgers following the templates. When ARARA ploughs and cultivators were introduced, they were equally pre-tested. The problems identified were that; the plough was relatively heavy for use in Fadama (clay) soil and the tines for cultivators were smaller. The design of Spike Tooth harrow and bund former were obtained from FAO's (1990) bulletin. Dimensions were allocated to this design. Following the same process for ridgers and ploughs, blacksmiths were used to fabricate these items. They were tested. The following problems were identified. The wooden frame used for frame construction was found to be weak and was replaced with the 5mm thick angle iron and the spike tooth made from 12.5mm diameter steel rod was replaced with the 25mm diameter steel rod. It was re-tested again and the performance was satisfactory. The bund former performed satisfactorily in terms of bund sizes and reduce human effort. The only problem was that, the bolts and nuts were not counter-sunked. Later, they were removed and counter-sunked.

Like ridgers, modified ploughs, harrows, cultivators and bund former were fabricated in large quantities and issued to farmers for demonstration purposes for possible adoption.

3.4.2 Carpenters and Welders:

Carpenters in the study area were familiar with workbulls carts construction. The design was improved by replacing body

frame work nails with bolts and nuts, scraps axle from Nissan and Landrover vehicle with stab axle bearing mounted on 25mm steel rod and the volume was increased as stated earlier. The carpenters constructed the carts in large quantities and distributed to farmers on loan for a period of 3 years. When single donkey cart was introduced in 1993 from Niger Republic, the same approach of modification for ridgers was applied to the carts. Carpenters produced the carts. Few samples were issued to farmers over a period of one year for demonstration and testing.

During testing, the draw bars were reported to be weak and broken frequently. Twenty five millimetre diameter steel pipes were used to replace the original ones. The frame work made from 3mm thick angle iron was replaced with 5mm thick angle iron for more rigidity. Large quantities were later constructed and issued to farmers on loan. Based on the single donkey design, single bull carts and a single camel cart were constructed and issued to farmers for testing and demonstration over a period of one year. The single bull carts and camel carts were constructed just by increasing the volume and making the draw bar adjustable to fit the size of a camel.

All the implements and carts, both imported and locally fabricated/constructed were monitored over the periods indicated above on different farmers field and tracks, through field visits, observations and inquiries from users for suitability and durability.

3.4.3 Animal Handlers:

With the introduction of alien implements and carts, animal handlers were selected and trained on the technologies. Forty animal handlers were selected, 2 representing each of the 18 Development areas and 2 each from Gashua and Nguru urban centres. They were selected based on previous experiences of handling existing animal drawn equipment (ridgers and workbull carts). They were trained by NEAZDP Appropriate Technology Specialist assisted by instructors. The contents of the training consists of implement operational technique, adjustment, fault detection, animal command and control, selection of workbulls, feeding of concentrates, health and agronomic practices. This was conducted for a period of 1 - 2 weeks in a selected farmers' fields. They in turn use to train other farmers who were beneficiaries and demonstrated to other farmers the new technologies in order to motivate them.

3.4.4 Introduction and Demonstration of Animal Drawn-Equipment:

Having tested and modified animal-drawn equipment/implements, they were then introduced to farmers, field officers (extentionists) and animal handlers, through demonstration. This was done by gathering all the aforementioned in farmers field at 4 locations (Dumburi, Dagona, Balle and Gwio-Kura) of the Programme area. Thereafter, animal handlers continued with this demonstration from village to village. Plates 1 to 5 depicts some of the newly introduced implements operation techniques and draught animals.



Plate 1: Demonstration of Ploughing Operation.



Plate 2: Demonstration of Harrowing Operation.



Plate 3: Demonstration of Single-bull Cultivation.



Plate 4: Demonstration of Single Camel Drawn Cultivation Operation.



Plate 5: Demonstration of Single Donkey Cultivation Operation.

3.5 Field Performance Evaluation of NEAZDP Animal Traction Programme After Modification:

Draught animals are usually evaluated for performance along with the equipment they pull. Since both the existing and modified equipment were issued to farmers over a period of 2 - 3 years, 2 samples each of ridgers, cultivators, ploughs and harrows were evaluated for performance efficiency and durability. For durability, all the introduced equipment were monitored through field visits, checking and witnessing their performances while in use by beneficiaries. The following introduced draught animals and equipment were evaluated.

A: **Draught Animals**

1. Pair of Workbulls
2. Single Workbull
3. Single Donkey
4. Single Camel.

B: **Implements**

1. Emcot Ridger for Workbulls.
2. Blacksmiths Improved Ridger for Workbulls.
3. Blacksmiths Ridger for Single Bull and Single Donkey.
4. Traditional 5-tines Blacksmith, and Cultivator for Workbulls.
5. Blacksmiths 3-tine Improved Cultivator for Workbulls
6. Blacksmiths Improved Cultivator for Single Bull and Single Donkey.

calculations:

$$N = \frac{C}{K} \quad \text{---------- 7}$$

Where,

N = No of Workbulls required

C = Cultivable Area (ha.)

K = 6 Ha. per Workbulls per annum.

If cultivable land is to be covered by workbulls, donkeys, camels and horses in a ratio of 4:3:2:1

$$N = \frac{R \times C}{K_B \text{ or } K_D \text{ or } K_C \text{ or } K_H} \quad \text{---------- 8}$$

Where

N = No. of Workbulls, or No. of Donkeys or No. of Camels or No. of Horses.

R = Ratio of the Draught Animals.

K_B = 6 ha. per Workbull per annum

K_D = 4 ha. per Donkey Pair per annum

K_C = 6 ha. per Single Camel per annum

K_H = 6 ha. per Single Horse per annum.

3.5.2 Evaluation of Draught Animal Physical Characteristics:

Important physical characteristics of an animal that could be used to estimate animal body weight were evaluated. These includes heart-girth, overall height and body length from front shoulder to the base of the tail of various draught animals. Fifty readings from the animals were recorded from 10 locations of the Programme area between the ages of 4 - 8 years. Steel measuring tape was used throughout out in the measurement. The equation (3) presented in section 2.2.2 was used to estimate body weights in the absence of weighing scale.

Based on the fact that draught animals will be able to pull between 10 - 20% of their body weights, from (3.5.2) above, tractive effort was calculated (FAO, 1994).

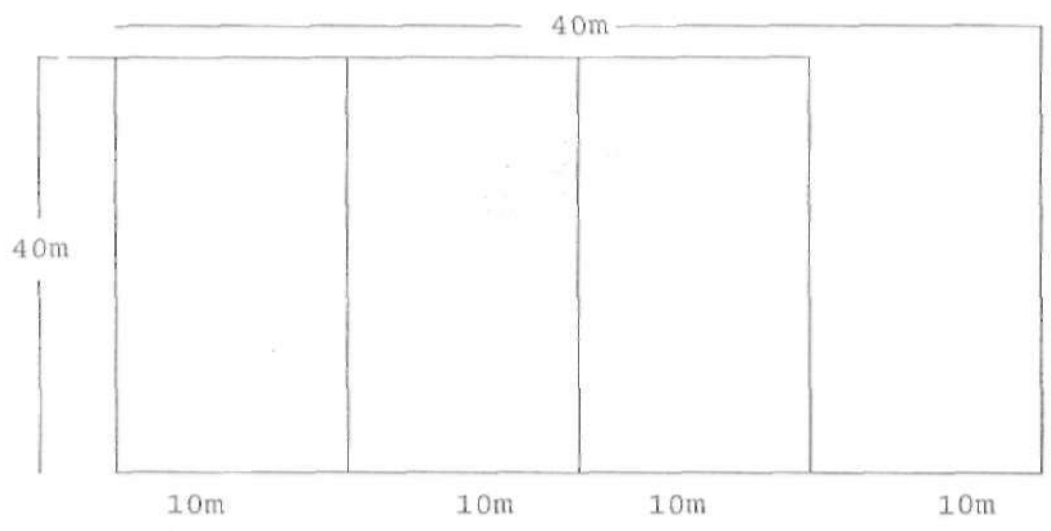
3.5.3 Evaluation of Implement and Cart Performance:

Implement and Cart performance in terms of suitability, durability and working efficiency were evaluated.

(A) Implement Performance:

(i) Experimental Design and Field Layout:

To determined working speed of draught animals, operation time and performance efficiency of various animal-drawn implements, a plot of 40m x 40m divided in a strip of 10m was marked on the test field as recommended by FAO (1994). Below is the layout of the test plot.



(ii) **Animal Working Speed (Km/h):**

To measure working speed, time (m/s) was recorded using a stop watch for every 20m distance travelled until the test plot was completed (FAO, 199). Fifty readings were recorded for workbulls ridging, ploughing and cultivation operation, while 30 readings were recorded for harrowing and bund forming operations because of differences in the width of work to complete an operation. For single donkey, single bull and single camel, 30 readings were recorded for ridging and cultivation operations. Average were calculated and converted to Km/h using equation (1) in section 2.2.2.

(iii) **Operation Time Per Hectare (h/ha.):**

From (ii) above, operation time h/ha. was calculated using equation (2) in section 2.2.2 for ridging, cultivation, ploughing, harrowing and bund forming operations for workbulls, single donkey, single bull and single camel.

(iv) **Implement Width and Depth of Cut (CM):**

The width of cut was calculated from equation (4) in section 2.2.2 and the average taken.

To measure the effective depth of cut, a graduated steel ruler was inserted into the tilled plots at several points within each strip. Fifty readings were recorded and the average was taken. Plates 6 and 7 depict measurement of width and depth of cut.



Plate 6: Measurement of Width of Cut.



Plate 7: Measurement of Depth of Cut.

(v) Implement Ridge Height, Top and Bottom Furrow Width (cm)

A graduated steel rule was inserted randomly between ridges of the ridged plot and 50 readings were recorded. Similarly, a measuring steel tape was used between ridges of the ridged plot to measure the bottom and top of the furrows randomly. Fifty readings were recorded. The averages were taken.

(vi) **Implement Draught Requirement:**

To measure the draught, a distance of 100m was marked on the field, as described in section 2.5.2. reading were recorded after 20m distance travelled for ridging, ploughing and cultivation. Fifty readings were recorded for each operation and the averages

taken. The draught was calculated from equation (5) in section 2.5.

(vii) **Evaluation of Inversion Efficiency of Implements:**

A frame work one metre square was randomly thrown on the test plot before ridging or ploughing and after ridging or ploughing within the test plot. The number of weeds before and after these operations were recorded. Fifty readings were taken and the average calculated. Inversion efficiency (%) was calculated from equation (6) in section 2.2.2. Plates 8 and 9 depicts counting the number of weeds before and after operations.



Plate 8: Counting the Number of Weeds Before Ploughing, Ridging or Cultivation.



Plate 9: Counting the Number of Weeds After Ploughing, Ridging or Cultivation.

(viii). **Implement Durability:**

Implements were monitored over 3 years of their utilization with the farmers. They were checked on worn out parts and associated operational and mechanical problems each year during and after operations.

B: **Animal and Cart Performance**

(i) **Durability and Loading Capacity:**

Parameters considered for cart performance during the study included; major repairs and rated load. All these were determined through field visits to uses and asking questions and making checks and observations on the cart after every year for 3 years of utilization.

During the study, the following parameters were recorded viz; cart major dimensions, laden and loading capacity, weight, yoke and harnessing techniques employed and their dimensions, type and size of axles, tyres, wheels and rims. Types of good, types of trades, distance travelled and time taken were also investigated as stated earlier.

3.5.4 Evaluation of Artisans (Blacksmiths, Carpenters and Welders)

The trained artisans were assessed in terms of product quality and strength. The assessment was based on skill score for constructing or fabricating a product. These included tool use, bending, cutting, layout, measurements, costing, forging and finishing. During the study, the following were also noted;

Product Cost/unit, rate of production, tools required and tools constraints.

The product was compared with the company make in terms of the listed score parameters. The [10] points score was considered as the standard of a company make for each parameter measured (Bai 1990).

3.5.5 Assessment of Artisan's Skill:

Two or more technical specialists wee required for the assessment. In the absence of judgement criteria, the following were used to assess skill performance.

Table: 3.1 Assessment Criteria:

S/N.	JOB DESCRIPTION	SKILL SCORE (10 POINTS EACH)
1.	Cutting	Should be in a straight line and smooth without zig-zag.
2.	Punching and Threading	Holes should be smooth, straight and without brushe. Cutting thread teething should be uniform when tap and dice are used.
3.	Bending	For U-bolt, its shape should be elliptical, for L-square, the angle should be 90°, if necessary 90° set square can be used to measure the angle.
4.	Planning	The surface should be smooth. Filling or touching with the hand alone will tell the degree of smoothness or by visual observation. Alternatively a Leveler can be placed on the surface at different places, once the surface is smooth, the water level will be at the centre.
5.	Joints	T-joints, L-joints or dove-tail joints is judged to be accurate once there is no gap. If accurate even without glue, the joint can still remain rigid.

6.	Forging and Tool Usage	For elongating, shorting, hardening and normalizing a metal, certain temperatures are required before the metal can be treated. Visual observation by a Specialist will tell him that the smither is knowledgeable or not. A good smith will be able to handle the tool in use correctly to avoid accident. This can be detected by specialist by visual observation.
7.	Measurements	Take a sample of a product from a blacksmith or carpenter, ask him to measure certain dimensions in feet or metres. This one is a straight forward judgement, if he knows, you will know, if he is messing up, you will still know if he knows both or one of the units, you will still know.
8.	Costing	Similar to (7) above, ask him how does he sale a ridger or cultivator. Then, ask him to estimate the cost of materials, transportation and his labour to come up with the total cost plus profit margin. You will then know whether or not he knows it.
9.	Layout, Finishing and Polishing	Take a Blacksmiths' or Carpenters' product. Look at all the angles, joints, counter sunk nuts. Measure certain lengths to ensure that it is square or rectangle. Then, finally its finish. If good you will know, if not you will equally know.

3.5.6 Assessment of Animal Handlers

Each ox-trainer was observed during the training session in terms of animal control, implement manoeuvrability, implement adjustment and fault detection, harnessing techniques and quality of job. For every skill, 10 points were scored and the general performance was evaluated as percentage of the overall skill scores as recommended (Bai, 1990).

Table: 3.2 **Assessment of Farmers Skills:**

S/N.	JOB DESCRIPTION	SKILL SCORE (10 POINTS EACH)
1.	Animal Command	A good farmer is one who commands the animals by giving instructions, such as stop, go and then without beating them to do whatever he wants.
2.	Implement Adjustment	He should be able to adjust the implement for shallow or deeper work by understanding wheel and hitching point adjustments. He should be able to find appropriate chain length through pre-testing.
3.	Implement Control	A farmer should stand straight without bending on the implement and without pressing it down. This will affect performance.
4.	Implement Manoeuvrability	The farmer once perfect will be able to handle a ridger, cultivator and mouldboard plough. With a ridger straight ridges are expected. With an untrained animal, the farmer will still be able to manipulate the implement even if the animals are dragging.
5.	Implement Fault detection	A well trained farmer should be able to know if the implement is faulty. Such as bolt and nut loosening or frog winding which will affect its performance.
6.	Patience	He has to be resistant when animals are not trained to avoid rushing.

3.5.7 Level of Technology Adoption and Economic Assessment

After five years of the Programme, a questionnaire was designed and administered to 360 workbulls beneficiaries, donkeys beneficiaries, animal handlers, artisans and non-workbulls owners. One hundred and sixty cf the respondents were those who owned animal traction packages and adopted them to various degrees fully, particularly or not at all. Fifty of the respondents were those who wee motivated and owned animal draught power and implement by themselves. Fifty of the respondents were those who perceived the technology through demonstration or with others and were willing to possess it through credit or personal finance.

For economic assessment, data obtained were farm household sizes, hecterage, number of days to cultivate family land using workbulls and manual labour, number of household labour, number of days to accomplish family farm using workbulls and manual labour, number of days for using workbulls per annum on family farm, relatives and hiring, number of bags conveyed by carts, distance travel, time taken and nature of track. Finally, number and types of products produced by artisans.

CHAPTER: FOUR

RESULTS AND DISCUSSIONS:

4.1 *Results of Base-line Survey:*

The population of the NEAZDP area is 1.28 million, of which about 870,000 are rural people within the 18 Development areas (DA) under NEAZDP operation. The climate is semi-arid to arid, temperature ranges between 45 to 50°C and rainfall varies from 250-500mm. The total cultivable land within the 18 DA's is about 592,694 ha for both upland and flood plain cropping.

The survey was carried out in the 18 DA's of NEAZDP revealed that each DA has between 18 to 24 villages headed by a Development Area Promoter (DAP) residence at each of the DA's called pilot village. The total number of existing draught animals, animal-drawn equipment and artisenal skill availability/capabilities as obtained in the survey are presented in this section.

4.1.1 Draught Animals and Existing Equipment:

Results of the base-line survey showed that there were 2,358 workbulls, 2,358 ridgers and 2,358 carts in the 18 DA's of NEAZDP (Table 4.1). There were 3024 donkeys, 400 camels and 1,571 horses in the 18 DA's. Most of the ridgers, were EMCOT type made by John Holt Nigeria Limited, Zaria, while of them were 300 blacksmiths make purchased from Potiskum in Yobe State but outside the programme catchment area. Others were purchased from

Gujungu at Jigawa State. One 3-tine cultivator ARARA make was seen with a blacksmith brought for repairs.

It was gathered that the cultivator was brought from a village in the neigbouring Niger Republic in 1993. Five units of the 5-tines (blacksmith make) cultivators were seen with some farmers which were purchased from Gujungu market at Jigawa State in 1993.

The availability of workbulls and equipment in the study area can be attributed to the fact that workbulls technology was earlier introduced to the then Borno State since 1928, therefore, it may be that previous extension efforts gave these large numbers. All of the workbulls were privately owned without any from credit. Muguram and Balle DA's have the largest number. This may be due to the fact that most settlers in Muguram are from Kano and Sokoto States who had initial idea of animal traction.

TABLE: 4.1 Availability of Draught Animals and Existing Equipment:

DEVELOPMENT AREA (DA)	NO. OF VILLAGES	NO. OF WORKBULLS	NO. OF DONKEYS	NO. OF CAMELS	NO. OF HORSES	NO. OF RIDGERS	NO OF CARTS
1. GUMSA	20	80	108	3	50	80	80
2. KASKA	20	0	70	27	70	0	0
3. WACHAKAL	19	152	150	0	60	152	152
4. YUSUFARI	18	320	500	112	173	320	320
5. BALLE	19	400	107	4	56	400	400
6. G/KURA	24	250	342	7	44	250	250
7. BULANGUWA	19	30	200	15	45	30	30
8. DAGONA	21	42	100	0	10	102	102
9. DAPCHI	19	102	6	0	10	102	102
10. FUTCHIMIRAM	19	5	600	36	208	5	5
11. KANAMMA	18	25	145	73	206	25	25
12. GORGORAM	19	60	32	0	7	60	60
13. MUGURAM	19	600	47	31	17	600	600
14. DEGELTURA	22	18	100	32	300	18	18
15. KARASUWA	19	40	40	24	68	40	40
16. DUMBURI	21	135	103	0	47	135	135
17. YUNUSARI	20	35	71	24	73	35	35
18. MACHINA	19	64	293	42	108	64	64
TOTAL	355	2,358	3,324	400	1,571	2,358	2,358

Balle is along Maiduguri from where the technology started before spreading to the remaining parts of the northern Yobe State. Kaska area has nothing initially, because most of the area was covered by sand dunes and oasis. However, there are some parts of the area which are relatively flat for animal traction application.

The survey results as indicated above revealed that other draught animals such as donkeys, camels and horses are available, but mostly used as pack animals for transportation of limited number of goods, ceremonial purposes and for water lifting from wells. Their use for tillage and carting operations has been least adopted, due to probably late introduction of the techniques using such animals.

4.1.2 Artisenal Skill Availability and Assessment:

Table 4.2 shows the number of existing blacksmiths, carpenters and their initial level of skill capabilities. It is seen from the table that there are 34 blacksmiths and 44 carpenters resident in the 18 DA's of NEAZDP.

Generally, with regards to fabrication of animal-drawn equipment, only 4 blacksmiths could fabricate ridgers while 10 could repair ridgers. On the initial products of the 4 blacksmiths, the bolts and nuts of the ridgers were not counter sunked, the finish was very poor, the punches (holes) were not smooth, cutting edges also not smooth and some materials poorly

selected. Tools are mostly locally made without using standard anvils, drills, grinders, vice, saws, top and bottom fullers, top and bottom swages etc.

Only 14 carpenters were capable of constructing and repairing local carts. The carts were fairly good, but joints were not standard and finish very poor. Timbers some times are left-overs purchased from builders instead of new ones from market shades. Tools such as a-clamp, sash-clamp, tenon-saw and sun-paper as well as standard joints and proper finish were lacking with the carpenters.

The highest number of carpenters and blacksmiths are found in Yusufari, Balle, Gorgoram, Yunusari, Gwio Kura, Karasuwa, Muguram and Dapchi. This may be due to availability of local market centres in these DA's.

TABLE: 4.2 **Distribution of Artisans and Skill Assessment:**

DEVELOPMENT AREA:	NO. OF BLACKSMITHS	NO. OF CARPENTERS	INITIAL SKILL CAPABILITIES
1. GUMSA	2	3	1) Four blacksmith have capabilities of fabricating ridgers
2. KASKA	2	2	2) Ten blacksmiths have capabilities of repairing ridgers
3. WAHCHAKAL	1	2	3) Twenty blacksmiths together with other mentioned were capable of making and repairing local tools such as hoe, knife, axes, digger, rake, scissors, ear-rings, hand rings, cultlers etc.
4. YUSUFARI	2	4	4) Fourteen carpenters were capable of constructing local cart and repairs
5. BALLE	3	4	5) Thirty carpenters together with 14 mentioned were capable of making village house windows & doors. Other skills were making of benches, chairs, tables and local cupboards without proper joints and finish
6. GWIO KURA	2	3	6) Four carpenters were capable of making standard rafters for modern buildings
7. BULANGUWA	2	2	"
8. DAGONA	2	1	"
9. DAPCHI	3	2	"
10. FUTCHIMIRAM	1	1	"
11. KANAMMA	1	2	"
12. GORGORAM	3	3	"
13. MUGURAM	1	3	"
14. DEGELTURA	1	2	"
15. KARASUWA	2	3	"
16. DUMBURI	1	2	"
17. YUNUSARI	3	3	"
18. MACHINA	2	2	"
TOTAL	34	44	"

4.2 Primary Field Evaluation of the Existing Draught Animals and Equipment:

As a result of increase in the price of Emcot ridgers, Indian make ridgers were acquired and tested for suitability. Mechanical and operational problems were identified and improvements made. Locally constructed carts were initially studied in terms of design & rigidity through observations. This section deals with the evaluation of the introduced equipment.

4.2.1 Performance Evaluation of the Introduced Equipment:

The Indian ridger earlier introduced were evaluated during primary testing. The problems identified were:- (1) The beam curve was very broad i.e. above 90° which affected the share rake angle, consequently prevented it from getting into the soil properly, (2) The rudder and the cutters prevent the implement from getting into the soil because they were hooked by stumps and roots of grasses while at work, and, (3) The bolts and nuts that connected the wings to the frog got loosen due to vibration. However, the frame work; beams, shares, frog, breast plates, steering wheels and type of adjustment possibilities were found satisfactory. The Emcot ridger earlier introduced without testing was found acceptable by the farmers. The only problem was that they were reported to be relatively heavy for young workbulls at the age of training and the subsequent year i.e. 4 to 5 years. The beam length was also found to be very long and even some farmers went ahead to cut it in order to reduce the length. Visual observations of the locally constructed carts showed that, the volume of the cart was not adequate, the types

of joints did not offer rigidity and almost everything on the cart were scraps i.e. second hand. That is why durability and life span could be a limiting factor with these types of carts.

4.3 Modifications to the NEAZDP Animal Traction Programme:

The earlier introduced equipment were modified based on the problems identified during primary performance evaluation. This section presents the modifications made based on the identified problems.

4.3.1 Modification on Indian Ridgers:

As described in section 3.3.1 of the methodology, blacksmiths were used to modify the ridgers. The rudder and the coulters were completely removed from the ridgers, the beam curve was harmmered to correspond to the Emcot ridger beam curve of approximately 90° and the bolts and nuts that normally got loosen were replaced with steel rods bent at the two ends. About 1,099 units were purhcased, modified and distributed to farmers over the past 2-3 years. Figure 4.1-4.4 depict the existing (Indian & Emcot) modified Indian and blacksmith improved ridgers.

4.3.2 Modification of Existing Locally Constructed Carts:

As described in section 3.3.2 of the methodology, carpenters were used to modify the carts. The body frame work nails were replaced with the bolts and nuts, the volume of the carts was increased, new tubes were used instead of second hand, stab axle bearing mounted on steel pipe were used to replace Nissan and

Landrover vehicle rear axle scrap. About 1,846 units of the modified version were constructed and issued to farmers over 2-3 years. Figure 4.5 and 4.6 showed existing and modified locally constructed workbulls carts.

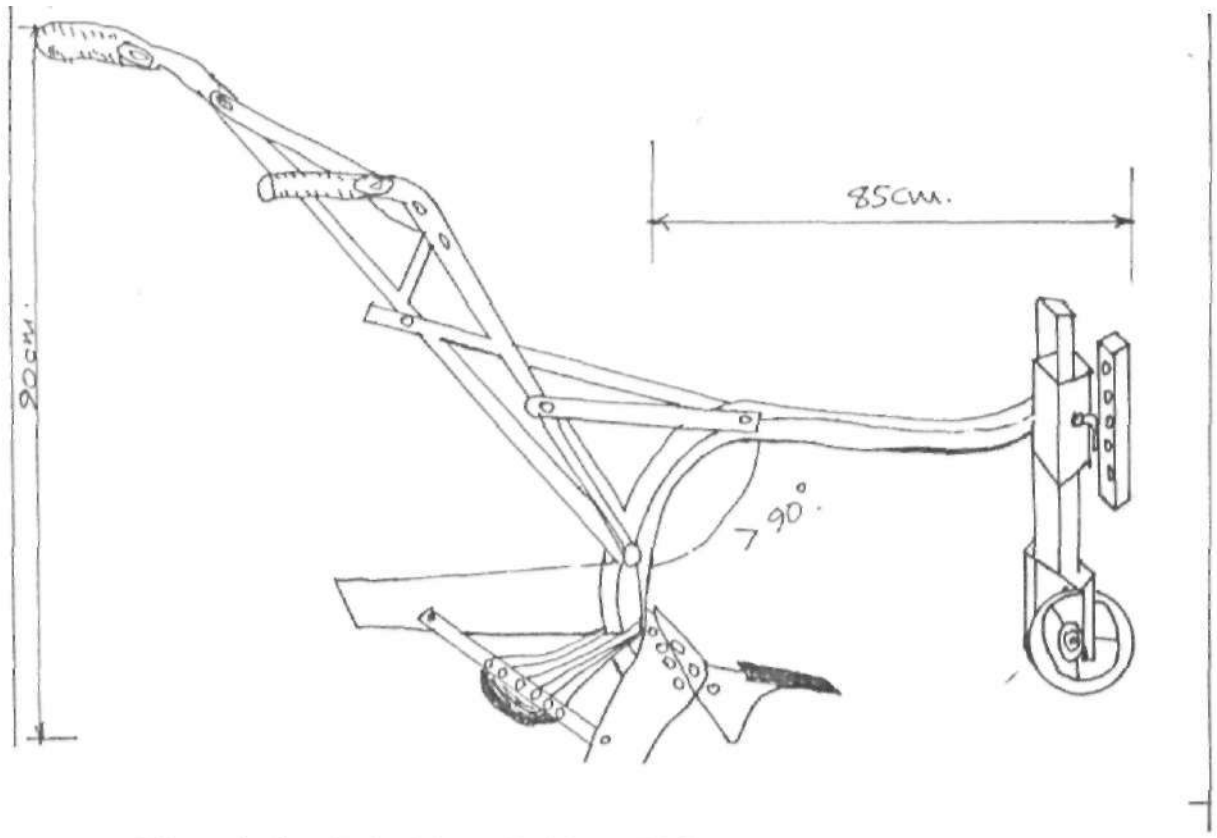


Fig: 4.1 Existing Indian Ridger

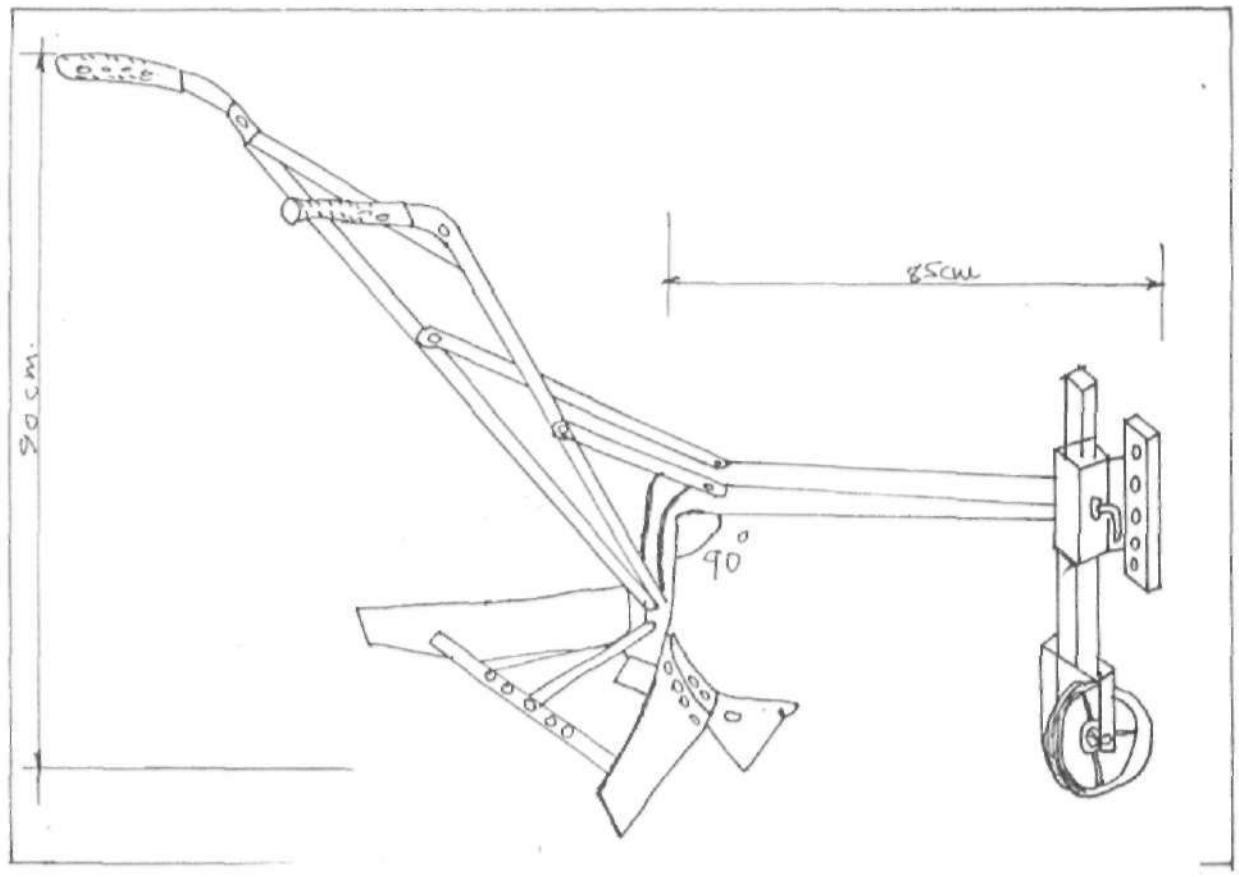


Fig: 4.2 Blacksmith Modified Indian Ridger

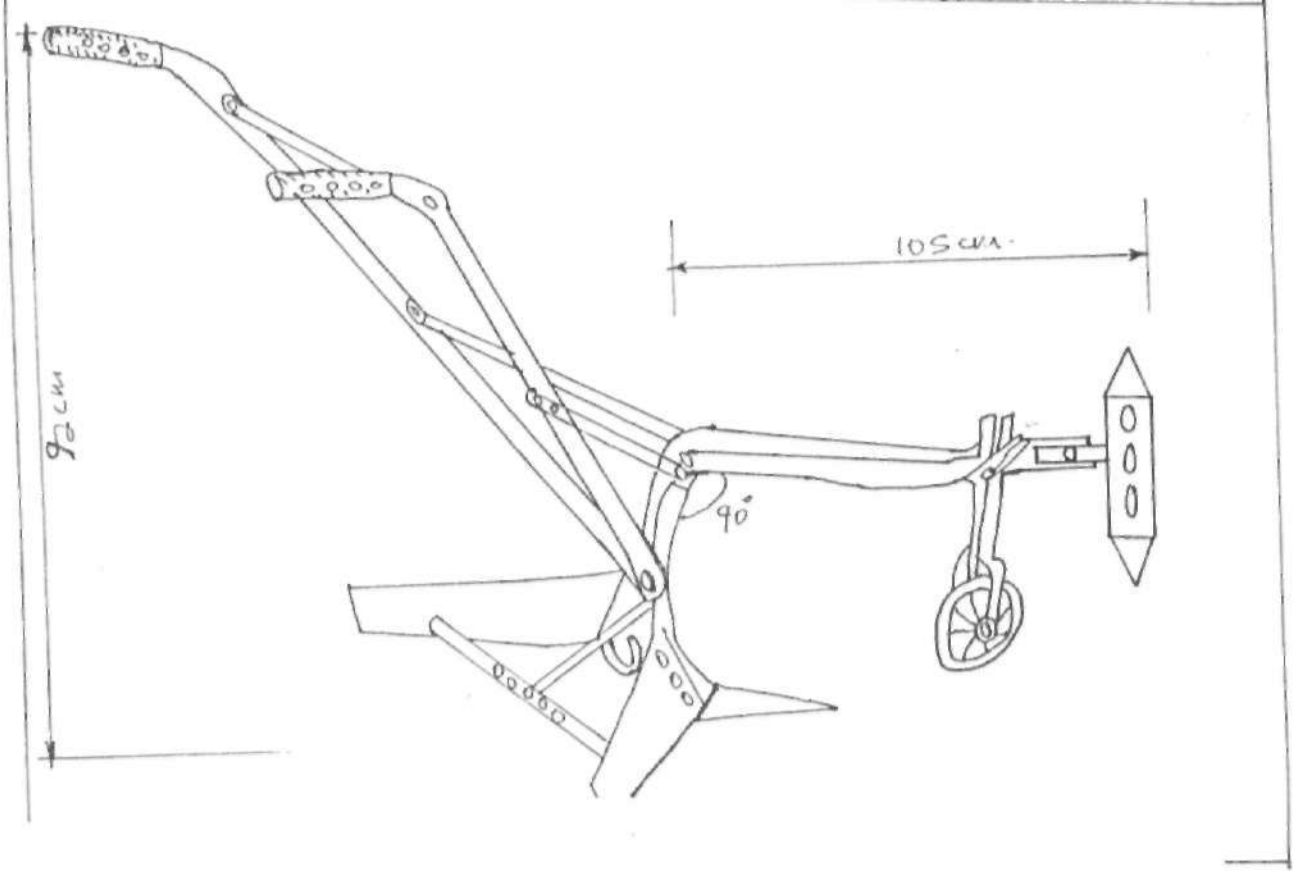


Fig: 4.3 Existing Emcot Ridger

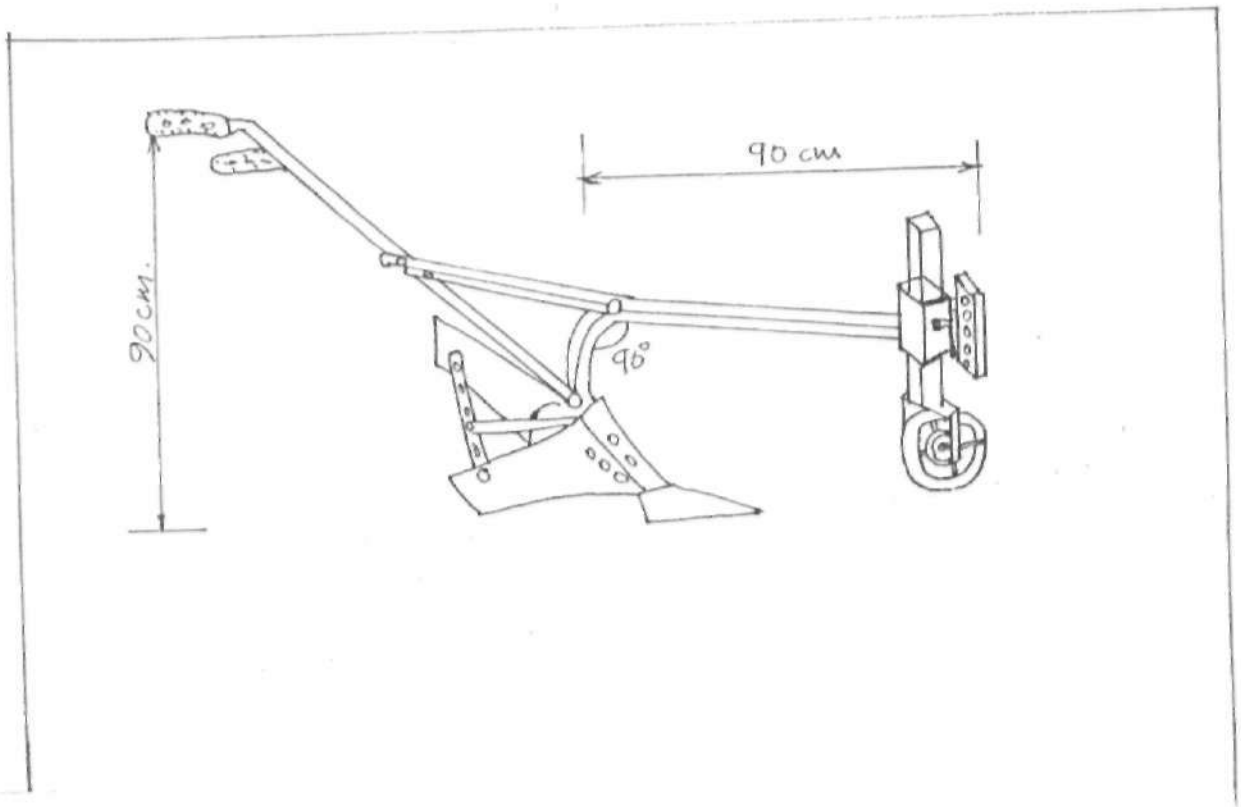


Fig: 4.4 Blacksmith Improved Ridger

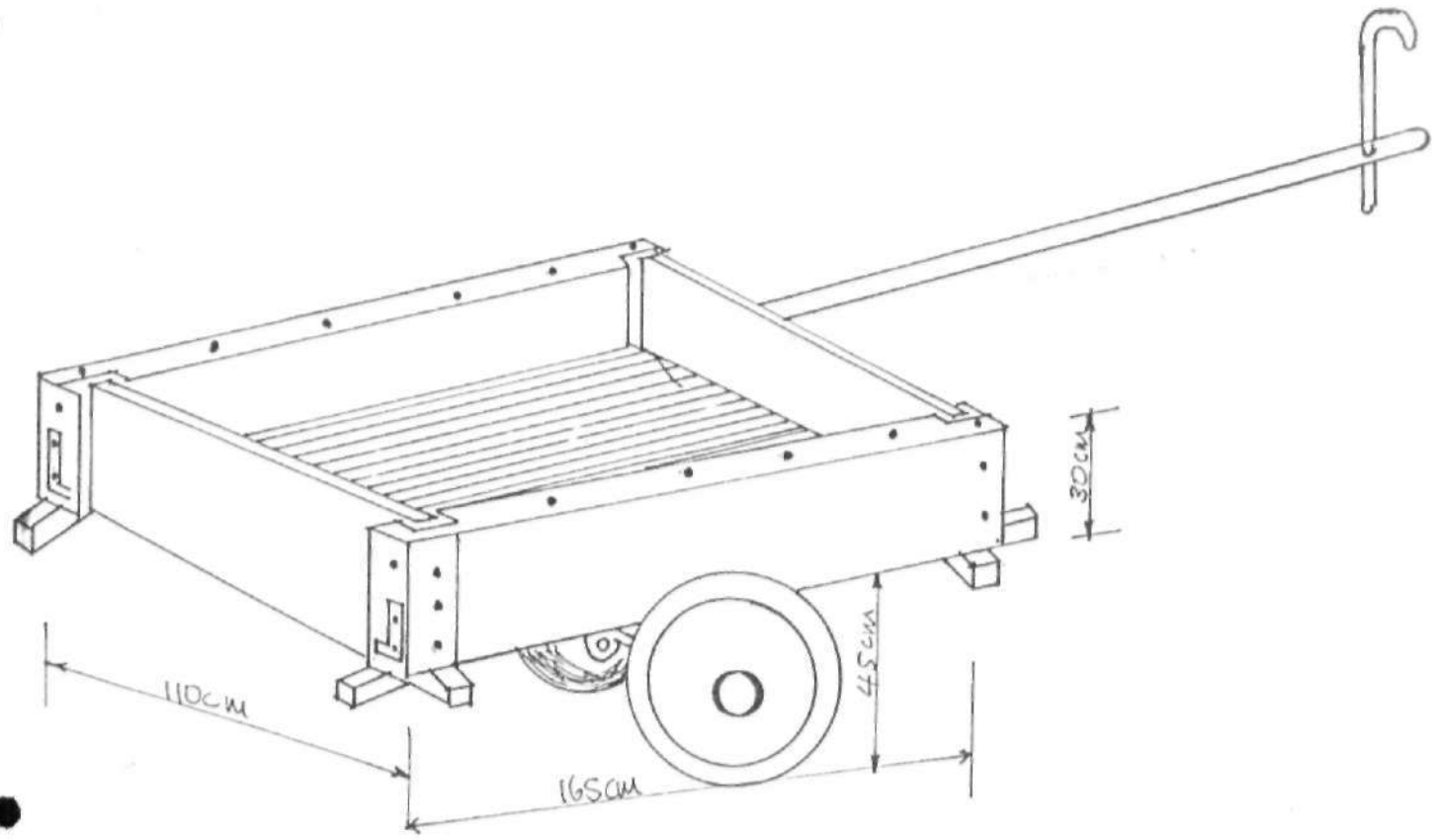


Fig: 4.5 Locally Constructed Workbulls Cart

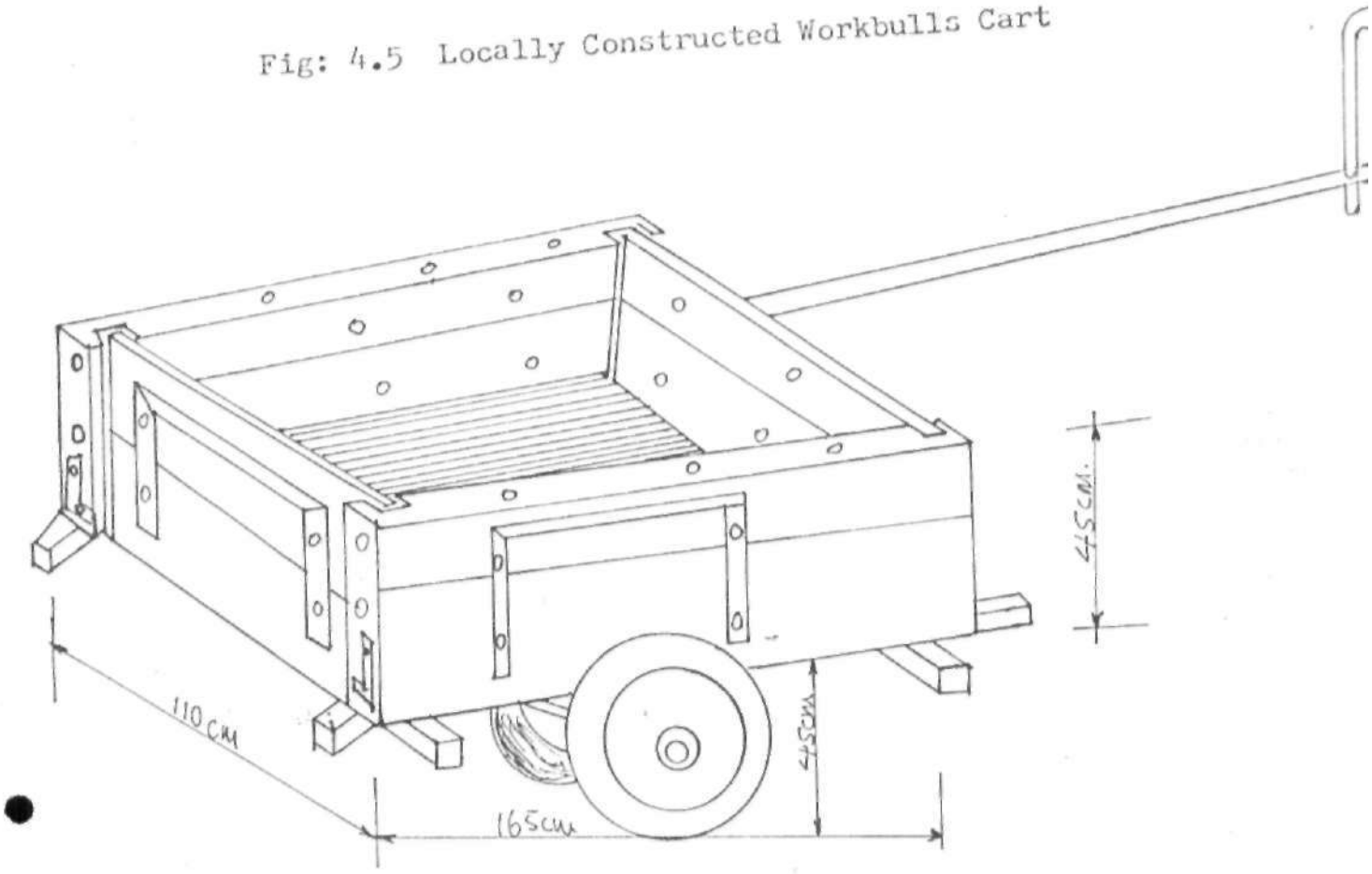


Fig: 4.6 Improved Locally Constructed Workbulls Cart

4.4 Incorporation of Artisans and Animal Handlers into the NEAZDP Animal Traction Programme:

In order to sustain NEAZDP Animal Traction Programme (N.A.T.P), blacksmiths were incorporated for the fabrication, maintenance and repairs of the existing introduced equipment as well as those newly introduced. Similarly, carpenters were incorporated for the construction, maintenance and repairs of the existing introduced carts and as well as those newly introduced. In both cases, urban base welders were involved in the fabrication of certain parts that required the use of electricity such as hitching points, steering wheel and single animal cart metal frame work. Animal handlers identified or selected from the local farmers were incorporated to train farmers in the newly introduced technologies. To perform these functions, they were all trained and issued with the tools and training packages.

4.4.1 Blacksmiths and Welders:

Based on the survey conducted, 18 blacksmiths plus one residence in urban centre were selected, each representing a DA. They were issued with the basic tools Appendix: 1 and trained on skills such as drilling, proper finish, costing, measurement, heat treatment of different metals etc, and fabrication of cultivators, ridgers and ploughs. They were later offered with the contract to produce implements for the programme as well as produce for local market. Figure 4.7-4.13 depicted the company and blacksmith of the aforementioned newly introduced animal-drawn implements.

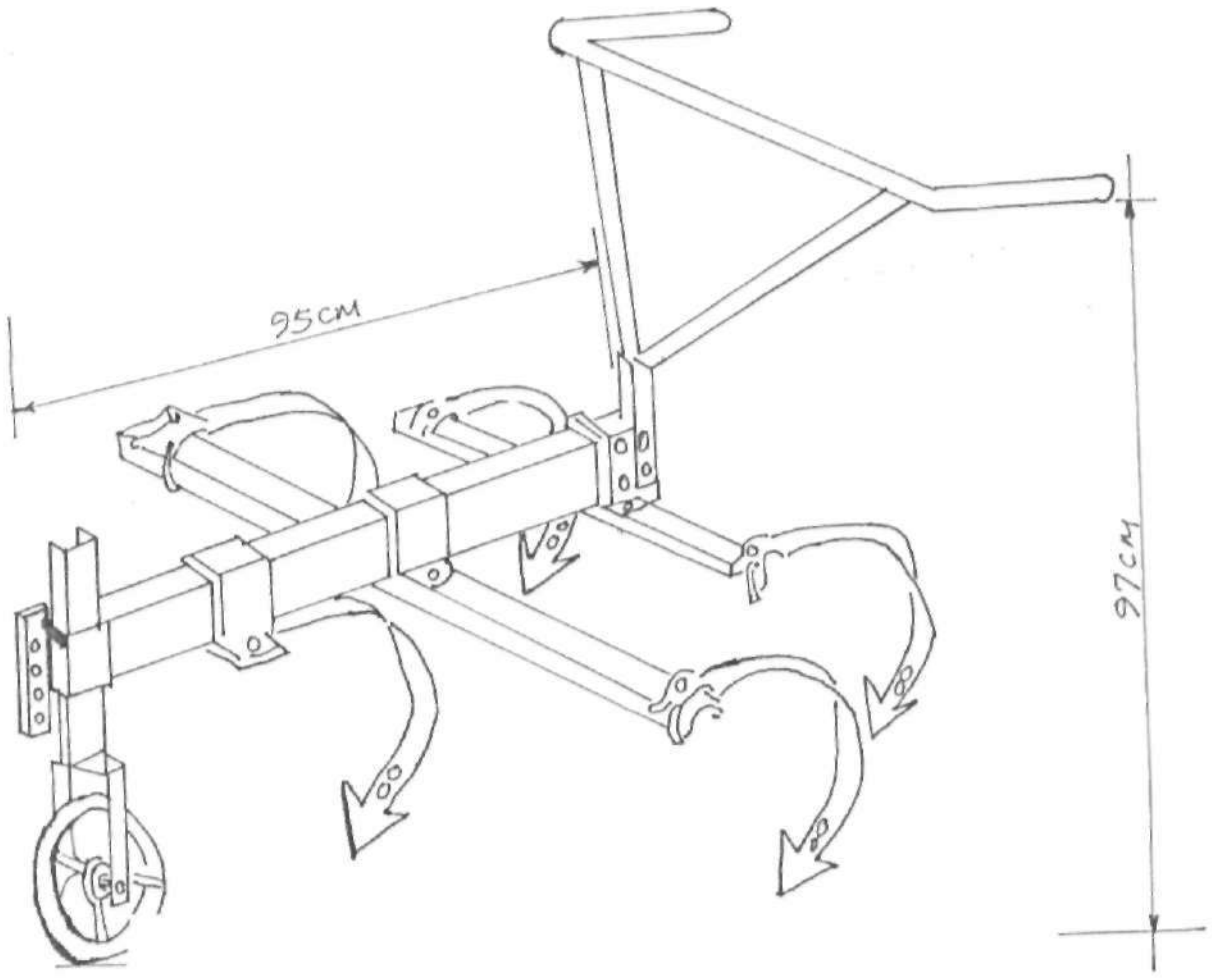


Fig: 4.7 Arara Cultivator

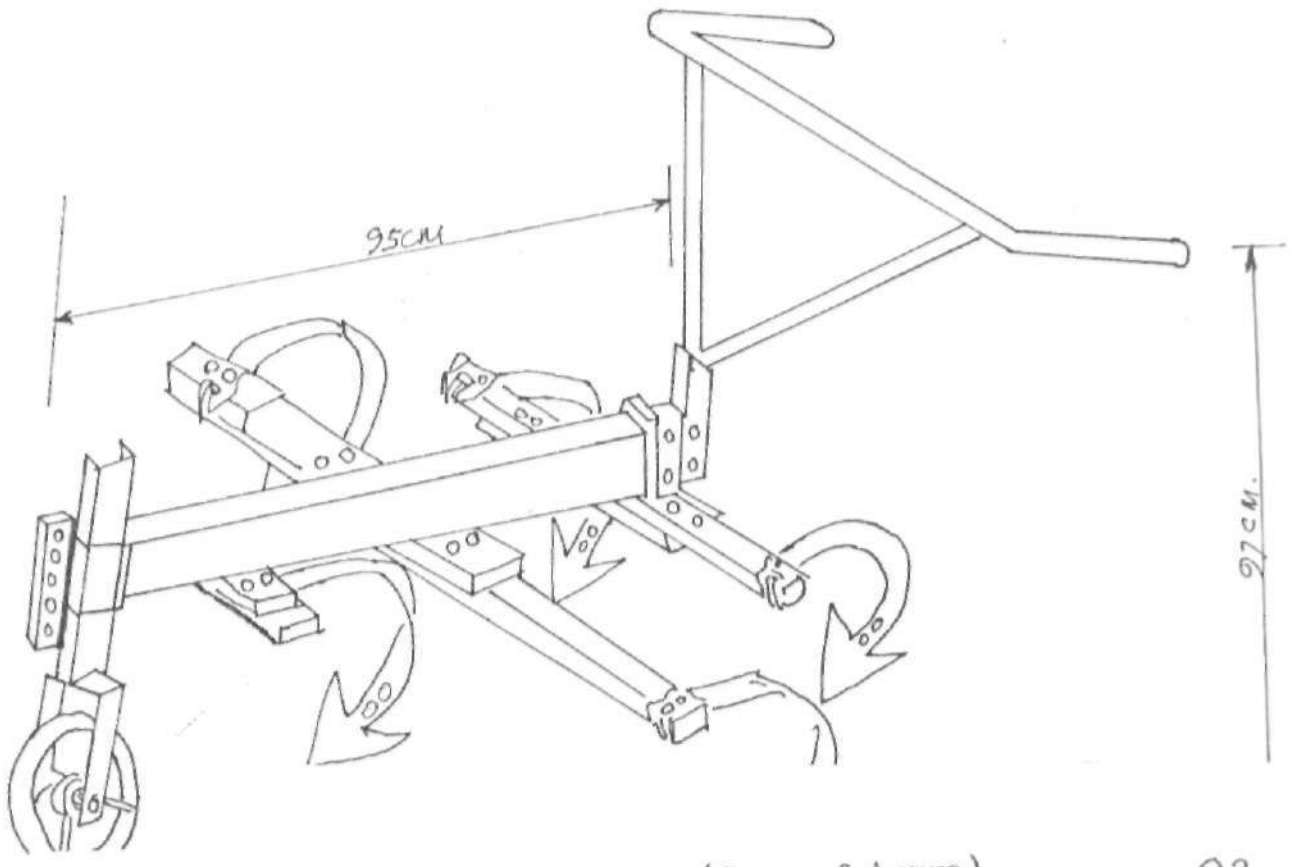


Fig: 4.8 Blacksmith Cultivator (Copy of Arara)

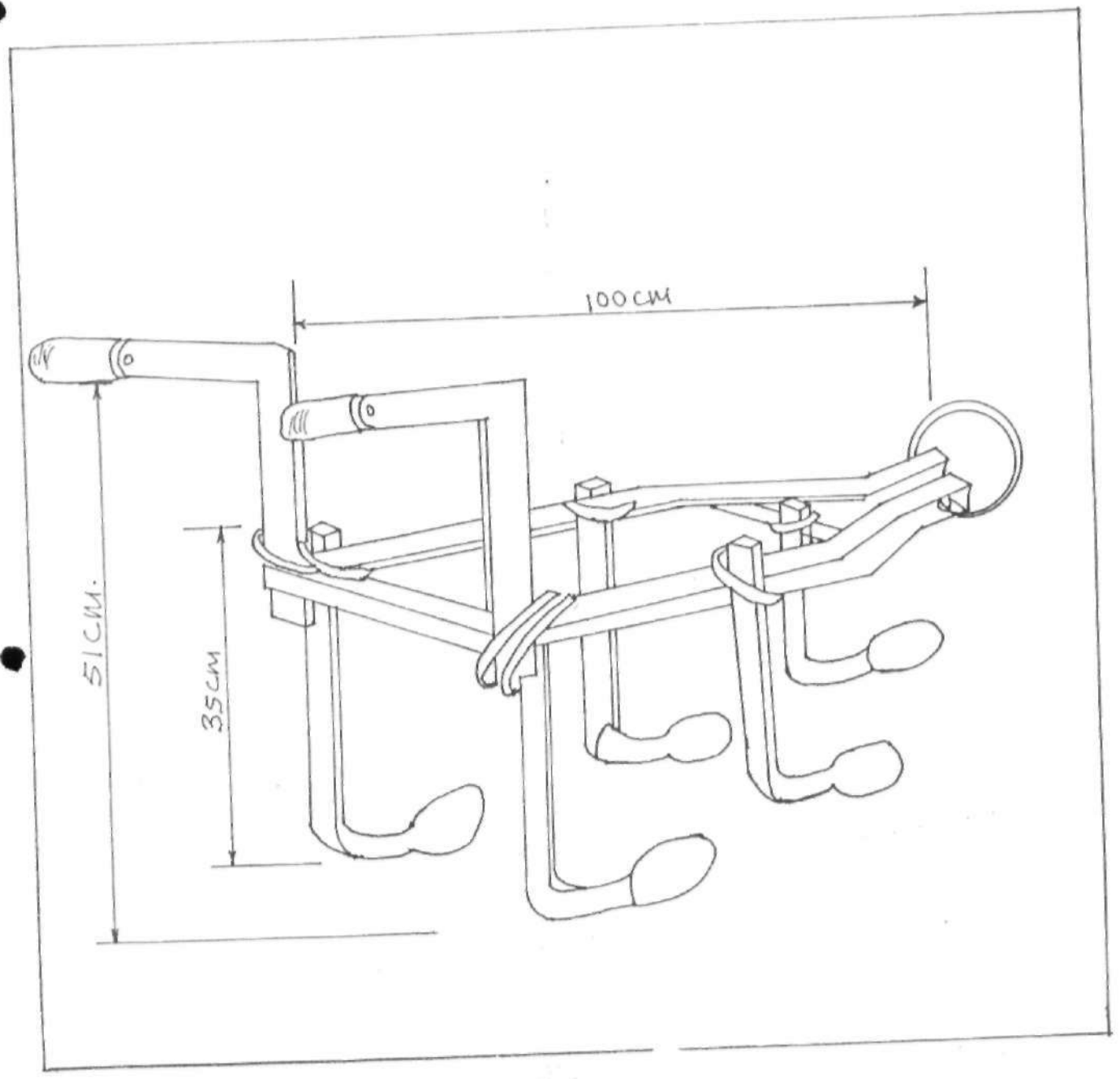


Fig: 4.9 Traditional Blacksmith Cultivator

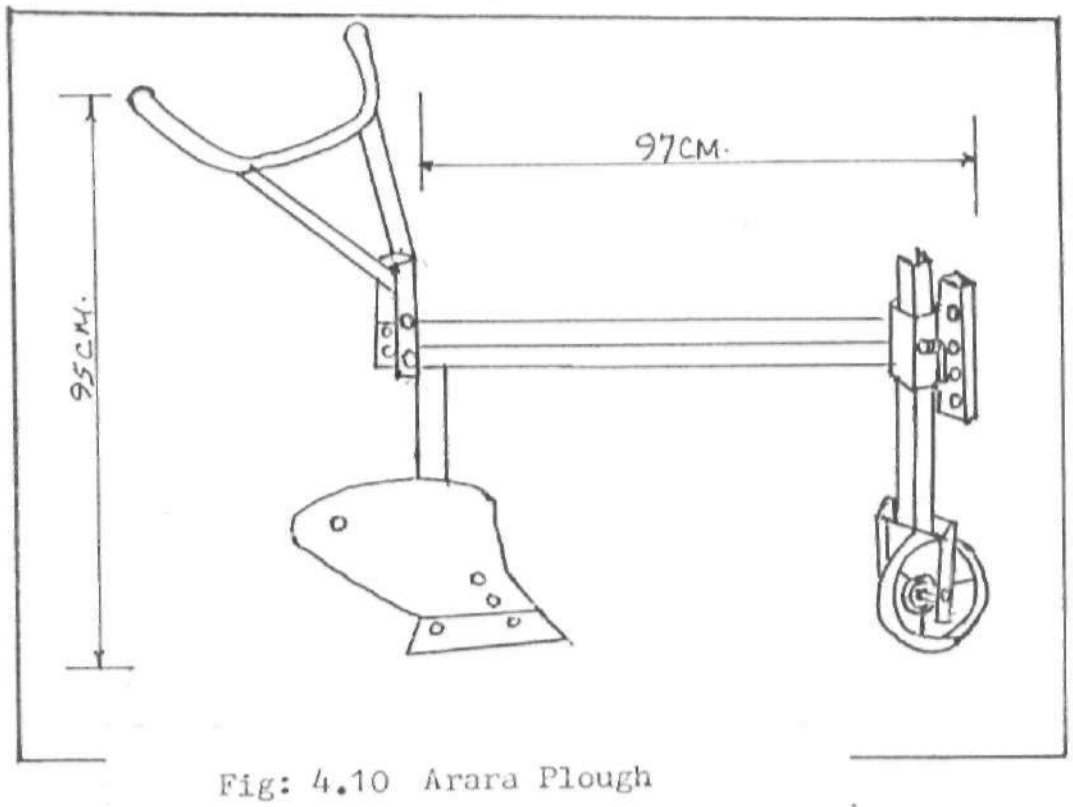


Fig: 4.10 Arara Plough

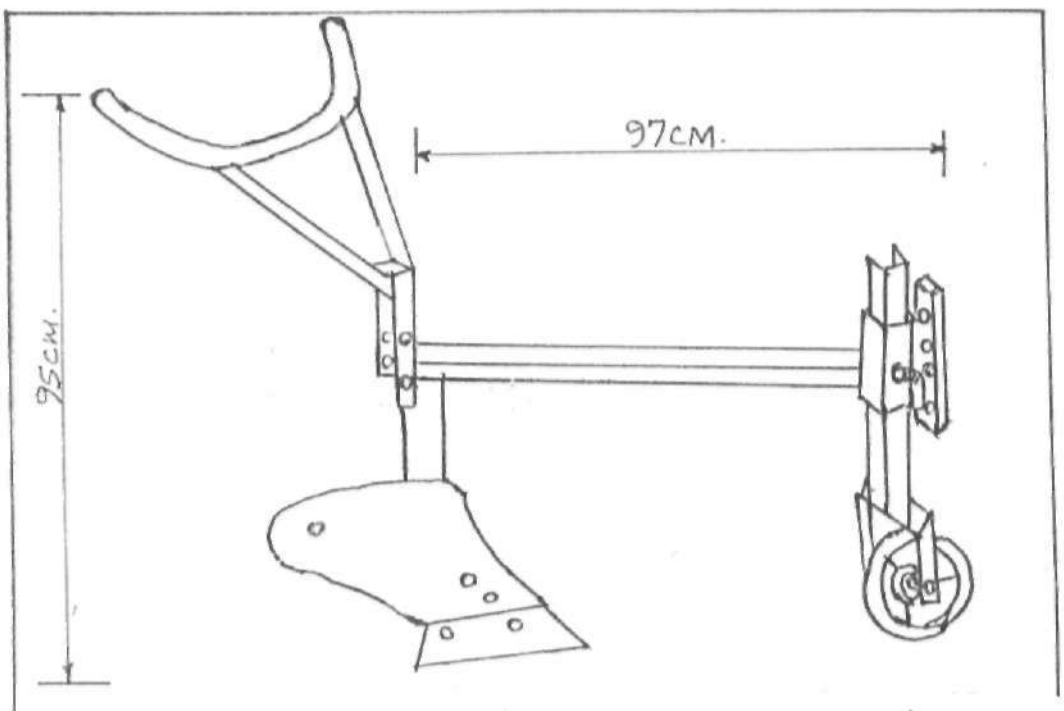


Fig: 4.11 Blacksmith Plough (Copy from Arara)

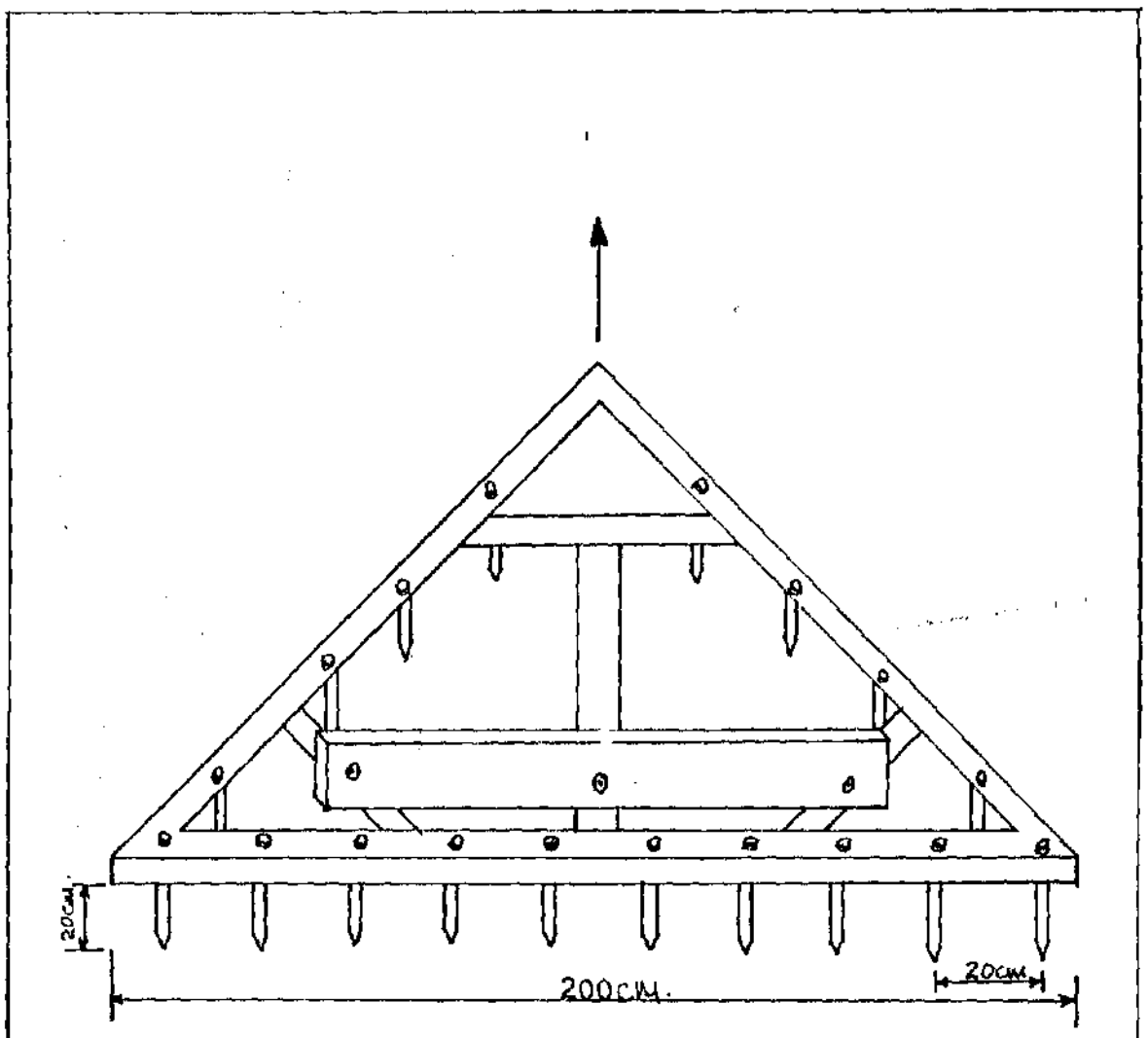


Fig: 4.12 Blacksmith/Welder Make Spike Tooth Harrow

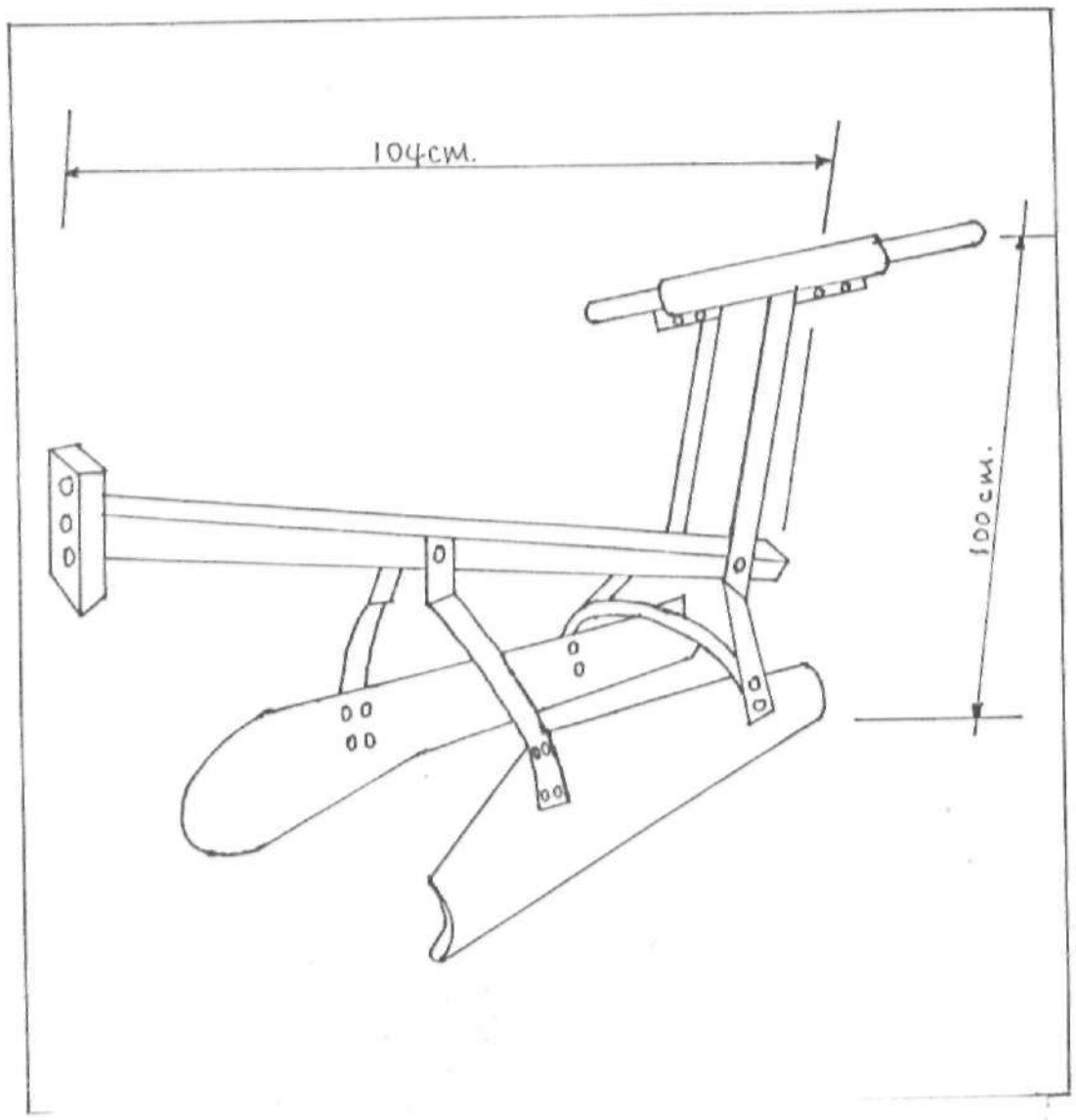


Fig: 4.13 Blacksmith/Welder Make Bund Former

Table 4.3 shows the specifications of the implements evaluated and Table 4.4 shows the products produced by the trained blacksmiths. It shows that about 1,099 Indian make ridgers were adjusted and modified. Over 922 ridgers, 279 cultivators and 20 mouldboard ploughs were fabricated locally for NEAZDP and other farmers. Alhaji Rabiu, Alhaji Mai Anguwa, Tata Karasuwa and Audu Makeri fabricated the highest number of implements. This could be attributed to the fact that they were among the best smithers and demands in the areas were very high. All blacksmiths were able to fabricate ridgers and cultivators, while Alhaji Rabiu and Tata Karasuwa were able to fabricate mouldboard plough in addition to ridgers and cultivators. In addition to these products; sickles, knifes, hoes, axles of various sizes were also fabricated by blacksmiths and still are the main products of the peasant farmers.

TABLE: 4.3 **Specifications of Implements Evaluated**

		OVERALL LENGTH	RAIL ANGLE (DEGREES)	WIDTH OF TOOL	HEIGHT (cm)	BEAM DIMENSION (cm)	SHANK DIMENSION (cm)	WHEEL DIAMETER	WELDING RIGHT	BOLT SIZE	TINE LENGTH	WEIGHT (kg)	COST 1996
*RIDGER	INDIAN TYPE A	209	-	60	90	90	-	22-26	-	25	0	43.26	4500
*RIDGER	INDIAN TYPE B	182	-	60	90	85	-	22-26	-	25	0	43.55	4500
*RIDGER	INDIAN TYPE C	174	-	60	90	85	-	22-26	-	16	-	34.02	4500
*RIDGER (EMCOT)	JOHN HOLT ENG.	214	-	70	52	105	-	17	-	25	0	44.39	8500
*RIDGER	BLACKSMITH	177	-	55	90	90	-	20	-	19	0	21.74	2500
*RIDGER (MEAZDP IMPROVED)	BLACKSMITH	174-177	-	55-70	-	-	-	20	-	16-19	0	21.74	3000
MOULDBOARD PLOUGH	JOHN HOLT ENG.												
MOULDBOARD PLOUGH	ARARA CANADIAN	160	45°	37	95	97	12 X 25	22	9	19	0	94.02	9000
MOULDBOARD PLOUGH	MR. YAMIA W/SHOP, MAIDUGURI	160	45°	37	95	97	12 X 25	22	9	19	0	26.28	5000
MOULDBOARD PLOUGH	E/MITH WELDING W/SHOP GASHUA	160	45°	37	95	97	12 X 25	22	9	19	0	27.64	3000
3 AND 5 TINE CULTIVATOR	ARARA SUDAN	160	30°	60	95	97	16 X 17	22	10	16	57X33	30.64	5000
3 TINE CULTIVATOR	WELDING W/SHOP GASHUA	160	30°	60	95	97	16 X 17	22	10	16	57X33	26.92	2500
3 TINE CULTIVATOR	GUGUNGU BLACKSMITH	165	30-60°	52	94	90	15 X 16	26	9	14	50X32	26.26	2500
3 TINE CULTIVATOR	NGURU BLACKSMITH	155	30-45°	42	87	96	15 X 22	14	8	16	47X30	13-24.04	2500
3 TINE CULTIVATOR	JAKUSKO BLACKSMITH	187	30-60°	56	106	97	20 X 22	13	16	16	45X37	29.72	3000
TRADITIONAL CULTIVATOR	BLACKSMITH	142	45-60°	51	100	-	10 X 12	0	0	10	56	37.56	2000
SPIKE HARROW	GASHUA WELDING W/SHOP	56	50°	200	16	200X96X16	19	0	11	19	19	35.56	4000

BEND FORMER	GASHUA WELDING W/SHOP	155	-	100	104	-	22 X 90	0	7	17	0	29.08	8500
OPTIMUM/RECOMMENDED	VALUES	174	30-43°	-	90	90	-	20	-	13	57X23	26-28.79	---

* Ridgers (Hassan's results of 1992)
\- Means not measured
\- Means no component or part

TABLE: 4.4

A: Blacksmith Products:

S/N	NAME	DEV. AREA	RIDGER (OX-/DONKEY)		CULTIVATOR (OX/DONKEY		M/B PLOUGH		TOTAL	
			NEAZDP	PRIV	NEAZDP	PRIV	NEAZDP	PRIV	NO	%
1.	Alh. Mai Anguwa	Jakusko	3	50	40	100	-	-	193	6.5
2.	Kanamma Artisan Association	Kanamma	100	3	-	-	-	-	103	3.5
3.	Dala Kaglma	Balle	129	1	-	-	-	-	130	4.4
4.	Isa Makeri	Dagona	84	2	-	-	-	-	86	2.9
5.	Dalah B. Buhari	Degeltura	69	-	-	-	-	-	96	2.3
6.	Ali Makeri	Dumburi	105	5	-	-	-	-	110	3.7
7.	Adamu Makeri	Gorgoram	133	-	-	-	-	-	133	4.5
8.	Muazu Nasaleh	Gwio Kura	184	25	-	10	-	-	219	7.3
9.	Tata Karanuwa	Karanuwa	108	40	-	2	10	-	160	5.4
10.	Mustapha Kore	Machina	102	-	-	1	-	-	103	3.5
11.	Audu Makeri	Muguram	285	35	10	40	1	-	371	12.4
12.	Alh. Rabiu Nguru	Nguru Wachakal	50	55	518	15	10	-	650	22.1
13.	Umaru Makeri	Bulanguwa	92	-	-	-	-	-	92	3.1
14.	Baba Bukar	Dapchi	62	2	-	2	-	-	66	2.2
15.	Modu Shuwari	Futchimiram	94	-	-	-	-	-	94	3.2
16.	Shatima Kagalma	Gumsa	111	1	-	-	-	-	112	3.8
17.	Mustapha Makeri	Kasaka	109	2	1	-	-	-	112	3.8
18.	Jibrilu Ali	Yunusari	74	1	-	-	-	-	75	2.5
19.	Yakalu Abasawi	Yusufari	96	1	-	-	-	-	97	3.3
			1799	222	109	170	20	-	2983	

4.4.2 Carpenters and Welders:

Like the blacksmiths, 30 carpenters were selected, 10 were resident in urban centres representing 18 DA's. They were issued with the basic tools (Appendix: 2) and trained on joints, proper finish/layout, costing, measurement and timber seasoning. Construction of modified carts and other furnitures.

Figure 4.14 and 4.15 depict the newly introduced sing animal carts. Table 4.5 shows the specifications of carts evaluated, while Table 4.6 shows the products produced by the trained carpenters. It shows that there are about 3,036 ox-carts constructed by carpenters between 2-3 years, out of which 1,982 were NEAZDP credit carts and 1,054 were produced for local market. Gwio Kura, Dumburi, Balle, Dapchi and Gumsa carpenters produced more carts than their colleagues. This may be due to the fact that NEAZDP and private ox-owners in these areas are more than the others. Even though, other products were taken into account, Adamu Yariya and Alhaji Kallamu were said to have more market because they were resident in Local Government Headquarters, therefore might had more demand.

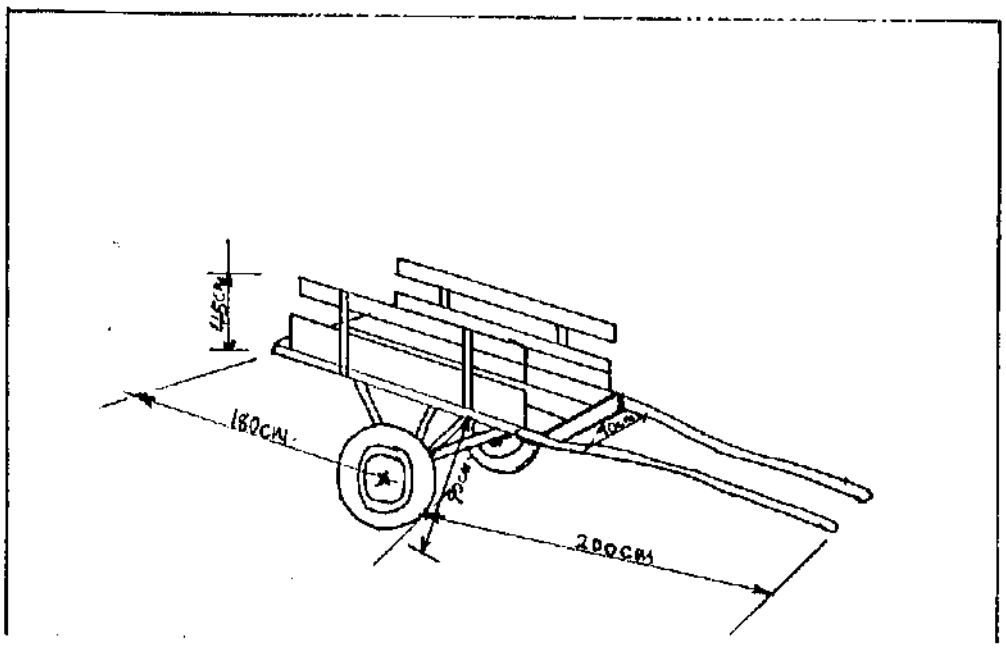


Fig: 4.14 Carpenter/Welder Make Single Donkey Cart

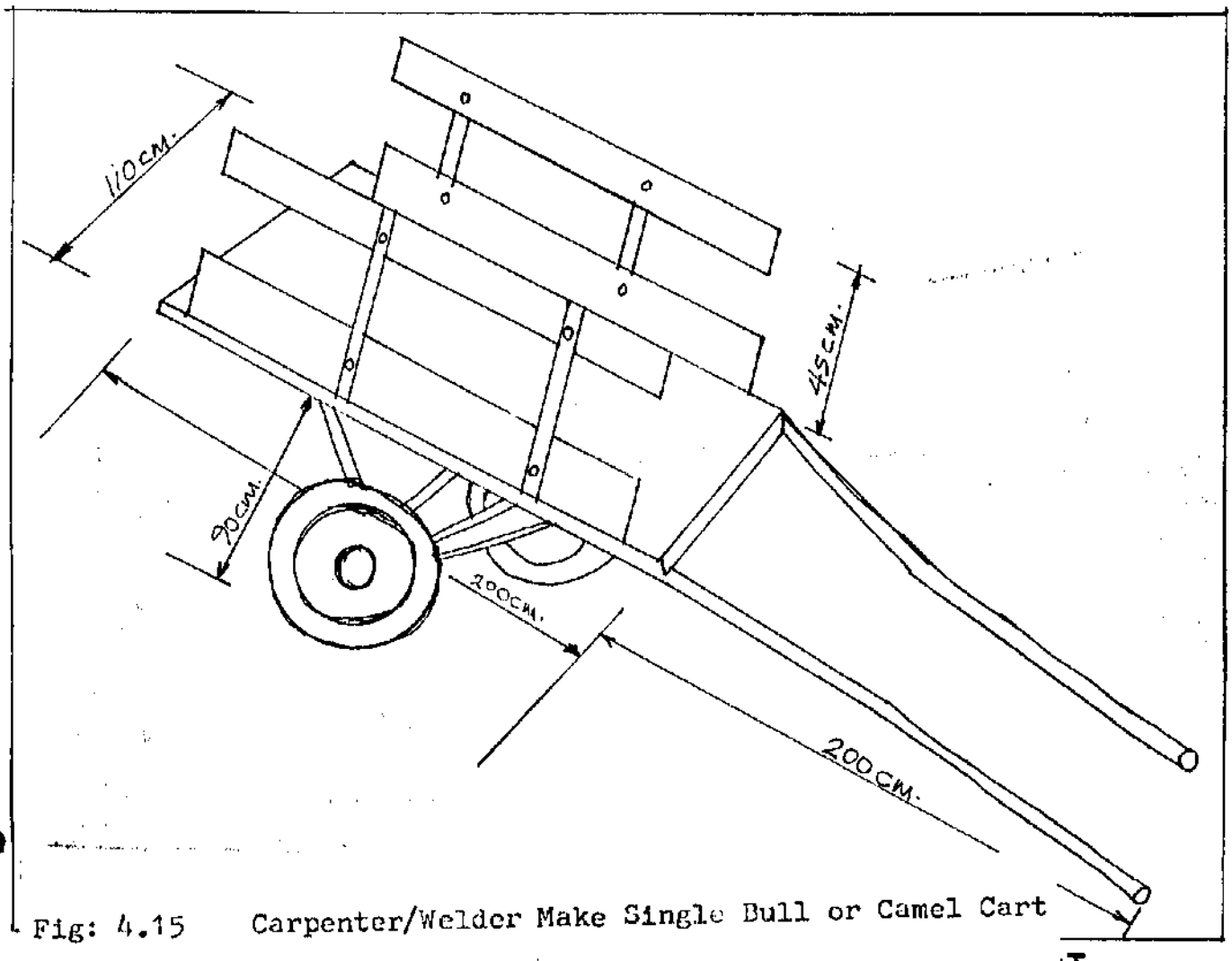


Fig: 4.15 Carpenter/Welder Make Single Bull or Camel Cart

TABLE: 4.5 Specifications of Carts Evaluated:

TYPE OF CARTS	MANUFACTURE /PRODUCER	PARAMETERS								
		TYRE SIZE	TYRE WEIGHT (kg)	AXLE WEIGHT (kg)	RIM WEIGHT (kg)	BODY WEIGHT (kg)	HEIGHT OF CART (cm)	DEAD WEIGHT OF CART (kg)	VOLUME OF CARTM'	LADEN WEIGHT OF CART (kg)
OX-CART (1991 MODEL)	NEAZDP TRAINED CARPENTER	15	19	19-38 (Nom/LR)	9	90(F)	45	137-156	0.42	DEAD WEIGHT PLUS 30-80KG
OX-CART (1992 MODEL)	NEAZDP TRAINED CARPENTER	16	19	19(L/R)	9	90(F)	45	137	0.42	DEAD WEIGHT PLUS 30-80KG
OX-CART (1993 MODEL)	NEAZDP TRAINED CARPENTER	16	19	18(Nom) 30(N/J)	9	110(F)	45	157-169	0.71	DEAD WEIGHT PLUS 30-80KG
OX-CART	LOCAL CARPENTERS	16	20	38(Nom)	9	105(F)	43-47	153-172	0.42	DEAD WEIGHT PLUS 30-80KG
SINGLE BULL CART	NEAZDP TRAINED WELDER - GASHUA	14	8	24(PG)	5	77(C)	105	114	0.81	DEAD WEIGHT PLUS 30-80KG
DONKEY CART	NEAZDP TRAINED WELDER - GASHUA	19	10	40(IN)	10	77(C)	90	157	0.71	DEAD WEIGHT PLUS 30-80
HORSE CART	NEAZDP TRAINED WELDER - GASHUA	14	8	24(PG)	5	135(C)	90	162	0.91	DEAD WEIGHT PLUS 30-80KG
CAMEL CART	NEAZDP TRAINED WELDER - GASHUA	14	8	24(PG)	5	135(C)	90	162	0.91	DEAD WEIGHT PLUS 30-80KG

Dead weight - Total weight of cart
Laden weight - Weight of carts plus operator
NSS - Nissan Axle
LR - Landrover Axle
PG - Peugeot Axle
IN - Indian make Axle
NJ - NEAZDP John Holt Axle
F - Fixed Body
C - Colapsible Body

TABLE: 4.6 **Carpenters Products:**

S/N	NAME	DEV. AREA	OX-CART PRODUCTION NRAZDP		OX-CART PRODUCTION PRIVATE		TOTAL	
			NO	%	NO	%	NO	%
1.	Bukar Kafa Buba	Balle	129	6.5	40	3.8	169	5.6
2.	Idri Fantami	Bulunguwa	91	4.6	60	5.7	151	5.0
3.	Abdullahi Mohammed	Bulunguwa	0	0.0	3	0.3	3	0.1
4.	Modu Karfe	Dageltura	0	0.0	4	0.4	4	0.1
5.	M. Samaila Goni	Dageltura	69	3.5	55	5.2	124	4.1
6.	Audu M. Dumburi	Dumburi	105	5.3	130	12.3	235	7.7
7.	Bura Mazumma	Futchimiram	94	4.7	20	1.9	114	3.8
8.	Mamman Tafa	Gorgoram	133	6.7	70	6.6	203	6.7
9.	Adamu Gwayo	Gorgoram	73	3.8	0	0.0	73	2.4
10.	Goni Kolomi	Gumsa	0	0.0	4	0.4	4	0.1
11.	Musa Mohammed	Gumsa	111	5.6	60	5.7	171	5.6
12.	Adamu Dauda	Gwio Kura	0	0.0	0	0.0	0	0.0
13.	Abdu Buji	Gwio Kura	184	9.3	40	3.8	224	7.4
14.	Mustapha M. Sunna	Kanamma	100	5.0	40	3.8	140	4.6
15.	Idi Hassan	Karamuwa	19	1.0	5	0.5	24	0.8
16.	Alhaji Liman	Karamuwa	89	4.5	50	4.7	139	4.6
17.	Ado Mustapha	Kaska	109	5.5	15	1.4	124	4.1
18.	Yakubu Kaska	Kaska	30	1.5	0	0.0	30	1.0
19.	Nojiyya Barma	Machina	72	3.6	12	1.1	84	2.8
20.	Kanta M. Abba	Machina	30	1.5	8	0.8	38	1.3
21.	Rabiu M. Yau	Muguram	55	2.8	80	7.6	135	4.4
22.	Musa Dauda	Muguram	30	1.5	40	3.8	70	2.3
23.	Yerima Yusufari	Yusufari	74	3.7	30	2.8	104	3.4
24.	Mustapha A. Mamman	Yusufari	0	0.0	5	0.5	5	0.2
25.	Alhaji Kallamu	Yusufari	96	4.8	70	6.6	166	5.5
26.	Hamza M. Audu	Dagona	8.	4.2	50	4.7	134	4.4
27.	Bulama Usman	Dapchi	22	1.1	120	11.4	152	5.0
28.	Bulama U. Bukar	Dapchi	40	2.0	10	0.9	50	1.6
29.	Sheriff A. Barko	Futchimiram	94	4.7	20	1.9	114	3.8
30.	Idi Mohammed	Kanamma	0	0.0	2	0.2	2	0.1
		TOTAL	1992		1054		3036	

Table 4.7 shows the products produced by the trained fabricators (welders) resident at Gashua, Nguru and Geidam. The results showed that urban based artisans will be able to fabricate items that can not be fabricated at village level workshops. This is due to the availability of power source i.e. electricity as well as tools that are not readily available at the village level. Between 2-3 years about 20 bucket pumps, 31 mouldboard plough/frames, 57 Wheel Ashasha, 18 singlebull carts, 9 water bowsers and 84 stab axles were fabricated. Others included; 103 donkey carts, 301 spike harrows, 190 watering cans, 180 buckets, 100 feedtrough, single camel cart, single horse cart and 20 blacksmith work benches.

Comparatively, the products or urban based fabrication workshop were more qualitative than those of village artisans and all of them tended to be more familiar with measurements, costing of products and proper layout of framework. This could be attributed to the fact that most of them had Primary or Secondary education or received on-the-job training with the educated master (trainer). Important to note is that welders also received NEAZDP training through model or prototype development. After successful fabrication, a contract to fabricate 807 different kinds of animal-drawn equipments as showed in the Table 4.7 was then awarded.

TABLE: 4.7 Product Produced by Urban-base Trained Welders (i.e Metal Fabricators.

ITEM DESCRIPTION	IRON TO IRON COMPANY	YUNUSA ABDULHAMID WELDING WORKSHOP	SANUSI WELDING WORKSHOP	ALHAJI UMARU WELDING WORKSHOP	WAKSHAMMA WELDING WORKSHOP	ABUDULLAHI BULTORI TIN SMITHING INDUSTRY	LADAKU FABRICATION COMPANY	TOTAL NO.	%
Bucket Pumps	12	-	-	-	-	-	1	12	1.5
Animal Drawn Plough Beam Complete Plough	20	-	-	-	10	-	1	31	3.8
Wheel Aahasha Welder	-	12	12	32	-	-	1	57	7.1
Single Horse Cart	-	-	-	-	-	-	1	1	0.1
Single Bull Cart	-	-	-	-	-	-	18	18	2.2
Water Bourrer Animal Drawn	8	-	-	-	-	-	1	9	1.1
Stab Axle Fabrication	-	1	1	-	-	-	32	84	10.4
Single Camel Cart	-	-	-	-	-	-	1	1	0.1
Donkey Cart Construction	-	50	50	-	-	-	3	103	12.8
Ox-drawn Wagoon	-	1	-	-	-	-	1	1	0.1
Watering Cans	-	-	-	-	-	190	-	190	23.3
Buckets	-	-	-	-	-	180	-	180	22.3
Feedtrough	-	-	-	-	-	100	-	100	12.4
Blacksmith Bench	-	-	-	20	-	-	-	20	2.5
								807	

4.4.3 Animal Handlers:

Trained animal handlers were offered with workbulls loan package consisting of a pair of workbull, ridger and a cart. Those in fadama (clays) areas were issued with ploughs, harrows and cultivators and those in the upland (loamy and sandy loam) areas were issued with cultivators only for demonstration purposes.

Their skill capabilities at the end of 3 years together with that of Artisans are discussed in the next section.

4.5 Field Performance Evaluation of NEAZDP Animal Traction Programme After Modification:

After modification of the NEAZDP animal traction programme and the subsequent application of the modified methods over 3 years, the availability, distribution and utilization of draught animals were again evaluated. In addition, the physical characteristics of the draught animals, implement performance, cart performance as well as artisans and animal handlers were assessed. Similarly, the impact of the programme as regards the level of technology adoption and the economics of animal traction after the modification were assessed. The findings are discussed in this section.

4.5.1 Availability, Distribution and Utilization of Draught Animals:

Table 4.7 shows the distribution of both NEAZDP assisted and private owned draught animals in the 355 villages in NEAZDP area as at 1995. Results obtained revealed that there were 1,982 workbulls disbursed by NEAZDP to farmers, and 2,358 and 1,835 workbulls owned by farmers before and during NEAZDP pcriod of 3 years respectively. These represented 330 ha, 393 ha and 306 ha respectively cultivated by workbulls. These corresponded to only 0.06%, 0.07% and 0.05% of the cultivable land area of NEAZDP. Similarly, NEAZDP disbursed 79 donkeys, 1 camel and 1 horse.

TABLE: 4.8 **Availability, Distribution, and Utilization of Draught Animals in NEAZDP as at 1995**

S/N	DEV. AREA	NO. OF VILLAGES	PAIRS OF WORK BULLS			SINGLE DONKEYS		SINGLE CAMELS		SINGLE HORSES	
			NEAZDP	PRIVATE BEFORE	PRIVATE DURING	NEAZDP	PRIV	NEAZDP	PRIV	NEAZDP	PRIV
1	GUMSA	20	88	80	48	1	128	0	5	0	55
2	KASKA	20	107	0	6	1	86	0	39	0	73
3	WACHAKAL	19	137	152	109	10	152	0	0	0	67
4	YUSUFARI	18	123	320	180	1	691	0	212	0	273
5	BALLE	19	203	400	67	6	177	0	6	0	66
6	GWIO KURA	24	209	250	57	2	442	0	8	0	54
7	BULANGUWA	19	97	30	49	2	274	0	20	0	65
8	DAGONA	21	77	42	59	1	115	0	0	0	9
9	DAPCHI	19	101	102	16	1	12	0	0	0	15
10	FUTCHIMIRAM	19	79	5	25	45	1033	0	46	0	258
11	KANAMMA	18	52	25	68	1	185	0	83	0	262
12	GORGORAM	19	128	60	73	1	132	0	0	0	7
13	MUGURAM	19	159	600	654	2	87	0	1	0	17
14	DEGELTURA	22	60	18	86	1	285	0	44	0	308
15	KARASUWA	19	73	40	48	1	88	0	28	0	78
16	DUMBURI	20	117	135	56	1	273	0	0	0	47
17	YUNUSARI	21	70	35	136	1	171	0	44	0	79
18	MACHINA	19	102	64	96	1	493	0	64	1	138
		355	1,982	2,358	1,835	79	4,836	1	600	1	1,896
	HECTARAGE (ha)		330	393	306	20	605	6	100	6	316
	PERCENTAGE (%) OF THE CULTIVABLE AREA		0.06	0.07	0.05	0.002	0.10	0.001	0.02	0.001	0.05
	NUMBER OF DRAUGHT ANIMALS TO COVER LAND AREA	-		*39,513*		*44,402*		*19,756*		*9,878*	

These represents 10 ha, 6 ha and 6 ha respectively of the cultivated area of NEAZDP. Farmers in their individual households possessed 4,836 donkeys, 600 camels and 1,896 horses. Had it been adopted, these would have covered an area of 605 ha, 100 ha and 316 ha, respectively, which represented about 0.10%, 0.02% and 0.05% of the cultivable land area. Appendix 3 shows the assessment form/sheet used to obtain these informations.

Generally, in terms of effective utilization, only 1,029 ha of the land area is cultivated by NEAZDP assisted and private owned workbulls, which represented 0.18% of the cultivable land area of NEAZDP. Spencer (1985) reported that in Nigeria as a whole animal traction is employed on less than 15% of the cultivable area since its inception in the 1920's. This could be attributed to the fact that credit schemes are limited and farmers too are very poor to purchase the workbulls by themselves despite realising the significance of animal traction.

Results also showed that farmers at present still purchase workbulls on their own inspite of the limited resources they possess as compared to credit schemes. This implies that farmers have realised the importance and benefits of animal power farming.

Therefore, to cope with the NEAZDP cultivable land area of 592,694 ha, 98,782 workbulls are required based on 6 ha per annum per workbull, 4 ha, 6 ha per annum for donkey pair, single camel and single horse respectively. Assuming, donkeys, camels and horses will be fully employed, 39,513 workbulls, 44,402 donkey pairs, 19756 single

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4:3:2:1 are required. From experience, about 2000 pairs of workbulls are harnessed annually from credit and private ownership. This implies that 44 years are required to cope with the NEAZDP cultivable land area.

Table 4.9 shows the distribution of animal-drawn equipment disbursed as components of draught animals package as at 1995. The results contained in the NEAZDP management report of 1995 showed that there were 1,982 workbull ridger, 18 single bull ridgers, 79 donkey ridgers, 89 workbulls cultivators, 18 single bull cultivators, 2 donkey ridgers, 40 workbulls plough, 285 harrows. Also disbursed were 2,002 carts for workbulls, single bull, single donkey, single camel and horse.

4.5.2 Evaluation of Draught Animals

Physical Characteristics:

Table 4.17 indicates draught animal body dimensions and estimated body weights of workbulls, donkeys, camels and horses. It shows that oxen age between 4-8 years weigh between 219kg to 636kg with an average of 347kg. The length of the animal from the shoulder to tail (L), height of the animal (H), animal girth length (G) range between 121 to 167cm, 114 to 142cm and 140 to 206cm respectively. Donkeys of age 48 years weigh betwen 100kg to 244kg with an average of 144kg. The L, H and G vary between 75 to 105cm, 85 to 114cm and 120 to 152cm respectively. Camels of age 4-8 years weigh between 236 to 622kg with an average of 472kg. The L, H and G vary between 130 to 160cm, 150 to 220cm and 140 to 205cm respectively. Horses of age 48 years weigh

between 308kg to 428kg with an average of 365kg. The L, H and G varies between 130 to 160cm, 130 to 145cm and 150 to 172cm respectively. Appendix 4 shows details of these parameters.

TABLE 4.9 Distribution of Animal-drawn Equipment by NEAZDP as at 1995

DEVELOPMENT AREA	NO. OF VILLAGES:	RIDGERS			CULTIVATORS					CARTS			
		WORK BULLS	SINGLE BULL	SINGLE DONKEY	WORK BULLS	SINGLE BULL	SINGLE DONKEY	PLOUGHS (WORKBULLS)	HARROWS (WORKBULLS)	WORK BULLS	SINGLE BULL	SINGLE CAMEL	SINGLE HORSE
1. GUMSA	20	88	1	1	5	1	-	2	20	88	1	-	-
2. KASKA	20	107	1	1	5	1	-	0	0	107	1	-	-
3. WACHAKAL	19	137	1	10	5	1	-	0	0	137	1	-	-
4. YUSUFARI	18	123	1	1	5	1	-	0	0	123	1	-	-
5. BALLE	19	203	1	6	5	1	-	3	40	203	1	-	-
6. GWIO KURA	24	209	1	2	5	1	2	3	40	209	1	-	-
7. BULANGUWA	19	97	1	2	5	1	-	0	0	97	1	-	-
8. DAGONA	21	77	1	1	4	1	-	12	40	77	1	-	-
9. DAPCHI	10	101	1	1	5	1	-	3	20	101	1	-	-
10. FUTCHIMIRAM	19	79	1	45	5	1	-	0	0	79	1	-	-
11. KANAMMA	18	52	1	1	5	1	-	3	25	52	1	-	-
12. GORGORAM	19	128	1	1	5	1	-	4	40	128	1	-	-
13. MUGURAM	19	159	1	1	5	1	-	5	20	159	1	-	-
14. DEGELTURA	22	60	1	1	5	1	-	5	20	60	1	-	-
15. KARASUWA	19	73	1	1	5	1	-	0	0	73	1	-	-
16. DUMBURI	20	117	1	1	5	1	-	0	20	117	1	-	-
17. YUNUSARI	21	70	1	1	5	1	-	0	0	70	1	-	-
18. MACHINA	19	102	1	1	5	1	-	0	0	102	1	-	-
TOTAL	355	1982	18	79	89	18	2	40	285	1982	18	-	-

Comparatively, all the data fall within the range reported in the literature. Musa (1989) indicated that Zebu cattle (Bororo) weigh between 300-400kg. FAO (1994) reported that Zebu cattle weigh between 300-375kg, donkey weigh between 80-125kg, camels weigh between 300-600kg and horses weigh 300kg. While ILO and UNCHS (1986) reported that bull weigh between 210-900kg, donkey between 190-300kg, horse between 385-850kg and camel weigh between 370-600kg. Generally, data have variation and this could be due to environment, feeding, body size and training. Since it has been reported by FAO (1994) that draught animal could pull 10-20% of their body weights, results in the table indicate that workbulls can pull between 215-127 N, donkeys between 98 to 479 N, camels between 231-1220 N and horses between 302-839 N. Comparatively, Geo and Mcdowell (1980) reported that workbulls can pull between 207-883 N, donkeys between 186-294 N, camels between 363-588 N and horses between 382-834 N.

TABLE 4.10 **Draft Animals Characteristics**

TYPES OF DRAUGHT ANIMALS	BREEDS	AGE RANGE	BODY DIMENSION			ESTIMATED WEIGHTS (kg) *AVERAGE W.	ESTIMATED TRACTIVE EFFORTS 10-20% OF W(N)
			L (cm)	H (cm)	G (cm)		
1. WORKBULLS	BORORO (ZEBU)	4-8	121-167	114-142	140-206	219-636 * 347± 2.68	215-1247
2. DONKEYS	MOSSI	4-8	75-105	85-114	120-152	100-244 * 144±1.46	98-479
3. CAMELS	ARABIAN (DROMETRY)	4-8	130-160	150-220	140-205	236-622 * 472±2.28	231-1220
4. HORSES	-	4-8	130-160	130-145	150-171	308-428 * 365±2.07	302-839

L = Length of the body from should to the base of the tail (cm)
H = Height of the animal from the ground level (cm)
G = The heart girth length (cm)
W = Weight of the animal (kg)
N = Estimated tractive efforts (Newton) is obtained from 10-20% of the estimate body weight.

Data shows considerable variation, so also observed and reported by Geo and Mcdowell (1980).

The reasons for the variations may be draught animals are of different body conformation, could be found in different environment, have different feeding and training regimes. However, the results will serve as a basis for chosing implement weight and goods to be transported by the draught animals studied.

4.5.3 Evaluation of Implements and Carts Performance

i) Draught Animals Performance for Various Field Operations:

Table 4.11 shows the average performance of various draught animals evaluated (details are presented in appendices 5 to 8). It is seen from the appendix that a pair of Bororo breed of workbulls aged 6 years and 325.45kg each exhibited speeds of between 2.5 to 3.1km/h, 2.7-3.7km/h and 1.2 to 2.1km/h for ridging, cultivation and ploughing operations, respectively. Their respective field coverages were 5-7 h/ha, 3-5 h/ha and 12-28 h/ha in sandy soils. The working speeds for ploughing operation in clay soil ranged from 1.1 to 2.2 km/h and the field coverage were 12 to 28 h/ha.

The working speeds for single bull weighing 335.50kg for ridging and cultivation operations in sandy soil were 2.5-3km/h and 2.7-3.6km/h, while the field coverages were 6-9 h/ha and 5-8 h/ha respectively. The working speeds for single donkey weighing 142.28kg for ridging and cultivation operation in sandy loam soil was 1.9 to 3.0km/h and 2.6 to 4.0km/h, while the field coverages

were 7-14h/ha and 6-9 h/ha respectively. The working speeds for single camel weighing 470.25kg for ridging and cultivation operations in the sandy loam soil were 3.5-3.6km/h and 3.5 to 4.0km/h, while the field coverage were 4-7 h/ha and 3-5h/ha respectively. The implement draft requirements for ridging, cultivation and ploughing operations in sandy soil ranged between 2138-3119 N, 441-981 N and 1334-2667 N respectively, while the draft requirement for ploughing operation in clay soil ranged between 2981-3815 N.

Generally, all data fall within the ranges reported by various researchers. For example, Musa (1989) reported operation time h/ha between 6-8h/ha, 6-7 h/ha and 17-25h/ha for ridging, harrowing and ploughing operations respectively. However, he did not specify the type of soil. ILO and UNCHS (1986) reported working speeds of between 2.4 to 4.0km/h, for donkeys, horse and workbulls, while a speed of between 3.5-4.0km/h was reported for camel. FAO (1990) reported implement draught requirements of 520 N, 1158 N and 1668 N for cultivation, harrowing and ploughing operations respectively, thus soil was not specified.

Results further showed that faster speeds were recorded for cultivation operation, followed by ridging and ploughing operations. So, also the draft requirements. This may be due to the weight of the implements, depth of cut and the degree of weed infestation and soil type. Comparing ploughing in sandy soil and clay soil, it is seen that the working speeds were relatively the same, but highier draft requirements were obtained

in clay soil with the same implement. This may be because in sandy soil, the implement got deeper upto 20cm, where as in clay soil the depth was much lower (7cm).

TABLE 4.11 Draught Animals Performance for Various Field Operations:

DRAUGHT ANIMALS	BREEDS	AGE	ESTIMATED BODY WEIGHT (kg)	FIELD OPERATION AND SOIL TYPE	IMPLEMENT WEIGHT (kg)	AVERAGE IMPLEMENT DRAUGHT REQUIREMENT (N)	AVERAGE WORKING SPEED (km/h)	AVERAGE FIELD COVERAGE (h/ha)
1. PAIR OF WORKBULLS	BORORO	6	325.45	Ridging (sandy loam) cultivation (sandy loam) ploughing (sandy loam) Ploughing (clay)	**44.39 37.56 34.02 34.02	2481±1.41 755±1.17 2040±1.54 2189±1.38	2.7±0.19 3.1±0.11 1.5±0.11 1.3±0.81	6±0.75 4±0.62 16+1.04 18±1.02
2. SINGLE BULL	BORORO	6	335.50	Ridging (sandy loam) Cultivation (sandy loam)	21.74 14.04	- -	2.7±0.23 3.4±0.10	6±0.80 5±0.80
3. SINGLE DONKEY	MOSSI	6	142.28	Ridging (sandy loam) Cultivation (sandy loam)	21.74 13.04	- -	2.5±0.14 3.2±00.39	10±1.01 8±0.80
4. SINGLE CAMEL	DROMETRY	6	470.25	Ridging (sandy loam) Cultivation (sandy loam)	44.39 30.84	- -	3.5±0.16 3.8±0.10	5±0.89 4±0.89

* - Weight of each bull.
** - Figures rounded to near W. Average of 50 readings ± standard eror

Other adduced reasons could be due to sticky nature of the soil as well as the weeds infestation as at the time of conductiong the experiment.

The results also showed that single animals moves a little faster than paired. This may be due to the fact that with collar harness it is free to move, has limited fatique and for single donkey and single bull, the implements they pull were lighter compared to the ones pulled by paired workbulls using yoke harness. Musa (1989) stated that donkey speed is relatively higher than that of workbulls provided they are not overloaded or over worked. Geo and Mcdowell (1980) stated that single animal can attain almost full of its effort, while effort is reduced by 7.5%, 15%, 22%, 30% and 37% for pairs of 2,3,4,5, and 6 animals respectively. Kaul (1989) obtained 50% increase in tractive effort using collar harness as compared to yoke harness.

ii) **Implements Performance:**

Table 4.12 indicates the performances of various implements evaluated. Details are given in Appendices 9-14 . It is seen from the table that both Emcot and blacksmith make ridgers have

about the same height of ridge and same bottom furrow width. But they differed slightly in both theoritical and effective width of work as well as in weights. The weed cutting/inversion efficiency was about 90% which can be said to be very good. The distinctions between the two ridgers in terms of theoritical and effective width of work was due to the design. That is, it was

blacksmith make ridger to cope with the arid zone workbulls tractive efforts.

The theoritical width of work of both ARARA and blacksmith make ploughs were found to be the same because, the blacksmith make is a copy of the ARARA make. The effective width of work ranged between 40-45 cm and 40-52cm and the depths of work ranged between 16-23cm and 20-26cm for blacksmith and ARARA ploughs respectively in sandy and loam soil. The effective width and depth of cut of ARARA plough ranged between 56-57cm and 7-9cm in clay soil.

The theoritical width of work were the same, they differed in effective width of work as well as the depth of work, because the ARARA make is heavier, it could get deeper into the soil as compared to blacksmith under the same soil condition. It also had the tendency to lift and invert more soil at further distance than the blacksmith, hence its effective width of work became slightly bigger. Both the ploughs scored the same efficiency of weed inversion i.e. 99% which is regarded as excellent.

The theoritical and effective width of work for traditional and improved blacksmith cultivators ranged between 50 - 53cm and 60 - 64cm respectively. Their depths of work ranged between 9-15cm and 11-15cm respectively. There is a slight difference in these parameters probably because of different designs. Though both the cultivators scored 90% and above, it can be said that

the improved cultivator is more efficient and easy to control. This can be attributed to the fact that the improved cultivator has a steering wheel and depth adjustment alternatives which allows the implement to work at shallow depth if required, at the same time the steadying wheel provides easy handling of the implement as well as smooth running of the implement during pulling and turning.

TABLE: 4.12: **Implement Performance Characteristics:**

IMPLEMENT TYPE	IMPLEMENT WEIGHT/ SOIL TYPE (kg)	AVERAGE IMPLEMENT DRAUGHT REQ (N)	AVERAGE HEIGHT OF RIDGE (cm)	TOP FURROW WIDTH (cm)				BOTTOM FURROW WIDTH (cm)		EFFECTIVE DEPTH OF CUT (cm)	WIDTH OF CUT (cm)	SOIL INVERSION CUTTING EFFECTIVE (%)
				THEO	EFF	THEO	EFF	THEO	EFF			
MBOT RIDGER	44.59 (SANDY LOAM)	2481±1.41	20±1.01	70	64±0.87	-	30±1.01	-	20±1.01	-	-	93±0.88
BLACKSMITH RIDGER	54.84 (SANDY LOAM)	2184±1.16	20±0.89	65	42±0.35	-	30±1.09	-	20±1.09	-	-	95±1.01
ARARA PLOUGH	54.01 (SANDY LOAM)	2040±1.54	-	-	-	-	-	-	-	21±1.01	47±1.15	99±0.80
BLACKSMITH PLOUGH	24.28 (SANDY LOAM)	1487±0.24	-	-	-	-	-	-	-	20±1.01	43±1.01	99±0.118
TRADITIONAL BLACKSMITH CULTIVATOR	33.57 (SANDY LOAM)	755±1.71	-	-	-	-	-	-	-	13±1.01	51±0.95	80±1.11
BLACKSMITH IMPROVED CULTIVATOR (ARARA COPY RIGHT)	24.28 (SANDY LOAM)	647±1.38	-	-	-	-	-	-	-	12±0.89	41±0.57	87±0.88
SPIKE TOOTH HARROW	35.56 (CLAY)	-	-	-	-	-	-	-	-	18±1.04	186±1.0 4	78±1.17
BLACKSMITH DOUBLE RIDGER	31.74 (SANDY LOAM)	-	13±0.89	50	37±0.34	-	13±0.37	-	15±0.37	-	-	86±1.04

Average of 50 readings ± standard eror

The traditional make on the other hand did not possess steadying wheel, therefore depth of work is not controllable and turning became difficult. Both the animal and the operator were subjected to additional fatigue in lifting and dragging the implement without wheel. Another advantage of the improved make is that 17cm strip is left between work as compared to 23cm obtained with the traditional. This limited strip left between work requires little effort to accomplish the job manually.

The theoritical width of work for spike tooth harrow was found to be 200cm, its effective width of work ranged between 180-195 cm and the depth of work ranged between 18-19cm. Its raking efficiency was 79% which is considered quite good. Even though the Harrow weighed 35kg it was found to be easy to pull. Together with average human weight of 75kg, the animal pulled about 101kg of weight. This was considered however a difficult task, the harrow was drawn on already ploughed field which was earlier pulverized. This was done following conventional method i.e. ploughing followed by harrowing operation which permited easy penetration of the tines due to initial ploughing.

The blacksmith donkey ridger comparatively has smaller ridger height, top and bottom furrow width and was slightly found to be less efficient than ox-team ridger, in terms of depth and width of work as well as better ridges. Senapate and Satpathy (1989) reported ploughing inversion efficiency between 57 to 86% which is close to what has been obtained during the study. Ramstand (date not specified) reported that plough weight of 32kg

and spike harrow 37kg and a ploughing depth of 7cm. These values fall within the locally fabricated implements during the study.

Generally, there are differences between data obtained in this study compared to those reported by previous researchers. These could be due to soil type, degree of weed infestation, weight and shape of implement and implement sharpness.

There is no difference in cross-sectional area of animal-drawn bund as compared to manually formed. However, manual bund can be larger or smaller depending upon the requirements, while animal bund forming is faster and can reduce manual effort appreciably.

iii) **Implement Durability:**

Monitoring Emcot, Indian modified and blacksmith improved ridgers over 3 years of utilization indicated that, the beam, frog, breast plates, wings and handle frames performed satisfactorily and still remained rigid. However, the wheel bearing (bushing) for Indian and blacksmith makes required replacement. Most of the Indian make shares worned out and some were seen to be changed by farmers. The Emcot shares and blacksmiths hardened shares were found in good working conditions across the 18 DA's.

In terms of shares, landside, beam and wheels, the ARARA ploughs, blacksmith make ploughs and the cultivators were in good conditions. Similarly the spike tooth harrows were not worn out.

This may be because, they were recently introduced and were used for a period of only 2 years. The bund former was still undergoing further testing within the programme, therefore required to be assessed when fully engaged.

TABLE: 4.13 **Comparison Between animal-drawn Bund and Manual Bund:**

IMPLEMENT/ MANUAL	HEIGHT OF MOULD (cm)	TOP SECTION OF MOULD (cm)	BOTTOM SECTION OF MOULD (cm)
BUND FORMER	20-23	22-24	34-37
MANUAL	27	26	41

iv) **Cart Performance and Assessment:**

Table 4.11 shows the averages of animal-drawn carts performance characteristics. Details of loading capacity, types of track and distance travelled can be seen in appendixes 15(a), 15(b) and 17. Results showed that workbulls carts weighing between 157-172kg dead weight carried between 700-1,200kg and travelled a distance of 1-45km at a speed of 3-5km/h. Higher speed were recorded on tared and hard-pan tracks while lower speeds were obtained on sandy tracks. Under the same speeds and track conditions, single bull cart conveyed 600-900kg, single donkey between 400-600kg with the lighter carts between 114 to 157kg dead weights. A donkey as pack conveyed between 100-200kg at the speed of 3-5km/h over a distance of 1-20km. A camel as pack conveyed between 200 to 300kg at the same speed, while horse conveyed between 80-150kg and move over a distance of 1-50km as came before resting.

Adeoti (1989) reported similar working speeds for draught animals, while Musa (1989) reported that donkey can pull 5 times the load it can carry on its back when using light carts and access roads. Donkeys are relatively faster as observed during this study but did not travel long distance as compared to camels and workbulls using cart. Camel as pack animal travelled about 50km with the 300kg load before resting and moved independly provided feeds were made available while resting.

Comparatively, these values falls within the ranges reported by Musa (1987) and Adeoti (1989) as indicated earlier.

TABLE 4.14 Carts Performance Characteristics

TRANSPORT SYSTEM	CHARACTERISTICS:							
DRAUGHT ANIMAL	CART WEIGHT (kg)		LOADING CAPACITY (kg)		SPEED (km/h)		DISTANCE (km)	
	RANGE	AVERAGE	RANGE	AVERAGE	RANGE	AVRRAGE	RANGE	AVERAGE
WORKBULLS	157-172	168±0.82	700-1200	825±2.48	3-5	4±0.12	1-45	15±2.07
SINGLE BULL	114-157	132±0.32	600-900	685±1.42	3-5	3±0.82	1-45	15±1.23
SINGLE DONKEY	114-157	130±0.72	400-600	502±2.62	3-5	4±0.72	1-45	15±3.04
SINGLE CAMEL	114-157	140±1.20	-	-	-	-	-	-
SINGLE HORSE	114-157	140±1.20	-	-	-	-	-	-
A DONKEY (PACK)	-		100-200	148±2.82	3-5	4±0.84	1-20	16±0.27
A CAMEL (PACK)	-		200-300	262±1.04	3-5	4±0.92	1-50	30±1.52
A HORSE (PACK)	-		80-150	102±2.04	3-5	4±0.98	1-50	30±2.24

Average of 50 readings ± standard eror

v) **Carts Performance Evaluation:**

The carts were assessed through constant field visits, checking and inquiring from cart users after 3 years of utilization. Results obtained indicated no major faults. The only constraint observed was that the draw pole of all the 18 issued to farmers did frequently break due to poor choice of materials. Galvanized iron pipe was used in some of the carts instead of steel pipe. No problem of axle bearing was reported, because, a new Indian make axle was used. The frame work made from 5mm thick angle iron was still rigid without any sign of bending or welding defects. Compared to single bull cart made from 3mm thick angle iron, the 5mm angle iron frame work though heavier was still rigid. The wooden frame carts for workbulls were still very good. The main problem associated with workbulls carts was the bearing because of scrap axles from Nissan and Landrover vehicles as explained in section 3.2.2. Camel and horse carts had the same materials with the donkey cart frame work, though lasted or utilized for one year. The carts were mounted on scrap axle from Peugeot transmission shaft coupled to Peugeot wheel, hub and bearing. From the one year application, they are still alright.

4.5.4 Assessment of Artisans Skill:

Based on the criteria discussed in section 3.5.5, external examiners were drawn from Ramat Polytechnic Centre for Appropriate Technology (RAMCAT). During the assessment score sheets were issued to the Specialists to assess each artisan. Their assessment was combined with that of NEAZDP specialists and

and the averages were taken. The skill score was compared with that of John Holt standard implement which was taken as 100% score.

Table 4.15 indicates the skill score for various trained blacksmiths. The results showed that on an average basis, the score ranged between 44% to 78%. That is most or all of them passed the skill examination. This may be due to the fact that all of them were traditional smithers before they obtained additional skill training. The results further revealed that they were good in cutting, bending and punching which they were used to before the training.

The lowest Score was recorded for measurement and costing followed by finishing. This could be due to the fact that none of the artisans had attended a formal school apart from Dumburi blacksmith.

Therefore, understanding a design through measurements as well as costing their products became difficult. It was observed that a good finish to attract market value had not been recognized by most artisans. Most of them could handle tools correctly once they got used to. But their tool maintenance was still poor. This is because they packed all tools in a box or some are thrown within the premises of work. They did not sharpen, polish and clean their tools regularly until it was excessively damaged. These had been noted and more vigerous advocation on appropriate handling has been emphasized during training session, field visits and inspections. Another important observations made on blacksmith is that they were used to working while seating down as traditionally

practiced. However, with the introduction of modern tools and animal-drawn implements, some jobs required standing. Observations made were that they did heavy jobs such as beam making while standing on installed modern equipment, while other jobs were done while seating.

Table 4.15: **Blacksmith Skill Assessment**

S/N	NAME OF BLACKSMITH	DEV. AREA	CUTTING	PUNCHING	BENDING	TOOL USAGE	THREADING	FORGING	FINISHING	MEASUREMENT	COSTING	TOTAL SCORE (%)
1.	Yakubu Abisoye	Yusufari	8	8	7	8	6	7	7	5	5	69
2.	Ali Makeri	Dunburi	8	8	7	8	9	6	6	6	6	76
3.	Cete Gana	Kanasuwa	8	8	8	9	8	9	8	6	6	79
4.	Kasuwa N'arim	Kanambe	8	6	7	9	8	7	8	5	5	72
5.	Jibrilu Ali	Yunusari	7	6	6	6	6	6	6	5	5	63
6.	Baba Bukar	Dapchi	7	7	6	6	6	7	6	4	5	60
7.	Audu Makeri	Muguram	8	8	8	9	8	8	9	6	6	78
8.	Umaru Makeri	Bulangawa	6	5	5	4	4	5	4	2	4	44
9.	Mustapha Makeri	Kaska	7	7	7	6	8	8	7	4	4	67
10.	Alh. Rabiu Nguru	Wachakal	8	8	8	9	8	8	8	6	6	77
11.	Shettima Kaigama	Gumsa	7	7	7	6	5	6	5	5	4	58
12.	Dala B. Buhari	Degeltura	8	7	8	8	7	6	7	6	5	69
13.	Mal. Ma'aru	Dagona	7	8	6	6	7	6	8	5	5	67
14.	Modu S. Lwari	Futchimiram	6	5	4	6	5	5	4	4	4	48
15.	Adamu Gorgoram	Gorgoram	7	7	6	8	8	7	7	4	5	66
16.	Dala Kalgibe	Balle	6	7	6	7	6	7	6	4	4	59
17.	Mustapha Kore	Machina	7	8	7	6	6	7	7	5	5	64
18.	Bulama Makeri	Gwio Kura	8	8	8	6	6	6	7	5	5	72
		TOTAL SCORE (%)	73	72	67	74	69	66	69	49	49	

Table 4.13 shows the skill score of the trained carpenters. The results showed that the score ranged from 49% to 76%. That is all of them passed the skill examination. This could also be attributed to the fact that all of them were practitioners before their skills were upgrated. The highest score was recorded on joint (71%) and measurement (71%), while the least score was in costing (49%). As stated earlier, they were practising the trade that was why cutting, planning is not a problem.

Comparatively, carpenters understand measurements in feet because their local products also require precision for them to match well. However, costing of final product and laying out with accurate angle of frame work was a problem as observed for blacksmiths. Like Blacksmiths, carpenters also kept their tools any how and did not polish, clean and sharpen their tools until excessively damaged. This has been noted and a lot of extension work has been done to improve the situation. Important results noted was that a blacksmith with his 2-3 family labour or co-worker will make a ridger in 1½ to 2 days, a cultivator in a day and a plough in 1½ days. While, a carpenter alone will be able to make one or two ox-carts per day.

Generally, comparing the products of trained artisans with the untrained, it is evident that the trained ones had proper joints, better finish, better awareness of the concept of costing and capable of producing items such as ridgers, cultivators, ploughs, harrow and animal carts that their untrained colleagues could not produce.

Table 4.16: **Carpenters' Skill Assessment**

S/N	NAME OF CARPENTER	DEV. AREA	SOWING	PLANNING	JOINT	POLISHING	TOOL USAGE	MEASURE'T	COSTING	LAYOUT FINISH -ING	TOTAL SCORE (%)
1	Mustapha M. Sunna	Kannama	8	7	9	7	8	8	6	6	73
2	Idi Mohammed	"	6	5	6	6	6	6	4	5	54
3	Alhaji Kallamu	Yusufari	8	7	8	7	7	8	5	8	73
4	A. Mamman	"	5	6	6	5	6	6	4	6	53
5	Ali Maremi	Futchimiram	7	6	5	6	6	5	5	5	56
6	Musa Mohammed	Gumsa	7	7	7	6	7	8	5	6	66
7	Bulama Bukar	Dapchi	7	6	7	7	7	7	4	5	61
8	Audu Buji	Owio Kura	6	6	7	6	6	6	5	6	60
9	Rabiu M. Ya'u	Muguram	8	7	8	6	7	8	6	6	70
10	Musa Dauda	Wachakal	8	6	7	6	7	7	5	6	64
11	Audu M. Dumburi	Dumburi	8	7	8	7	7	8	5	5	69
12	Idirisa Fantami	Bulanguwa	7	8	9	8	8	7	5	6	71
13	Adamu Gwayo	Gorgoram	6	6	7	6	7	8	5	4	60
14	Samaila Goni	Degeltura	7	7	7	6	7	8	5	4	63
15	Bukar Kafa	Balle	7	8	7	6	7	7	8	6	70
16	Baba Buba	"	8	9	9	7	8	8	6	6	76
17	Kanta Abba	Machina	7	6	6	5	6	7	5	4	57
18	Nojiya Barma	"	5	5	5	4	5	6	5	4	49
		TOTAL SCORE	69	66	71	62	68	71	49	54	

4.5.5 Assessment of Animal Handlers Skills:

Based on the assessment criteria presented in section 3.5.6, all the 40 trained animal handlers were assessed during training sessions. Results of the skill assessment are presented in Table 4.17. It is seen that the 40 trained animal handlers scored between 48 to 92%. This means that all of them passed the examination. The highest score of 80-92% was obtained by those who had earlier been trained on ridgers at Maiduguri Farm Centre. They understood other implements such as cultivators, ploughs and harrows easily and at the same time adjusted working depth properly and were able to detect implement faults.

Results further revealed that all the 40 handled ridgers and cultivators perfectly, while 9 of them handled ploughs and harrows. This may be because of the 9 were resident in fadama (clay) areas where ploughs and harrow were issued.

Comparing trained animal handlers with other farmers who had not been trained, it is evident that the trained ones who are used as trainers could detect implement fault, proper adjustment of working depth, can handle various implements and command animals very well. Single harnessing is a skill that only trained ones can do.

TABLE: 4.17 Trained Animal Handlers Skill Assessment

NAME OF TRAINER	SKILL SCORE (10 Point for each skill)						TOTAL SCORE (%)
	ANIMAL CONTROL	IMPLEMENT MANOEUVRABILITY	IMPLEMENT ADJUSTMENT	ANIMAL COMMAND	PATIENCE	IMPLEMENT FAULT DETECTION	%
1. ABBA AGO DAGONA	10	9	9	10	8	9	92
2. GALADIMA KARE	7	8	6	7	8	5	68
3. ADAMU ZALUM	7	8	6	7	8	5	68
4. ADAMU MUSA	6	7	5	6	9	5	63
5. IDI JIKAN BOKA	6	7	5	6	9	5	63
6. ZANGOMA KARASUWA	10	9	9	9	8	9	90
7. ALHAJI KARBE	9	9	8	8	8	8	83
8. GARBA KARASUWA	9	9	8	8	8	8	83
9. DALA ISA	6	6	7	7	9	6	68
10. HELMA GALADIMA	9	9	7	7	9	5	77
11. MAISAMI CHUBABO	5	5	6	6	8	4	57
12. JAURO CHALARBO	5	5	6	6	7	4	55
13. USMAN DUMBURI	9	9	7	7	9	6	78
14. MOHAMMED NA BOSO	6	5	6	5	8	4	57
15. YERIMA TELA	6	5	6	5	8	4	57
16. ABDULKARIM TAFANJAMA	7	7	7	7	7	7	70
17. LAWAN KACHALLA	7	5	5	5	8	5	58
18. AHMADU IDI	5	5	6	6	7	4	55
19. BABANNA GWIO	9	7	7	6	8	5	70
20. INUSA DOKI	9	7	7	6	8	5	70
21. MALLAM MUSTAPHA	9	8	8	8	9	6	80
22. MAL. MUSTAPHA ALAGARNO	8	9	8	8	6	6	75
23. BULAMA KOLO	6	5	6	5	8	4	57

24. GARKIN TASHA JAJI	5	6	5	6	8	4	57
25. ADAMU SAURO	5	5	6	6	7	4	55
26. MODU LAWAN KYARI	6	6	7	7	9	6	68
27. WANI LAWAN	6	7	5	6	9	5	63
28. MAINA NUTTI	5	5	5	5	5	4	48
29. BUKAR MACHINA	9	9	7	7	9	6	78
30. GONI MODU	5	5	5	5	5	5	50
31. MALLAM MODU	5	4	5	6	5	4	48
32. ABUBAKAR MUSTAPHA	4	5	6	5	5	4	48
33. KAURA CHIROMA	6	6	6	6	6	4	57
34. GONI KONGORE	5	5	6	6	4	4	50
35. HARUNA S. FAWA	6	6	5	5	4	4	50
36. WAKIL YUSUFARI	7	8	5	6	6	4	60
37. BAKWALOGI DAGONA	8	8	8	8	8	6	77
38. GAMBO JAJI	8	8	8	8	8	6	77
39. MUSA HARUNA FAGA	7	7	7	6	6	5	63
40. SALEH BADE	5	4	5	6	5	4	48
TOTAL SCORE (%)	68	67	64	65	72	54	

4.5.6 Level of Technology Adoption and Economic Assessment:

Figure 4.16 shows the acceptance score of various technologies introduced. Questionnaire used and details of the respondent scores in percentage are presented in appendices 16(a) and 16(b) respectively. Ox-ridging and ox-carting were the most widely accepted technologies with a score of 100% each. This is because these technologies were introduced as far back as 1928 by colonial masters and there was alot of extension work done from that time uptill the time of this study and at the same time they were the first package issued to farmers by NEAZDP. Presently, almost 100% of farmers in the arid zone are aware of these technologies and are interested in acquiring them either personally or through credit schemes. Due to high degree of understanding, ox-ridger is now being used for rice cultivation, 1st and 2nd weeding, apart from ridging. This application has been innovated by farmers themselves. Ox-weeder (cultivator) though recently introduced has also received a high degree of acceptance with a score of 92%. Farmers are now very much aware of it. Farmers, due to their innovative ability have introduced the weeder to rice cultivation. Its performance has been quite satisfactory. Also recently introduced, but, highly accepted (a score of 80%) is the donkey carting. Only 20% of those issued with the donkey carts did not use it properly. This is because, most of them have converted the donkey cart to ox-cart due to high profitability attained from ox-sales. Which is about 3-4 times purchasing price of the workbulls after 3 years of use.

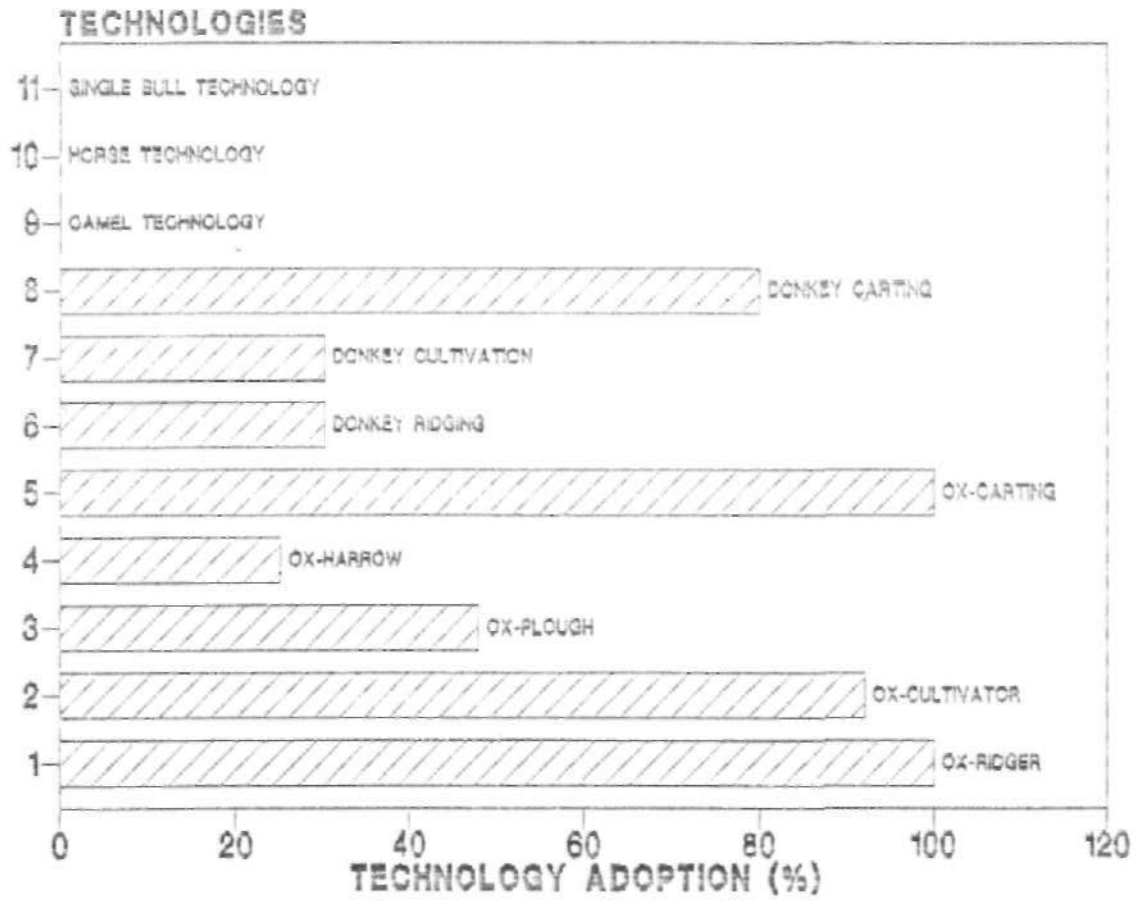


FIGURE: 4.12 LEVEL OF TECHNOLOGY ADOPTION

A camel ridger and cultivator have been offered to one farmer only. Monitoring the farmer showed that he has effectively used the implements and has started motivating other farmers to put request. For camel carting, it is yet to gain momentum because the beneficiary has used it only once after the initial testing and demonstration. The camel traction will be assessed better after some years.

The ox-plough and ox-harrow are least adopted. This may be because they were recently introduced and only a few of them had received proper training on ploughing operation. Though not shown in table, most of the high scores were recorded by ox-trainers who had been well trained with the implement and had been issued with one each for demonstration purposes. However, as time goes on with the intensive extension services offered these implements will be assessed better for acceptability and application.

The donkey ridger and cultivator were found to be less accepted. The reasons so observed during the study was that ox-ridging and cultivation are predominant and earlier introduced, therefore less attention is paid to donkey field operation. Again as observed workbulls traction are more profitable than donkey due to appreciating value of workbulls and workbulls work for elongated period than donkeys. The quality of operation are better done with workbulls as compared to donkey ridging and cultivation as also observed during the field work.

The socio-economic assessment conducted (appendixes - 15b and 16) showed that a farmer with workbulls obtained 2 times grain product over non-workbulls farmer having same family labour. Farm sizes ranged between 3-12 hectares and 1 to 10 hectares for workbulls farmer and non-workbulls farmer. A farmer spent between 3-20 days with workbulls and 22-65 days using manual effort to accomplish first and second field operation (ridging/weeding). A farmer with workbulls spent 29 days annually, 19 on his farm, 4 for relations and 6 for hiring to others. These data showed significance of animal traction in the arid zone. The data fall within those reported in other regions. For example, Bell and Kemp (1986) in Sierra-leone found that typical oxen are used for 30-40 days per year, Cobel (1986) reported that the average annual use of oxen is 41 days and concluded that the appreciating value of oxen make animal traction potentially attractive. Anthony (1988) in North-eastern Ghana concluded that animal traction investment over short (5 years) and medium (10) years periods was profitable. He obtained 17% increase in yield over non-workbulls farmer. Musa (189) reported that 255% yield and income per hectare was obtained from workbulls utilization when efficient equipment and management techniques are employed. Gabon et al. (1992b) obtained a net profit of N5,000 per annum using animal traction in NEAZDP area, similarly Christensen (1994) obtained a value cost ratio of 1.7, 5 and 2.5 for manual, workbulls and tractor benefits respectively. This implies animal traction farmer obtained about 3 times return over non-animal traction farmer in NEAZDP area.

From the data obtained elsewhere, Gabon et al. (1992) and Christensen (1994) in NEAZDP area coupled with the socio-economic data obtained during this study, animal traction is very beneficial to farmers in the arid zone. This is because of field timely operation, reduced human labour, efficient field operation, yield and animal value.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusion:

Base-line survey results showed that there were only workbulls used for traction purposes, all owned personally without any from credit schemes. Other animals such as donkeys, camels and horse were available but generally used as pack animals for transportation, ceremonies and water lifting from rural wells. There were also artisans/blacksmiths and carpenters with the initial skills in ridger fabrication and repairs, and local ox-cart production. Most existing animal drawn equipment found were Johnholt makes with limited quantities fabricated by blacksmiths. Artisans were found to also engaged in fabrication of local tools such as hoes, sickles, knifes, axes and construction of local furniture. Artisans products particularly joints, layout, finish, costing and measurements were poor. Animal handlers were only aware of ridger and ox-cart. Having received additional skills, the artisans were capable of fabricating all the newly introduced animal-drawn equipment. The animal handlers have disseminated new operational techniques to the other farmers in the study area.

Initial testing and evaluation showed operational and mechanical problems with imported Indian make ridgers. Performance of modified Indian ridgers were satisfactory. Trained artisans fabricated ridgers, cultivators, ploughs, spike tooth, harrows bund formers, ox-carts and single animal carts which were distributed to farmers for utilization over a 3 years

period.

In terms of weed cutting/inversion efficiency, depth and width of cut, proper ridges, the modified Indian ridgers, blacksmith and carpenters fabricated/constructed animal-drawn equipment performed satisfactorily under Arid Zone conditions. Animal-drawn carts performed satisfactorily except those made from scrap rear axles that required bearing replacement and tyres.

Field test results showed that arid zone draught animals possessed about the same tractive efforts as the animals of other regions reported in the literature, therefore can withstand equal tasks provided they are properly trained and maintained. Single camel was found to pull implement meant for a pair of workbulls and could perform such tasks as ridging and cultivation faster.

The study also revealed that inspite of the efforts been made to promote animal traction, only 0.18% of the cultivable area of NEAZDP is being cultivated using animal power. The study further showed that 44 years are required to cope with the cultivable land area of NEAZDP from the present ownership from credit scheme and personal ownership. Ox-ridging, Ox-carting, Ox-cultivation, Donkey carting are the most widely adopted followed by Ox-ploughing. Economic assessment conducted at the end of the study indicated that animal traction could be beneficial to farmers in the arid zone of Nigeria.

Based on the results of this study, the following conclusions can be drawn.

1. Prior to the establishment of NEAZDP, only workbulls were used for traction purposes while others were employed as pack animals.
2. It is possible to modify locally available animal-drawn implements/equipment for better performance.
3. Incorporation of trained local artisans (B/smiths, Welders and Carpenters) into small scale manufacturing industry will greatly enhance the availability of simple farm mechanization technologies in the rural market.
4. Trained animal handlers can effectively train other farmers in the technologies of handling of animals and maintenance of animal-drawn technologies.
5. Arid Zone draught animals possessed similar tractive efforts as those found in other regions.
6. Forty-four years are required to cope with the cultivable land area of NEAZDP based on the current strength of draught animals.
7. Ox-ridging, Ox-carting, Ox-cultivation, Donkey carting are the most widely adopted animal operations in the NEAZDP Programme area.
8. Animal traction could be beneficial to farmers in the arid zone of Nigeria.

5.2 Recommendations

The following recommendations can be drawn from the study.

1. To introduce animal-drawn equipment and related technologies, an appraisal of the available equipment and skills is recommended. This will ensure that necessary improvement (if any) are made on the equipment before mass dissemination to farmers.

2. For sustainability of animal traction programme, incorporation of blacksmiths, carpenters, welders and animal handlers to provide continuous services is recommended. This should be coupled with provision of necessary tools, training kits and cash to purchase materials for production.

3. In order to cope with the cultivable land area, it is recommended that the Government should continue with provision of credit to purchase draught animals and equipment.

4. It is recommended that loan packages should consist of a pair of workbulls, a cart, a ridger and a cultivator for the upland farmer. While a pair of workbulls, a cart, a ridger, a cultivator, a plough and harrow for the Fadama (rice/irrigation) farmer.

5.3 Recommendations for Further Studies

The following are recommended for further studies.

1. This study limited itself to the determination of only implement draft requirements. The functional relationships between draft and other important parameters such as speed, depth of cut, implement weight, weed infestation, etc need to be established for the arid zone.

2. Only Zebu workbulls were found to be in use as draught animals in the arid zone. Currently there is influx of white cattle (Bunji) which have potential as draught animals. It is recommended that a study be conducted to establish their performances in the arid zone.

3. A comparative study of the tractor, animal and manual farming methods to establish plant growth and yield data is recommended for further investigation in this unique farming system of the arid zone.

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25.	File, flat 8" bastard cut with handle No. 26786	1
26.	File, round, 10" bastard cut with handle No. 26781	1
27.	File, 1/2 round, 8" bastard cut with handle, No. 26785	1
28.	File, square, 8" with handle No. 26784	1
29.	Rule, engineers, 600mm, steel, with No. 27168	1
30.	Rasp file, 8" with handle No. 26784	1
31.	Hand grinder 8" wheel No. 26370	1
32.	Callipers, inside 12" No. 27205	1
33.	Hacksaw, ads-8"-12" no. 26183	1
34.	Hacksaw, blades HSS (pkt) 100 pcs. No. 26187	1
35.	Adjustable wrench 254mm No. 25076	1
36.	Pilers, engineers 7" No. 25406	1
37.	Self grip wrench 10" No. 25596	1
38.	Tape measures, 3m, automatic receit No. 27016	1
39.	Tinsips 11" GILBOXA sith pattern No. 25677	1
40.	Set twist drills 1-13mm 10.5mm, HSS No. 26485	1
41.	Set twist drills, 6.9mm, 10.4mm, 14mm, 16mm, 17.5mm, 20mm, HSS No. 26383	1
42.	Set hand taps + dies with wrenches and stocks, 6, 8, 12, 16 and 20mm No. 26639	1
43.	Scribe Engineers 160mm, No. 27215	1
44.	Drill, breast 1/2", STANLEY No. 1.3 - 748	1
45.	*Drill sharpener attachement for twist 3-18mm, to be used with bench grinding machine.	1

SET OF CARPENTRY TOOLS:

DESCRIPTION:	QUANTITY:
1. Jack plane (steel) STANLEY No. 5	1
2. Smoothing plane (steel) STANLEY NO. 3	1
3. Rebate Plane STANLEY No. 10	1
4. Rip Saw (600) STANLEY No. 1-55-421	1
5. Panel Saw 400mm STANLEY No. 1-15-512	1
6. NEST (set) of Swages No. 26067	1
7. Tenon Saw 350mm STANLEY No. 1-15-255	1
8. Ordinary Firmer chisel 6, 10, 13, 16, 20, 25mm, No. 26221	1
9. Bevelled Edged Firmer (chisel) 6, 10, 13, 16, 20, 25mm No. 26224	1
10. Mortise chisel 4, 8, 12, 16, 20, 26mm	1
11. Oil stone, 150 x 50 x 20mm No. 27777	1
12. Tape measure (3m) automatic recoil, No. 27016	1
13. Centre bit 6mm, No. 26326	1
14. Auger bit, 6, 20, 12, 16, 22, 26mm	1
15. Gimlet, 8mm, No. 26326	1
16. Claw Hammer 27mm, face dia. No. 25744	1
17. Triangular file, 8", 2nd cut, with handle No. 26783	1
18. Flat file, 8", 2nd cut with handle No. 26781	1
19. Round file, 8", 2nd cut with handle No. 26786	1
20. Spoke shave STANLEY No. 51	1
21. Try square - 6" No. 27153	1
22. Try square - 12" No. 27153	1
23. Type rule 50m (metric) No. 27034	1
24. Rasp, 300mm, with handle No. 26874	1
25. Pincers, 200mm No. 25587	1
26. Sliding bevel, 200mm, No. 27160	1

27.	Medium Grade sand paper (pkt) of 50 pcs. No. 401 C	1
28.	Smooth Grade sand paper (pkt) of 50 pcs. No. 401 C	1
29.	Saw setter No. 26147	1

Assessment Sheet for Draught Animals Availability and Distribution in NEA7DP.

DEVELOPMENT AREA	VILLAGES	NO. OF WORKBULLS		NO. OF DONKEYS		NO. OF CAMELS		NO. OF HORSES	
		NEAZDP	PRIVATE	NEAZDP	PRIVATE	NEAZDP	PRIVATE	NEAZDP	PRIVATE

Appendix: 4

DRAUGHT ANIMALS PHYSICAL CHARACTERISTICS:

	WORK BULLS				DONKEYS				CAMELS				HORSES			
S/N	L (cm)	H (cm)	G (cm)	W (kg)	L (cm)	H (cm)	G (cm)	W (kg)	L (cm)	H (cm)	G (cm)	W (cm)	L (cm)	H (cm)	G (cm)	W (cm)
1.	133	134	167	343	75	91	120	100	130	150	140	236	130	140	160	308
2.	121	114	143	229	105	112	152	224	160	220	205	622	160	145	170	428
3.	148	136	172	405	80	90	125	116	140	160	150	291	135	140	160	320
4.	121	120	140	219	85	110	135	145	140	170	180	419	130	145	135	289
5.	140	130	170	374	90	110	140	163	145	180	170	387	150	140	160	355
6.	150	140	172	410	105	108	150	218	160	200	160	379	155	142	141	376
7.	162	140	206	636	106	91	125	153	160	200	185	506	160	141	162	388
8.	162	142	180	485	108	90	135	182	145	210	167	352	160	140	170	428
9.	150	138	172	410	90	89	140	163	145	210	170	387	160	142	170	428
10.	148	130	170	395	90	85	135	152	150	210	162	364	155	143	162	376
11.	167	140	170	435	80	90	125	116	155	187	162	376	145	145	162	352
12.	121	120	140	219	85	90	120	113	155	188	180	464	160	145	160	379
13.	135	125	143	255	78	110	120	104	155	190	180	464	135	130	160	320
14.	142	132	145	236	75	117	150	156	135	190	200	499	130	130	170	347
15.	144	134	146	284	75	113	150	156	130	190	200	481	130	130	170	347
16.	146	135	147	292	85	114	152	244	130	190	200	81	135	133	170	347
17.	150	140	180	449	85	90	135	145	135	190	200	499	140	135	163	352
18.	152	140	182	466	90	95	125	130	135	210	195	475	150	135	160	355

19.	160	140	185	506	100	107	120	133	135	210	195	475	152	135	165	383
20.	162	140	178	475	100	106	120	135	150	220	185	475	152	135	160	380
21.	167	142	176	478	95	108	120	126	150	210	185	475	156	140	165	393
22.	152	140	162	369	95	110	125	137	145	215	192	494	158	140	170	422
23.	140	130	160	331	95	110	130	148	145	150	190	484	160	130	170	428
24.	148	132	152	316	80	110	135	135	160	150	180	479	160	135	170	428
25.	152	140	162	369	80	85	140	145	160	150	185	506	130	136	185	411
26.	155	141	163	381	80	90	130	163	150	150	175	425	132	138	180	395
27.	160	140	160	379	80	90	125	116	145	165	170	387	142	140	160	336
28.	160	141	164	398	80	90	120	107	1442	175	175	402	140	130	175	396
29.	128	122	145	249	85	91	120	113	150	165	180	449	145	131	160	343
30.	130	135	165	327	95	92	120	126	155	200	220	573	160	132	160	379
31.	152	140	162	369	80	110	120	107	100	190	140	290	130	140	160	308
32.	160	141	180	479	85	108	125	125	140	200	202	528	130	145	165	327
33.	142	132	162	345	90	95	130	141	145	185	162	352	160	130	150	333
34.	141	130	143	267	88	110	140	159	155	200	165	390	150	142	165	378
35.	143	140	140	259	86	91	142	160	160	210	185	506	159	143	172	435
36.	133	11	142	248	91	89	125	131	145	210	185	459	160	130	150	333
37.	128	142	178	375	91	100	135	153	155	210	185	490	154	135	152	329
38.	150	140	170	401	92	110	355	155	160	215	203	610	145	130	152	310
39.	152	130	148	308	95	108	125	137	160	210	201	598	145	140	162	352
40.	152	130	148	308	100	110	140	181	160	200	200	591	135	130	150	281
41.	162	132	165	408	102	95	130	159	160	200	200	591	160	135	155	355

42.	160	140	168	408	103	99	130	161	150	190	195	527	160	130	150	333
43.	160	140	168	419	104	89	125	150	150	195	198	544	160	140	165	403
44.	145	132	163	356	105	110	135	177	145	180	185	459	160	140	165	403
45.	148	135	165	373	95	108	130	140	140	175	280	443	165	12	168	431
46.	148	135	166	377	85	104	130	133	138	180	185	437	150	142	168	391
47.	146	133	167	376	85	102	120	113	140	175	180	419	155	140	160	367
48.	130	130	146	256	85	92	120	113	150	190	200	555	145	139	155	322
49.	128	125	145	249	90	90	120	120	155	200	200	537	150	1442	163	368
50.	122	121	143	231	90	91	125	130	160	210	181	485	140	140	158	323
TOT	7203	6722	8987	17328	4494	4990	6521	7209	7428	9550	9145	23632	7420	6820	8053	18251
AVG	144	134	162	347	90	100	130	144	149	191	183	472	148	138	161	365
MIN	121	114	140	219	75	85	120	100	130	150	140	236	130	130	150	308
MAX	167	142	206	636	105	114	152	244	160	220	205	622	160	145	172	428

L = LENGTH OF THE ANIMAL FROM THE SHOULDER TO THE TAIL (CM)
H = HEIGHT OF THE ANIMAL (CM)
G = ANIMAL GIRTH LENGTH (CM)
W = WEIGHT OF THE ANIMAL (CM)

WORKBULLS PERFORMANCE DATA FOR RIDGING OPERATION

NO OF SAMPLES	WORKING SPEED AT EVERY 20/20 TRAVEL (M/SEC)	OPERATION TIME (HOURS/HA)	DYNAMOMETER PULL AT EVERY 20M TRAVEL (KG		DRAFT FORCE PULL FORCES X COSθ (KG		PENETROMETER RESISTANCE AT EVERY AT 20M (N/M)	
			B/SMITH RIDGER	EMCOT RIDGER	B/SMITH RIDGER	EMCOT RIDGER	B4R	AR
1	0.80	5.5	236	318			1.75	
2	0.76	6.5	236	281			1.00	
3	0.82	6.0	236	281			160	
4	0.86	6.0	236	236			0.80	
5	0.80	6.0	281	227			1.50	
6	0.75	7.0	318	218			1.60	
7	0.71	5.5	236	318			1.50	
8	0.72	4.5	236	318			1.50	
9	0.70	5.0	236	318			2.25	
10	0.80	5.0	236	318			1.00	
11	0.76	5.20	281	318			1.00	
12	0.72	5.30	281	236			1.00	
13	0.74	5.50	318	236			1.00	
14	0.70	5.60	318	227			1.50	
15	0.82	6.0	318	227			1.25	
16	0.86	6.0	236	227			1.50	
17	0.80	6.5	236	227			1.50	
18	0.70	7.0	236	236			1.50	
19	0.76	7.0	236	318			1.50	
20	0.72	7.0	236	318			1.50	
21	0.73	6.5	236	318			1.25	
22	0.74	5.5	236	318			1.00	
23	0.70	5.5	236	318			175	
24	0.73	5.5	236	318			1.50	
25	0.74	6.5	236	227			1.25	
26	0.70	6.0	218	236			1.00	
27	0.80	6.0	218	318			1.00	
28	0.82	6.0	218	318			1.00	
29	0.70	6.0	218	318			1.00	
30	0.71	7.0	236	318			1.50	
31	0.73	6.2	236	318			1.25	
32	0.74	7.2	236	318			1.50	
33	0.80	5.5	236	318			1.50	

34	0.74	6.10	218	227			1.50	
35	0.74	4.5	218	272			1.50	
36	0.82	5.5	318	272			1.50	
37	0.71	6.3	318	272			1.29	
38	0.72	6.5	218	272			1.00	
39	0.73	6.5	218	281			1.00	
40	0.76	7.0	218	281			1.00	
41	0.80	6.0	218	281			1.50	
42	0.71	6.0	218	281			1.50	
43	0.70	7.0	236	281			1.25	
44	0.70	7.0	236	281			1.25	
45	0.72	6.0	236	281			1.50	
46	0.73	6.0	236	281			1.50	
47	0.72	6.5	236	272			1.50	
48	0.72	5.5	218	227			1.50	
49	0.72	5.30	218	318			1.50	
50	0.80	5.40	218	318			1.50	
TOT	37.50	300	12193	13790			66	
AVG.	0.75	6	243	276	221	253	1.3	
MIN MAX	0.70 0.86	4.5 7.2	218 318	218 318	200 292	200 292	0.80 2.25	

B4R = BEFORE RIDGING AR = AFTER RIDGING

WORKBULLS PERFORMANCE DATA FOR CULTIVATION (WEEDING) OPERATION:

NO. OF SAMPLES	WORKING SPEED AT EVERY 20/20 TRAVEL (M/SEC)	OPERATION TIME (HOURS/HA)	DYNAMOMETER PULL AT EVERY 20M TRAVEL (KG)		DRAFT FORCE PULL FORCES x COS (KG		PENETROMETER RESISTANCE AT EVERY 20M (H/M)	
			TRAD. B/SMITH CULT.	IMPRD B/SMITH CULT.	TRAD. B/SMITH CULT.	IMPRD B/SMITH CULT.	B4C	AC
1	0.82	3.5	73	73				1.50
2	0.78	4.0	82	45				1.50
3	0.86	4.0	74	82				1.50
4	1.02	4.0	82	64				1.50
5	1.02	3.0	91	64				1.50
6	0.86	3.5	100	54				1.50
7	0.82	3.5	73	91				1.50
8	0.85	3.5	82	82				1.50
9	0.92	5.0	82	64				1.25
10	0.94	5.0	91	100				1.25
11	0.92	5.0	91	64				1.25
12	0.84	5.4	91	45				1.25
13	0.80	4.5	82	82				1.50
14	0.76	4.5	73	68				1.20
15	0.74	4.2	73	68				1.20
16	0.82	4.5	82	68				1.25
17	0.90	4.3	91	45				1.25
18	1.00	4.5	91	64				1.25
19	0.92	4.5	82	45				1.50
20	0.84	4.0	73	45				1.20
21	0.84	4.0	73	45				1.25
22	0.92	4.0	73	64				1.25
23	0.84	4.0	82	64				1.25
24	0.82	4.2	82	68				1.50
25	0.80	4.1	91	91				1.00
26	0.84	4.1	91	91				1.00
27	0.92	3.5	91	100				1.00
28	1.00	3.5	91	68				1.25
30	0.90	4.0	82	82				1.50
31	0.68	4.5	82	82				1.25
32	0.92	3.5	73	45				1.50
33	0.82	4.0	91	64				1.50
34	0.82	4.0	82	68				1.50

35	0.82	3.0	82	68				1.50
36	0.82	3.0	82	70				1.25
37	0.92	3.50	73	70				1.25
38	1.00	3.50	91	71				1.25
39	1.00	3.50	91	82				1.25
40	0.82	4.50	82	5				1.25
41	0.82	4.50	82	45				1.50
42	0.92	4.0	82	54				1.50
43	0.92	4.10	82	70				1.25
44	0.92	4.20	91	68				1.25
45	0.92	3.80	91	68				1.25
46	0.94	3.90	75	68				1.25
47	0.85	4.20	73	68				1.50
48	0.64	4.50	73	64				1.50
49	0.84	4.50	73	64				1.50
50	0.84	4.0	75	60				1.50
TOT	43.10	20.05	4220	3306				67.35
AVG	0.862	4	84	66	77	61		1.3
MIN	0.74	3	73	45	66	41		1.50
MAX	1.02	5.4	100	100	92	92		4.20

B4C = BEFORE CULTIVATION
AC = AFTER CULTIVATION

WORKBULLS PERFORMANCE DATA FOR PLOUGHING OPERATION

NO OF SAMPLES	WORKING SPEED AT EVERY 20/20 TRAVEL (M/SEC)	OPERATION TIME (HOURS/HA)	DYNAMOMETER PULL AT EVERY 20M TRAVEL (KG		DRAFT FORCE PULL FORCES X COST (KG£		PENETROMETER RESISTANCE AT EVERY AT 20M (N/M)	
			B/SMTH PLOUGH	ARARA PLOUGH	B/SMTH PLOUGH	ARARA PLOUGH	B4P	AP
1	0.56	12	136	136			1.50	
2	0.50	12	209	136			1.50	
3	0.48	12	191	218			1.50	
4	1.40	12	181	218			1.25	
5	1.52	16	181	272			1.25	
6	0.52	16	191	218			1.25	
7	0.48	16	209	227			1.00	
8	0.85	12	209	218			1.00	
9	0.42	20	209	272			1.00	
10	0.40	28	191	272			1.00	
11	0.38	16	191	272			1.50	
12	0.58	20	191	272			1.50	
13	0.52	28	181	272			1.50	
14	0.52	16	181	272			1.25	
15	0.52	16	181	227			1.25	
16	0.48	16	181	218			1.50	
17	0.42	28	209	218			1.50	
18	1.48	20	191	218			1.50	
19	0.41	12	209	218			1.50	
20	0.38	12	136	218			1.50	
21	0.42	12	209	136			1.50	
22	0.35	12	209	136			1.50	
23	0.32	20	209	136			1.50	
24	0.56	12	209	272			1.25	
25	0.40	15	209	272			1.50	
26	0.48	17	191	227			1.50	
27	0.44	20	191	227			1.50	
28	0.41	12	181	218			1.50	
29	0.42	16	181	218			1.50	
30	0.40	16	191	136			1.25	
31	0.50	16	191	218			1.50	

32	0.51	16	181	218			1.50	
33	0.42	20	209	218			1.50	
34	0.40	12	181	218			1.50	
35	0.42	12	191	272			1.25	
36	0.44	12	191	218			1.25	
37	0.44	12	209	218			1.25	
38	0.45	20	181	218			1.50	
39	0.44	28	181	218			1.50	
40	0.42	16	181	218			1.50	
41	0.40	16	191	227			1.50	
42	0.40	16	209	227			1.50	
43	0.42	16	209	227			1.25	
44	0.44	12	209	227			1.00	
45	0.48	12	181	227			1.00	
46	0.56	12	181	227			1.00	
47	0.52	12	191	272			1.50	
48	0.58	16	191	272			1.50	
49	0.48	16	209	218			1.50	
50	0.40	20	209	218			1.50	
TOT.	22.69	800	9423	11337			68.25	
AVG.	0.45	16	188	227	172	208	1.4	
MIN MAX	0.32 0.58	12 28	136 209	136 272	125 192	125 250	1.00 4.50	

B4P = BEFORE PLOUGHING
AP = AFTER PLOUGHING

SINGLE DONKEY, BULL AND CAMEL PERFORMANCE DATA FOR CULTIVATION (WEEDING) AND RIDGING OPERATIONS

NO OF SAMPLES	SINGLE DONKEY				SINGLE BULL				SINGE CAMEL			
	RIDGING		CULTIVATION		RIDGING		CULTIVATION		RIDGING		CULTIVATION	
	WORKING SPEED (m/sec)	OPERATION TIME (hr/ha)	WORKING SPPED (m/sec)	OPERATION TIME (hr/ha)	WORKING SPEED (m/sec)	OPERATION TIME (hr/ha)	WORKING SPEED (m/sec)	OPERATION TIME (hr/ha)	WORKING SPEED (m/sec)	OPERATION TIME (hr/ha)	WORKING SPEED (m/sec)	OPERATION TIME (hr/ha)
1	0.556	10	1.112	7	0.80	7	0.89	5	0.973	5	1.112	5
2	0.834	12	1.112	8	0.80	6	0.92	4	0.950	5	1.112	4
3	0.556	10	1.000	7	0.80	7	0.92	4	0.920	5	1.102	4
4	0.540	12	0.834	6	0.76	7	0.94	4.5	0.920	5	1.112	4
5	0.740	13	0.834	6	0.76	7	0.76	4.5	1.00	4.5	0.980	3.50
6	0.740	14	0.834	6	0.76	7	0.84	5.50	1.00	4.5	0.980	3.50
7	0.834	9	0.920	8	0.74	8	0.90	4.50	1.00	4.5	0.990	3.50
8	0.834	9	0.920	8	0.73	6	0.92	4.00	0.973	5.00	0.990	3.50
9	0.740	9	0.834	8	0.76	5.50	0.90	4.00	0.973	6.00	0.980	3.50
10	0.640	9	0.780	7	0.74	6.50	0.92	4.30	0.890	6.00	0.990	3.10
11	0.630	10	0.750	8	0.78	6.50	0.92	5.50	0.890	6.00	0.980	3.10
12	0.556	8	0.734	7	0.80	7.50	0.89	5.50	0.890	6.00	0.980	3.10
13	0.556	7	0.820	8	0.70	7	0.88	5.50	1.00	6.00	1.000	3.10
14	0.580	8	0.840	6	0.90	6.50	0.84	5.00	0.920	5.00	1.000	5.00
15	0.740	8	0.920	6	0.82	6.50	0.98	4.50	0.973	5.00	1.000	4.00
16	0.780	8	0.920	8	0.80	5.50	1.00	4.50	0.973	5.10	1.112	3.50
17	0.820	7	0.920	8	0.80	5.50	1.00	4.00	0.980	5.20	1.112	3.50
18	0.556	10	1.000	9	0.80	5.50	0.92	4.00	0.980	5.50	1.112	4.00
19	0.720	8	1.112	8	0.74	5.00	0.82	4.00	0.985	6.50	1.112	4.00

20	0.720	7	1.000	8	0.74	5.00	0.94	4.50	0.985	7.00	1.112	4.00
21	0.720	9	0.834	9	0.74	5.00	0.98	5.20	1.00	6.50	1.112	4.00
22	0.830	7	0.800	8	0.74	7.00	0.92	5.20	0.890	5.50	0.990	4.50
23	0.820	7	0.780	9	0.80	7.00	0.88	5.20	0.990	4.50	1.000	4.50
24	0.556	7	0.920	8	0.80	8.00	0.85	6.00	0.990	4.00	1.000	3.10
25	0.556	8	0.820	8	0.72	8.00	0.94	6.00	0.920	4.00	1.000	5.10
26	0.556	12	0.830	8	0.70	6.80	0.98	6.00	1.00	4.00	1.000	5.20
27	0.556	12	0.830	8	0.70	8.00	1.00	5.20	1.00	4.00	1.100	5.20
28	0.740	12	0.780	8	0.70	6.80	0.80	3.50	1.00	4.00	1.100	4.00
29	0.820	12	0.820	9	0.70	8.00	0.84	6.50	0.990	5.00	1.100	4.50
30	0.820	12	0.820	8	0.70	8.00	0.80	6.00	0.973	5.00	1.112	4.50
TOT.	20646	286	26.340	230	2284	186	28.05	142.1	28.928	147.8	31.494	112.9
AVG.	0.688	10	0.878	8	0.76	6	0.936	5	0.965	5	1.049	4
MIN MAX	0.540 0.894	7 14	0.734 1.112	6 9	0.70 0.90	5 8	0.76 1.00	3.50 6.50	0.850 1.00	4 7	0.980 1.112	310 5.20

WORKBULLS RIDGE IMPLEMENTS PERFORMANCE DATA

NO OF SAMPLES	BLACKSMITHS RIDGER							EMCOT RIDGER							
	Height of Ridge (cm)	To furrow width (cm)	Bottom furrow width (cm)	size of strip leftover (cm)	Inversion (%)			Height of Ridge H (cm)	Top furrow width (cm)	Bottom furrow width (cm)	Size of strip leftover (cm)	Inversion (%)			
					No. of WB4R	No of WAR	%					No of WB4R	No of WAR	%	
1	26	40	20		80	1		19	44	26		80	12		
2	18	46	19		96	4		27	47	31		96	16		
3	23	40	18		103	4		26	35	21		103	36		
4	24	43	23		166	26		22	41	27		166	46		
5	17	41	27		90	10		21	40	21		90	4		
6	23	41	19		120	8		21	40	21		80	3		
7	18	40	19		102	25		22	38	21		110	2		
8	18	40	19		80	4	√	22	39	27		120	1		
9	17	45	10		60	2		19	40	26		80	4		
10	24	43	18		105	3		19	40	22		60	4		
11	23	43	18		95	6		19	46	30		90	10		
12	18	43	19		80	10		19	44	31		85	26		
13	17	46	21		80	8		22	45	28		102	12		
14	26	40	21		42	12		21	45	25		85	0		
15	25	40	23		107	1		21	45	20		85	0		
16	24	40	23		100	2		20	45	20		91	0		
17	18	40	20		91	4		19	43	19		100	0		
18	18	40	18		82	4		19	46	19		150	4		
19	18	41	19		85	20		20	40	18		80	3		
20	17	40	19		75	10		19	41	18		60	18		

49	21	40	24		50	4		20	40	20		90	0	
50	22	45	26		50	4		22	41	20		95	0	
TOT.	1010	2088	1011		4167	224	95	1080	2213	1151		4530	304	93
AVG	20	42	20		-	-	95	22	44	23		-	-	95
MIN MAX	17 25	40 46	18 26		-	-	-	19 27	35 46	19 31		-	-	-

WB4R = WEEDS BEFORE RIDGING
WAR = WEEDS AFTER RIDGING

21	17	43	18		70	1		20	41	22		50	1		
22	17	43	20		64	2		19	42	22		110	2		
23	17	41	21		63	3		20	42	20		90	5		
24	18	40	21		50	0		21	42	20		81	8		
25	24	40	21		52	0		21	42	21		70	1		
26	24	46	23		120	0		21	45	26		90	2		
27	21	45	19		101	0		20	46	25		50	20		
28	25	40	19		80	0		19	46	30		81	1		
29	23	41	18		70	0		20	45	21		80	4		
30	18	43	20		60	1		20	40	19		120	8		
31	18	44	19		90	2		20	41	19		80	0		
32	18	43	19		90	10		19	40	26		80	0		
33	18	43	20		91	1		20	44	30		90	0		
34	19	40	23		100	2		19	45	21		100	0		
35	17	41	23		80	0		22	43	22		104	0		
36	21	40	20		82	0		23	43	27		106	4		
37	24	40	20		70	0		24	42	22		95	2		
38	23	41	19		86	4		20	40	20		85	3		
39	20	42	19		88	2		20	41	19		90	1		
40	18	43	18		98	1		23	46	19		90	1		
41	18	40	18		96	0		19	44	18		106	2		
42	20	40	18		100	5		23	43	20		104	5		
43	21	41	20		102	5		21	43	23		80	0		
44	23	43	21		104	6		20	40	24		85	10		
45	18	43	21		100	4		20	46	25		90	20		
46	12	40	20		94	0		20	45	25		90	1		
47	18	43	19		67	1		20	42	19		85	0		
48	20	42	23		60	2		26	43	18		80	2		

WORKBULLS CULTIVATION (WEEDING) IMPLEMENTS PERFORMANCE DATA

NO. OF SAMPLES	BLACKSMITH CULTIVATION (TRADITIONAL)						BLACKSMITH CULTIVATION (IMPROVED)					
	Effective width of work (cm)	Depth of work (cm)	Strip size b/w work (cm)	Efficiency (%)			Effective width of work (cm)	Depth of work (cm)	Strip size b/w work (cm)	Efficiency (%)		
				No. of WB4C	No. of Uncut WAR	%				No. of WB4C	No. of Uncut WAR	%
1.	50	14	26	27	19		60	13	19	40	0	
2.	50	9	19	30	3		64	14	13	30	0	
3.	50	11	10	40	6		61	11	17	20	0	
4.	11	13	17	31	0		67	15	10	25	0	
5.	53	12	29	20	4		63	14	19	30	0	
6.	50	14	20	40	3		63	12	14	40	1	
7.	52	15	30	41	2		63	13	17	41	1	
8.	50	14	19	50	1		64	12	17	10	2	
9.	50	14	19	25	0		61	12	17	19	2	
10.	50	13	20	35	0		60	11	18	20	3	
11.	50	12	23	40	4		60	11	19	21	0	
12.	52	9	24	60	10		64	17	19	40	4	
13.	51	10	25	70	0		64	14	19	30	1	
14.	51	14	20	25	5		63	14	17	32	1	
15.	51	14	23	20	4		60	11	10	40	0	
16.	52	15	20	40	3		62	11	13	19	0	
17.	50	9	24	41	2		62	12	16	10	0	
18.	49	13	25	30	0		61	11	16	24	0	

19.	53	13	26	32	3		60	11	16	23	0	
20.	50	13	20	20	2		60	12	15	15	0	
21.	50	14	19	10	4		64	13	15	20	0	
22.	50	14	10	25	0		64	14	15	40	0	
23.	50	14	24	30	10		63	12	15	30	0	
24.	51	15	24	32	1		63	12	13	31	0	
25.	52	11	24	30	1		64	12	13	40	0	
26.	50	9	25	20	3		60	12	13	41	0	
27.	50	10	26	25	3		60	12	17	50	0	
28.	50	13	28	60	0		60	13	17	60	0	
29.	50	13	13	13	0		60	12	13	20	0	
30.	50	13	25	40	0		64	11	13	21	1	
31.	50	14	24	30	3		60	11	19	40	0	
32.	49	14	24	40	2		64	11	19	41	0	
33.	50	14	24	40	4		64	11	17	30	0	
34.	52	13	25	32	1		63	12	17	31	0	
35.	50	10	25	32	1		50	13	17	19	0	
36.	50	14	25	30	3		64	11	17	20	0	
37.	50	13	25	40	2		63	12	13	17	0	
38.	50	13	24	41	4		64	12	13	15	1	
39.	50	1	20	20	1		64	13	10	12	3	
40.	52	15	24	25	3		65	13	17	30	2	
41.	52	15	23	20	2		63	12	19	25	3	
42.	50	13	29	24	4		60	12	19	40	2	
43.	49	15	26	23	0		60	12	16	15	2	
44.	50	14	26	19	0		60	12	16	10	3	

45.	53	15	26	10	1		60	11	16	20	4	
46.	50	13	25	20	3		62	11	16	20	0	
47.	50	17	24	22	2		63	11	16	27	0	
48.	51	12	19	10	0		63	12	10	15	0	
49.	50	13	20	15	0		63	13	19	14	4	
50.	50	14	20	60	0		60	13	19	20	1	
TOT.	2525	646	1171	1626	156	90	3044	607	837	1383	39	90
AVG	51	13	25	-	-	90	61	12	17	-	-	97
MIN.	50	9	17	-	-	-	60	11	13	-	-	-
MAX.	53	15	26	-	-	-	64	15	19	-	-	-

WB4C = WEEDS BEFORE CULTIVATION
WAC = WEEDS AFTER CULTIVATION.

WORKBULLS PLOUGHING IMPLEMENTS PERFORMANCE DATA

NO. OF SAMPLES	BLACKSMITH PLOUGH					ARARA PLOUGH				
	EFFECTIVE WIDTH OF WORK (CM)	DEPTH OF WORK (CM)	INVERSION (%)			EFFECTIVE WIDTH OF WORK (CM)	DEPTH OF WORK (CM)	INVERSION (%)		
			NO. OF WAP	NO. OF NO WAP	%			NO OF WAP	NO OF NO WAP	%
1	45	18	1540	2		40	24	400	1	
2	40	23	1002	3		51	26	1400	5	
3	44	22	102	1		45	22	1005	2	
4	45	16	90	4		41	21	560	3	
5	40	18	60	5		40	23	400	4	
6	44	16	80	2		45	23	250	1	
7	45	18	102	4		50	23	162	2	
8	45	18	1000	3		40	23	90	3	
9	44	18	95	1		45	23	85	6	
10	44	18	85	2		43	23	1060	1	
11	44	23	80	4		41	25	500	2	
12	44	22	92	5		40	23	350	3	
13	43	22	98	1		40	21	450	4	
14	40	21	106	2		44	21	600	0	
15	45	20	104	3		45	26	90	0	
16	45	20	80	4		51	26	185	1	
17	44	23	95	1		45	25	85	2	
18	42	23	85	2		45	22	102	0	
19	40	23	400	1		45	22	60	0	
20	40	23	250	1		45	24	90	6	
21	40	22	260	3		45	23	101	4	
22	43	22	240	4		46	23	102	1	
23	42	21	185	8		50	24	95	2	
24	44	20	160	6		40	25	96	3	
25	44	18	90	4		42	26	84	4	
26	45	18	95	3		43	21	80	5	
27	40	18	102	10		40	21	90	0	
28	40	19	108	1		45	22	95	0	
29	41	19	80	2		50	22	100	0	
30	45	20	90	4		51	21	95	0	
31	45	23	92	7		51	22	100	0	
32	45	22	102	1		45	24	300	0	
33	40	22	100	1		50	26	240	0	
34	45	22	90	2		50	23	90	1	
35	45	21	1002	3		51	21	1000	1	

36	45	16	400	4		52	23	1700	2	
37	40	23	250	8		51	23	96	3	
38	44	16	450	1		45	23	85	0	
39	44	16	200	0		45	21	200	5	
40	44	22	165	0		45	21	101	2	
41	45	22	170	2		44	21	205	2	
42	45	22	85	4		40	21	302	1	
43	45	21	90	5		40	22	800	0	
44	44	19	95	2		40	22	908	0	
45	40	18	85	1		45	23	88	8	
46	41	18	108	3		50	20	95	2	
47	41	18	230	4		50	20	187	1	
48	45	18	230	10		50	20	204	4	
49	45	21	700	1		51	21	360	6	
50	45	23	500	5		52	20	92	8	
101	2081	1006	12560	156	90	2320	1169	14085	89	99
AVG	42	20	-		90	47	23	-	-	99
MIN	40	16	-	-	-	40	20	-	-	-
MAX	45	23	-	-	-	52	26	-	-	-

WB4P = WEEDS BEFORE PLOUGHING
WAP = WEEDS AFTER PLOUGHING

WORKBULLS HARROWING IMPLEMENT PERFORMANCE DATA

NO OF SAMPLES	EFFECTIVE WIDTH OF WORK (cm)	DEPTH OF WORK (cm)	RAKING EFFICIENCY %		
			No of exposed WB4H (cm)	No. of exposed WAH	%
1	180	18	5	1	
2	180	18	2	1	
3	190	17	3	1	
4	182	18	1	0	
5	182	18	4	0	
6	195	18	8	0	
7	180	18	10	1	
8	190	18	1	1	
9	180	19	4	2	
10	180	18	4	2	
11	190	19	4	3	
12	190	18	3	1	
13	188	18	2	0	
14	180	18	6	0	
15	185	17	1	0	
16	190	17	0	0	
17	195	18	0	1	
18	185	18	0	2	
19	180	18	0	1	
20	185	18	2	2	
21	180	19	1	0	
22	195	19	8	0	
23	190	19	6	1	
24	195	18	8	1	
25	185	18	10	1	
26	180	17	1	0	
27	180	18	1	0	
28	180	18	1	0	
29	195	18	4	0	
30	180	18	5	0	

TOT.	5567	541	105	22	79
AVG.	186	18	-	-	
MIN MAX	180 195	17 19	-	-	

WB4H = WEEDS BEFORE HARROWING
WAH = WEEDS AFTER HARROWING

DONKEY RIDGE IMPLEMENT PERFORMANCE DATA

NO OF SAMPLES	HEIGHT OF RIDGE (cm)	TOP FURROW WIDTH (cm)	BOTTOM FURROW WIDTH	INVERSION %		
				No. of WB4R	No of WAR	%
1	13	24	14	204	40	
2	11	23	12	90	10	
3	11	25	14	85	5	
4	14	29	13	300	95	
5	10	27	12	60	4	
6	10	30	11	95	2	
7	14	30	13	107	50	
8	13	30	14	80	30	
9	14	23	15	90	10	
10	14	24	13	100	5	
11	14	24	13	102	2	
12	14	24	13	75	0	
13	10	29	14	60	0	
14	11	29	11	75	0	
15	11	28	12	220	18	
16	10	27	12	210	25	
17	10	24	14	72	35	
18	10	27	14	85	45	
19	10	27	13	75	0	
20	11	28	12	90	0	
21	14	28	13	100	0	
22	12	29	13	210	8	
23	12	30	13	310	1	
24	14	30	13	91	2	
25	14	29	12	81	10	
26	12	27	14	72	4	
27	12	25	13	90	0	
28	12	26	13	80	18	
29	14	28	14	70	25	
30	13	30	15	60	30	
TOT.	601	814	389	3329	466	86

AVG.	20	27	13	-	-	
MIN MAX	18 22	23 30	11 15	-	-	

WB4R = No of weeds before ridging
WAR = No of weeds after ridging.

WORKBULLS BUND FORMING IMPLEMENT PERFORMANCE DATA AND MANUAL BUND FORMING

NO OF SAMPLES		OX-TEAM TOP		MANUAL		
	HEIGHT OF MOULD FORMED (cm)	TOP WIDTH OF MOULD (cm)	BOTTOM WIDTH OF MOULD (cm)	Height of Mould (cm)	Top width of Mould (cm)	Bottom width of Mould (cm)
1	22	23	35	26	24	40
2	20	20	36	28	25	41
3	19	22	35	24	20	40
4	18	20	34	22	26	39
5	22	21	34	25	25	38
6	20	22	34	24	26	36
7	20	22	35	24	27	35
8	21	24	33	23	25	35
9	19	24	33	20	25	35
10	19	23	34	19	25	40
11	20	20	33	20	26	40
12	18	20	32	28	26	40
13	19	24	30	30	26	41
14	20	24	30	30	26	39
15	20	23	32	30	22	45
16	22	20	33	31	27	46
17	19	22	34	30	28	47
18	20	23	34	32	28	50
19	22	24	34	40	25	50
20	20	24	36	40	24	50
21	19	24	30	40	24	50
22	20	23	35	41	23	51
23	20	23	34	26	25	41
24	20	23	35	25	25	38
25	20	24	35	20	26	38
26	22	20	30	25	26	40
27	21	20	30	26	27	40
28	19	23	30	20	28	42
29	20	23	35	20	30	40
30	20	20	35	25	30	35

TOT.	601	668	1010	814	775	1242
AVG.	20	22	34	27	26	41
MIN	18	20	30	20	20	35
MAX	22	24	36	41	30	51

LEVEL OF TECHNOLOGY ADOPTION

NO OF PARTICIPANTS INTERVIEWED	ACCEPTANCE/EFFECTIVE UTILIZATION OF THE TECHNOLOGY (YES/NO)								
	Ox-ridging	Ox-Wedding	Ox-Plough-ing	Ox-harrow-ing	Ox-cart-ing	Donkey Wedding	Donkey Cart-ing	Camel Wedding /Ridg-ing	Camel Cart-ing
1	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
2	Yes	Yes	Yes	Yes	Yes	No	Yes	-	-
3	Yes	Yes	Yes	Yes	Yes	No	Yes	-	-
4	Yes	Yes	-	-	Yes	No	Yes	-	-
5	Yes	Yes	-	-	Yes	No	Yes	-	-
6	Yes	Yes	-	-	Yes	No	Yes	-	-
7	Yes	Yes	-	-	Yes	No	Yes	-	-
8	Yes	Yes	-	-	Yes	No	Yes	-	-
9	Yes	Yes	-	-	Yes	No	Yes	-	-
10	Yes	Yes	-	-	Yes	No	Yes	-	-
11	Yes	Yes	-	-	Yes	No	Yes	-	-
12	Yes	Yes	-	-	Yes	No	Yes	-	-
13	Yes	Yes	-	-	Yes	No	Yes	-	-
14	Yes	Yes	-	-	Yes	No	Yes	-	-
15	Yes	Yes	-	-	Yes	No	Yes	-	-
16	Yes	Yes	-	-	Yes	No	Yes	-	-
17	Yes	Yes	-	-	Yes	No	Yes	-	-
18	Yes	Yes	-	-	Yes	No	Yes	-	-
19	Yes	Yes	Yes	No	Yes	No	Yes	-	-
20	Yes	Yes	Yes	No	Yes	No	Yes	-	-
21	Yes	Yes	Yes	No	Yes	No	Yes	-	-
22	Yes	Yes	Yes	No	Yes	No	Yes	-	-
23	Yes	Yes	Yes	-	Yes	No	Yes	-	-
24	Yes	Yes	-	-	Yes	No	Yes	-	-
25	Yes	Yes	-	-	Yes	No	Yes	-	-
26	Yes	No	Yes	No	Yes	No	Yes	-	-
27	Yes	No	Yes	No	Yes	Yes	Yes	-	-
28	Yes	No	Yes	No	Yes	Yes	Yes	-	-
29	Yes	No	-	No	Yes	Yes	Yes	-	-
30	Yes	Yes	-	Yes	Yes	Yes	Yes	-	-
31	Yes	Yes	-	Yes	Yes	Yes	Yes	-	-
32	Yes	Yes	-	Yes	Yes	Yes	Yes	-	-
33	Yes	Yes	-	Yes	Yes	Yes	Yes	-	-
34	Yes	Yes	No	No	Yes	No	Yes	-	-

35	Yes	Yes	No	No	Yes	No	Yes	-	-
36	Yes	Yes	No	No	Yes	No	Yes	-	-
37	Yes	Yes	No	No	Yes	No	Yes	-	-
38	Yes	Yes	No	No	Yes	No	Yes	-	-
39	Yes	Yes	No	No	Yes	No	Yes	-	-
40	Yes	Yes	No	No	Yes	Yes	Yes	-	-
41	Yes	Yes	No	No	Yes	Yes	No	-	-
42	Yes	Yes	No	No	Yes	Yes	No	-	-
43	Yes	Yes	No	No	Yes	Yes	No	-	-
44	Yes	Yes	No	No	Yes	Yes	No	-	-
45	Yes	Yes	No	No	Yes	No	No	-	-
46	Yes	Yes	No	No	Yes	No	No	-	-
47	Yes	Yes	Yes	No	Yes	No	No	-	-
48	Yes	Yes	Yes	No	Yes	No	No	-	-
49	Yes	Yes	Yes	No	Yes	No	No	-	-
50	Yes	Yes	No	No	Yes	No	No	-	-
TOT.	50/50	46/50	14/29	7/28	50/50	15/50	40/50	-	-
PERECENTAGE (%)	100	92	48	25	100	30	80	-	-

QUESTIONNAIRE FOR ANIMAL TRACTION
ADOPTION/ECONOMIC ASSESSMENT:

A: Questionnaire For Ox-Team Owners/Donkey Team:

Name of the Farmer:.....

Village/DevelopmentArea:.....

==========

1. Do you own Ox-team? ..... Yes/No.

2. How did you own the Ox-team? (NEAZDP, Personally, Other NGO.

3. How many days does it take you to finish your farm with Ox-team? .....

4. How many days does it take you to finish your farm manually without Ox-team?.....

5. Did you increase the size of your farm?..... Yes or No.

6. How many family labour do you posses in your house? .....

7. How many bags (100kg) of millet or sorghum or cowpea or rice and/or all do you obtain per season using Ox-team? .....

8. How many bags (100kg) as above do you obtain when using manual effort/labour? .....

9. Approximately what is the size of your farm(s) in hectares .....

10. Do you hire your Ox-team? .....

11. Do you offer service of Ox-team to your relatives? ..... Yes or No.

12. How many days per season do you use your Ox-team?

i) For your own use:..... days.
ii) For relative's use:..... days.
iii) For hiring:..... days.

13. Do you use your team for the following activities?

i) Ridging ..... Yes, No.
ii) Weeding using a ridger:..... Yes, No.
iii) Weeding using a cultivator:..... Yes, No.
iv) Ploughing:..... Yes, No.
v) Harrowing:..... Yes, No.
vi) Transportation:..... Yes, No.
vii) Water lifting:..... Yes, No.
viii) Rice cultivation using ridger: ..... Yes, No.

14. What kind of goods do you transport?

i) Human beings:..... Yes or No.
ii) Agric. produce: ..... Yes or No.
iii) Water carrying:..... Yes or No.
iv) Mud/clay: ..... Yes or No.
v) Bricks: ..... Yes or No.
vi) Crop stalk:..... Yes or No.

15. A part from ridgers, are you aware of any animal-drawn implement? If yes, name them, if not why?
.....
.....

16. How many bags of Agric. produce can your Ox-team carry?

i) Millet: ..... bags
ii) Sorghum: ..... bags
iii) Cowpea: ..... bags
iv) Rice: ..... bags
v) Onion: ..... bags
vi) Dry vegetable: ..... bags
vii) Corn/millet stalk: .....bundles.

17. What is the shortest distance your ox-team can travel with load: ..... kms.

18. What is the longest distance your ox-team can travel with load: ..... kms.

19. What is the nature of the road: ..... hardpan or sandy soil or tared and/or all?

20. Name problems of ox-team utilization/bulls or implement or cart: .....

21. A part from crop residues and open pasture grazing, how much in terms of money do you invest (spent) on (additional supplementary feeds, medicine, water and shelter etc) on your ox-team handling per a year? =N=: .....

22. Is ox-team a profitable venture:.....
.....
.....

23. What advice can you give to farmers:.....
.....
.....

24. What advice can you give to Government or NGO's: .....
.....
.....

Appendix: 16a

FIELD PERFORMANCE DATA OBTAINED FROM WORKBULL USERS

NO. OF PEOPLE INTERVIEWED	LAND PREPARATION (HOURS/HA)					DISTANCE TRAVELLED WITH LOAD	LOADING CAPACITY (OX-TEAM)						
	Ridging	Weeding /Cult.	Ploughing	Harrowing	Weeding		Millet (Bag)	Sorghgum (bag)	Cowpea (bag)	Rice (bag)	Onion (bag)	Dry Veg. (bag)	Stalk (bdle)
1						10-20	7	10	5	-	-	-	12
2						2 - 15	10	10	8	-	-	-	10
3						1 - 15	10	10	8	12	8	15	13
4						5 - 10	8	8	6	10	7	20	16
5						20 - 40	12	12	10	10	10	21	10
6						7 - 10	10	10	10	15	8	15	12
7						5 - 15	10	10	10	12	10	20	17
8						5 - 15	10	10	10	12	10	20	17
9						4 - 9	7	7	8	8	6	15	10
10						5 - 6	10	10	10	10	10	15	17
11						3 - 5	9	9	9	11	8	15	15
12						1 - 20	9	9	12	12	7	20	20
13						4 - 20	7	7	10	10	8	15	10
14						5 - 20	8	8	10	15	6	20	20
15						6 - 14	7	8	8	9	8	15	16
16						1 - 20	7	7	10	10	6	20	15
17						1 - 30	10	10	8	12	8	15	15
18						2 - 40	8	12	6	13	10	20	20
19						5 - 30	10	8	7	13	7	22	20

20						2 - 45	10	7	5	14	8	25	22
21						1 - 40	8	10	4	12	8	20	30
22						1 - 35	10	8	7	10	7	15	15
23						1 - 20	10	9	8	12	7	14	15
24						2 - 40	9	10	8	8	8	15	12
25						2 - 35	10	10	8	12	10	20	12
26						5 - 30	10	8	8	-	-	15	17
27						2 - 35	8	10	8	-	-	20	15
28						3 - 40	10	10	6	-	-	20	30
29						1 - 20	10	9	7	-	8	25	25
30						2 - 25	12	10	8	-	7	15	20
31						1 - 30	10	10	8	12	8	15	20
32						2 - 30	10	10	7	12	7	10	25
33						2 - 40	12	9	8	12	7	16	15
34						1 - 20	9	10	8	10	7	10	15
35						2 - 40	9	9	8	12	7	16	15
36						1 - 35	9	10	8	10	7	18	15
37						1 - 20	9	8	8	8	12	22	25
38						1 - 25	9	10	10	12	6	21	25
39						1 - 10	10	12	8	13	6	20	20
40						1 - 40	8	10	7	1	8	15	25
41						2 - 25	12	10	6	-	-	-	15
42						3 - 15	12	10	6	-	-	-	15
43						1 - 40	10	12	6	-	8	15	18
44						1 - 45	10	8	8	10	8	20	20
45						2 - 30	12	9	6	12	-	-	25

46						1 - 40	12	10	7	-	-	20	30
47						1 - 18	10	10	7	12	-	20	10
48						1 - 45	8	8	8	12	8	22	15
49						1 - 50	9	9	6	10	7	10	15
50						2 - 25	12	10	7	12	6	20	10
TOT.						142-1350	484	460	374	455	309	809	876
AVG						3 - 27	10	9	7	12	8	10	10
MIN						1 - 45	7	7	5	8	6	15	10
MAX.							12	12	10	15	10	25	30

Appendix: 16b

SELECTED SOCIO-ECONOMIC DATA OBTAINED FROM WORKBULLS AND NON-WORKBULSS:

S/N	NON OX-TEAM FARMERS							OX-TEAM FARMERS							
	NO. OF FAMILY LABOUR	SIZE OF FARM	YIELD ha (Bags)	NO. OF DAYS 1ST WEEDING	NO. OF DAYS 2ND WEEDING	NEED FOR OX-TEAM (YES/NO)	ANY SERVICE OF OX-TEAM (YES/NO)	NO. OF FAMILY LABOUR	SIZE OF FARM (ha)	YIELD (Bags)	NO. OF DAYS FOR RIDGING OPERATION	COST OF OX- MAINT (N)	LAND PREPARATION (DAYS) PER SEASON		
													P	R	H
1	3	5	25	30	25	Yes	Yes	5	12	40	10	6,000	30	10	30
2	5	5	10	20	15	..	..	4	12	116	5	6,000	40	3	0
3	3	4	18	30	30	..	..	4	4	11	6	500	7	2	20
4	5	5	24	31	27	..	..	2	5	28	7	500	20	2	30
5	2	3	0	22	20	..	..	6	10	53	13	3,000	40	15	20
6	7	10	50	27	20	..	..	4	10	30	20	4,000	60	4	0
7	3	5	10	30	30	..	..	2	8	100	15	1,200	60	0	0
8	4	5	16	21	21	..	..	3	10	80	10	1,000	10	5	15
9	4	5	15	35	25	..	..	8	12	5	5	6,000	10	5	7
10	10	3	7	30	30	..	..	20	6	85	3	5,000	14	7	0
11	15	6	75	25	20	..	..	3	6	21	3	4,000	3	3	4
12	5	4	35	25	30	..	..	5	2	30	4	0	12	10	20
13	6	3	15	20	25	..	..	3	4	71	4	0	5	5	20
14	2	2	8	12	10	..	..	5	3	30	4	2,000	14	8	20
15	2	1	6	21	21	..	..	7	6	56	10	5,400	15	4	8
16	4	2	10	30	30	..	..	3	3	42	5	1,800	15	10	15
17	1	2	10	30	30	*	*	10	10	95	8	5,000	30	5	0
18	4	4	18	30	25	*	*	8	6	50	7	1,300	40	2	0
19	3	4	12	28	30	..	..	5	4	40	3	2,000	28	6	0
20	2	2	7	25	25	..	..	3	5	28	4	0	40	0	0
21	3	4	15	32	30	..	..	4	5	32	5	0	20	0	0
22	5	6	20	35	35	..	..	3	6	25	7	500	10	0	0

23	4	4	10	30	30	..	..	3	3	20	4	1,000	5	5	2
24	3	5	8	31	28	..	..	4	4	30	5	1,500	8	2	3
25	6	7	30	30	28	..	..	5	10	87	10	2,000	20	0	0
26	4	4	12	30	25	..	..	4	9	50	8	1,200	15	2	0
27	5	5	20	30	25	..	..	3	4	30	4	3,000	10	0	0
28	3	2	10	31	28	..	..	3	3	25	3	4,000	20	2	2
29	3	2	8	28	28	..	..	7	5	40	5	900	10	3	5
30	4	2	10	27	27	..	..	6	4	45	3	500	15	2	5
31	5	3	15	26	30	..	..	3	3	30	4	0	30	0	3
32	10	5	20	30	25	..	..	4	2	30	3	0	30	0	7
33	11	4	25	32	30	..	..	2	3	28	4	0	30	0	4
34	2	1	7	30	28	..	..	3	3	48	4	3,000	20	10	0
35	3	2	14	32	28	..	..	5	3	50	4	2,000	25	5	0
36	4	3	12	25	20	..	..	6	4	24	3	4,000	10	10	10
37	5	4	15	20	20	..	..	8	4	40	5	1,200	15	10	0
38	3	3	15	18	18	..	..	10	5	45	6	1,500	15	0	5
39	3	3	10	14	14	..	..	3	4	32	3	2,000	10	0	10
40	2	2	10	18	18	..	..	3	5	37	5	2,000	10	10	0
41	5	5	15	30	30	..	..	2	5	28	6	3,000	14	7	7
42	3	5	13	31	31	..	..	3	2	30	3	3,000	7	0	0
43	4	6	20	32	28	..	..								
44	3	4	12	25	20	..	..	10	3	30	4	1,000	7	7	7
45	3	5	18	28	30	..	..	3	2	32	3	500	8	3	10
46	4	6	24	28	28	..	..								
47	6	8	30	28	28	..	..	4	4	52	5	500	30	10	10
48	8	5	18	28	20	..	..	3	4	40	6	800	10	5	0
49	5	6	15	30	32	..	..	3	3	30	4	700	10	0	0
50	2	4	9	32	30	..	..	4	5	100	6	1,500	20	0	0

TOT.	255	105	823	1343	1271			267	225	2116	279	103,000	527	213	289
AVG.	5	4	16	27	25			5	5	42	6	2,060	19	4	6
MIN-MAX	1 - 45	1 - 10	6 - 75	12 - 35	10 - 50			2 - 20	3 - 12	11-118	3 - 20	0 - 6,000	5-60	0 - 15	0 - 30

P = PERSNONAL

R = RELATIVES

H = HIRING

Appendix: 17

FIELD PERFORMANCE DATA OBTAINED FROM DONKEY TRACTION USERS:

NO. OF PEOPLE USING DONKEY PACKAGE				LOADING CAPACITY (BAG)				
	TRANSP. WITH A CART	RIDGING	WEEDING	Millets	Sorghum	Onion	Dry Veg.	Rice
1	Yes	-	-	4	4	3	8	6
2	Yes	-	-	5	5	4	10	6
3	Yes	-	-	4	4	3	8	6
4	Yes	-	-	3	3	4	6	5
5	Yes	-	-	5	5	5	7	5
6	Yes	-	-	4	4	5	8	6
7	Yes	-	-	4	4	4	10	6
8	Yes	-	-	5	4	5	8	6
9	Yes	-	-	5	5	4	6	6
10	Yes	-	-	5	5	3	10	6
11	Yes	-	-	5	5	3	12	6
12	Yes	-	-	4	4	4	15	5
13	Yes	-	-	6	6	5	10	5
14	Yes	-	-	6	6	5	15	6
15	Yes	-	-	3	3	3	8	7
16	Yes	-	-	4	4	4	7	8
17	Yes	-	-	4	4	5	6	8
18	Yes	-	-	8	8	4	6	5
19	Yes	-	-	3	3	5	6	5
20	Yes	-	-	4	4	4	8	5
21	Yes	-	-	5	5	5	8	6
22	Yes	-	-	5	5	5	10	4
23	Yes	-	-	4	4	4	10	5
24	Yes	-	-	4	4	3	10	6
25	Yes	-	-	4	4	3	10	5
26	Yes	-	-	4	4	4	12	7
27	Yes	-	-	5	5	5	8	8
28	Yes	-	-	6	6	5	6	6
29	Yes	-	-	3	3	3	8	5
30	Yes	Yes	Yes	2	2	3	8	5
31	Yes	-	-	5	4	3	10	6
32	Yes	-	-	5	5	3	8	8
33	Yes	-	-	4	4		10	6
34	Yes	-	-	4	4	4	8	8

35	Yes	-	-	6	6	3	8	6
36	Yes	-	-	5	5	4	10	5
37	Yes	-	-	4	4	3	10	8
38	Yes	-	-	5	5	3	7	6
39	Yes	-	-	5	5	4	8	6
40	Yes	-	-	4	4	4	10	7
41	-	-	-	6	5	5	10	7
42	-	-	-	4	4	5	10	7
43	-	-	-	4	4	6	8	10
44	-	-	-	3	3	5	8	6
45	-	-	-	4	4	3	8	8
46	-	-	-	5	5	3	8	6
47	Yes	Yes	-	5	4	3	7	6
48	Yes	Yes	-	4	4	4	12	8
49	Yes	Yes	-	4	4	3	12	6
50	Yes	Yes	-	3	3	4	8	8
TOT.	41 (82%)	6 (12%)	1 (2%)	230	218	196	434	309
AVG.				5	4	4	9	6
MIN.				3	3	3	6	4
MAX.				6	6	6	15	8