Draft animals in the world

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Abstract

The paper, illustrated with photos, considers draft animals with worldwide geographical and historical perspectives and examples of the diverse operations undertaken. In various regions and at different times, domesticated animals such as cattle, buffaloes, yaks, horses, donkeys, elephants, camels, llamas, goats, reindeer and dogs have been used as transport animals (packing, pulling sledges or carts and/or riding). Draft animals have been important for soil tillage, and can be used for planting, harvesting and associated agricultural processes (irrigation, threshing, milling, logging). Some options for yoking, harnessing and combining work animals are reviewed. There have been major changes in animal power use in the past 150 years, with increasing motorization worldwide but also some expansion in the areas of draft animal use. Motors have a strong comparative advantage over animals for rotary movements (milling and irrigation), but less for steady pulling, intermittent short-distance transport and manoeuvrability in constrained or difficult environments. People continue to use or adopt animal power if they see benefits (including labour-saving, environmental and ethical advantages) and there is a supportive environment. They stop using draft animals if affordable motorized alternatives are available, they lack labour and/or the prevailing environment is unfavourable or lacking supporting service providers. There is need to overcome the common perception that draft animals are old-fashioned. This requires education and positive audio-visual and social media information. Heritage organizations could assist by combining retrospective information with modern, forward-looking examples of draft animals, and working with national and international networks of user-groups, researchers and concerned stakeholders.

Résumé

L'article, illustré de photos, examine les animaux de trait dans une perspective géographique et historique mondiale et donne des exemples des diverses opérations entreprises. Dans diverses régions et à différentes époques, les animaux domestiqués tels que les bovins, les buffles, les yaks, les chevaux, les ânes, les éléphants, les chameaux, les lamas, les chèvres, les rennes et les chiens ont été utilisés comme animaux de transport (pour le bât, tirer des traîneaux ou des charrettes et/ou monter). Les animaux de trait ont été importants pour le travail du sol et peuvent être utilisés pour la plantation, la récolte et lestravaux agricoles associés (irrigation, battage, mouture, abattage). Quelques options pour atteler, harnacher et associer les animaux de trait sont passées en revue. L'utilisation de la force animale a connu des changements majeurs au cours des 150 dernières années, avec une motorisation croissante dans le monde entier mais aussi une certaine expansion dans les domaines d'utilisation des animaux de trait. Les moteurs présentent un avantage comparatif important sur les animaux pour les mouvements rotatifs (fraisage et irrigation), mais moins pour la traction régulière, le transport intermittent sur de courtes distances et la maniabilité dans des environnements contraints ou difficiles. Les gens continuent d'utiliser ou d'adopter la traction animale s'ils y voient des avantages (notamment en termes d'économie de main-d'œuvre, d'environnement et d'éthique) et s'il existe un environnement favorable. Ils cessent d'utiliser les animaux de trait si des alternatives motorisées abordables sont disponibles, s'ils manquent de main-d'œuvre et/ou si l'environnement est défavorable ou s'il n'y a pas de prestataires de services. Il est nécessaire de surmonter la perception commune selon laquelle les animaux de trait sont démodés. Cela passe par l'éducation et par une information positive dans les médias audiovisuels et sociaux. Les organisations patrimoniales pourraient apporter leur aide en combinant des informations rétrospectives avec des exemples d'animaux de trait modernes et tournés vers l'avenir, et en travaillant avec des réseaux nationaux et internationaux de groupes d'utilisateurs, de chercheurs et de parties prenantes concernées.

Kurzfassung

Der mit Fotos illustrierte Beitrag befasst sich mit Zugtieren aus weltweiter geografischer und historischer Perspektive und zeigt Beispiele für ihre vielfältigen Einsatzmöglichkeiten. In verschiedenen Regionen und zu verschiedenen Zeiten wurden domestizierte Tiere wie Rinder, Büffel, Yaks, Pferde, Esel, Elefanten, Kamele, Lamas, Ziegen, Rentiere und Hunde als Transporttiere (zum Tragen, Ziehen von Schlitten oder Karren und/oder zum Reiten) eingesetzt. Zugtiere waren wichtig für die Bodenbearbeitung und können für die Aussaat, die Ernte und die damit verbundenen landwirtschaftlichen Prozesse (Bewässerung, Dreschen, Mahlen, Holzeinschlag) eingesetzt werden. Es werden einige Optionen für das Anspannen, Anschirren und Kombinieren von Arbeitstieren untersucht. In den letzten 150 Jahren hat sich die Nutzung der tierischen Arbeitskraft stark verändert, wobei die Motorisierung weltweit zugenommen hat, aber auch die Nutzung von Zugtieren zugenommen hat. Motoren haben einen starken komparativen Vorteil gegenüber Tieren bei rotierenden Bewegungen (Fräsen und Bewässerung), aber weniger bei gleichmäßigem Ziehen, intermittierendem Kurzstreckentransport und Manövrierfähigkeit in eingeschränkten oder schwierigen Umgebungen. Die Menschen nutzen weiterhin tierische Antriebskraft oder entscheiden sich für sie, wenn sie die Vorteile sehen (u. a. Arbeitsersparnis, ökologische und ethische Vorteile) und ein günstiges Umfeld vorhanden ist. Sie stellen die Nutzung von Zugtieren ein, wenn erschwingliche motorisierte Alternativen zur Verfügung stehen, es ihnen an Arbeitskräften mangelt und/oder das vorherrschende Umfeld ungünstig ist oder es an unterstützenden Dienstleister:innen fehlt. Es gilt, die weit verbreitete Meinung zu überwinden, dass Zugtiere altmodisch sind. Dies erfordert Aufklärung und positive audiovisuelle und in den sozialen Medien verbreitete Informationen. Heritage-Organisationen könnten dabei helfen, indem sie historische Informationen mit modernen, zukunftsorientierten Beispielen von Zugtieren kombinieren und mit nationalen und internationalen Netzwerken von Nutzer:innengruppen, Forscher:innen und Betroffenen zusammenarbeiten.

Resumen

El artículo con fotografías ilustrado examina animales de tiro desde una perspectiva geográfica-histórica global. En diversas regiones y épocas, animales domesticados como el ganado vacuno, búfalos, yaks, caballos, asnos, elefantes, camellos, llamas, cabras, renos y perros se han utilizado como animales de transporte (embalando, tirando de trineos o carros y/o montando). Los animales de tiro han sido importantes para el laboreo del suelo, y pueden utilizarse para la siembra, la cosecha, entre otros (riego, trilla, molienda, tala). En los últimos 150 años se han producido importantes cambios en el uso de fuerza animal, con una creciente motorización en todo el mundo, pero también una cierta expansión en las áreas de uso de los animales de tiro. Los motores tienen una gran ventaja comparativa sobre los animales para los movimientos rotativos (molienda y riego), pero menos para el arrastre constante, el transporte intermitente a corta distancia y la maniobrabilidad en entornos limitados o difíciles. Si los beneficios son visibles, existe una tendencia entre la población a utilizar o a adoptar la tracción animal en los trabajos agrícolas en los entornos que lo permiten. La tracción animal se ve sustituida por alternativas motorizadas en los entornos donde esta es más asequible o donde se carece de proveedores de servicios de apoyo. La percepción común sobre los animales de tiro, su relación con la era preindustrial y el uso de estos de forma anticuada es un imperativo de cambio. Para ello es necesario educar e informar de forma positiva a través de medios audiovisuales y sociales. Las organizaciones patrimoniales podrían ayudar combinando información retrospectiva con ejemplos modernos de animales de tiro con vistas al futuro, y trabajando con redes nacionales e internacionales de grupos de usuarios, investigadores y partes interesadas.

Introduction

This paper will endeavour to provide a concise overview of draft animals in the world, taking historical, geographical, technological and socio-economic perspectives. It is based on the authors' reading, personal observations in over a hundred countries and discussions with colleagues of various disciplines in numerous countries. It will start with an historical view and end with some current issues in the 21st century. It will briefly consider the various types of draft animals, and some of the equipment associated with the wide range of operations draft animals can perform. This overview, including the many photographs that illustrate it, is intended to introduce the subject and provide a basis for understanding the diversity and complexity of draft animal issues. It is intended to stimulate interest, discussion and encourage readers to delve deeper into the many multi-disciplinary issues being skimmed through. While taking a worldwide perspective, it is complemented by a companion overview paper by the same authors that concentrates on sub-Saharan Africa[1].

From the outset, it must be stressed that the authors are aware of the problems associated with such an overview and request a sympathetic understanding. It is necessary to simplify complex issues and provide generalizations that do not represent all situations and circumstances. For all the subjects and issues dealt with, there are other works that go deeper and provide more detailed, authoritative information. The authors encourage readers to look for more specialized expertise for understanding the different historical periods, the equipment used, the biology and welfare of the animals and the socio-economic issues of specific countries, communities and people of different status, wealth, age, gender, culture and ethnicity.

Historical, geographical and cultural perspective

The origins of draft animals

Exactly where and when the first animals were used for work is a source of archaeological conjecture and a continuing debate. Table 1 provides simplified, approximate timelines.

Many of the larger species of work animals may well have been initially kept for meat and milk and were subsequently trained for use in transport by carrying goods or dragging loads[3]. The use of simple ard ploughs has been associated with remains of early domesticated cattle and buffaloes, but the dates of the first uses of work cattle and buffaloes remain debateable.

The spread of draft animal technologies

Once animal species had been domesticated, and technologies to permit transport and/or tillage had been invented, the animals and the technologies gradually spread, through migration, trade and military campaigns.

- Between 5000 and 2000 years ago, the use of draft animals had spread throughout most of Asia, North and Northeast Africa and Europe
- Between 2000 and 500 years ago, pack and riding animals spread through the Sahel
- Europeans carried wheeled transport and tillage technologies to the Americas (about 500 years ago) and to West, Southern, East and Central Africa (about 350-150 years ago). The spread of draft animal technologies in Africa is discussed in the companion paper[4].

The value of animals to permit the movement of humans and goods, through riding, packing, sledges and wheeled transport is clearly highly beneficial, and draft animals can assist trade, military operations and governance. Their value for tillage depends on the agricultural systems in operation. The greatest benefit is likely to come on flood plains, where floods replenish soil nutrients, and it is possible to till the ground and grow crops every year. It is no coincidence that the development of some civilizations and the early use of ard ploughs appears to have occurred in flood-plain areas, including Mesopotamia, the Nile valley, the Indus valley and various significant water courses in South, Southeast and Eastern Asia.

Away from such sites, the predominant system of crop cultivation tends to involve shifting cultivation. Trees and shrubs are felled and burned, and crops are planted in the ash-enriched soil. After one or two years, the farmers move to a new site and the forest or woodland gradually grows back. Under this type of system, that has been widely used in the past century in parts of Africa, Asia and the Americas, the roots of trees and shrubs remain in the soil and tillage with animals is impracticable. Only when the stability of communities and the shortage of available land justify the effort of removing the roots from the soil, is it worth moving to animal-powered tillage

Animal type	Domestication (years ago)	Location	Initial work uses
Bos taurus cattle	10,000	Mesopotamia region	Transport and tillage
Bos indicus cattle	7,000	South Asia	Transport and tillage
Water buffaloes	6,000	South Asia and Southeast Asia	Transport and tillage
Donkeys	6,000	Egypt / Northeast Africa	Transport
Horses	5,500	Eurasian Steppes	Transport
Bactrian camels	5,000	Central Asia	Transport
Dromedaries	4,000	Northeast Africa/Arabian Peninsula	Transport
Llamas	4,000	Multiple Andean locations	Transport
Dogs	4,000	Artic circle (Asia/America)	Transport
Reindeer	2,000	Siberian arctic	Transport

Table 1 – Simplified timeline of the domestication of some draft animal species[2]

1 Mudamburi/Starkey 2022.
2 Based on many different sources.
3 Russell 2012.
4 Mudamburi/Starkey 2022.

and the use of natural or artificial fertilizers. This helps to explain why the use of draft animals for tillage did not spread rapidly in sub-Saharan Africa, and comparable farming systems in parts of Asia and the Americas. Another issue in sub-Saharan Africa was the stratification of some farming systems, with crop farmers keeping only small livestock and certain tribes maintaining cattle herds in itinerant systems that moved the animals in search of pasture.

Draft animals become an integral part of cultural heritage

As work animals are adopted within societies, they and their associated technologies become part of the prevailing culture. People identify strongly with their local animals, yokes, implement designs and methods. The animals and their technologies are included in local songs, festivals and works of art. The local yokes, harnesses and brassware are proudly reproduced and replicated, and may differ from those of neighbouring communities and countries. The detail included in the painting of carts, the carving of yokes and the decoration of harnesses and saddles is far more than is justified by their utilitarian uses. The effort and costs of such decoration are justified by cultural appreciation and proud tradition.

The cultural heritage of draft animal artifacts is appreciated and preserved by numerous museums around the world. The art of ancient Egypt is exceptional, with work animals (oxen, cows, donkeys, horses and, in the later periods, camels) proudly displayed in bas-reliefs, three-dimensional models included in burials and the artwork of papyrus paintings. In India, there are many local breeds of cattle developed in different areas as work animals, and numerous variations in cart design, specific to particular geographical areas. In Europe too, the animal-drawn cart designs are specific to particular regions. In the Museum of English Rural Life in UK, there is a large collection of cart and wagon designs, each associated with particular counties. The traditional designs of ploughs used for swamp rice cultivation vary throughout South and Southeast Asia as do the yokes. In France, withers yokes are traditional in many departments, while yokes tied to the horns may be used in neighbouring areas. There is no geographical logic to the distribution of these two very different types of yoke but farmers in all areas say that their yoking system is superior to that of their neighbours. In Portugal, heavy, elaborately carved and painted yokes are used, that are not ergonomically beneficial to the animals, but they give the animal owners cultural pride. Similarly, the colourfully painted ox carts of Costa Rica are a cultural heritage.

Different cultural traditions can develop over the centuries, but they can also arise very quickly. In some areas of sub-Saharan Africa, draft animals only spread widely from the 1950s, and in this time the design of yokes and the colour of carts has become 'traditional' in specific geographical areas. The painting all ox carts (made by different workshops) yellow, or blue or blue-and-black reflects a new local tradition, rather than the colour preferences of individual owners[5].

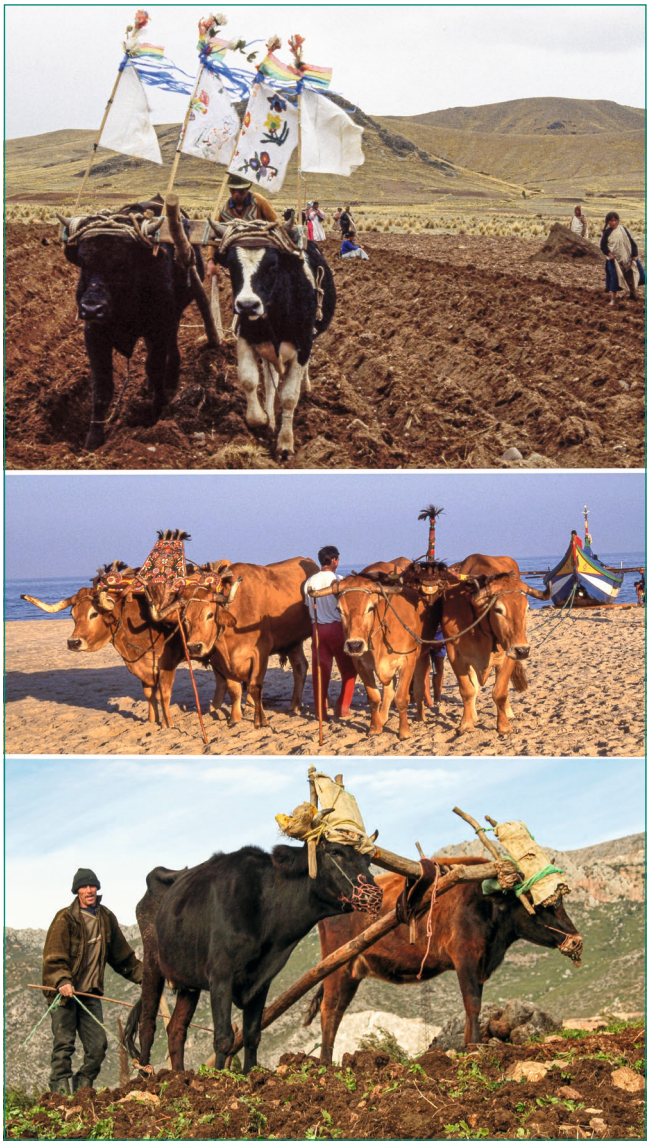

Figure 1 *– Cultural heritage reflected in ox yokes. Top: Flags on yoke celebrating potato planting in Bolivia. Middle: Heavy carved and painted yokes on fishermen's oxen in Portugal. Bottom: Yoke extensions to reduce fly nuisance on cows in Morocco*

Affordability, status and gender issues

In modern times, western media (fixated by motorization) has tended to portray work animals as a backward technology used by poor people. However, the poorest people do not, and never have, owned work animals. Modern-day owners of work animals may be poor relative to richer people owning tractors and trucks, but they are wealthy compared with many of their peers who cannot afford the cost of buying and maintaining work animals. A woman with a donkey to carry her sack is not as poor as her neighbour who must carry her sack herself. Hence, the expression in Ethiopia 'a woman without a donkey is a donkey'.

Work animals have always been expensive in terms of their purchase price (or their potential sale value if bred by the owner). In addition, there are the investments in time and resources in order to train the animals and care for them throughout the year, including in times of feed shortage (such as dry seasons or winters). Keeping animals close to the homestead may require storing and carrying feed resources. Allowing animals to graze freely

5 Starkey 2001.

may require herding supervision, fencing and/or risk of theft. One mitigating solution employed by resource-poor smallholder farmers in many countries throughout the world, has been to use cows for work. This removes the need to feed oxen during the lean months and increases the benefits as the working animals also provide milk and calves.

***Figure 2** – People pulling implements due to lack of animal power in Bolivia (top) and India (below)*

As with many technologies in the early years of adoption, only high-status people can afford to own working animals. Then as the technology spreads and becomes mainstreamed, others can invest in the benefits of working animals. Since their early domestication, horses have been considered as high-status animals, as have camels, in countries where these are important. In many cultures, men are considered as being of higher status than women, and to this day working horses, camels and oxen are usually owned and used by men. Donkeys, on the other hand, have often been considered as low status animals, and women have been responsible for them. While the 'low status' association of donkeys and women has been (and remains) unfortunate, women have been able to benefit from the load carrying capacity of donkeys. The recent high Chinese demand for *ejiao* (donkey gelatine) has led to the value of donkeys soaring and the consequent decimation of donkey populations[6]. Sadly, some men have sold donkeys that were greatly benefitting women.

6 Cheng 2018; Donkey Sanctuary 2019; Brooke 2019.

Diverse species and breeds

Diverse draft animals:

Around the world at least twenty types of animal have been used for work. The main draft animals have been bovids, including cattle (*Bos taurus* and *Bos indicus*) and water buffalo, the equids (horses, donkeys and mules) and the camelids (dromedary, Bactrian camels and llamas). Certain other species have filled important niche roles in particular environments. These include other bovids (yaks around the Himalayas, banteng in Indonesia and goats in many countries), Asian elephants, cervids (reindeer) and dogs. Other species (including moose, zebra. African buffalo and African elephants) have been trained successfully but were never widely used. Various animals also perform other work operations for humans, but these do not really come under the category of 'draft animals'. For example, sheep dogs and guide dogs are specialized working animals, donkeys can guard small livestock, messenger pigeons have been important for communications and rats have been used for bomb detection. While the local importance of all the work animals is acknowledged, this overview paper will concentrate on those animals that have been most widespread in the world and are still used in large numbers, especially the bovids and equids.

Bovids: *Bos taurus*, *Bos indicus* and water buffaloes

There are two main species of cattle (although whether they are species or subspecies is being debated). The humpless cattle (*Bos taurus*) have been used for millennia in the Middle East, North Africa and Europe. Humped cattle or zebus (*Bos indicus*) originated in South Asia and spread around Asia and into Africa in prehistoric times, where they have been bred to form a wide variety of indigenous zebu breeds. In the past 500 years humpless and humped cattle breeds have been exported to the Americas and throughout the world, leading to many crossbreds and some distinct breeds based on the hybrids. In West Africa, away from the Sahel, there are some dwarf cattle, notably the N'Dama, that are also humpless *Bos taurus* breeds. These evolved to become tolerant to the enzootic trypanosomiasis (sleeping sickness) and so they could inhabit the forest fringes that can still prove fatal to zebu cattle. Although they are small, N'Dama cattle have been successfully used for work since the 1920s[7].

There are many breeds of water buffalo, but two main types. Swamp buffaloes, with long, straight sweeping horns, have been bred mainly for meat and for work, notably for rice cultivation for which their large feet are well adapted. River buffaloes or dairy buffaloes, that typically have tightly curled horns, have been bred for milk production, although some (notably the surplus males) are used for work[8]. Swamp buffaloes are mainly used in rice farming systems in South and Southeast Asia (although in the region as a whole, far more oxen than buffaloes are used for rice cultivation). Dairy buffaloes are widely maintained on the Indian sub-continent and are also important in Egypt and some parts of southern Europe[9]. Although dairy buffaloes can be used for work, most working buf-

7 Starkey 1981.
8 FAO 1977.
9 Ibd.; Gilbert et al. 2018.

faloes are of the swamp type. The comparative advantages of buffaloes over cattle are that they can survive on low quality feed (including rice straw), they are individually strong (due to their weight) and they have large feet that allows them to walk easily in swamps. However, their thermoregulation through sweating is greatly inferior to cattle (hence their tendency to cool off in standing water) and so they can become heat stressed if worked hard. They are also slow at breeding and susceptible to some diseases to which zebu cattle are more resistant.

Figure 3 *– The two main types of buffalo. Top: Swamp buffalo with swept horns in the Philippines. Below: Dairy buffalo with curled horns in Pakistan*

An American academic team made an erroneous suggestion that the water buffalo could be an ideal animal for Sub-Saharan Africa[10] and this resulted in some failed attempts to introduce them as work animals. Their susceptibility to disease was problematic, they were expensive, and decades would be required to breed up a significant population. Moreover, local resistant zebu breeds were readily available and inexpensive, and a pair of zebus could achieve more in tillage in rice swamps or upland soils than a single buffalo[11].

Gender issues for 'oxen'

Throughout the world, oxen have been, and remain, the most used animals for soil tillage. In English (and many other languages) the word 'oxen' (or buey, bœuf, boi) means a work animal and/or a castrated male animal. The two meanings are overlapping because most working cattle have been castrated males. However, not all working cattle are castrated oxen. In some countries, including Chad, Nigeria and Mexico, intact bulls may be used for ploughing and even riding. Some 'work oxen' are cows and this is quite common in Southern Europe, Turkey, North Africa, Indonesia and the altiplano of Bolivia. Papyrus paintings from ancient Egypt clearly portray udders on some of the working animals. As has been noted, smallholder farmers with intermittent draft work may use cows that provide a better return on feed and labour resources, providing calves and milk as well as work, manure and meat. This switch from oxen to cows has been a farmer-led innovation, by farmers with modest work requirements and limited access to feed resources. Some professional researchers and agricultural extension workers had not noticed this trend, and only learned about this practice when they looked closely below the working animals or talked with the farmers. It is not uncommon to hear people concerned about the impact of the work on achieving and fulfilling pregnancy. However, provided there is adequate nutrition, cows (as with humans) are able to carry out a modest amount of physical work without interfering with successful reproduction. The comparative advantages of oxen and cows for work was well illustrated in Portugal in the last decades of the 20th century, by an example of 'the exception that proves the rule'. Almost all the smallholder farmers who had not mechanized, used cows intermittently for transport and a modest amount of tillage. Another use of working cattle in Portugal at this time was to launch fishing boats and pull in long fishing nets. All these working cattle were castrated oxen, as they were needed to work in teams at least twice a day on almost every day of the year. Oxen

10 BOSTID 1981.

11 Starkey 1990.

Figure 4 *– Two cows with head yoke ploughing in Spain*

were better for the commercial specialized application, while cows were more appropriate for the multipurpose requirements of smallholder farmers.

Equids: horses, donkeys, mules and hinneys

Horses

Historically, horses have tended to be high-status transport animals, used for riding (including racing) and pulling chariots, carts and wagons. They tended to have high purchase and maintenance costs, which contrasted with the cheaper, multipurpose and less risky cattle, that could be more easily afforded for farming and transport operations, and which could be converted into valuable meat if necessary. Over the years, breeding has led to the light, fast thoroughbred racing horses, the heavy, strong draft horses and the intermediate, strong but fast horses used for military purposes. All three types, as well as smaller ponies, can be used for work, depending on their availability, cost, maintenance needs and work requirements. In South Africa, horses rejected by the racing industry have been used to pull coal delivery carts and some have also been used by small-scale farmers for tillage.

Historically, and to this day, the main use of horses has been for transport which benefits from their important comparative advantage of speed. In industrialized countries, as motor power increasingly replaced working animals on farms and roads, urban collection and delivery services based on horse carts and wagons persisted for decades. This was because animal transport is well adapted to short distance travel and much waiting. This advantage, combined with the high-status image of horses, also makes horse carriages common around tourist locations in many countries in the modern world.

In Europe, between the 13th and 19th centuries, horses gradually replaced oxen as the main animals used to pull ploughs and other implements[12]. The slow transition was repeatedly interrupted by wars, that increased the demand by the military for horses. The development of more complex implements for seeding and harvesting accelerated the change, as the speed and acceleration of horses were well-adapted to pulling the new machines. Heavy horses were shipped around the world to the Americas (mainly to temperate and highland areas), South Africa and Australia. Equids seldom thrive in hot, humid conditions and the use of horses in Africa and other tropical areas is primarily in semi-arid and highland zones. Here they are mainly used for transport, with a relatively small number being used for tillage.

Donkeys

Donkeys are well adapted to arid environments, and they do not thrive in the humid tropics. They need less feed and attention than horses. They are mainly used as transport animals in semi-arid zones and mountainous regions, notably for packing and pulling carts. Larger types of donkeys can be ridden, and some of the larger breeds have been selected for a gait that provides a comfortable ride. Their ability to carry packs on narrow paths in mountainous environments, gives them a comparative advantage over most motorized transport. They also have the advantages of being cheap (relative to other work animals), of low risk of theft and able to survive on minimal feed resources. However, in the past decade, the high Chinese demand for *ejiao* (donkey gelatine) has greatly increased their value and thereby the theft risk. Donkeys are generally smaller than cattle and horses (although there are some very large breeds) and can only pull relatively small implements, unless they are harnessed in teams. Nevertheless, smallholder farmers who own donkeys may use them for light tillage operations, particularly if they have no alternative animals.

Mules and hinnies

Mules are crossbred animals made by crossing a female horse and a male donkey. Hinnies are made from crossing a male horse with a female donkey. The hinny cross is more difficult to produce, and hinnies are much less common. Both crosses combine the resilient sturdiness and sure-footedness of the donkey with the larger size of the horse, with mules generally being bigger and stronger than hinnies. Since mules and hinneys are sterile, there are no breeding populations and specialized mule breeders are able to charge high prices. Mules tend to be used as dedicated transport animals (packing or pulling carts or wagons), for example by full-time commercial transporters. They can be used for riding and for tillage but are this is less common. Their temperament and cost encourage owners to keep them employed throughout the year.

Figure 5 *– Top: Hinny used for pack transport in Nepal. Below: Large mule weeding maize in USA*

12 Collins 2010.

Camelids

The use of dromedaries (one hump camels), Bactrian camels (two humps) and llamas has been important in specific environments. Dromedaries evolved in arid, sandy environments and their heat tolerance, water conservation, large feet and long stride make them excellent for riding and pack transport in arid zones, notably the Middle East and the countries bordering the Sahara. They can also be used for pulling carts or wagons, including in northwest India and in Pakistan. Where they are owned and used for transport (their main role), they can be used for tillage, but their height does not make draft operations particularly easy. In some countries, camels have been used for irrigation and to turn mills to extract oil from seeds or olives[13].

Bactrian camels evolved in the Asian steppes and are adapted to cold weather and stony ground. They have mainly been used for riding and pack transport, with only limited examples of wheeled transport and tillage.

Llamas, and the much small alpaca, evolved in the Andes and have been used for centuries as pack animals. Their use for riding, wheeled transport and tillage has been minimal. While farmers who keep llamas for their meat and wool will sometimes use them for pack transport, most commercial transporters switched to donkeys and then, where roads were available, to motorized transport.

The use of camelids for transport continues in their various specialized zones, notably in circum-Saharan countries and India, but it has declined significantly due to motor transport.

Figure 6 – Women using pack llamas in Ecuador

Diverse harnessing systems

There is a huge range of saddles (for packing or riding) and harnessing systems for linking the animals to implements, carts or machines. The remains of ancient harnessing systems are quite rare (due to decay) but are part of the archaeological evidence of draft animal use.

Numerous designs of saddles, yokes, collars and harnesses have been developed over the years and have often become part of folk art and a cultural heritage. Aspects of their design are often robustly defended by their users, with equally vocal advocacy by the users of different designs in neighbouring areas.

Bovids

Yokes have been, and remain, the most common way of linking oxen, cows or buffaloes to the chains or beams used to pull implements, carts or wagons. There are two main types of yoke, that can be used with pairs of animals (most common) or single animals. Withers yokes rest at the base of the neck and the animal pushes with that part of its body (the withers). Head or horn yokes are tied to the horns and provide a more rigid attachment. This makes them particularly suitable for operations requiring the animal to brake the load being pulled (such as a cart or a log in forestry operations). Both types are widely used throughout the world, with withers yokes the most numerous as they are the dominant yokes in much of Asia and Africa. Head/horn yokes are particularly common in Latin America. While both types are widely defended by their owners, there appears to be no compelling evidence to show either type is particularly efficient or beneficial to the animals[14]. This is partly due to the huge variation of designs, so within-type variations make between-type comparisons difficult. However, badly made or badly fitted yokes of either type can cause problems, notably skin injuries.

Figure 7 – Top: Oxen with carved horn/head yoke in Mexico. Below: Oxen with pole-type withers yoke in India

Collars or breastbands are widely used with horses but are seldom used with bovids. There are historical examples of oxen working with collars, and in a small part of Europe (including parts of Germany and Switzerland) three-pad collars have been developed for use with single animals. However, despite some promotion attempts, such technologies have never become widespread, partly because yokes are effective and tend to be much cheaper and easier to fit.

13 Starkey 2000.

14 Id. 1989.

Equids

Equids are usually harnessed with breast bands or collars, although there are some historical and geographical examples of equids working with yokes. A well-fitted collar is considered the most comfortable and efficient means of harnessing a horse, mule or donkey for hard work, but it is also the most expensive and complicated means of doing so. In the tropics and subtropics, full collars are rarely employed. Throughout the world, breast band harnesses are widely used for light operations including carting. Carting operations generally require a small saddle on the back of the animal to take the downward load, and such saddles (as with pack saddles) have pads lying on each side of the vertebrae so that there is no direct pressure on the backbone[15].

The manufacture of leather harnesses is skilled work and good harnesses are expensive. This is particularly problematic for donkey users, as a good harness may cost more than the value of the animal itself. Therefore, low-income farmers and transporters often use cheaper materials, notably tyre rubber, webbing, sacking or ropes. These can damage the animals' skin particularly if joins are made using wire. In recent years some animal welfare charities have been promoting the local manufacture of equid harnesses from softer and less abrasive materials that are less expensive than leather.

Harnessing teams of animals

Most animals are worked singly (notably equids, water buffaloes and camelids) or in pairs (especially oxen). It is unusual for different types of animal to be worked together, although this sometimes happens when a farmer does not have a suitable pair of animals, and so substitutes an equid for a bovid. In North Africa, very different pairs of animals may be worked together, including cattle, equids and camels. This is made possible by each animal being fitted with a withers harness that connects with a beam (a 'belly yoke') running beneath the animals. With such a system, a donkey can plough with a camel, with the camel providing the strength and the donkey ensuring they walk in straight lines. However, linking different animals is always problematic for the animals as they have different strides and stepping rates.

Figure 8 *– Top: A camel and a mule fitted with withers bands and a 'belly' yoke ploughing together in Morocco*

15 Pearson et al. 2003.

Where two animals are insufficient for the power requirements, larger teams can be assembled. With oxen, this generally involves connecting pairs of animals in tandem with chains joining the various yokes. Teams of four or more animals can be used to pull wagons or implements, and this remains quite common in Southern Africa. Historically much larger teams were used for ploughing and pulling large wagons. The main streets of some towns in Africa, including Bulawayo, were made wide enough to allow wagons pulled by large spans of oxen to do a U-turn.

With equids, multiple pairs of animals can be harnessed in tandem with swingle trees behind the animals connected to eveners that connect with a chain to the next evener. For field operations, three or more equids, notably heavy horses, can be harnessed to work side-by-side, with a system of swingle trees and eveners to ensure the work is shared according to the strength of the various team members.

Large teams of draft animals allow one (or more) operator to control many animals, and so can be labour saving. However, large teams are slower and more complicated to harness, and require large fields in which to manoeuvre. In smaller fields, multiple teams of two animals pulling lighter equipment may be more appropriate, if sufficient labour is available.

Figure 9 *– A team of six donkeys pulling a three-furrow plough in South Africa*

Diversity of draft animal operations

Transport and soil tillage have been, and remain, the main uses of draft animals throughout the world, but work animals can also be used for many other more specialized operations including water-raising, crop processing and logging.

Riding and packing

One of the earliest uses of domesticated animals, notably equids and camelids, was getting them to carry people or goods. Millenia ago, horses became high-prestige animals allowing people (notably men) to travel fast and over long distances. This was very important for military purposes, and the use of cavalry in international warfare continued until the 20th century. Horse saddles and bridle systems were developed to improve the comfort and efficiency of riding. Camel saddles were also developed, and camels permitted both effective warfare and long-distance journeys and trading. Camels were also important for long-distance pack transport. Horses could also be used for packing, but their high status meant they tended to be used for riding and wheeled transport, allowing donkeys and mules to become the main pack animals.

Figure 10 *– Boy in Colombia riding to school on a donkey with a wooden saddle*

Donkeys have also been used for riding. Cattle have been used for riding (and warfare) and pack transport, but this has been, and remains, quite unusual.

In the 21st century, horses remain the main riding animal and are widely used in sport, recreation, ranching and for personal transport in remote areas. Donkeys and mules remain important pack animals in mountainous and remote areas, and still are available for use in military campaigns. Camels continue to be used for riding and packing in remote, arid areas as well as for prestigious sports.

Dragging and logging

Because dragging technology is so cheap and simple, it has been widely used with oxen in many countries and remains important for smallholder farmers in parts of Africa, Asia, Latin America, the Caribbean and Pacific. A simple V-shaped branch can act as the sledge, that is pulled by a chain attached to a yoke or harness. More complicated sledges can be used to move efficiently on snowy ground, and these can be pulled by dogs, equids or cervids. Training animals to drag loads, perhaps using simple wooden sledges to reduce the friction, probably happened early in domestication, preceding the wheel.

Figure 11 *– Pairs of oxen pulling sledges in Fiji (top) and Cuba (below)*

Logging uses similar principles, whether employed by a smallholder in North America dragging lumber or by a forestry enterprise extracting felled trees. Oxen, horses and mules tend to be the main animals used for logging, although the Asian elephant excelled at logging work. In addition to simple dragging with chains, friction can be reduced through the use of a simple sledge (to raise the leading end) or a sulky, a simple wheeled device that also raises the leading end to prevent it ploughing into the ground. With increasing concern for the environment, the benefits of animal logging over the use of heavy machinery are becoming more apparent. Some forestry enterprises in Europe are returning to animal-powered logging, to prevent the environmental destruction caused when forests have to be opened out to allow heavy machines to retrieve logs. Stratified systems are developed whereby animals (in Europe, mainly horses or mules) drag felled tree trunks to the tracks to which heavy machines are restricted.

Figure 12 *– Horse logging in Romania*

Carriages, carts and wagons

Various technologies involving draft animals pulling wheeled transport have been used for millennia. Until the 20th century, a high percentage of the world's land transport and trade depended on animal power. Two-wheel carts have been and remain the main wheeled transport pulled by bovids, equids and camelids, as they are relatively simple (and so cheap) as they do not require the two axles, four wheels and a steering mechanisms needed for carriages and wagons. However, animal-drawn carts with variable loads are not always well-balanced and tend to put some downward pressure on the animals. Four wheeled transport reduces the vertical load on the animals, makes loading and unloading easier (with or without animals in place) and allows much heavier loads to be drawn. So, carriages and wagons tend to be favoured by professional transporters and larger-scale farmers, while two-wheel carts are preferred by smallholder farmers and small-scale transport entrepreneurs.

In the 21st century, although the use of draft animals has declined, there are still tens of millions of ox carts in use worldwide, notably in India, as well as carts pulled by horses and donkeys, and to a lesser extent camels.

Figure 13 *– Top: Ox carts in Myanmar. Below: Horse pulling wagon of hay in Romania*

Ploughing, ridging and harrowing

The earliest ploughs were symmetrical ards with a wooden plough body attached to a long wooden beam that was pulled from the animals' yoke. From quite early times, the plough share became a metal chisel or spear that penetrated the earth. Such ploughs have remained in use for millennia, and many of the traditional ploughs used today in Asia, North Africa and Ethiopia (mainly pulled by oxen) conform to this pattern, albeit modified over the centuries of traditional use.

Figure 14 *– Farmer in Ecuador weeding with oxen using a traditional long-beamed ard plough*

Similar ards were introduced into Latin America by colonialists and have since become traditional. Ard ploughs perform tine tillage, which loosens the soil but does not invert it fully. A finer seedbed it made by a second pass, generally travelling in a different direction, and the loosened soil can be moved into ridges with the ard, if required.

Mouldboard ploughs were developed in Europe, to invert the turf or soil for weed control and in Asia to invert the soil in irrigated rice fields. With the industrial revolution, ploughs with wooden mouldboards were replaced by factory-made steel implements. Such ploughs were introduced around the world, including in sub-Saharan Africa. Despite the widespread availability of steel mouldboard ploughs for well over a century, ard ploughs generally remain important in the countries where they were (and are) widely used.

Symmetrical ploughs with two mouldboards are known as ridgers and these can be used for primary tillage, or for creating earthed up ridges from ploughed land. Ridging takes more effort and so is generally only done where there are benefits in water control or to maintain looser soil around the plant roots.

Figure 15 *– Pair of oxen in Cuba with a wide weeding yoke pulling a ridger to weed and earth up the crop*

Having broken the soil structure with a plough, larger clods can be broken down by passing with a harrow. This provides wide but shallow tillage using multiple tines. Ancient Egyptian harrows comprised a wooden frame and metal tines, and many traditional and modern harrows in use in the world today reflect this basic idea. With the industrial revolution came all-steel tine harrows and disc harrows (only suitable with strong animals). However, similar work can be achieved more cheaply by dragging branches of thorn-trees across ploughed land, and this has been used in some countries.

Puddling and levelling

Traditional ards or mouldboard ploughs can be used for primary tillage in rice production. However, irrigated rice requires the soil to be relatively impervious to water (to prevent it draining away) and for the field to be level, to ensure the water is of uniform depth and optimal for the rice plants. To achieve this puddling and levelling, animals (usually oxen) pull a plough around the flooded rice field, and through a combination of the implement and their footsteps, the soil is puddled so water is retained. Often at the same time, another pair of animals pulls a long horizontal bar across the field, moving soil from the higher ground to the lower areas. The weight of the operator standing on the leveller assists the process and the operator can stop and raise the implement to dump moved soil where it is needed. With multiple passes the field can be puddled and levelled and be ready for transplanting. Equids are seldom used in rice fields. Water buffaloes are very good at puddling and are the main draft animals in the Philippines and some other countries. Nevertheless, oxen puddle and level the majority of irrigated rice fields in the world that are cultivated using animal power.

Figure 16 *– Puddling and levelling rice fields using both oxen and tractors in Dominican Republic (top) and Nepal (below)*

Planting, weeding and spraying

Historically, and to the present day, most farming operations that use animal power involve primary and secondary tillage and transport. Planting has mainly been done by hand, as has weed control. This has been partly because planters require relatively complicated metering mechanisms to ensure appropriate seed spacing and without wide and uniform row spacing, weeding with animal power is difficult.

There is evidence of animal-pulled double-tube seed drills being used in China about two millennia ago and a similar design being patented in Italy in the 16th century. Single-tube planters dropping seeds behind an ard have been used in India. However, the initial development of the modern, multi-row seeder is generally attributed to Jethro Tull in the 18th century. Animal drawn seeders for small grain cereals gradually became widespread in the larger farms of Europe and North America and spread to other regions. Smaller scale farmers tended to continue with hand seeding and that remains common to this day. In West Africa, notably Senegal, the use of seeders for groundnuts, maize, beans and delinted cotton increased rapidly in the final decades of the 20th century, partly because some of the light, sandy soils allowed direct seeding without primary tillage. More recently, attention has been given to the use of heavier seeders and fertilizer applicators based on models currently in use in several

Latin American countries. These can allow direct seeding into the mulch remaining in conservation tillage systems and they have been recently trialled and promoted in parts of Africa and Latin America[16]. While initial research results appear favourable, the proof of the technology will be in sustained adoption.

Weeding with animal power is difficult with cereals that are closely planted, unless the crops are resistant to soil disturbance and trampling. In many traditional farming systems, plants were often multi-cropped and/or not in regular rows, so that weeding with animals was not practical without changing to line planting. However, perennial crops like vines could be weeded by simple animal-drawn tine tillage between the rows. Crops that are row-planted and widely spaced can be weeded with draft animals, whether working singly or in pairs. Animal-drawn weeding can save a great deal of manual hard work that is often performed by women. Single-row weeders can be a set of three or five tines or a ridging body that earths up the plants. Multi-row weeders are also available.

While animal-powered weeding can be beneficial in time saving and yields, it requires well-trained animals and fairly accurate row spacing, which are both investments in themselves. Hence weeding with draft animals is a more advanced technology that tends to be adopted some years after ploughing with animals has become a normal part of the farming system. Work animals can also be used to pull sprayers that distribute crop-protection chemicals, although this not a widely-used technology.

Figure 17 *– Weeding maize with animal power – Top: Ox in Myanmar Below: Horse in Portugal*

Harvest and post-harvest

Draft animals can be used for a wide range of harvest and post-harvest operations including, raising root crops, raising groundnuts, grain harvesting, grass cutting, threshing and various milling technologies. The oldest technologies, dating back several millennia, probably relate to threshing as animals can help remove grains from the seed ears by trampling or by pulling a simple threshing sledge over straw on a threshing floor. This technology is still used, notably in South Asia, Ethiopia and the Andes. Simple ards or ploughs or more specialized implements can be pulled through the soil to raise potatoes or crops like groundnuts. Such techniques remain common where such crops are grown in rows using draft animals (notably in Bolivia and the Sahel).

16 CIMMYT 2016; Chikulo 2019; FAO 2021.

Figure 18 *– Crop spraying with oxen in Cuba*

For most of human history, the cutting of grass and the harvesting of grain have been mainly manual operations, although there is continued research interest in the Gallo-Roman *vallus*, an animal-pushed implement that assisted the harvesting of grain[17]. Animal-drawn reapers and mowers were developed in the 19th century in Europe and North America and were mainly designed for the power and acceleration provided by two or more large horses. Adoption in those regions was quite rapid, but soon coincided with the development of traction engines and tractors. The technology remained in use in Eastern Europe until the end of the 20th century and also on the Amish farms in North America. While there was some spread to mainly horse-using farmers in Latin America, Southern Africa and Australia, there was little adoption by small-scale farmers in other regions, that generally relied on ox power.

***Figure 19** – Top: Shire horses pulling hay mower in UK. Below: Shire horse turning gear to power historic farm machinery in UK*

Using animals to process crops has had many long traditions, dating back millennia. Animals have been used to grind grains to flour, to extract oil from seeds or fruits, to pulp grapes or apples to make alcoholic drinks and to extract sugar from cane. The technologies generally involve an animal walking around in circles, pulling a beam that operates the mill. For crushing grains and fruits, the beam may connect to a stone wheel running in a channel containing the material to be crushed. Oil extraction may involve the beam being connected to a wooden pestle rotating in a mortar carved from a tree trunk. Sugar cane crushing involves a beam connected to geared vertical rollers that squeeze the juice out. This technology is only a few centuries old, but the traditional wooden *trapiche* for crushing sugarcane became widespread in parts of Latin America. Subsequently factory-made metal mills, using similar principles, became more common.

***Figure 20** – Oxen turning 'trapiche' mill to crush sugar cane in Honduras*

Animal powered mills have been used in most regions of the world, and many still exist. However, while animals are efficient at pulling loads in a straight line, they are less efficient at creating rotary movements, particularly as the equipment must be strong enough to remain intact should the animal's pull not correspond to the tangent of the circle. Small motors (petrol, diesel or electric) are able to produce high speed rotation that can be used for many milling operations. This partly explains why many animal-powered mills have been replaced, and animal powered milling technology is now quite rare.

Water raising

Using animals to raise water for household use, livestock or crop irrigation has also been a long-standing practice for millennia and has been used in most parts of the world. Simple mechanisms involve the animals walking away from a well, pulling a rope attached to the water container (such as a sheepskin bag) that needs to be raised. More complicated systems involve animals walking in circles to turn pumps. The ancient Egyptian *sakia* is a cleverly-designed spiral that draws up water from a shallow depth into an irrigation canal or other water receptacle[18]. While some similar designs of *sakia* are still in use today, the convenience of motor pumps has largely replaced animal-powered water raising throughout the world. Nevertheless, animal power is still used to raise water from some remote wells in circum-Saharan countries.

***Figure 21** – Raising irrigation water using a sakia in Egypt with a cow (left) and a donkey (right)*

17 Raepsaet 2002; AIMA 2017.

18 Löwe 1986.

Spread of motorization in the 20th century

For most of human history, there were no electric or fossil-fuel motors and most farming and land transport depended on draft animals and/or human labour. The situation changed in the 19th century with the development (with approximate dates) of steam locomotives (1802), traction engines (1859), tractors (1889), motor cars (1886), motorcycles (1894) and trucks (1896). While draft animals remained important in most regions of the world, throughout the 20th century, in the more industrialized countries cars, trucks and buses progressively replaced animal-drawn vehicles and tractors gradually replaced farm work animals. On a generational basis, the transition was gradual, but looking from the perspective of the millennium, the technological changes, and their socio-economic implications, were remarkably fast.

Investment in tractors can normally be justified by economies of scale, and so the processes of tractorization were generally associated with increases in farm sizes. Depending on the economic and land tenure situation of the country, farm size grew though the purchase of additional land, often the land of smaller farmers who had gone bankrupt. Where unused land was available, or it was controlled by authorities, farmers with tractors could be allocated additional land. Similar processes occurred as larger tractors and associated implements were developed. The tractors and machines were labour-saving, and the large farms no longer needed so many workers to tend the draft animals and perform manual work. So tractorization was associated with many smallholder farmers leaving farming and becoming employees in rural or urban areas, changing the socioeconomics of farming and rural economies as well as those of towns and cities.

Inevitably, richer farmers with larger holdings were among the early adopters of tractors, and those with smaller farms and less access to capital retained working animals. So, in Europe and North America, draft animals and tractors were both common until the 1950s. In the following 50 years, draft animals became increasingly uncommon. In low and middle-income countries, the process was much slower, and draft animals continued to be important for most of the 20th century.

There were numerous attempts to try to share the investment costs of tractor mechanization across multiple farms, through cooperatives or through public or private hire schemes[19]. The cooperatives and public schemes tended to have management problems, while the entrepreneurial schemes struggled to cope with high seasonal demand peaks. Success in serving rain-fed agricultural markets was very limited as everyone needed the tractors at the same time. Where there was widespread smallholder irrigation (as in the Punjab) the demand for tractors was much more uniform during the year, and this allowed some business models to work.

In low and middle-income countries, smallholder tractorization was uncommon for most of the 20th century. However, from the 1950s power tillers (2-wheel tractors) were increasingly adopted by smallholders in rice-farming systems in Asia and four-wheel tractors were increasingly available for hire in areas with much irrigated land.

19 Starkey et al. 1995.

Spread of draft animal technologies in 20th century

In parallel to the spread of tractors in the 20th century in industrialized countries (and in larger farms in other countries) animal traction was actually expanding in areas of Africa, Asia and Latin America. The areas of expanding use of draft animals were mainly in areas where farming had involved shifting cultivation using human labour. In such areas, farmers could often increase the land they cultivated annually, so justifying animal power through economies of scale.

In sub-Saharan Africa in the first half of the 20th century, animal power was introduced into farming systems and promoted by colonial authorities, often as part of schemes to increase the volume of export crops such as groundnuts and cotton. In the second half of the 20th century, independent governments, NGOs and development projects continued to promote and support an increasing use of animal power. This growth of animal traction in Africa is discussed further in the companion paper to this publication[20].

Throughout the 20th century and in the past two decades, religious groups (Amish and Mennonites) in north America have successfully continued to use animal power and steadily increased the total land area farmed by them[21]. Apart from their religious conviction, this has been helped by their lack of heavy debt (a bane for owners of expensive equipment) and their tendency to having large families and close cooperation.

***Figure 22** – Amish farmers in USA using a transport horse for light cultivation (top) and three heavy horses for ploughing (below)*

20 Mudamburi/Starkey 2022.
21 Starkey 2011.

In Europe, in the second half of the 20th century, animal power gradually decreased in the smallholder sector (accelerated by the end of the Soviet Union and the expansion of the European Union). One key factor causing people to give up draft animals was the lack of available family labour to assist with animal care. With smaller families, and spouses needing to work away from the farm to boost family income, labour was a key constraint. At the same time, labour rates were rising and machinery costs were falling relative to labour. Not only were the economic benefits of tractor use increasing, but also the support facilities for animal traction were decreasing, as local blacksmiths, harness-makers and farriers decreased due to the reduction in demand for their services. As animal traction users became fewer, there was no longer a critical mass of customers to allow the support services to thrive.

Nevertheless, the use of draft animals in Europe was both retained and newly adopted in particular niches where the environmental and socio-economic benefits of work animals outweighed the advantages of motorization. Some farmers continued to use animals because of their beliefs and preferences. This is sometimes dismissed as 'hobbyism' as the primary motivation is not economic necessity. However, draft animals still have a comparative advantage for certain operations, particularly if environmental impacts, sustainability, quality of life and organic agriculture premiums are fully acknowledged. The viable, beneficial uses of work animals in industrialized countries can including forestry logging, tillage between vines, farming on slopes and short distance transport with much waiting time (as in park maintenance). The scope of current use of horses in Europe is clearly shown on the social media sites of the Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation (FECTU)[22].

Figure 23 *– Smallholder farmers in Norway who have chosen to use horses for environmental reasons. Top: Double row weeding Below: Turning hay with a motor-assisted tedder*

22 FECTU 2022.

Comparative advantages of animal power and motors

Draft animals and motors have both advantages and disadvantages, depending on the operations, the environment and the availability and cost of labour.

Motors have a strong comparative advantage over animals for rotary movements, and this explains why the longstanding and widespread use of animals for milling and pumping with animals is now uncommon.

Motor transport has great advantages for moving large quantities of people or goods for long distances at high speeds on good road infrastructure. This explains the great decline of animal caravans carrying produce over long distances.

Animal power can be advantageous for low-volume, intermittent, short-distance transport, for manoeuvrability in cramped locations and for deployment in difficult terrain. This helps to explain the continued (and sometime renewed) use of animals for on-farm transport, for deliveries, for tillage in small fields and for uses in remote areas including mountainous terrain.

In agriculture, the primary benefit of mechanization is to save labour, and allow one unit of labour to cultivate more land. This is true whether moving from hand cultivation to animal power or changing from animal traction to tractorization. Thus, mechanization allows extensification (provided land is available). It is a commonly believed myth that mechanization leads to higher yields, whereas mechanization generally leads to lower yields per unit area, for a comparable input of seeds and fertilizer. Intensive agriculture, often with multi-cropping, gives the higher yields per hectare. The highest yields (for a given quantity of compost, manure or fertilizer) are found in hand-prepared farms or vegetable gardens, whether in smallholder farming systems in the tropics or in urban gardens in industrialized countries. Mechanization, with animals or tractors, allows one person to cultivate more land, and so can be justified if more land is available to the farmer. With more land, the total farm yield will be higher, even if the yield per unit area is lower. Tractor-powered farms do not generally lead to higher yields per unit area or per unit of fertilizer, but those using tractors are more likely to have access to capital or credit to afford higher quantities of fertilizer, hence the widely held belief that tractorization increases crop yields.

There are a few circumstances where problematic soil structure, such as hard pans beneath the surface, can be improved by deep ploughing or ripping with a tractor[23]. In such cases, combining occasional tractor use and animal powered tillage can be advantageous[24]. However, in most cases, soil structures can be improved through conservation agriculture and high yields per unit areas can be achieved using animal traction and appropriate fertilization.

Animal traction has one other characteristic that can be an advantage or a disadvantage, particularly in more industrialized societies: animals need caring for throughout the year, and this is usually labour-intensive. The advantage of this is that people and families benefit from

23 Tebebu et al. 2020.
24 Mudamburi 2016.

close relationships with the animals. Many farmers feel close bonds with their working animals, and this is lost if the animals are replaced by a machine. Close associations with animals are now being encouraged in certain circumstances to improve people's mental health[25]. However, the need to feed, water, groom and care for work animals can be a serious disadvantage where the availability of family time or paid labour is problematic. In many countries, the fact that there are fewer children and that these need schooling and other activities, reduces the ability of small farms to use family labour to share the caring of work animals. In commercial or municipal enterprises, machinery can be parked at weekends without incurring labour costs. Where work animals are used, staff must be paid to look after them at weekends.

Current world trends on policy support to draft animals

Historically animal traction was developed and spread through most of the world because of private entrepreneurship and the traditional norms of societies. Within societies there have been some attempts at draft animal control or regulation by authorities, for example through taxes, tolls, restrictions on use in particular areas or on certain days, timeslots for particular operations, the requisition of animals by the military or for the welfare of animals. As has been discussed, in the 20th century there were efforts by some authorities (notably in sub-Saharan Africa, but also parts of Asia and Latin America) to actively promote the use of work animals to complement manual labour. There have also been growing numbers of restrictions designed to improve animal welfare and/or to keep draft animals away from fast traffic or congested urban areas.

Based on the situations and trends reported here, it is possible to make several generalizations relating to the adoption, continuation and abandonment of draft animals.

- People using human-powered tillage and transport will adopt draft animals when they are available, adapted to the environment, affordable, profitable and socially acceptable.
- People retain animal power when it is profitable, socially acceptable or ecologically appropriate and/or when there are no easy alternatives (provided there is a supportive environment).
- People stop using draft animals if affordable motorized alternatives are readily available, profitable and socially acceptable.
- Some people and organizations choose draft animals because it is environmentally, socially or culturally appropriate for sustainable farming and specialized applications.

Since the 50s, the mainstream media, including television and films, have generally portrayed draft animals as historic (old-fashioned) and/or associated with poverty and drudgery. Indeed, it is quite often stated that supporting draft animal technologies is like promoting a 'a U-turn back to the stone age'. However, it has been stressed that draft animals require resources, and the poorest people cannot afford them.

25 Portaro et al. 2020; Ratschen et al. 2020.

During the second half of the 20th century, there was not only promotion of draft animal technologies in parts of Africa, Asia and Latin America, there was also considerable national and international public sector investment in draft animal research, education and training. During the 80s, most of the international agricultural research centres had animal traction research programmes, as did several United Nations agencies including FAO and ILO. Also, at this time, several European countries (including France, UK and The Netherlands) funded research centres in their own countries to carry out international research relating to animal power. Other donor countries, including Australia, Germany, Sweden and USA, also funded international animal traction research and networking, often in collaboration with universities in their countries. At the same time, research institutes in many middle- and low-income countries also had significant animal traction research programmes, including in India, Pakistan, Bangladesh, Vietnam, Brazil, Mexico, Bolivia, Ethiopia, South Africa and Zimbabwe. Much of their research related to implements, operations and animal husbandry, and this was complemented by socioeconomic research in many universities throughout the world.

During the first two decades of the 21st century, such efforts at national and international promotion and research declined markedly and have practically stopped. Throughout the world, including high-, medium and low-income countries, very little public money is now being spent on draft animal issues. In most countries, animal traction is no longer part of the curricula of schools or universities. There are few research institutions or universities anywhere that are actively engaged in draft animal issues. Even in low-income countries where animal power is still important in smallholder farming systems, few agricultural ministries are actively engaging with draft animal issues. Globally, there is minimal investment in research about, or support for, draft animal technologies. One notable exception is the work of some animal welfare charities that are trying to improve the care of working animals, although their work is highly localized within certain countries. Their influence is likely to be increased through the formation of the Equid Power Network in collaboration with FECTU[26].

Requirements for successful animal traction

Considering the ancient and recent history of draft animal use and support in the world, it is possible to summarize the prerequisites needed to allow animal traction to thrive.

- An easily accessible supply of suitable and affordable animals
- Available and affordable labour to maintain and work with animals
- Knowledge of training and operational working practices
- Affordable and available animal nutrition and health care
- Available and affordable harnessing and equipment and its repairs (local artisans)
- A supportive environment without excessive fear of theft, obstruction or ridicule.

26 Equid Power Network 2022.

Where animal traction is increasing there is generally a positive spiral of all these prerequisites, making adoption and use increasingly easy. However, in an area where animal traction is decreasing, there is a vicious circle of a contracting market affecting the availability of inputs and support, making continued use increasingly difficult.

Strategy for a supportive environment for draft animals

A supportive environment to allow people to adopt or to continue using draft animals is one that helps to facilitate the various prerequisites listed that are required for successful animal traction use.

If the affordability of animals, implements and other inputs is a major issue, there may be a case to facilitate credit to the end users or to the supply chains serving them. In the case of zones of introduction, subsidies have been proved highly effective in stimulating the market demand required for a subsequent sustainable, unsubsidized upward spiral of increasing demand and therefore better supplies. Regulation may be required if the availability of animals is being constrained: for example, banning the trade in donkey gelatine or restricting the slaughter of healthy young oxen.

The aim should be sustainable private sector support services that can ensure the availability of appropriate animals, nutrition, animal health care, implements, harnessing, spare parts and repairs. NGOs and local associations of users and/or suppliers can assist by working with farmers and with service providers to identify problems and facilitate collaboration with the various stakeholders to find appropriate, acceptable solutions. Governments and authorities should provide an enabling environment to allow smallholder farmers, private sector suppliers and NGOs to jointly ensure the successful continuation or growth of draft animal use. However, currently the great majority of governments and authorities in the world do not have any positive policies or strategies designed to permit animal traction to thrive.

The priority for supporters of draft animal usage in the coming decade must be to inform, educate and influence existing policy makers, the media and entire populations to ensure authorities are facilitating the necessary enabling environment. Policy makers do not want to be seen by their peers and electorates as promoting a 'U-turn back to the stone age'. So, they and their relevant reference groups must all be influenced to understand that animal traction can be positive for the users, the environment and the local economies.

Influencing policy makers and populations will not be easy but it could be achieved through champions (individuals/organizations), media education and influence (audio-visual information and resources), research (to provide data and indicators to inform policy) and the national and international networking of users, activists and supporting organizations.

Local and international champions can be very influential. Nelson Mandela famously rode into a stadium on a donkey cart, and in 2020, social media in Namibia was excited to see video clips of the Mayor of Windhoek ploughing with oxen. Sympathetic social media influencers or international celebrities could play an important role in making the public more sympathetic to draft animal power.

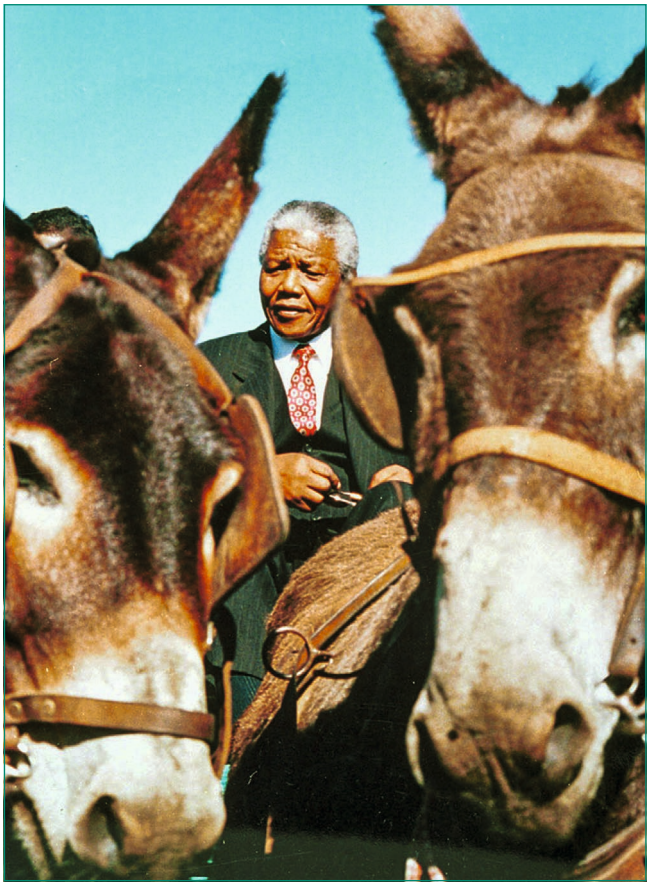

Figure 24 *– Nelson Mandela acting as a champion for donkey users as he entered the Upington Stadium on a donkey cart on South Africa's Freedom Day in 1977*

There is an urgent need for good videos and resource materials to educate school children, students, the public and policy makers. These need to be accessible in the growth area of social media, from where more people, notably the younger generations, gain their information and ideas. Research is needed to ensure that data and indicators are available on the level of use of animal power and the efficiency of local support systems. In the past, a great deal of time and money has been spent on top-down research inventing, reinventing and modifying implements (often without reviewing existing options in the world). Frequently these had minimal impact as equipment designs were not the limiting factor in that farming system or transport operation[27]. More attention needs to be paid to participatory research and understanding from the point of view of the draft animal users (or potential users) how animal power can best serve the farming or transport system and what are the key social, economic and technical constraints and how they can be alleviated. Where appropriate, such research should incorporate environmental issues notably climate change resilience and mitigation. The research should be highly gender sensitive, recognising the importance of animal traction for women and changing gender roles in the management, use and benefits of draft animals.

Heritage institutions such as living history farms and museums should proudly display (physically and digi-

27 Starkey 1988.

tally) the traditional uses of animal power, but also link this to modern applications whether national or international. Such retrospective and forward-looking displays and exhibitions would benefit from much more active networking between draft animal user groups, activists and researchers. Networks have proven highly successful in increasing information exchange, improving peer recognition and creating a critical mass for lobbying and action[28].

Through concerted efforts in and between the 'Global North' and the 'Global South', the historic importance of draft animals can be combined with a modern vision of the future, where the sustainable use of draft animals is recognized nationally and internationally as being beneficial to their owners, the environment and to the local economies.

Bibliography

AIMA 2017 AIMA (International Association of Agricultural Museums) Newsletter 10, 2017, URL: https://usercontent.one/wp/www.agriculturalmuseums.org/wp-content/uploads/2017/04/aima_newsletter-nc2b010-spring_2017.pdf [06-01-22].

BOSTID 1981 BOSTID, The water buffalo: new prospects for an underutilized animal (Washington DC 1981).

Brooke 2019 Brooke, East Africa donkey skin crisis. URL: https://www.thebrooke.org/sites/default/files/Images/2 to 201 ratio/Countries/Kenya/Brooke East Africa donkey skin crisis_0.pdf [06-01-22].

Cheng 2018 K. Cheng, Hundreds of thousands of donkeys are stolen, slaughtered and skinned in Africa to feed China's demand for 'anti-ageing' medicine. URL: https://www.dailymail.co.uk/news/china/article-5846655/Donkeys-stolen-skinned-Africa-feed-Chinese-demand.html [06-01-22].

Chikulo 2019 S. Chikulo, Climate-smart agriculture: a winning strategy for farming families in El Niño seasons. URL: https://www.cimmyt.org/news/climate-smart-agriculture-a-winning-strategy-for-farming-families-in-el-nino-seasons [06-01-22].

CIMMYT 2016 CIMMYT, Building a sustainable future: a history of conservation agriculture in southern Africa. URL: https://www.cimmyt.org/news/building-a-sustainable-future-a-history-of-conservation-agriculture-in-southern-africa [06-01-22].

Collins 2010 E. Collins, The latter-day history of the draught ox in England, 1770-1964. Agricultural History Review 58, 2010, 191-216. URL: http://www.jstor.org/stable/41330067 [06-01-22].

Donkey Sanctuary 2019 Donkey Sanctuary, Under the skin report. URL: https://www.thedonkeysanctuary.org.uk/sites/uk/files/2019-12/under-the-skin-report-english-revised-2019.pdf [06-01-22].

Equid Power Network 2022 Equid Power Network. URL: https://www.equidpower.org/ [06-01-22].

FAO 1977 FAO, The water buffalo. Food and Agriculture Organisation (Rome 1977).

FAO 2021 FAO, Sembradoras a tracción animal y para tractor de un eje en agricultura de conservación. Food and Agriculture Organisation (Rome 2021). URL: https://www.fao.org/teca/es/technologies/8156 [12-04-22].

FECTU 2022 Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation (FECTU). URL: http://www.fectu.org and https://www.facebook.com/Fectu/ [06-01-22].

Gilbert et al 2018 M. Gilbert/G. Nicolas/G. Cinardi/S. Vanwambeke/T. Van Boeckel/G. Wint/T. Robinson, Global distribution data for cattle, buffaloes, horses, sheep, goats, pigs, chickens and ducks in 2010. Nature Scientific Data, 5:180227 2018. URL: doi: 10.1038/sdata.2018.227 [06-01-22].

Löwe 1986 P. Löwe, Animal powered systems: an alternative approach to agricultural mechanization (Braunschweig 1986).

Mudamburi 2016 B. Mudamburi, A comparison of the performance of Namibia-specific conservation and conventional tillage technologies as used for pearl millet production in Northern Namibia. University of Namibia PhD Dissertation (Windhoek 2016).

Mudamburi/Starkey 2022 B. Mudamburi/P. Starkey, Draft animal issues, constraints and opportunities in Africa (2022).

Pearson et al. 2003 A. Pearson/T. Simalenga/R. Krecek, Harnessing and hitching donkeys, horses and mules for work (Edinburgh University 2003). URL: https://www.vet.ed.ac.uk/ctvm/Research/DAPR/Training Publications/Harness Hitching Donkeys/Harness Hitching donkeys Oct06.pdf [12-04-22].

Portaro et al. 2020 S. Portaro/G. Maresca/A. Raffa/G. Gemelli/B. Aliberti/R. Calabrò, Donkey therapy and hippotherapy: two faces of the same coin? Innovations in Clinical Neuroscience, 17, 2020, 20-21. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7239561/ [12-04-22].

Raepsaet 2002 G. Raepsaet, Attelages et techniques de transport dans le monde gréco-romain (Brussels 2002).

Ratschen et al. 2020 E. Ratschen/E. Shoesmith/L. Shahab/K. Silva/D. Kale/P. Toner, Human-animal relationships and interactions during the Covid-19 lockdown phase in the UK: Investigating links with mental health and loneliness. PLoS ONE 15/9, 2020, e0239397. URL: https://doi.org/10.1371/journal.pone.0239397 [12-04-22].

Russell 2012 N. Russell, Social zooarchaeology: humans and animals in prehistory (Cambridge 2012).

Starkey 1981 P. Starkey, Farming with work oxen in Sierra Leone (Freetown 1981).

Starkey 1988 P. Starkey, Perfected yet rejected: animal-drawn wheeled tool-carriers (Braunschweig 1988).

Starkey 1989 P. Starkey, Harnessing and implements for animal traction (Braunschweig 1989).

Starkey 1990 P. Starkey, Water buffalo technology in northern Senegal. USAID. URL: https://pdf.usaid.gov/pdf_docs/pnaec245.pdf [06-01-22].

Starkey 1998 P. Starkey, Networking for development (London 1998).

Starkey 2000 P. Starkey, The history of working animals in Africa, in: R. Blench/K. MacDonald (eds.), The origins and development of African livestock: archaeology, genetics, linguistics and ethnography (London 2000), 478-502.

Starkey 2001 P. Starkey, Local transport solutions: people, paradoxes and progress. World Bank (Washington DC, 2001). URL: http://www.ssatp.org/sites/ssatp/files/publications/SSATP-WorkingPapers/SSATPWP56.pdf [12-04-22].

Starkey 2011 P. Starkey, Livestock for traction and transport world trends, key issues and policy implications. Food and Agriculture Organisation (Rome 2011). URL: 10.13140/RG.2.2.29674.34245 [06-01-22].

Starkey et al. 1995 P. Starkey/F. Jaiyesimi-Njobe/D. Hanekom, Animal traction in South Africa: overview of the key issues, in: P. Starkey (ed.), Animal power in South Africa: empowering rural communities (Gauteng 1995), 17-30.

Tebebu et al. 2020 T. Tebebu/ H. Bayabil/T. Steenhuis, Can degraded soils be improved by ripping through the hardpan and liming? A field experiment in the humid Ethiopian highlands. Land Degradation & Development 31, 2020. URL: DOI 10.1002/ldr.3588 [12-04-22].

28 Id. 1998

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