**Equine production and Draft Animal Power Utilization**

**CHAPTER1: INTRODUCTION**

**1.1. Definition of Terminologies**

**Grooming;** keeping coat clean and in good condition.

**Halter straps; or** cords around head of animal which can be pulled by hand, rope or rein to control its head.

**Harness-**the whole power transmission system attaching the animal to its work load.

**Harrow-** a wooden frame with 15 to 20 metal spikes to break soil clods and to level the surface.

**Packing=** placing a load on to the back of an animal for it to transport

**Rein-** strap held in hand of rider or driver and attached to a bridle or halter for controlling an animal.s head.

**Ridger-** a plough with two mouldboards to make a furrow and two small ridges on either side.

**Ripper -**a toolbar or plow-frame with a single angled tine used for opening a narrow band of soil for direct seeding; also called chisel-plow.

**Scarified** a cultivator with rather light tines made from spring steel.

**Tillage-** preparation of land for crop-bearing.

**Tines-** the soil-contacting descending bars of a cultivator or teeth of a harrow.

**Traces- the** chains or ropes used to transmit the draft force from the collar or breast-band harness to the work load.

**Wagon** an agricultural or freight vehicle with four wheels.

**Withers** part of equine just behind where the neck joins its back.

**Withers yoke-** a yoke positioned on the withers; often called neck yoke.

**Yoke -** strong bar, usually made of wood, which an animal can push against in order to pull an implement.

**1.2. Role and socio-economic importance of equines in Ethiopia and other regions.**

 Agricultural mechanization has become a high priority in developing nations. This is important because farmers using traditional techniques are unable to produce sufficient food for increasing populations. Mechanization can expand the area under cultivation and provide better soil preparation, leading to greater harvests.

Government extension services therefore strive to give farmers tools, information and advice to enable them to increase productivity.

 Benefits of mechanization to farmers include

* Lightened 'workloads,
* better and more regular yields, or
* An easing of problems caused by short growing seasons or insufficient labor.

Mechanization also can help to produce income with which farmers can acquire goods and services. Yet mechanization is not practical or economical for every farmer. Acceptance of new techniques increases dependency on outside technical assistance/ thus the farmer who already produces enough food for his family may be reluctant to risk a known harvest (traditional yield) for an uncertain gain in productivity.

The search for agricultural technology that meets the needs and desires of both farmers and governments has led to increased interest in animal traction, sometimes called "light mechanization".

Farmers, agronomists and agricultural extension services often cite the following advantages of using animal traction:

1. **It reduces the difficulty of labor and makes farming a more appealing occupation**.
* Farmers who might seek employment in other areas are encouraged to develop existing skills and abilities and improve operations.
1. **It increases productivity.**
* Replacing hand hoes with draft animals and equipment, farmers can double or triple the area cultivated, thereby increasing crop yields.
1. **It is affordable technology.**
* Animals and equipment are low in cost compared to tractors.
* Low-interest loans are often available through government or sponsoring agencies.
1. **Animals and equipment can be supplied locally, creating less dependence on external resources than tractors and other machinery**.
* Tractors need fossil fuels, spare parts, and maintenance know-how which may *not* be available to farmers.
1. **Used on a small scale, it does not require radical changes in cropping patterns or the role of family or hired labor.**
* Although it does reduce manpower needs in some field operations, the reduction is not drastic and labor can shift to other activities like planting, spraying, harvesting and caring for animals and harness.
1. **It creates work opportunities**.

The use of animal traction can stimulate the development of

* Increasing jobs for local blacksmiths,
* carpenters, and
* Leather makers who produce needed equipment.

It also creates work in the areas of **transport, water-pulling, and tillage on a contract basis**. (Farmers can hire out their teams and equipment.)

**1.3. Major Constraint of Draft animal power Utilization**

The main challenges to demonstrating the role and impact of working animals on livelihoods and their role in poverty reduction and food security were identified as the following:

* Lack of recognition of working animals in sectorial policies, programmes and strategies. Working animals do not appear in most national agricultural or rural transport strategies and policies. They are rarely acknowledged as a specific group and not usually addressed through livestock interventions, which tend to prioritise production animals. As a result they are also absent from other important livestock-related sectors such as education, research and animal health. Working animals are also currently absent from donors’ livelihoods-related programmes and policies. Similarly, NGOs actively working on poverty reduction are not considering the critical contributions of working animals that are not sources of food or fibre. Despite their role in disaster management and recovery, working animals are not consistently included in the relevant humanitarian policies and frameworks.
* Lack of data on working animals including on their economic contributions and roles. The qualitative benefits of working animal use are well recognised by the animal owners and their families. However, there is very little evidence of the monetary value of draught animal power (DAP) versus human labour, which means that farmers and other groups that use working animals may not be aware of the impact of those animals on their income.
* Lack of recognition as the main source of power for smallholder farmers. The Experts noted that in more developed countries there has been a gradual loss of skills in training animals for draught work and an apparent trend towards new adopters and re-introducers of draught power wishing to buy trained animals rather than doing the training themselves. They also highlighted the importance of maximizing the use of indigenous knowledge in order to avoid “perfected” equipment that is not useful or desirable to the end-user.

**1.4. Feeding, Selection, Housing of equine**

Draft animal need several important feed components - energy, protein, vitamins, minerals and water. Different feeds contain these components in different amounts.

Provided natural pasture is abundant and feeding of draft animal should not be a major problem. Besides forage (or roughage) from grazing, the animals may be fed additional forage and concentrates provided by the farmer, depending on age and workload.

In general, feeding strategies should be aimed at maintaining adequate body condition during periods of work stress or reproductive stress.

Some preserved forage or concentrates should be stored for such periods. This is particularly important if draft animal have to work at the end of the dry season, when natural pasture is scarce.

A properly fed animal will

* live longer,
* work harder and
* Resist diseases better.
* If well fed, females will become pregnant sooner, and pregnant and nursing Jennies will produce bigger and healthier foals.
* Foals given extra food at weaning will grow faster, survive disease better and end up larger.
* Supplements are most important in the following circumstances:
* Local grazing is poor because of drought or over-grazing.
* Animals must walk long distances for food.
* Donkeys do not get at least six grazing hours each day.
* Female donkeys are in the last three months of pregnancy or they are nursing a foal.
* Young foals are growing, especially between 6 and 18 months of age.

**Forage feeding.**

In general, forage consists of leaves and stalks of plants (grass, maize Stover, etc.). Draft animal need to eat forage every day. The quality of forage depends on plant species and age, season and weather conditions. Example , donkeys are selective feeders, they need to have a wide variety of plants to choose from when grazing.

Draft animal can be fenced, staked, herded or left to graze unsupervised. If they are herded or range freely, they will be able to seek out a range of plants. If donkeys are staked, it is important to move their stake daily, or even twice per day. If they are fenced, it is better to have several small paddocks rather than one large one.

The most common forage supplements are crop residues. These include groundnut hay, and maize and sorghum Stover. The leaves of legume fodder trees (e.g., *Leucaena, Sesbania* and some *Acacias)* are rich in protein and can also be fed to donkeys. Other sources of fodder include sugar cane.

Young plants, as well as those growing in cooler, drier seasons provide more nutrients than older plants. The quality of conserved forages (such as dried grass and groundnut hay) depends both on the quality of the original product and on the way it has been stored. They should be stored in a dry place. Forages that become wet and mouldy or dusty can be very unhealthy. If the available forage is not of sufficient quantity or quality to keep donkeys in suitable body condition, they may need to be given some concentrates as well.

**Concentrates feeding.**

Concentrates are generally seed grains and milling by-products such as wheat bran, oilseed cake and molasses. Concentrates contain more energy, and often more protein and minerals, than do forages. And they are generally more expensive.

The choice of concentrate feed will depend on local availability and costs. Good (but expensive) concentrated feed includes milled grains such as maize, sorghum and millet.

Soiled grains considered unsatisfactory for human consumption can be used, provided they are not mouldy. Cottonseeds, cottonseed cake, groundnuts, and groundnut cake are all good. Dried cassava root, green bananas can be used. If they are available, brewer, grains can be fed. feeds like molasses, which provides energy and can be poured on top of bran or forage.

Maize bran from traditional pounding is very good. Rice bran and wheat bran can also be fed, but should not form the entire diet, particularly not for young animals, as the range of nutrients is very limited. The amount to be fed may be 1 to 2 kg per day. Finely ground bran may need to be mixed with a little water, to prevent choking.

**Selection**

**Selection of Individual Draft Animals**

Once farmers decide what kind of draft animal will be used, they must be able to

* Choose individual animals which are sound and trainable have considerable work expectancy and resale value.
* Selecting a good draft animal is a matter of evaluating both physical and behavioral attributes.
* Age, sex, conformation (shape), and temperament are helpful criteria for judging a draft animal's value.
* The farmer's total animal needs must be noted when judging an individual animal.
* If it is to be used as a pair, it should be roughly the same age and size as its work mate, and should be the same sex.

**Age of Bovine Animals**

Ideally, farmers should raise their own draft cattle or purchase them when they are very young. This allows the farmers to provide proper nutrition during the critical growth stage as well as to observe and shape the animal's behavior long before it is put to work. Oxen are, normally put to work between the ages of three and four years.

They may be trained at two to three years of age and given light work for a season. However, before the age of three, oxen have little power, and hard work can stunt their growth or cause abnormal development of bone and muscle.

After the age of four, animals may be difficult to handle and train; they must be broken of old habits before their power can be used. Although oxen can work until they are 12 or older, many farmers prefer to sell them as soon as their work capacity tapers off.

 A common practice is to work oxen hard until age seven or eight, use them as a reserve or alternate animal (or pair) for a season or two, and then sell them for butchering. When buying an ox, the purchaser-can determine the animal's age by counting its teeth. Because the approach of an unfamiliar person may cause the animal to shy or to struggle, it is best to have the owner open the animal's mouth. Otherwise restrain the animal and pry open the mouth by pulling up on the nostrils and down on the lower jaw.

Cattle have front teeth only in the lower jaw.

 Temporary teeth appear, at one month. The first permanent teeth appear at age two. By age five, the animal has a full set of permanent teeth. The age of. Older animals can be determined by observing the wear patterns of the teeth and matching them to the patterns. An alternate method is to count the number of rings oh the animal's horns; each ring corresponds to one year of growth, the first ring appearing at age two.

**Age of Equine Animals**

Recommended ages for training and working equine animals are very similar to those outlined for cattle. However, in practice, these animals are worked until they are older because until their meat is less valuable.

As the animal grows **older, the** enamel wears off the tooth, givingit a smooth, white grinding surface(the dark center disappears).

 Theteeth grow longer and begin to slant;the entire mouth elongates. Comparethe side views of the four- andthirty-year-old horse and note theincreased pointing of the jaw.

The correct method for opening the animal's mouth is as follows:

* Place the palm of one, hand under the animal's jaw;
* Insert the thumb and middle finger into the animal's mouth on either side of the lower jaw, at a point behind the teeth;
* Rub or press the gums **with** these fingers; this will cause the animal to open its mouth;
* Grasp- the tongue with the other hand, pull the tongue out, and hold it to one side
* so that teeth can be seen

**Housing of equine**

The housing of donkeys can be kept very basic.

* Depending on the climate and season, a small shelter is sufficient.
* It should have at least a roof and three closed sides that face the prevailing wind directions.
* There must be enough space to lie down and the floor should not be damp or cold.
* Barbed wire enclosures should not be used for enclosing donkeys.
* Many donkeys will try to get through or jump over and injure themselves.
* The fence or shelter does not have to be very strong since donkeys will not use great force to get through a fence.

**CHAPTER 2. Scope and Development of Draft & Pack Animals**

**Origins and expansion**

The recorded history of animal power in Africa starts about 6-5000 BC in Egypt with the first drawings of oxen and ard plows occurring in the III Dynasty (Haudricourt and Delamarre, 1955). These, together with the engravings of oxen and plows in early Mesopotamian civilisations, appear to constitute some of the earliest records of animal traction anywhere in the world. It is possible that the *maresha* animal-drawn plow was spreading in Ethiopia at the same time as animal traction was developing in ancient Egypt, but there are fewer records from this period in Ethiopian history.

**Ethiopia and the Horn of Africa**

Ox-drawn plows appear to have been used in Ethiopia for at least two millennia, and possibly a much longer, although the origins of the *maresha* ard plow are not known. The single-handled Ethiopian scratch plow is very different in design from the two-handled plow used in Egypt. The *maresha* is more like a spear, pulled through the soil using a long beam. Goe (1987) reviewed several theories concerning its origins or introduction. Stiehler (1948) suggests the ard plow was introduced 2600-3000 years ago by Semitic-speaking peoples invading from South Arabia. Another view is that the plow was already in use at this time, having spread from Cushitic speaking peoples of Nubia in northeast Sudan (Simoons 1965). Linguistic evidence suggests that the ard was in use ‘several millennia’ before the South Arabian invasion, which might make the Ethiopian plow the oldest in

**Stationary applications of animal power**

Animals may also be used to pull water from wells. In North Africa, mote systems are employed, where an animal walks down a slope and pulls on the rope attached to a leather water bag (Löwe 1986). Some motes have self-emptying systems. Descending the slope makes it easier for the animal to raise the water. All types of work animals may be used. Elsewhere, notably in circum-Saharan Africa and the Horn of Africa, animals are also bused to pull water from simple wells. Such systems are most common in pastoral areas, where large numbers of animals must be watered at the same time.

***Threshing***

North Africa and Ethiopia and Northern Somalia for threshing In this operation, the animals walk round in circles over beans or cereals, separating the husks from the grain. There is a strong geographical distinction between systems using a central tethering post and those which simply make use of random trampling movements.Threshing is a seasonal operation and the species used are those that are readily available because they are maintained for other work.

***Milling***

Animal power is used for milling in a band stretching from Somalia to Chad. Oilseeds such as sesame or groundnuts are placed in a large wooden pestle, carved out of the trunk of a large tree. The animal walks around pulling a counter-balanced frame attached to a large wooden mortar. This grinds the seeds, extracting the oil. The animals employed are often oxen but camels may be used in Sudan and Somalia.

**Animal power for riding and pack transport in sub-Saharan Africa**

Horses, donkeys, camels and cattle have been used for riding and pack transport in parts of sub-Saharan Africa for centuries, if not millennia. However, relatively little is known about the history of these applications of animal power. Certain pastoralist groups in the continent, including several in West Africa, ride cattle and use them as pack animals.

**Animal power for cultivation and wheeled transport in sub-Saharan Africa**

Ethiopia, together with a few neighbouring parts of the Horn of Africa, is exceptional in sub-Saharan Africa, since farmers have been using animal power for tillage for thousands of years. However, in most sub-Saharan African countries, animal traction for tillage and wheeled transport was introduced during the colonial period. The process of introduction and adaptation is still continuing.

There are various factors that may be responsible for the late adoption of plows in sub-Saharan Africa. In much of the continent, different tribal groups have specialised in animal-rearing and in crop production. Thus many crop-growing farmers did not own potential work animals. Moreover, many traditional farming systems have been based on bush-fallow rotations. The bush is cut down and burned, and seeds or tubers planted in the cleared area. There is no need to till the land with a plow. In any case this would be difficult since the soil is full of roots. Seeds can be scattered or planted in small pockets, for which a simple digging implement is appropriate. In farming systems with long periods of bush fallow, weeds do not present major problems. Provided the fallow periods are long, such systems can be quite productive in terms of yield per unit of human labour. It is only when human population pressures necessitate short fallow periods that it becomes justified to clear the land of roots and stumps and to plow. Thus, in much of sub-Saharan Africa, the necessary social, environmental and agricultural conditions to favour the use of plows have not really existed. Indeed, there are still parts of Africa where the plow is not really economically justified.

**CHAPTER 3. Role of Draft animal power in Developing Countries**

**Strategies for Improvement of Draught Animal Power Supply:**

The main species of draught animals used forcultivation in Ethiopia are oxen. The use of oxen for cropproduction in this country dates back to several millennia. Despite the huge draught animal resources of the countrythe use of other species such as horses, donkeys, camels and mules for cultivation are quitelimited. In addition to their popularity in the transport sector. Donkeys are being preferred to cattle for tillage in parts of sub-Sahara Africa owing to their better comparative advantages to survive and perform during draught under poor feed recourses. Horses and mules usually used for cart puling rather than ploughing. Camels are used for mining, cart puling and even for draught power supply in Ethiopia. Previous works indicate that donkeys could be cheap alternative draft power sources for tillage if managed and used proper conditions. The use of the huge equine resource of Ethiopia as draft power sources for cultivation will therefore improves the availability of draft power and thus alleviates the problem of draft power scarcity for timely cultivation.

***Proper Working Strategies:*** The way draught animals are used the time, level and duration of work greatly determine their health and productivity

***Time and Duration of Work*:** The time of the day determines the work capability of draught animals. If the day is too hot it causes heat stress that will result in less performance. In hot climates, heat loss by convection becomes less effective than in a cool climate and hence the animal has to rely mainly on evaporative losses through sweating and/or panting and/or drooling. Failure to dissipate the heat associated with work limits the amount of work done in a hot climate. To avoid heat stress, oxen should be made to work during the coolest times of the day i.e. early morning (from 12-4:00 AM) and late afternoon (8:00-12:00 PM). The duration of work done by the animals generally depends on; food input or the body condition score (nutritional status), physiological status particularly in females (non-pregnant cow can work for longer time without being stressed and time as indicated above. Average working duration for oxen on ploughing that are on good nutrition and body condition is about 5-6 hours per day

***Avoid Seasonal Use of Working Animals*:** In most areas the use of oxen is seasonal associated with the cropping season which is the peak period of work. Thus oxen are almost left idle for the rest of the year. Due to this they will be stressed whenever they are called for work during the next cropping season. Stress effects may lead to increased susceptibility to various infectious agents. This seasonality can be avoided by using draught animals such as oxen for other operation throughout the year for example for cart pulling to keep them exercised and/or trained throughout the year

***Care and Management*:** Working Horses: It is absolutely essential that horses have complete confidence in being handled by human beings before any attempt is made to train them, for either riding or harness work. With the exception of thoroughbred race horses, which commence training at two years old or earlier, most horses undergo a gradual training up to 3 years of age. This includes teaching them to be led and familiarizing them to bits, rollers and harness. In the fourth year, if sufficiently mature, breaking and schooling for riding or draught purposes can be done.

Grooming, which is a general care, is carried out not only for ensuring cleanliness and improves the appearance of the animal but also prevents disease and promotes health. Some important points of considerations during grooming of draft horses include:

* Thorough removal of dirt and dried sweat sticking to the coat using a dandy brush or a wisp of hay or straw. Then a body brush that penetrate through coat and contact with the skin can be used
* Attention must be given specially to those areas of skin, which are in contact with the saddle or harness fittings where sweat may accumulate
* Horses should be lightly groomed before going to work but should be given vigorous grooming on their return

Horses need to be shod to protect the feet from excessive wear when working on hard surfaces, to prevent the wall from splitting and to prevent slipping. Only people who have had proper and sufficient training horse should attempt shoeing. But all people working with horses should recognize whether or not shoeing has been correctly carried out.

**The essentials of well-shod hoof are the following**

* The bearing surface of both shoe and foot should be level. The shoe rests on the barring surface of the foot which consists of the lower edge of the wall and includes a small part of each of the bars, a white line and small part of the margin of sole.
* The angle of the hoof should be maintained and each side of the foot should be level when viewed from rear and front
* The outer edge of the shoe should follow the wall.
* Consistent with its ability to withstand wear and tear with its ability to withstand wear and tear for a month, the shoe should be as light as possible
* The minimum numbers of nails should be used and their points should emerge at the correct distance up the wall of the hoof.
* The outer surface of the wall should be untouched except for removing horn for the reception of clips and to make beds for clenches (small hooks). The frog, sole and bars should not be pared away, but loose fragments of cartilage can be removed

Some of the recommended management measures for working oxen include the following.

* They should not be made to work or plough on hard surfaces since predisposes to hoof injury. If they must work they should be shod.
* Bullocks should be trained for work at early ages and should not be brought to full work until they are 3 years of age.
* Check and remove pack clay between the claws regularly. Sometimes stones also enter between the inter-digital skins that predisposes to inter-digital colibacillosis. Stabling area thus should be clean and dry. If wet, the animal will easily be susceptible to physical damages and infections such as mud fever and dermatophillosis.
* Weight estimation should be done correctly for proper dosing, feeding and for determination of draft capability of animals to enable match with the proper implement.
* Castration of working bulls is important because it avoids undesired behavior. In most tropical countries castration is done late about four years of age. This is important for a bull to attain its secondary sexual characters such as heavy short neck, powerful shoulder, stronger musculature, well developed hump so that the bull easily fit with the harness [2].
* Oxen should get appropriate feeding regimen according to the amount of work performed

The advantages of animal power over human power are twofold. First; draft animals are five to ten times more powerful than humans, so they can pump more water in a shorter time which tends to make the irrigation operation more efficient and productive. Second; by freeing the operator from having to work the water-lifting device, he can often manage the water distribution system more effectively. In effect, the use of an animal provides the equivalent power of several people, generally at a fraction of the cost.

Animal tractions are an appropriate, affordable and sustainable technology which is increasingly being used in eastern and Southern Africa.

 **The benefits of animal traction are:**

* Providing smallholder farmers with vital power for cultivation and transport.
* Empowering rural communities and providing an alternative but complementary power option.
* Providing employment and transport, and promoting food production and security, thereby leading to a higher standard of living.
* Relieving women of the burden of transporting water by hand, head or wheelborrow. Animals are easy to use and donkeys, specifically, can be handled by children and women.
* Making transportation of the harvest and shopping easier.
* Improving fertility by ploughing manure from draught animals back into the soil.
* It is an affordable and sustainable technology. In comparison with mechanical systems, animal power has the advantage to rural families of of being available, timely and affordable.

**Tractors vs animal power**

Tractors provide the power to push and pull farm machinery and are designed with one thing in mind: utility. The best type of tractor to use should be determined by the farm’s acreage, physical layout, and soils, as well as the tasks the tractor is needed for and the implements that will be mounted to it. Small-scale farms do not need large quantities of horsepower for mechanical tillage or weed cultivation. For intensive crop production, farmers generally can achieve their goals with tractors in the 5- to 30-horsepower range, but may need up to 30 additional horsepower for deep tillage.

**Advantages and disadvantages**

**Tractors**

* Tractors are more expensive to buy and to hire.
* They are much faster and timelier for those who own them, but those who hire tractors often have to wait a long time before they arrive to do the job.
* They are generally used for cultivating large areas and when the soil is hard.
* Tractors are generally only economical on large-scale commercial farms.
* Owing or hiring a second-hand tractor for a small farm will usually disempower the farmer.

**Animals**

* Animals can be bought for much less and are readily available, ensuring that the farmer does not have to wait to carry out his various activities and is in full control of his farming operations.
* They are less of a risk. Owning draught animals on a small farm will usually empower the farmer.
* Animals are easy to work with and can, in the case of donkeys, be used by women and children.

**Choosing between tractors and animals**

The farmer must decide which of the two options is:

* The most affordable and economically viable
* The most timely and manageable
* To his or her best advantage

The farmer may even decide to use both, and on marginal commercial farms this can be highly effective.

**4. Distribution of Draft animal power in Developing Countries**

Donkeys are maintained as pack animals in many African countries, particularly in North Africa, Ethiopia and parts of eastern Africa. Their employment has often been a long-standing tradition. When donkeys are used for pack work, it is normal to place some form of protective padding over their backs. This may be sheepskin, sacking or discarded cloth. Soft loads such as sand, fertilizers, canvas water containers and straw are placed symmetrically over the back and held in place by one (or more) leather or rubber straps around the girth or belly, and under the base of the tail. Hard loads such as firewood, stones or rigid containers are generally supported on simple wooden symmetrical saddle frames sitting on light padding and held in place with tail and girth straps. Simple pannier baskets may also be used .In Ethiopia, donkeys are widely used as pack animals and animals averaging 100-110 kg bodyweight regularly carry loads of 25-50 kg over distances of up to 20 km.

The distribution of donkeys in Africa is restricted by several ecological factors, notably the disease trypanosomiasis. With cattle being much more readily available, there has been some interest in the potential of cattle as pack animals while cattle do not readily take loads on their back, they can certainly be trained to do so. In parts of Mali and Chad cattle may be ridden for personal transport by farmers and some pastoralists in Sudan and Somalia use cattle to transport their effects when moving between sites. Bovine pack saddles were developed in Tanzania (King, 1940), but were not adopted. As animals can pull greater loads than they can carry, in most areas will probably be more productive than trying to develop systems of using cattle as pack animals. Where narrow paths restrict the use of conventional carts, it has been suggested that transport of goods could be on sledges or very narrow carts

Ethiopia has the second largest donkey population in the world, estimated to be in the range of 4-5 million. The majority of donkeys are found in the high lands with the region of Shoa, Gondar, Tigray, Gojjam and Wello having the greatest numbers. There are about 27 donkeys per 100 people, which is a high density by the world standard. (Fisha. G, Alemu.G, Friew .K, Abule.E & Ketema.Y, 1997). According to the data collected from Woredas agricultural offices in Amhara region there are about 514880 donkeys which is 70.6% of the total equines in the region. But, studies in several countries show that donkeys have survived draught years better than cattle. This combined with the high cost of oxen and or the effects of animal disease, has caused many farmers to turn to the donkey as an alternative power source.

**5. Draft and Pack Animal Species and their Attributes**

**5.1. Common Species of Draft animal power**

**5.1.1. Cattle**

Cattle are the major work animals world-wide. It is most common to use male animals because they are stronger than females and cattle herds always produce a surplus of males. Castrated animals are more docile than intact males. Thus, the most common working cattle are castrated bulls, known as oxen or bullocks. In some texts, the word oxen have been used to describe any working cattle. Since working cattle are generally castrated males, the two uses of the word generally overlap. Nevertheless, confusion can occur in regions where cows or bulls are used for work. In this text, an ox is a castrated bull of any breed that is used for work. The term bovid encompasses the animals that are closely related to cattle, including water buffaloes and yaks.

* Among cattle oxen are often preferred, because they are well-muscled and have good temperaments.
* An ox is a bull which has been castrated and trained to pull loads.

**5.1.2. Buffaloes**

The domestic buffalo is used extensively as a draft animal in Asia; less commonly in Egypt and the Near East. Buffalo work at aslower rate than oxen, but aregenerally considered to be strongerand better adapted to wet terrain. Swamp buffalo are employed extensively for draft in South and Southeast Asia for rice production. They are generally considered stronger, although slower than cattle. Buffalo are commonly trained at 3 to 4 years of age, although depending on the country and/or region, training may begin as early as 2 years or as late as 8.

**5.1.3. Horses**

After cattle, the main work animals world-wide are horses, donkeys (asses) and mules, known collectively as equids. In current English, a domestic ass is generally called a donkey. The word ass is now mainly confined to archaic, zoological or colloquial writings (and the statistics published by the Food and Agriculture Organization). Mules are non-breeding hybrid animals formed by crossing a female horse with a male donkey. They are stronger than donkeys and hardier than horses. The other possible cross (female donkey and male horse) is known as a hinney. These are much less common, partly because the cross is biologically much more difficult to produce.

Health problems and the need for very good management restrict the range and use of horses in the tropics. Horses tend to be high-status, expensive, specialized work animals. In North Africa, Senegal and some highland regions in Africa, horses maintained mainly for transport may be used briefly for crop cultivation. However, for most smallholders in tropical Africa, horses are unlikely to be used as work animals.

**5.1.4. Donkeys**

Donkeys are small work animals, well adapted to semi-arid areas. They do not seem to thrive in humid or semi-humid conditions, but they are reputed to survive better than Zebu cattle in tsetse-infested areas. They have great ability to live entirely on poor free range graz ing, and in serious drought conditions they tend to outlive cattle. The animal is mainly used for carrying pack loads, pulling light carts or for riding.

Donkeys are small work animals, well adapted to semi-arid areas. They do not seem to thrive in humid or semi-humid conditions, but they are reputed to survive better than Zebu cattle in tsetse-infested areas. They have great ability to live entirely on poor free range Grazing, and in serious drought conditions they tend to outlive cattle. The animal is mainly used for carrying pack loads, pulling light carts or for riding. In arid areas, the cost of maintaining cattle is often too great to make oxen a feasible-source of farm power.

Donkeys are better suited to these climates and often supply sufficient power for the kind of' agriculture practiced.

Donkeys are popular draft animals because they are inexpensive (often less than half the price of oxen on the live market), easy to train, and effective where shallow breaking rather than overturning of the soil is all that is needed before planting begins. The use of light equipment and the improvement of husbandry techniques have made it increasingly clear that donkeys are an important source of farm power.

Donkeys are often very inexpensive and have little, or no, disposal value. Although they have sometimes been considered as animals of ridicule or low status, they have excellent reputations as easily trainable and very dependable work animals. Children can easily manage donkeys.

 **Advantages of donkey**

* Friendly towards humans
* Willing to work
* Can turn in a small space
* Easy to train
* Need little supervision in work
* Can utilize poor feed well
* Not affected much by external parasites
* Need little water
* Can survive well in tsetse-infested areas
* Can survive droughts better than cattle
* Comparatively cheap to buy
* Strong relative to size
* Live and work many years in good care
* Useful for calming and guarding other kinds of animals
* Fast walking speed

**Disadvantages of donkey**

* Noisy when frustrated or lonely
* Friends not easily separated
* Uncastrated males aggressive towards other donkeys
* Skin easily wounded
* Wander long distances if not supervised
* Do not move out of the way of traffic
* Need shelter from cold and damp
* Meat not generally eaten
* Comparatively small in size
* Mature slowly
* Breed slowly

Both males (intact males are called jacks and castrated males are geldings) and females (Jennies) can be used for work. Donkeys reach maturity around four years of age, with maximum weights being reached 120-180 kg. Naturally, good management affects the speed of growth and final body characteristics. With good care, donkeys can have a working life of 12-15 years, and they can live even longer.

Castration will help to improve the temperament and reliability of males. However, good jacks are important for breeding, and farmers may be able to obtain fees for allowing their jacks to breed.

**5.1.5. Mules**

Mules are specialized work animals produced by crossing a female horse with a male donkey. They are therefore only found where both horses and donkeys breed well, notably in temperate, semi-arid highland areas. They make excellent, single-purpose work animals, being hardier than horses and stronger than donkeys. The great disadvantage of mules is that they are not fertile; so female horses have to be kept around to produce baby mules. This makes mules rather expensive.

**5.1.6. Camels**

Camels are used as pack animals through much of the Sahara. In Mauritania, Niger, Chad, Mali and Senegal they are used to supply power for drawing water; occasionally they are used to draw plows or light weeding implements.

**CHAPTER 6. Selection and Training of Draft animal power**

**6.1 Selection of Draft animal power**

**6.1.1. Qualities to be considered During Selection of Animal**

**1. Conformation**

Conformation refers to the form or shape of an animal. A shape which shows the normal characteristics of its species and breed. An animal used for draft must have a build well suited for pulling. Have powerful shoulders and legs, and have a broad frontal dimension that will accommodate the placement of a harness. It must be big enough to deliver, alone ‘or in a pair, the power needed to pull equipment for an extended period of time. It must also be able to exert the concentrated or "instantaneous" effort needed to overcome temporary increases in the draft requirement caused by roots, rocks, hard soil, or inclines.

While some animals are bred to produce good draft abilities, within any breed individual animals vary greatly in these qualities, and care must be taken to choose those with the most potential.

A thin but well-balanced animal can be strengthened with a good diet, health care, and work. However, an animal with a swayback, bad legs or impaired vision will be a constant source of trouble.

Good draft animals, regardless of species or breed, will have the following qualities:

* head, well proportioned; squarish, sculptured look
* balanced vision and hearing; head carriage high and straight ,normal mouth; good teeth and jaw structure
* body should have depth and width; short, full neck, full shoulders, broad chest, and straight, broad back
* Awide, thick hindquarters
* short legs, straight and square to the body; ample bone
* clean, well-developed joints; no swelling or unusual boniness; no turning in or out of knees or hoofs; free movement of limbs
* Feet straight, hard; normal angulations of hoof.
1. **Temperament**
* Select or retain animals with a responsive behaviour.
* Eliminate very nervous animals that get easily frightened and those that are aggressive to other animals and to people.

***HEALTH:***

* Discard cattle suffering from major injuries, diseases or defects like:
* Limping or lame animals
* Deaf animals
* Animals that don't see properly or are totally blind
* Weak or sick animals
* Discard pregnant females, especially those which are 2 months away from delivery
* Discard those with breathing problems: irregular or fast breathing, because they will get exhausted after moving for a very short time and will fail to pull the implement to the end.

Temperament refers to the nature or disposition of an animal. Part of its temperament is determined genetically, both by breed and parentage; some of it is learned— a response to the treatment it receives from other animals or the people who raise ‘and handle it.

Temperament is reflected in an animal's behavior, The way it moves and acts, and the way it reacts to the things around it.

It' is difficult to know much about temperament from the quick evaluation that usually precedes the purchase of a draft animal.

The buyer must guess, from what is observable, whether or not an animal will accept new routines or maintenance and training, behave well in a pair, and prove to be a spirited yet steady paced and manageable worker.

A basically lethargic bull, for example, may become very alert or nervous at the approach of a stranger, exhibiting a fierceness that could be misinterpreted as a strong yet controllable spirit. A donkey that is mishandled and mismanaged might kick or butt at its owner, or at any adult, but be led away quite easily by a child. The buyer must be aware of such possibilities and at the same time draw some basic conclusions about the animal’s ‘temperament

***The following are signs of good temperament*:**

Its temperament is affected or shaped by its physical condition.

• The animal accepts the handling of the owner.

The owner can pick up the animal's foot, open its mouth; lead it with a rope without having to use force or harsh measures.

• It does not shy or kick at other animals.

The buyer should try to be present when it is being turned out with a herd or put into a corral with other animals. If an animal is unusually aggressive or cowardly, it may not work well in a pair. Aggressive animals force their work-mates to shy or lean out of the yoke or harness, while cowardly animals' may refuse to step evenly with their mates, lagging behind.

**3. Animal Breed:**

Select local cattle breeds as they are used to the environment: the local disease challenge, prevailing climate conditions, quantity and quality of food available and the traditional management systems.

**4. AGE**

*Select* ***young oxen or bullocks*** of between 11/2 and 3 years old. Young animals are light, cheap, easy to train, and they can accept commands. The selected young animal must have good growth potential; this will profit the farmer when he sells it for meat. Young animals also have a longer working life.

**5. WEIGHT**

* Select a young local Zebu weighting between 150 - 300 kgs.
* Select only those animals with a potential to gain weight.

Thus, eliminate an animal which falls below or goes above the recommended weight limit, because the animal will either be too light to pull the draft during the training or too heavy to move during the training.

**What Does the Body of Good Draft Cattle Look like (Conformation?**)

In general, the animals you choose for work should be strong, heavy, healthy, docile and intelligent. They should be calm but not lazy.

Which are the most important parts of the body of a draft animal?


Fig. 1.: A draft animal must have strong and well conformed legs, a straight back and the correct neck to carry the yoke.

The legs must be normal. If they are not normal the joints wear out soon.


Fig. 2: No! It must not have X-legs!; No! It must not have O-legs!; Yes! The legs are normal


Fig. 3 No! The foot must not be too straight!; No! It must not be bent too much!; Yes! It must be slightly bent!


Fig.4 Yes! The back must be straight!; No! It must not be bent down or concave No! it must not be bent up or convex.

**6.1.3. Selection of Donkey, Horses and Mule**

**Selection characteristics**

Before describing the characteristics of a working donkey, some basic knowledge is needed of English names of parts of the animal, as shown in the figure below.



When selecting an animal for work certain physi-cal characteristics should be observed. These include: a large frame with wide shoulders and a deep chest, a straight back and well-muscled straight legs which have a 90° angle to the ground (figure 2). In young animals large knees are an indication of future thickness, but even in a large-kneed foal, the knees should not touch.The donkey should have good eyesight and agility (liveliness) and an attractive hair coat, without skin diseases or an abundance of ticks. It is important to observe an animal while it is working, to detect whether it has a physical disability, such as coughing, poor breathing, lameness, sores or wounds.

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The sole of a donkeys hoof should be concave underneath; only the front part and the edges touch the ground. The shape of the hoof should be as round as possible. The angle between the pastern and the ground should be about 50-60 degrees, being slightly steeper in the front legs. The hoof angle and the pastern angle should be similar. Animals with feet abnormalities should not be selected (figure 3).

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In addition to sound physical characteristics, an animal should have a suitable temperament. It should be responsive, but not excitable or aggressive. However, the extent to which an animal develops into a good working animal will also depend on its relationship with its handler. No animal will perform well if its handler is cruel or inconsistent

**6.2. Training Working Animal**

Training animals for traction involves an understanding between the trainer (yourself) and the animals. The animals need to trust you. For that we need to be patient and reward them for good behavior.

**Reasons for Training Animals**

* Trained animals can do more work in a shorter time.
* Trained animals hear and accept commands (voice commands)
* Trained animals pull better, like a team with well-coordinated movements.
* They are easier to control.
* They are able to pull heavy loads for longer periods.

**Note:**

In order to train animals, a trainer must follow some principles to achieve good results during the whole exercise. The reason for this is that cattle are not used to work unless they know the training steps.

**Seven Principles to Consider When Training:**

1. The approach must be simple, calm, patient, persistent, and the trainer needs to be firm (not to show fear to the animal).

2. There should always be a routine and a repetition of the training steps, so that the animal adopts the new behavior.

3. Spoken commands and names should be few and simple such as: “Go”, “Turn left”, “Turn right”, “Reverse” or “Stop”. Remember to always use the same language during and after the training.

4. Train either early in the morning or late in the evening so as to avoid the heat of the day.

5. Reward the animal for any positive behavior, then correct bad behavior immediately and don't reward. Rewarding the animal includes; patting on back, calling the animal's name, grooming him or giving some food.

6. Complete every step in the training programme before moving to the next one. Do not move to the next step, unless the animals have understood the one before.

7. To carry out the training you need the following items: a trained animal, a proper kraal, a good

 Pegged training field and tools (ropes, different types of yokes, ploughs, weeders, loads and

Sledges).

**6.2.2. Training stages and Duration of training**

**STEP 1: Roping and Walking**

The purpose here is for the trainer to get used to the new animal, to create friendly conditions and to remove fears/suspicions from the animals.

You should tie the oxen with ropes and make them walk in circles without yokes. To tie you can use halters or nose punched animals (as explained below). Each time you train, you reduce the rope that separates you from the animal, so that you come closer to it and this one keeps on gaining trust



**These exercises take 2-4 hours per day for 2-3 days**

The animal should learn to accept commands, so by the end of this step the animal should be able to go left or right, to stop or start and even to go backwards following the voice commands.

This step ends when a trainer is able to move closer to the animal, to put a rope around the neck, name the animals, make them walk or move and stop using simple commands.

**STEP 2: Harnessing and Walking the Animals**

In this step, harnessing or yoking is done in the kraal. After that, the animals are moved to the field. The objective here is for the animals being trained are able to accept harnessing and removal of the harness while they are outside the kraal.

If a trained animal is there, use it to train the new one, so that they learn to move in pairs. By the end of this step, the pair of animals should be able to move forward, stop, turn left, turn right and eventually turn and walk back using voice commands e.g. go, stop, turn-left, turn-right, about-turn, etc.

The items used here include a yoke, ropes, a kraal, a training field and trained animal



**These exercises should take 3-4hours per day for 7-10 days**

**STEP 3: Pulling Loads**

The purpose is to train the muscles of the animals and for them to gain strength to pull heavy loads. During this step, varying loads are introduced from 20, 30, 40, 50 kg /log.

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**These exercises are done in the field, 2 hours per day, for 7-14 days.**

**STEP 4: Pulling Implements**

Implements such as ploughs, weeders, harrows, planters, etc, are introduced in this step



**This can be done for 3-4 hours per day for 3 days**

**6.2.3. The Qualities of Good Trainer**

Training of animals requires patience, firmness, perseverance and above all, consistency. Continuity of the training programme is of prime importance as the animal can soon forget previous lessons when breaks occur.

The following points may therefore be useful to the trainer (who is preferably the farmer):

* Keep a calm, patient and consistent approach to the animal(s).
* Follow the training steps as described and repeat until full control of the animal is obtained.

Do not try to train the animal too quickly, but follow the animal’s acceptance of the training.

* Reward correct behavior of the animal with a short rest, some choice food, given always with a word like good so that in the end the word alone will function as reward.

**Voice commands**

The number of voice commands should be kept to a minimum and as short as possible. The following list of words and sounds can easily be taught to a donkey. It is useful to make use of one standardised set of short words that are also used by other farmers in the region, so that if a donkey changes owners, the confusion will be limited.

|  |  |
| --- | --- |
| Word  | Intended effect |
| No | Stop the donkey’s action |
| Good | Verbal reward for donkey |
| Come | Move donkey towards speaker |
| Home | Send donkey home |
| Shed | Send donkey into shed |
| Harness | Donkey to stand still for harnessing |
| Move  | Start donkey moving |
| Faster  | Speed up donkey |
| Stop | Stop forward movement of donkey |
| Reverse | Donkey to go backwards |
| Straight | Donkey to move in a straight line |
| Right  | Donkey to turn right |
| Left | Donkey to turn left |
| Leg | Donkey to lift leg |
| Furrow | Donkey to follow the furrow |

**CHAPTER 7. Animal Drawn Implements**

**7.1. Primary Tillage Implements**

Primary tilling is performed by different types of plows, discs, rot tillers, and spading machines.

The moldboard plow is one of the oldest implements used for soil preparation; it consists of one or more curved pieces of metal, called bottoms, attached to a frame. The bottoms are pulled through the soil to cut and then invert, either partially or wholly, the soil. One- to 4-bottom plows are common for small-scale production, and each bottom requires approximately 10 to 15 horsepower from the tractor. Plows come in various shapes and sizes, which determine the depth of the plow and how it moves the soil. Disc coulters can be added to the front of the plow to cut the soil so that the bottom penetrates the soil more effectively.

**7.1.1 Single Furrow Mould Plough**

In regions of moderately high rainfall, where also the heavier soils are found, weeds are a serious problem. The weeds can be buried by inverting the soil with a **mouldboard plough**. The degree of inversion depends on the cohesion of the soil and the shape of the mouldboard. As it moves soil to one side, the mouldboard plough clears a distinct furrow. By continually turning soil into each previous furrow a farmer can systematically cultivate a field in one operation, covering both weeds and surface trash.

**Ard**

The practice of removing organic matter and residues is common, for example by burning or by the grazing of animals. Measures for applying extra organic material, such as green manure and animal dung, are not being exploited in most regions. In that case, inversion of soil may not be desirable as it may increase the rates at which soil moisture is lost and humus is decomposed. Under semi-arid conditions a fine tilts may be dangerously susceptible to erosion. A coarse seedbed preparation, with the ard for example, reduces these erosion risks

Though ards have been in use for thousands of years, they still are clearly well adapted to many contemporary-farming systems. Among the design features commonly found are:

* the use of a single, symmetrical share set at a fixed angle to the ground;
* use of a long beam between the body of the implement and the yoke;
* provision of a single handle for control;
* Use of materials and construction techniques that allow fabrication by village artisans.

Numerically, ards are the most important animal-drawn implements in the world.

An ard plough is symmetrical on either side of its line of draft. As the share and the body of the plough pass through the ground, the soil is fractured and disturbed equally on either side, due to the symmetrical construction.

**Scarifies**

Another practice in semi-arid regions, where heavy weed growth has not developed, is the use of a scarified. The scarifier is normally equipped with rather light tines made from spring steel. These vibrate, loosening the soil and reducing the risk of damage when encountering obstacles. This implement rapidly opens the land after the first or second rain of the season to improve infiltration of the next rains.

When using a pair of donkeys, only three tines should be attached. One is placed at the front and the other two at the rear of the implement. The appropriate choice must be made according to local field conditions, and it also depends upon the type of point fitted. Under normal conditions, a team of four donkeys can pull a scarifier with five times. Lateral spacing between each tine must be equal and varies normally between 15 and 20 cm. It is particularly important on an expanding frame such as the Houe Manga that each tine be aligned in the direction of advance

**Ripper**

Where the soil is practically free of weeds a ripper can be used to open a narrow band of soil ready for seeding. The rest of the soil is left undisturbed, if possible under a mulch cover to keep that soil cool and moist. The ripping system is not widely used yet, but highly promoted in the interest of soil conservation.

Single**,** symmetrical, angled tines may be used for tillage in semi-arid conditions. These are mounted onto steel beams or toolbars, as commonly used in sub-Saharan Africa. In Zambia the Magoye ripper was developed as an attachment to a local plough or ridger frame (figure 38). It is recommended for a breaking. Operation to make planting furrows for maize instead of a ploughing operation. On heavy soils this operation should take place right after the onset of rains but on light soils it can even be done before the rains start. Dry soil shatters better and by doing this operation ahead of time, the usual high demand for labour and draft animals at planting time can be decreased.

**7.1.2 Ridging plough (Ridger)**

Another fast system of soil cultivation is ridging. Ridging ploughs are symmetrical around their line of draft and the two mould boards turn soil to both sides (figure 39). In each pass through the soil a ridger makes one furrow and two small ridges. In normal use the furrows are so spaced that two small ridges are combined to make one larger one. Alternatively a ridger attachment is added to a common plough. The fact that not all the land is tilled. The soil under the ridges is not disturbed.

Ridging, as a method of cultivation, developed in many African countries before animal traction was introduced. Its rapid and superficial manner of working very light soils is highly prized.

When using a properly designed ridger for direct ridging on soils where also ploughing can be done effectively, the draft requirements for these two operations will be comparable. In heavy soils however, direct ridging could lead to the formation of large aggregates that could hamper seed germination. In those conditions soil may have to be broken first with tines or a mouldboard plough and ridging becomes a secondary tillage operation.

**7.2. Secondary Tillage Implements.**

Secondary cultivation is aimed at both reducing the clod size and leveling the soil surface or forming it into the required shape by ridging.

Depending on how rough or crusted the soil is and how much plant residue remains, using secondary tillage equipment can further refine and level the soil before seeding or planting. Harrowing is used for shallow tillage and is most commonly practiced after plowing. Harrows can be used to break down the furrow slices caused by the plow, reduce clods, smooth out the soil surface, and kill young weeds. The types of harrows include light disc harrows, chain-link harrows, spring-tooth harrows, and spike-tooth harrows. If sod has been plowed under, the disc harrow will not bring lumps of sod up to the soil surface—unlike the spring-tooth or spiketooth harrow. Although spike-tooth harrows do not pulverize the soil as well as other types of harrows, they can sometimes be used to cover broadcast seed.

Field cultivators consist of a toolbar with different implements mounted on it. They are heavier than harrows and are used when the soil is too rough, is too compacted, or has too much residue for a harrow. The toolbar usually has C-shanks or S-shanks with sweeps, tines, chains, or rollers attached to the bottom.

**7.2.1. Planting Equipments**

**1. Furrow Openers or Row Markers**

A harrow may be as simple as a few tree branches or a wooden plank or a log, weighted down with stones or the weight of the operator and pulled across the field by the animals. A common harrow consists of a wooden frame with 15 to 20 metal spikes, which breaks the clods, mixes the soil and helps to level the surface. The spikes should be able to penetrate down to a depth of between 5 and 8 cm . Excessive pulverizing of the soil should be avoided as the surface will then become vulnerable to wind erosion and some soil types will later form hard crusts after rain.

The correct hitching is very important to achieve best results. The size of the animals and length of the pull chain affect the way in which the harrow floats across the surface. The implement should be one meter behind the animals’ hooves and remain level during the work. Excessive surface vegetation will block the tines and greatly reduce penetration. It is therefore important to correctly plough the field and to invert the soil properly beforehand.

Harrowing is the process of smoothing and leveling a plowed field. The harrow breaks clods and works the tops of furrow slices into a fine, moisture-retaining bed where seeds germinate easily. Higher germination rates resulting from harrowing are explained by improved structure of the seedbed: It is better aerated, it is moisture-retaining, there is more contact between the seed and .soil particles; large air pockets and clods are eliminated and seeds are easily covered and some weeds are killed.

**2. Planters**

**Seeders and planters**

The objective of sowing is to place seeds at an appropriate depth in the soil with an optimal spacing between seeds. It has repeatedly been shown by comparative trials that accurate planting produces higher and more reliable average yields than random seed placement. The object of a seeder is to obtain such accurate and reliable seed placement conveniently and at an acceptable cost.

The main manual techniques for sowing are broadcasting, dibbling and drilling. Broadcasting involves the scattering of seeds over the soil surface followed by some mixing of the topsoil.

Dibbling necessitates the making of a small hole into which are dropped one or more seeds. Drilling is the process of making a narrow furrow into which seeds are placed at regular intervals after which the furrow is covered with top soil and loosely compressed. The various manual processes may be either combined with, or replaced by, animal traction techniques.

Most animal drawn seeders are based on the drill principle, and have a furrow opener that penetrates the soil, a metering mechanism, that determines seed rate, and some form of seed tube that transports the seed to the furrow. There is generally some system for covering the seeds in the furrow and lightly compacting the soil. Row seeding can be achieved using a plow (arc or mouldboard) as a furrow opener and hand-metering by dropping the seeds into the furrow. If furrow depth is not constant there will be seed wastage, but with no capital outlay, this may be acceptable. The problem of accurately aiming the dropped seeds can be overcome by the provision of a plastic seed tube that drops the seed behind the plow

Broadcasting has historically been the major method of seeding grasses and small cereals such as Wheat' teff and rice. When broadcasting is combined with animal traction, soil is generally plowed several times to obtain a satisfactory seedbed, or plowed once and then harrowed. The seed is scattered by hand and then a light seed harrowing (or seed plowing with an arc) ensures that seed is incorporated into the topsoil. Once seed is distributed in this way, further animal traction operations are virtually impossible without damaging the crop. Very light harrowing as a means of early weeding is technically possible but seldom practised in the tropics. The broadcasting of wheat and rice may be replaced by animal-drawn single-row seeders or multi-row seed drills.

**4. Weeding Implements**

Weeds compete with crops for light, water, and nutrients and they can affect a farm’s economic bottom line. Weeds can reduce crop yields through competition with cash crops, promote pests and disease, and even be problematic in the harvesting process. As a result, there is a large cost associated with controlling weeds. Minimizing weed growth both in the short term and the long term should be considered when designing a cropping system. Careful planning to limit weeds’ competition with cash crops and to reduce the amount of time, fuel, and other resources spent on controlling weeds can be vital to a farm’s economic viability.

There are several techniques for effectively controlling weeds, including chemical and culture approaches, as well as the use of cultivation tools. Many of the control techniques can be integrated together to be more effective. All of the techniques are focused on either preventing weed seeds from germinating (pre-emergence) or suppressing established weeds (post-emergence).

In most cases, the farmer who uses animal power will plow and plant more ground than can be weeded by hand. The weeding operation can be accompanied with a' weeding sweep or with a cultivator.

Sweeps work at shallow depths, uproot rig weeds and loosening soil between row crops. They come in various widths to accommodate various inter-row distances.

The sweep has several functions:

• It scrapes a shallow furrow" between rows, cutting or uprooting weeds in its path. In additon, it pushes some soil to the sides, covering weed seedlings growing between plants on the row.

• It bjailds a light bank of soil against the row. The soil helps shade and support roots of the plants, and also covers fertilizer distributed at the base of the plants.

• It loosens soil, improving aeration and moisture retention.

Timing is very important. Weeds must be killed before they compete with crops for soil nutrients and water reserves. The f-first weeding is performed as soon as weed seedlings appear between the crops.

**7.5. Transport Equipment**

Pulling is generally a more efficient way of moving things than packing, because most of the load is not borne by the animal. Moreover, the load does not have to be prepared in a special way to fit the animal. The most simple load vehicle is a sledge made out of a Y shaped tree branch. The sledge is attached to the animal by a trek chain.

**7.5.1. Sledges, Carts and Wagons**

1. **Sledges**

Wooden sledges are quite widely used in certain areas of eastern and southern Africa, Madagascar and parts of Asia and Latin American southern Africa simple sledges are made by joining two wooden beams in the form of a V, or by selecting a naturally occurring fork in the branch or trunk of a tree.

The **advantages** of sledges are that they are cheap and simple to make and maintain. They have a low centre of gravity and they are narrow, enabling them to be used on tracks too narrow or steep for carts. They can often be used in sandy, muddy or rutted conditions where a cart might become stuck. However, there are many **disadvantages**. In most conditions they require more effort to pull than a cart. They have limited clearance and can be stopped by stumps. Most importantly they tend to accelerate erosion by leaving rutted tracks, often only passable by other sledges, which become watercourses during heavy rains.

1. **Carts**

Carts pulled by animals are widely used for rural transport; there may be 40 million in operation worldwide, the majority in Asia. Many carts are constructed in a way that combines artisanal skill with traditional folk arts. Most carts employed in the world are made mainly of wood, and use traditional designs of wooden poked wheels. However carts with steel frames and pneumatic tyres are becoming increasingly common. Once a suitable and affordable cart design becomes available, the adoption of carts can be quite rapid and even eclipse the agricultural usages of draft animals

Two-wheeled animal-drawn carts are much more common than four-wheel carts due to their lower cost, lighter weight, lower complexity and greater maneuverability cities and market towns, carts may be operated full-time on a hire basis by transport entrepreneurs. Only about ten percent of African farmers who own draft animals have a cart, but the importance of carts to the agricultural sector is much greater than the simple numbers imply. While other implements are used for a small number of days each year, carts are generally used throughout the year. Thus in terms of overall implement usage in Africa, the total number of cart-days each year would be second only to the number of prow-days.

Carts are two-wheeled vehicles. They can be small and light, pulled by one donkey, or may carry over one ton and be hitched to a team of donkeys. Carts are becoming very popular, especially in Africa, as they can be used on rough roads and throughout the year, while other implements can only be used for a small number of days each year.



3. **Wagons**

Wagons are four-wheeled vehicles with a higher weight capacity than carts. They also have the advantage that the wheels support the whole load, so that the animal power is only needed for forward movement. Wagons can be left with loads in place even when the animals are not present. However, wagons have a more complicated design to ensure maneuverability and stability, which makes them heavier and more costly. They are best suited to tarred and level roads and to areas where the increased load capacity is cost-effective.



**7.5.2. Pack Transport**

Donkeys and mules are the main pack animals in most regions of the world. Mules are produced by crossing a female horse with a male donkey. Mules are larger and stronger than donkeys, but donkeys are cheaper to buy and to maintain. The reliability of donkeys is legendary. Once trained, donkeys can follow particular routes with minimal supervision; they will wait patiently for several hours and they can often be trusted to return "home" unattended. Horses can be fast and efficient pack animals, although they are not as hardy as donkeys. Being more expensive to purchase and maintain than donkeys, horses are used mainly for high-value or strategic operations. Camels are excellent pack animals, unrivalled in their ability to cope with severe desert conditions, but they also are more costly than donkeys. Llamas and yaks are locally used in the foothills of the Andes and Himalayas. It is rare for cattle to be used as pack animals.

Donkeys are maintained as pack animals in many African countries, particularly in North Africa, the Sahel, Ethiopia and parts of eastern Africa. Their employment has often been a long-standing tradition. When donkeys are used for pack work, it is normal to place some form of protective padding over their backs. This may be sheepskin, sacking or discarded cloth. Soft loads such as sand, fertilizers, canvas water containers and straw are placed symmetrically over the back and held in place by one (or more) leather or rubber straps around the girth or belly, and under the base of the tail. Hard loads such as firewood, stones or rigid containers are generally supported on simple wooden symmetrical saddle frames sitting on light padding and held in place with tail and girth straps. Simple pannier baskets may also be used .Pannier baskets with opening bottoms that allow loads to be shed easily have been used in Western Samoa (FAO, 1986). In Ethiopia, donkeys are widely used as pack animals and animals averaging 100-110 kg bodyweight regularly carry loads of 25-50 kg over distances of up to 20 km.

The distribution of donkeys in Africa is restricted by several ecological factors, notably the disease trypanosomiasis. With cattle being much more readily available, there has been some interest in the potential of cattle as pack animals.

**Loads and comfort -**Because donkeys are so docile and willing, it is easy to overload them. Some farmers make donkeys carry goods equal to the weight of the donkey.

A pack donkey ought to be comfortably loaded. An even load of reasonable weight on its well-padded back will allow a donkey to walk long distances with little or no attention.

Loads should be kept as close to the animal as possible. Tall loads are unstable, particularly if they are not well balanced. They are more likely to be uncomfortable and to shift during motion. In extreme cases they may cause a donkey to fall. At the end of the working day, pack saddles and pads should be removed to allow grooming.

**Packing rules**

***Load balancing*** -All loads should be balanced evenly, with similar weight and bulk on either side of the animal so that it is comfortable.

***Back padding* -**Two-layer padding material between the pack load and the donkey’s back is required for protection of its skin. The layer that rests on the skin should be both soft (to provide protection) and absorbent (to take up sweat). It has to be washed or replaced regularly, to avoid growth of noxious bacteria. Several layers of cotton material or sheepskin are ideal for this purpose.

The second layer should provide a cushioning effect. Well-suited are a folded blanket or a straw-filled sack. With the latter it is important to sew the bag into sections to prevent the straw or other filling (animal hair or kapok) from falling to one end. A protective piece of skin or leather or a plastic sheet may cover the cushioning layer.

**Protection of the backbone**

The back padding should be shaped in such a way that it prevents any direct pressure on the backbone. Therefore, a pack saddle or pack frame is recommended.

This system can be used to train donkeys. Light sacks are used of which the weight can be gradually increased as the animal becomes used to the load. Although this system is convenient, the pack-frame shown in figure 9 is preferably used to carry heavier and/or bigger sacks.

**CHAPTER 8. Harnesses systems of Draft animal power**

**8.1. Some mechanical principles**

**8.1.1. A very simplified approach to some mechanical principles**

Simple principles (rather than learned rules) can be useful when it comes to assessing the advantages and disadvantages of various designs, and the significance of any modifications and adjustments.

In addition to some basic mechanical principles, it will be helpful to be familiar with the main units of measurement relating to animal-powered implements. The day-to-day application of such units is not essential because comparative performances are more relevant than absolute values in the majority of field situations: farmers are more concerned with whether a particular combination of animals and implement can achieve acceptable work in a reasonable time, than with numbers illustrating weights, draft and power. Nevertheless there are great advantages in using standard units of measurement since this facilitates exchange of information between people in different countries, in the past meaningful exchange has been hampered by the wide range of different units that have been used when assessing animal drawn implements (horsepower, kilowatts, kilogram force, pound force, Newton’s, joules, miles per hour, kilometers per hour, meters per second, square meters per hour, hours per hectare, acres per day, etc.).

 Whenever practicable, internationally accepted standard units have been used in this book. Such units are merely convenient measures of magnitude, and do not convey any information as to the authority or reliability of numbers. While measurements obtained under accepted standard and repeatable test conditions can be widely applicable, there are very few standard measurements relating to animal draft, other than implement and animal weight and physical dimensions. When draft animals work pulling implements in a farmer's field or at a research station there are so many highly specific variables influencing the situation that the actual figures may have little relevance away from the conditions in which they were obtained. Thus although the use of international units is to be encouraged, these should not be confused with international test standards, and great care should be taken when interpreting data obtained in different circumstances Similarly, because local conditions are so variable, it is generally unwise to ascribe "typical" values to agricultural operations.

**8.1.2. Forces and vectors**

The first mechanical principles that might be recalled are those relating to forces. (Some people may even remember that Newton's first law was that a body will remain at rest or in straight-line motion unless acted upon by a force. His second related to changes in momentum and direction of movement as a result of forces, while his third was that actions and reactions are equal in magnitude and opposite in direction).

The standard unit of force is a Newton (symbol N). The definition of a Newton is based on the force resulting from acceleration acting on a mass of one kilogram. Since the acceleration due to the Earth's gravity is about 9.8 meters per sec, the weight of one kilogram mass (on most of the earth's surface) is about 9.8 Newton’s,



**Fig:** Illustration of the vertical and horizontal components of draft forces.

(Fig. ). Such a pull has an upward component and a forward component. If the pull were at an angle of 45°, these horizontal and vertical forces would be equal, so that as much of the applied

force is being used in "lifting" as in "pulling". If it were possible to change the 45° pull into one that was almost parallel to the ground, the same force would have a much greater horizontal (forward) effect. One means of achieving a more effective horizontal force would be the use of a very long traction chain, and another would be to lower the point from which it were pulled. In terms of horizontal pull, short-legged oxen with a low-hitched harness and a very long traction chain would be more efficient than long-legged camels with a high hump harness and short chain. This exaggerated example illustrates two points: firstly that agriculturalists do not have to be engineers to be able to consider in a very simple but useful way the forces involved in the application of harnesses and equipment, and that such consideration may well lead to ideas for improving field adjustments or overall designs; secondly what may be theoretically optimal in terms of one aspect of efficiency may not be appropriate in terms of operational convenience or animal availability. Over-long chains make turning very difficult and short legged mini-beasts may not have sufficient power, speed or endurance. In practice, design considerations such as convenience, cost, availability and even appearance may outweigh technical refinements.

**8.1.3. Work and power**

Work involves moving a force through a distance. As an implement is pulled through the soil, the animal or team exerts a tractive force and as it moves across a field, it performs work. Work done is not a function of time, so that however long an operation takes, the actual work done is the same. Plowing a field to a particular standard and depth entails the same amount of work (in principle) whether it is completed in one morning, in one day or in many days, whether the work is done by a single animal, a pair, or by a large team, and whether the animals pull a narrow plow through a long distance or a wide plow through a shorter distance. (In practice there may be some small differences since some frictional forces vary with speed and surface to volume ratio).

 Although the actual work achieved in terms of plowing will be the same in all the cases cited, the number of animals and the rate of work may well have significant implications for total energy expenditure. (Animals are constantly using metabolic energy for maintenance, in a way comparable to the non-stop idling of a vehicle engine, so that a slow job or one involving more than one animal may involve higher metabolic energy expenditure; animals also perform work moving themselves, so that the shorter the distance they travel, the less work they do moving themselves; in such cases pulling a wide implement though a short distance will involve less energy for walking than pulling a narrow implement through a long distance).

Power is the rate of doing work, and therefore unlike work, power is a function of time. Historically power was assessed in terms of what a draft animal might perform, and was measured in units called horsepower (hp), units that are still quoted today in some countries. The "imperial" horsepower unit was suggested by James Watt who timed a horse and also his new steam engine as they pulled weights up a well shaft: he concluded that a horse could work at a rate equivalent to lifting a 550 pound weight through one foot in one second.

It should be noted that while many of the terms such as force, draft, work and power have specific scientific definitions, they are also used in a more general and loose sense by agriculturalists and farmers. Subjectivity and context can bring to these words a wide variety of meanings. For example, oxen are often said to be more "powerful" than horses.

Harnesses link animals to implements; while they do not alter the actual draft of the implement, they can influence how the draft is partitioned between vertical and horizontal vectors. Harnesses do vary slightly in their efficiency as transmission systems, so that greater or lesser amounts of energy are dissipated in the harnessing system itself or in unproductive work. Harnesses do not affect the intrinsic power of an animal, which is determined largely by its species, size, weight and past history. However through ergonomic aspects of design, notably those relating to comfort, harnesses may influence an animal's ability and/or willingness to use its power.

**8.1.4. Levers**

Much to do with equipment design and adjustment can be explained by reference to principles of levers. The "eveners" used in the harnessing of multiple teams are simple levers, as are yokes. In either case if the position of attachment of the hitching is moved from a central position, levers of unequal length are created. The weaker animal requires a longer lever to help it, while the stronger can make do with the shorter one. Pressing down on the handle(s) of a plow can be thought of as a lever action. The rear of the plow-body acts as a fulcrum (pivoting point) so that downward leverage on the handle(s) causes the share to move upwards to a shallower depth. (Such a movement is one of the many reflex responses associated with plowing; it is most obvious when plowing at a reasonable speed in light soils; in heavier soils and at low speeds the plow is unlikely to be sufficiently in equilibrium to allow the operator to distinguish between the different leverage effects).

**8.2 Harnessing**

In both English and French, the word harness (harnais) has been predominantly used in the relatively narrow sense of the straps and fittings used for hitching and controlling horses or donkeys, and dictionaries in both languages generally define harness with reference to horses.

The harness links the animal to the cart or implement. So, to be effective, it has to tap the power of the animal in the right places. In some parts of Africa, donkeys, horses or mules are used with withers yokes (also called neck yokes), similar to those used for cattle.

**8.2.1. Types of harnesses**

**8.2.1.1 Yokes**

For working oxen, the hitching together has generally involved a rigid yoke ("joug" in French), and historically the word "yoke" could also be used to describe a team of oxen. The French word

"attelage" has no single word equivalent in current English usage but refers to the system of hitching animals together whether it be the yoking of oxen or the harnessing of horses.

The wide range of yoking types falls into two main categories, those tied to the horns of the animal and those taking power mainly from the withers. The `'withers" of an animal refers to the part of the back that is over the shoulders, directly above the first thoracic vertebra. In Zebu (Bos indicus) cattle the withers are immediately in front of the hump.

1. Forehead yoke (rare).
2. Horn/head yoke (regionally common).
3. Withers/shoulder yoke (common).
4. Three-pad collar (rare).
5. Breeching strap (rare).
6. "Withers" of the animal.

**8.2.1.2 Collar and Breast Band Harnesses**

The webbing breast band may be made from strips of webbing which are sewn together to fit the donkey. The width of the breast band is about 6 cm. The neck strap is 4 cm wide and not adjustable.

Leather parts are used to reinforce the breast strap at the connections with the neck strap and the triangular ring. Short breast bands with one neck strap have the advantage of connecting the traces near the power point. Long breast bands with two back straps are required where the implement needs a certain amount of lifting, like single mould board ploughs without a support wheel.

A similar design can be made with rubber from an old car tire. The breast band is cut from the tread of the tire (6 cm wide) and the neck strap from the tire casing (5 cm wide). The joints are stitched together with thin wire. To avoid hurting the donkeys’ skin, make sure that the wire is pulled tightly toward the outer side while stitching, so that the wire is well sunken into the rubber on the inner side of the breast band, which touches the donkey. Edges should be rounded. Conveyor belts, joined by bolts, can also be used instead of tire rubber. Padding must be applied to absorb sweat and to protect the skin.

**Breast protectors**

Most sores and wounds are caused by poor quality or ill-fitting breast bands in combination with traces that are fixed directly to a rigid part of the cart and not to a swingle tree. Instead of heavy cloth or sheep skin as padding for the above-mentioned breast bands, one may also make a simple removable and therefore easily washable breast protector. It is a cushion made of foam rubber and canvas placed between the strap and the donkeys’ breast, which can be buttoned to the breast strap.

**Collar harness with straight hames**

A recent design made in South Africa uses straight wooden bars padded with sheepskin. The hame straps are made of home-tanned leather. They are simply tied together in a way that will easily allow adjustment. The saddle shown is part of the full harness, including a breeching made from old fire hose, needed for pulling a cart.

**Three-pad collar harness**

A special donkey collar harness developed in Kenya is modeled after European cattle and horse collars. The harness comprises two wooden hames, hinged by leather straps at the top and joined by a leather strap at the bottom. The hames are shaped to match the contours of the animal. The shoulders are protected from direct contact with the hames by two pads, made of canvas and stuffed with cattle tail hair, recovered from butcheries. The third pad is made of leather and is attached to the lower of the two top straps, which rests on the withers. The load is passed by nylon traces from the hames to a swingle tree. For pulling operations, a back and girth strap with trace holders are used to prevent entanglement of the traces and the donkeys’ hind legs.

Three-pad collar harnesses are expensive compared to harnesses discussed previously, because they are produced by artisans using good quality materials like hardwood, leather and canvas. However, over one thousand of them have been made in Kenya on demand and those who can afford them like them very much for their comfort, power, efficiency and durability.

**8.2.1.3 Harnesses for camels**

Camels are widely used for pack transport in arid areas and sometimes they are used to pull carts and power irrigation systems or grinding mills. The fact that camels have a high value for transport operations generally restricts their employment for agricultural operations. The long legs of camels allow them to cover ground quickly, but this height poses some problems for effective harnessing. Unless the traces of a camel harness are long (making turning difficult), the angle of pull is quite large, giving a significantly higher ratio of "lift" to "pull" than with less tall animals. Nevertheless it is not uncommon for camels to be used for crop cultivation in parts of North Africa, the Middle East, Pakistan and Rajasthan in India. In Sub-Saharan Africa the number of camels used for crop cultivation is very low, but it is reported that camels are being increasingly used for plowing in parts of Sudan, Ethiopia, Mali, Niger and Nigeria. Although collars can be used with camels, simpler and cheaper systems are usual. These had padded wooden hames and were held in place by back and belly straps, but it was found that withers yokes were actually more appropriate for cultivation work. The single camel withers yokes used in Niger were made from old lorry springs, well padded and fitted with large rings at each end to take the traces. They were held in place by a belly band and also small saddle and neck bands.

**9. Performance assessment of Draft animal power**

**9.1. Dietary Energy Requirements of Working Animal**

Horses, with the exception of those kept strictly for breeding, are subjected to some level of work. Nutrient recommendations are often based on these three levels of work effort:

* Light work: 2–3 hours per day
* Medium work: 4–5 hours per day
* Heavy work: 6–8 hours per day

It must be recognized that the intensity of work within these levels may vary greatly. The “medium” worked horse may be called upon to expend more energy in 5 hours than the “heavily” worked horse is in 8 hours. Therefore, the recommendations based on these work levels must be used only as a rough guide. It is up to the horse owner to adjust the feed ration accordingly.

**Table:** Daily Recommendations for Working Horses (Mature Weight = 900 kg = 1980 lb)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Level of work  | DE (Mcal) | CP (Kg/Lb) | Ca (g) | P (g) |
| Light  | 42 | 1.38 (3.04) | 63 | 38 |
| Medium  | 48 | 1.55 (3.41) | 72 | 52 |
| Heavy  | 62.1 | 1.55 (3.41) | 72 | 52 |

Note: Light work is equivalent to “moderate exercise,” medium work to “heavy exercise,” and heavy work to “very heavy exercise” for riding horses as listed in “Nutrient Requirements of Horses” 6th ed., National Research Council.

There are substantial increases in the energy needs of working horses as would be expected when you consider that energy is the major expenditure in performing work. This rather notable increase in the need for energy necessitates a change to higher energy feeds, particularly in the heavily worked horse.

Even though the recommendations for protein, calcium and phosphorus increase with increased work, the increases are less than the increase for energy. Protein is used primarily to rebuild muscle tissue. Calcium, phosphorus, and other minerals are lost at greater rates during work via sweating and urination. A good well balanced mineral mix with loose salt (fed free-choice) can easily meet the needs of the working horse.

**9.2. Energy Available for Work**

A good feeding program is essential in maintaining the strength and health of draft animals. Food is the fuel which an animal converts to energy and pulling power. Animals that are not fed enough of the right foods can show chronic fatigue, will lose the ability to work, and are more susceptible to disease. Excess calories are stored as fat, causing animals to become inefficient workers, lazy, stubborn, and ill-tempered.

A basic knowledge of the dietary needs of draft animals and of the nutritional content of available feeds will enable owners to plan a feeding program that will help their animals to work to their full potential.

Grazing draft animals’ need supplemental feeding for two reasons:

* To increase energy intake and prevent protein, vitamin-and mineral deficiencies.
* Because of limited grazing time or limited forages availability. Pulling loads is hard work.

Animals burn many more calories when working than when idle or grazing. This means that the energy requirements of an animal will increase with the work load. Experience and research in tropical areas have shown that animals need about twice their normal energy maintenance requirement when they are used for medium-intensity draft work.

Without this additional food, draft animals grow thin and weak, because they must burn body tissue in order to produce the energy needed to perform work. Not only do these animals lose strength, they become increasingly susceptible to injury and disease. An adequate diet is especially important to young draft animals because their growth may be stunted or their con-formation affected if food normally used to build bone and muscle must be converted into work energy during the critical early years.

Work animals have limited time to eat, since they work during the time they would normally be grazing or foraging for food. In the time remaining after work, they may not be able to find and eat enough grass to replace the calories lost during work.

**9.3. Basic units to Measure Performance**

The efforts of draft animals are often viewed only in terms of work accomplished, e.g., a plowed field, a harrowed rice paddy or goods transported. The basic inanimate physical principles such as friction, force, and speed which influence the process of doing the work are seldom considered; consequently, the power generated by animals is utilized inefficiently and less work is completed. An understanding of the physical principles involved when using animal power is essential for comparing the working ability and efficiency of draft animals between and among species. This chapter defines these principles and evaluates the effects on animal performance.

**9.3.1. Force**

The standard unit of force is a Newton (symbol N). The definition of a Newton is based on the force resulting from acceleration acting on a mass of one kilogram. Since the acceleration due to the Earth's gravity is about 9.8 meters per sec, the weight of one kilogram mass (on most of the earth's surface) is about 9.8 Newton’s, i.e. one kilogram of mass weighs about 10 Newton’s. Thus although some purists may object, for all practical purposes a Newton can be simply considered as a unit of force equivalent to 100 grams weight. Thus 10 N is equivalent to one kilogram (1 kg or 2.2 lb). Newton units are used in this book as these are the accepted international standard, and will be found in other references. Older texts have generally referred to kilograms force (1 kgf ~10 N) or pounds force (1 Ibf ~ 4.S N). Some authors have used deca-newtons (dN) which are broadly equivalent to kilograms and some have used kilo-Newton (kN) equivalent to 100kg force. However for most people it should be sufficient to remember that dividing the Newton figure by 10 will give the kilogram equivalent. By way of illustration, a low-draft implement such as a light seeder might impose a draft resistance force of about 200N; a small mouldboard plow in light soils might require a tractive force of 500N while a double mouldboard plow in heavy soils might require a force of 2000N.

**9.3.2. Work**

Work involves moving a force through a distance. As an implement is pulled through the soil, the animal or team exerts a tractive force and as it moves across a field, it performs work. Work done is not a function of time, so that however long an operation takes, the actual work done is the same. Plowing a field to a particular standard and depth entails the same amount of work (in principle) whether it is completed in one morning, in one day or in many days, whether the work.

The units used to measure work are joules (J), kilojoules (kJ) or megajoules (MJ). A joule is the work of moving one Newton through one meter. Since 1 kg weighs about 10 Newton, lifting one kilogram through one meter is equivalent to about 10 joules of work.

**9.3.3. Power**

Although cattle appear to have been first used in 3200 BC., by the Sumerians for transport, plowing, and threshing of grain, it was not until the 18th century that the power produced by animals while doing work was actually measured. The unit of measure was termed horsepower by James Watt, inventor of the first practical steam engine. To put his steam engine on the market, Watt needed to determine the number of horses his steam engine could replace. The amount of power was determined by using horses to pull a rope passed over a pulley attached to a weight at the bottom of a deep well. One horse could easily raise a weight of 100 lb (45 kg) while walking at 2.5 m (4 km) per hr or 220 ft (67.1 m) per min. This accomplished 22,000 ft lb (3041.6 kg m) of work). Watt increased this by 50% to allow for friction in his engine and for good measure, thus establishing 33,000 ft lb (4562.4 kg m) Per min.

**9.4. Assessment of Work Performance of Draft animal power**

**9.4.1. Units Associated with Work.**

The units used to measure work are joules (J), kilojoules (kJ) or mega joules (MJ). A joule is the work of moving one Newton through one meter. Since 1 kg weighs about 10 Newton’s, lifting one kilogram through one meter is equivalent to about 10 joules of work.

Similarly pulling a 1000 N force through 1000 m (1 km) is equivalent to about one mega joule of work. By way of illustration, during a relatively light work schedule, a pair of 250 kg oxen might achieve 2.5 MJ of work in a day by pulling a 500 N force through a distance of 5000 m; in a more rigorous schedule, a pair of 350 kg oxen might achieve 12 MJ of work in a day by pulling a 800 N force through a distance of 15,000 m. Seeding a hectare of land with a low-draft (200 N) implement at 60 cm spacing (requiring travelling 17,000 m) might represent 3.3 MJ of work. Similarly plowing a hectare of land with a small 15cm mouldboard plow in light soils might involve work of 33 MJ (a 500 N force through 66,000 m, the distance a 15 cm implement has to travel to cover a hectare). In theory, plowing with a double mouldboard plow adjusted to the same depth would involve the same amount of work as the draft force would be doubled (2 x 500 N) but the distance moved would be halved (33,000 m). Plowing a hectare of similar soil slightly deeper with 25cm single (or double plow) might involve 40 J (a 1000 N force through 40,000 m or a 2000N force through 20,000 m).

**10. Management of different Draft animal power**

**10.1. Housing of Draft animal power**

**10.1.1. Quality of Animal Shelter**

Because of their value, draught animals offer one of the best ways of introducing improved animal husbandry methods to local farmers. A simple shelter or lean-to would provide the necessary protection from rain. Shelters should have a sloping floor to allow run-off to keep them dry and clean, and dung should be removed daily to reduce the problem of flies. Good hygiene is essential and more harm than good can be caused by allowing houses or shelters to become dirty. Houses should be periodically disinfected and clean bedding provided. Troughs for food and water should be provided.

**10.1.2. Housing for Cattle**

It is important to give work animals a place where they can eat and rest unbothered by weather, insects, other animals, and uncomfortable restraints such as hobbles, short ties, and narrow stalls. In the tropics, animals do not need elaborate shelters, but stabling them in dry, comfortable surroundings contributes to their overall soundness and work value.

A lean-to with a straw roof provides shelter from heat, rain, and wind .A simple lean-to is a wall four or five meters long and two and a half meters high, with a canopy on one side. It is built on high ground so water drains away. The wall is situated so it blocks prevailing winds, and the roof made on the side opposite the wind. An earthen floor is adequate, but straw or sand should be kept in the area where the animal sleeps, or "beds down."

Manure and urine-soaked straw should be collected regularly to reduce fly populations and hoof infections. It makes excellent compost, but should not be piled or stored near the stable area.

A smoke fire made from a green log or slog burning stump helps keep the shelter area free of mosquitoes and flies.

Trough or rack can be built into the wall of the lean-to to hold hay, grain, salt licks or water buckets.

**10.1.3. Housing for Equines**

Draft animal house should be prepared using local simple material (i.e. wood, mud briks) to keep the cost to minimum.

In warm dry climate roof supported by poles, however in cool areas half or three quarters of walls is solid. The space requirement of the individual animal is 1.5 -2 ms wide. A yoking bar is fixed at height of 90cm -150cm from the ground used during feeding and watering, harnessing and health care routine.

Horses often prefer standing to lying on a hard, cold, or wet surface, so owners should make special efforts to ensure that bedding is ample.

**10.2. Feeding and Nutritional Requirement of Draft animal power**

**10.2.1 General Management of Feeds**

Draft animal need several important feed components - energy, protein, vitamins, minerals and water. Different feeds contain these components in different amounts. Provided natural pasture is abundant and feeding of draft animal should not be a major problem. Besides forage (or roughage) from grazing, the animals may be fed additional forage and concentrates provided by the farmer, depending on age and workload.

In general, feeding strategies should be aimed at maintaining adequate body condition during periods of work stress or reproductive stress. Some preserved forage or concentrates should be stored for such periods. This is particularly important if draft animal have to work at the end of the dry season, when natural pasture is scarce.

A properly fed animal will live longer, work harder and resist diseases better. If well fed, females will become pregnant sooner, and pregnant and nursing Jennies will produce bigger and healthier foals. Foals given extra food at weaning will grow faster, survive disease better and end up larger. Supplements are most important in the following circumstances:

* Local grazing is poor because of drought or over-grazing.
* Animals must walk long distances for food.

**10.2.2 Nutritional Requirements of Draft animal power**

Age, sex, amount of draft generated, and duration of work will determine energy requirements. Mature oxen for example, have requirements for maintenance and work, while immature animals and pregnant or lactating cows employed for draft have additional needs. Many of the estimated requirements in the literature are based on standards used for draft of non working animals in temperate regions and are often not representative of animal needs under "actual farming" conditions. This section examines available data on energy requirements for working animals and attempts to categorize three areas: maintenance, growth, and work. The effects of physical

**10.2.3. Supplementary Feeding of Draft animal power**

The amount of extra feed that draft animal need depends on their size, the amount of work done, the quantity and quality of pasture available and the type and quality of feed used for supplementation.

Draft animal have stomachs designed for frequent small meals (such as when grazing naturally) so the more often they are fed the better. It is not a good idea to feed a lot of forage in the morning before work.

Give small amounts then and during rest periods in the day. Supply supplementary forages in the afternoon and evening, allowing donkeys to feed during the night. A nursing jenny needs the equivalent of about 2 - 3% of her body weight a day if she is only fed forage. A working donkey needs about 3 - 4% of its body weight a day. Thus an average donkey will need about 4 to 6 kg of fodder a day if nursing or working. A jenny that is both nursing and working will need more. If a donkey cannot obtain this amount from available grazing, it will need supplements. In any case, if donkeys are fed concentrate each working day, they will require less grazing, and learn that work brings rewards. If a donkey is fed well, but is still thin, it probably has internal parasites which need treating.

**10.3. Health care and welfare of Draft animal power**

An animal in good health is one that is sound in body; and free from physical disease and pain.

Health, together with welfare, is fundamental to a productive working animal.

Pearson (1986) makes the important point that little benefit will be gained from better feeding, training and improved harnessing and implement design if health is neglected. Care is required to prevent stress and subsequent loss of health to ensure the animal can carry out timely work.

Draught animal husbandry should be as stress-free as possible. If animals are handled frequently, stress caused by contact with human beings will be negligible. Animals should be groomed (washed and brushed) and inspected daily for wounds, skin infections, signs of harness-rubbing and ticks. Hooves should be inspected and trimmed as necessary.

Prior to the main cultivation season, attention should be given to health and condition to ensure that animals will be able to complete the work necessary. Since stress can arise because of poor nutrition, attention at this time to building up body condition is important.

Good vaccines are available against rinderpest, anthrax, black quarter, contagious bovine pleuro-pneumonia, haemorrhagic septicaemia, pasteurellosis and tetanus, and drugs are available for protection against trypanosomiasis. It should be borne in mind that vaccinations should be given at a time that work stress does not interfere with the immune response. Animals should be tested for tuberculosis, brucellosis, trypanosomes, piroplasmosis, Johne's disease and helminths. Cattle can be sprayed strategically against ticks using hand sprays or washing. Routine drenching against roundworms and flukes is recommended, particularly where animals are working in wetter areas.

Ectoparasites such as lice can be treated with insecticides. Brushes should also be treated to stop the spread of mange. Ringworm, which is more common in younger animals, can be treated with tincture of iodine daily on the lesions. Wounds and scratches can predispose to other infections such as streptothricosis and should be washed and disinfected. Healing ointment will help protect the wound and keep flies off.

Proper nose rings should be used rather than rope to reduce irritation and laceration of the nasal septum. Horn injuries from tight ropes end neck and shoulder injuries from harnesses can easily be avoided by careful attention to harnessing methods. Ropes and harnesses should be disinfected regularly. Attention should be given to the possible dangers end causes of lameness in the locality where animals work or graze. Stones and earth can become stuck in the hoof, as well as thorns and other sharp objects. Strains and sprains need complete rest.

**10.4. Record Keeping**

**10.4.1. The Importance of Record Keeping**

Records are information preserved in permanent form, especially in writing. Sound and images can also be recorded. Farmers need to know the detail about their draft animals, price, age, and condition. Without records it will be difficult to remember the amount and condition of each animal.

Records expose strengths and weakness of an enterprise.

Importance of record keeping;

* Aids in selection of animals, which are most suitable for draught.
* Enables monitoring of farm implements and other accessories, procurement, depreciation and movement. E.g.: borrowing.
* Enables the stockowner to monitor profit or loss and take remedial.
* Provide use full information for planning, budgeting and securing of loans.