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Livestock for traction and transport:

world trends, key issues and policy implications

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world trends, key issues and policy implications

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Abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research, Canberra, Australia
ACP	Africa, Caribbean and Pacific
ACT	African Conservation Tillage Network
AEATREC	Agricultural Engineering and Appropriate Technology Research Centre, Uganda
AGA	Animal Production and Health Division, FAO
AGAL	Sector Analysis and Policy Branch of Animal Production and Health Division, FAO
ATNESA	Animal Traction Network for Eastern and Southern Africa
BOSTID	Board on Science and Technology for International Development
CEEMAT	Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical, France
CGIAR	Consultative Group on International Agricultural Research, Washington DC, USA
CIFEMA	Centro de Investigación, Formación y Extensión en Mecanización Agrícola, Bolivia
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement, France
CIRDES	Centre International de Recherche-développement sur l'Elevage en Zone Subhumide
CIVAM	Fédération Nationale des Centres d'Initiatives pour Valoriser l'Agriculture et le Milieu rural, France
CTA	Centre for Agricultural and Rural Cooperation
DAP	Draft (or draught) animal power
DAPAP	Draught animal power acceleration programme, Namibia
DFID	Department for International Development, London, UK
DGIS	Directorate General for Development Cooperation, Ministry of Foreign Affairs, The Hague
DRC	Democratic Republic of Congo
EARO	Ethiopian Agricultural Research Organization
ed, eds	Editor(s)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO on-line database: http://faostat.fao.org
FECTU	Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation
FOMENTA	Programa Regional de Fomento de la Tracción Animal, Honduras y Nicaragua
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH, Germany
HIV/AIDS	Human immunodeficiency virus / acquired immunodeficiency syndrome
IFRTD	International Forum for Rural Transport and Development (Secretariat in London, UK)
IIMA	Instituto de Investigaciones de Mecanización Agropecuaria, Cuba
ILCA	International Livestock Centre for Africa, Ethiopia (subsequently part of ILRI)
ILRI	International Livestock Research Institute, Nairobi, Kenya and Addis Ababa Ethiopia
IMAG	Instituut voor Mechanisatie (Institute of Agricultural Engineering), The Netherlands
INE	Instituto Nacional de Estatistica, Maputo, Mozambique
ISBN	International Standard Book Number
ISSN	International Standard Serial Number (for journals)
NARO	National Agricultural Research Organization, Uganda
NGO	Non-governmental organization
RDC	République Démocratique du Congo

RELATA	Red Latinoamericana de Tracción Animal y Tecnologías Apropiadas, Nicaragua.
REMVT	Revue d'élevage et de médecine vétérinaire des pays tropicaux (CIRAD, France)
RGTA-DI	Réseau Guinéen pour la Traction Animale Développement Integré
SADC	Southern African Development Community, Gaborone, Botswana
SANAT	South African Network of Animal Traction
SDC	Swiss Development Cooperation, Berne. Switzerland
SPANA	Society for the Protection of Animals Abroad, London
SIDA	Swedish International Development Cooperation Agency, Stockholm, Sweden
SSATP	Sub-Saharan Africa Transport Policy Program
UK	United Kingdom (of Great Britain and Northern Ireland)
US, USA	United States of America
WW2	World War 2 (Second World War)

Executive Summary

UNDERSTANDING ANIMAL TRACTION IN THE MODERN WORLD

Human, animal and motor power are all important in development. Animals contribute to poverty elimination, drudgery reduction and wealth creation. Animals assist men and women with crop production (ploughing, conservation tillage, planting and weeding) and transport (on-farm, marketing, riding and pack transport). Oxen are the main work animals in the world: bulls can work and cows provide resource-efficient power for smallholder farmers. Buffaloes (males and females) work well in Asian rice systems but are not as adaptable as cattle. Horses and mules are fast and good for transport and some tillage where they thrive (temperate and high altitude areas). Donkeys are small but hardy for transport in semi-arid areas, but do not thrive in humid tropics. Camels and other animals have qualities that limit widespread use.

Using animals for soil tillage allows people to prepare more land than human labour. This increases farm yields through timeliness and larger areas of cultivation. Work animals create synergy in nutrient cycles, farming and marketing systems: animals allow farmers to transport manures, harvest and market produce. They increase people's transport capacity and range and provide families and entrepreneurs access to supplies, services and livelihoods. Animals provide effective feeder transport to complement motorized vehicles. Work animals are multipurpose, producing profitable livestock products, including meat, milk and manures.

Farming and transport require power. Mechanization (animals or motors) increases labour productivity and reduces drudgery. Human, animal and tractor power are not exclusive: each has advantages depending on the environment, scale and socio-economic context. People aspire to prestigious, modern machines but tractors may not be appropriate on small farms. Large tractors are uneconomic in small, fragmented, rain-fed fields. Numerous subsidized tractor schemes have failed. Power tillers have proved effective in irrigated rice farms in Asia, but not for traditional, rain-fed crops elsewhere. Profitable mechanization may lead to land consolidation with many small farms replaced by fewer larger farms. Mechanization (animals or tractors) leads to changing labour patterns, greater economic disparity and urban migration. Animal traction support services (blacksmiths, harness makers, animal health) differ greatly from tractor requirements (fuel, spare parts, workshops). Mechanization may increase farmers' risks. Animals can be stolen or fall sick; tractors depend on external supply chains. While animals benefit families, men tend to be the owners and main users. Donkeys are more gender neutral. Farmers are aging. Children may care for animals and schooling restricts labour availability. Most owners care well for their animals but cases of animal cruelty or neglect must be addressed through education, legislation and enforcement, by national and local authorities and non-governmental organizations (NGOs). Well-resourced international NGOs provide some support in this area.

WORLD DISTRIBUTION AND CURRENT TRENDS

Data sources and estimates

There are few authoritative estimates of work animals: only some governments record their numbers. National herd figures from FAOSTAT[1] are good estimates for mules and donkeys that are kept for work. They are less reliable for horses and camels that may be kept for other purposes. Most cattle and buffaloes are maintained for meat or milk and these species require survey data to gauge working uses. Unsubstantiated estimates prepared around 1980 suggested 300-400 million working animals in the world. Since then, numbers in Africa have increased while there have been considerable decreases in some Asian countries, notably China and Bangladesh. Current world use may be 200-250 million.

[1] http://faostat.fao.org/

Africa and Madagascar

In North Africa, equids are still used for urban and rural transport (four million donkeys). Traditional use of work animals in agriculture remains important in Egypt (cows, buffaloes) and Morocco (horses, mules and donkeys). Some camels are employed for transport and agriculture, but this is not common. In the Ethiopian highlands, and some neighbouring areas, seven million oxen remain the main source of power for soil tillage. Five million donkeys are used for pack transport. Donkey carts are few but increasing. Horses and mules are widely used for riding. Urban horse carts are declining rapidly owing to motorized three-wheelers.

In West Africa, animal traction is expanding, following promotion in the twentieth century by commodity companies and extension services. There are high levels of adoption in the 400-800 mm rainfall zone. Work oxen in francophone West Africa increased six fold in the past 50 years, from 350 000 to two million. Oxen are the main agricultural work animals, but horses and donkeys are also used in the drier areas. Donkeys are increasing in numbers (4.5 to 6.3 million in the past decade) and geographical area (donkey line moving southward). More farmers are using N'Dama cattle for work in Guinea. In the humid zone, there are few cattle and no equids, but projects are considering the introduction of work oxen. Animal traction information exchange in West Africa has been assisted by networking.

In Madagascar, 300 000 ox carts remain important for transport. Cattle traditionally cultivated rice fields by trampling. Animal traction is gradually increasing in East Africa, notably in Tanzania with one million work animals and Uganda. Expansion was hit by the 2006 drought. Oxen pull ploughs and carts. Diversification to weeding and conservation tillage is spreading slowly. Donkey use for transport and light tillage is increasing. In Southern Africa, animal traction has been spreading since the seventeenth century and is traditional in many smallholder systems. In recent decades it has been promoted in several countries, including Malawi, Namibia and Zambia where it is spreading. In South Africa and neighbouring countries, the use of tractors on large farms and subsidized tractor hire schemes has diminished people's perceptions of animal traction. However, no viable system for using tractors for rain-fed crops on fragmented small-scale farms has been found. While oxen are the preferred animal for ploughing, droughts, overgrazing and theft have made donkeys more attractive. The Animal Traction Network for Eastern and Southern Africa (ATNESA) and national networks have promoted animal traction information exchange and produced many resource publications.

Asia and Pacific

China has a long tradition of using many work animals of several species, but accurate statistics are not available. Numbers probably peaked in the 1990s (perhaps 90 million work animals) and are now declining. Oxen and buffaloes are being replaced by tractors and power tillers, while motorcycles, three-wheelers and pickups are substituting for donkeys and horses. The trend is most evident in the flatter and more developed areas which are the most visible to policy makers. In the more remote and hilly areas, animal traction remains extremely important, and millions of animals are likely to continue to be used for many years.

India and other South Asian countries have a long history of animal traction, dominated by oxen. Buffaloes have been used in smaller numbers in humid areas, and horses, donkeys and camels have been used in the more arid and mountainous areas. Animals for tillage are declining, with sharp declines seen in Sri Lanka and Bangladesh where power tillers have been widely adopted. While four-wheel tractors now dominate the large farms and more fertile areas of India, the very large number of small farms has allowed the population of oxen to decrease at a slow rate, with perhaps 60-70 million remaining in use. While use of motorcycles and three-wheelers has affected the number of donkeys and horses, notably in urban areas, these species are tending to increase in the more remote areas as more people require access to transport. Thus the combined donkey population of Pakistan and Afghanistan has increased from 4.4 to 5.6 million in the past decade.

In Southeast Asia, tractors and power tillers have been replacing oxen and buffaloes in the river flood plains with large areas of rice cultivation, but animal traction remains highly persistent in the more remoter and hilly areas. In North and Central Asia, the large farms have tractors, but

horses and donkeys remain important for riding and transport. Similarly in West Asia, horses and donkeys remain important for transport in both rural and peri-urban areas. These transport animals may cultivate fields, but the use of oxen for agriculture is no longer common, except in remote areas. There is little use of animal traction in the Pacific but suitable technologies have been demonstrated and there may be scope for future promotion.

The Americas and Caribbean

In the Americas, the use of horses, donkeys and oxen was introduced 500 years ago and has spread through the region. In Mexico, Central and South America, oxen or bulls have been used for ploughing. While the large-scale farming sector has been tractorized, oxen remain common in smallholder farming systems. Horses are also used for cultivation, notably in Mexico, Brazil and Chile. While there is ongoing tractorization, work animals remain highly persistent. Tractors and animals may work in complementary way in some farming systems. While the image of animal traction is often 'macho', romantic and positive, there is little policy support. Animal-drawn carts are quite widely used for rural and urban transport, and Nicaragua and Cuba retain some public transport horse carriages. In Central America, the use of seeders and small-terrace farming has been spreading in Nicaragua, Honduras and Guatemala, following promotion and a regional network initiative. The traditional use of pack llamas has declined greatly, but donkeys, with a higher load capacity, remain important in the Andes and in Mexico. The donkey population in the Americas remains stable. In USA, most farms have long used tractors, but the area of profitable horse-powered Amish farms is currently expanding. In Cuba, the trend to tractorized farming systems was reversed when the end of the Soviet bloc caused fuel shortages and economic problems. Work oxen subsequently doubled from 160 000 to 300 000 showing animal traction revival is possible if there is appropriate commitment. Elsewhere in the Caribbean, animal traction remains important for agriculture and transport in Haiti and the Dominican Republic, although motorcycles, three-wheelers and power tillers may reduce the demand.

Europe

In Western Europe, animal power has almost disappeared from commercial applications, except in special situations, such as organic farming, horse logging, tourism and fragile environments. As it declined, animal power persisted in remote areas and for transport, including urban collection and deliveries. The patterns of donkey decline in Europe illustrate how rural people retain donkeys until they can afford motor power. Italy had 790 000 donkeys in 1938. These declined to 324 000 in 1968 and crashed to 24 000 in 2008. The donkey populations of Greece (400 000) and Bulgaria (300 000) remained fairly constant between 1938 and 1968. Since then they have declined significantly, with the Greek decline curve leading that of Bulgaria. An exception is the island of Hydra in Greece, where no private motor vehicles are allowed and mules, horses and donkeys remain in use for all major transport functions. Animal traction for agriculture and transport remains important in Eastern Europe, but the pattern of replacement is continuing in a similar way to Western Europe. Rural and urban transport uses persist where there is no adverse legislation. Reasons for abandoning animals include the availability and affordability of tractors and vehicles and credit to buy them. Also important is changing demography, and the time constraints of maintaining work animals on small farms with little family labour.

CONCLUSIONS

Animal power is widely used around the world, with areas of decline, stability and expansion. Hundreds of millions of people benefit from work animals. Six world-wide trends are evident.

1. People replace human-powered tillage and transport with animals when they are available, adapted to the environment, affordable, profitable and socially acceptable. This explains the animal traction growth areas, such as sub-Saharan Africa.
2. People replace animals with motor power when the latter is available, affordable, profitable and socially acceptable. This explains the trends seen in the richer countries and the more fertile and accessible areas of developing countries.

3. People retain labour-saving animal power when it is profitable and socially acceptable and when there are no easy alternatives available. This explains the high persistence of animal power in much of the world, including Ethiopia, the rapidly industrialising countries (Brazil, China, India, Indonesia, Mexico, Viet Nam) and the stability of some donkey populations. One problem is that young people influenced by media images may consider animal power to be too old-fashioned to be socially acceptable.
4. Some people and organizations choose animal traction because it is environmentally or socially appropriate for organic farming and special applications of high status.
5. Public sector investment in animal traction research, education, training and promotion has declined in the past 25 years. There is little international research. Public investment in animal traction is mainly in the areas of expansion in Africa.
6. The world's media is increasingly portraying animal power as old-fashioned. The media frequently uses animal traction to illustrate poverty and under-development. It seldom reports that it can be a possible solution for reducing current poverty.

The implications of the trends are complex. In areas of animal traction adoption, increased farm power, crop-livestock integration and transport capacity should lead to greater, sustainable production, stored harvest, marketed produce and incomes. There may be vulnerability to livestock disease and theft. Replacing animals with tractors may increase soil compaction and affect organic manure availability for fertilizer or fuel. Tractors seldom increase yields per hectare but do increase labour productivity that with land consolidation displaces farm labour and encourages urban migration. Motorization tends to reduce biodiversity and increases vulnerability to supply chain failures and climate-change problems. As climate change stimulates extreme weather, transport animals may prove increasingly important for access following natural disasters. Drought resistant donkeys may have wider applications. The low public sector investment in animal traction could adversely affect farmers in zones of expansion, where adoption can directly reduce poverty and drudgery. 'Priming the pump' to gain a critical mass of users and support services generally requires 'project' support.

Animal traction is resilient, even without a supporting policy environment. With laissez-faire policies, the existing trends will generally continue, with areas of decline, stability and slow growth. However, as fewer people learn about work animals, it will be more difficult to formulate appropriate policies relating to their use in agriculture, transport and poverty reduction. Ill-informed policies will tend to marginalize animal traction users. Farmers are aging. The outmoded image will affect young people, speeding up the rejection of animal traction and its support services, weakening the synergy and accelerating the downward spiral of insufficient market-demand and inadequate support facilities. For those that can afford motor power, this is not a problem. But people struggling with only human power may be prevented from benefiting from animals because of their poverty and the lack of project-led facilitation of adoption.

The biggest constraint to animal traction in the world is its poor, old-fashioned image that affects all stakeholders. It inhibits national authorities and aid agencies from treating animal traction as a serious modern option, complementary to human and motor power. Politicians and development workers too often focus poverty reduction debates on replacing animals with motors. More attention needs to be given to proactive means for helping poor individuals and communities to use work animals effectively to improve their lives and livelihoods. However, people cannot take animal traction seriously if they think it is outdated and no longer relevant.

FAO and other international organizations could have a major impact by providing more information to national authorities, educational systems and the media explaining the benefits of animal traction in a modern world. Networks are effective for sharing information and providing the critical mass needed for influence, recognition and professional support. Networks require few resources but have large impacts by linking people in different disciplines and countries. Network members can jointly review limiting factors, solutions and possible interventions to reduce poverty and increase sustainable growth with animal traction.

Introduction

Human, animal and motor power are all important in development. Domestic animals work for men and women in all regions of the world. Animals assist in poverty elimination, drudgery reduction and wealth creation. Animal traction is particularly important for food security in smallholder farming systems. Animals can assist directly with crop production (ploughing, ridging, conservation tillage, planting and weeding). Food production, food distribution and rural trade are also assisted through animal-powered transport (on-farm, marketing, riding and pack transport). Animals save people (often women) time and effort by carrying water and household necessities. Animal power can also be used for water-raising, milling, logging, land excavation and road construction. Many different types of animal are employed, particularly cattle (oxen, bulls and cows), buffaloes, horses, mules, donkeys and camels.

Farm production and rural transport require power. There are three main options: human work, animal power and the use of motors. These are not necessarily exclusive or competitive. Human, animal and machine power can be complementary and can coexist in the same household or farm. The choice depends on local circumstances. The most appropriate power source for any operation depends on the work to be done and the relative desirability, affordability, availability and technical efficiency of the various options. If much work needs to be done, human power alone generally is slow and tiring. Investment in mechanization (using animal or motor power) can increase the productivity of human labour, reducing drudgery and helping to overcome poverty.

In this document, animal traction will be seen in both an historical and a global perspective: to understand existing trends, it is important to understand the cultural context and past experiences, whether long-term or recent. It is also vital to understand differences between population groups and socio-economic conditions, particularly in the context of poverty analysis. There are many different actors in the animal traction debate, all with different concerns and needs. It is important to bear in mind the decision maker in his air-conditioned 4x4 vehicle, the old man and his oxen in a remote valley, the young man and his motorcycle in a peri-urban area and the woman and child leading a donkey carrying produce and water.

Understanding animal traction in the modern world

ANIMALS USED FOR WORK AND THEIR COMPARATIVE ADVANTAGES

Oxen, bulls, cows, buffaloes, horses, donkeys, mules, camels

Cattle are the most widespread work animals. Oxen or bullocks (castrated males) are docile and strong and are the main type of work animal in the world. Non-castrated bulls can be used effectively, and these are popular in Latin America and parts of West Africa. Cows are the most productive work animal overall, providing not only work, but milk, offspring, manure and finally meat and hides. Provided they are well-nourished, fertility is not a serious constraint. Cows tend to be used where land and feed resources are very limited and there are insufficient resources to maintain animals only for work.

Water buffaloes are individually strong and have large feet that can walk easily in mud. They can survive on relatively poor nutrition based on rice straw. However, the thermoregulation of buffaloes is less efficient than cattle (hence their reputation for bathing) and they can overheat if worked hard. They are generally robust, but sensitive to trypanosomiasis. Reproductive rates tend to be lower than cattle. While buffaloes are iconic in rice production systems, and they are important work animals in some south and southeast Asian countries, many more oxen than buffaloes work in Asian rice production systems. Dairy buffaloes thrive in Egypt and for many years there have been discussions and some trials (largely unsuccessful) concerning the possible future roles of water buffaloes in sub-Saharan Africa (BOSTID, 1981; Starkey, 1990; Ngongo, 2010).

Horses are fast with good acceleration, making them excellent transport animals. In many countries, transport horses also assist intermittently with small-scale crop cultivation. Horses are not as robust as cattle and need better (and more expensive) care and feeding. They do not thrive in humid, tropical conditions. However, in temperate regions and in arid or high altitude areas in the tropics horses can be very usefully employed for ploughing and other farm operations. The limited market for horse meat means that old horses have lower resale value than oxen.

Donkeys are mainly smaller than cattle and horses but they are very robust and resistant to drought. Farmers joke that they seem to survive on air and sand. While they do need adequate nutrition they have less impact on the food resources of fragile environments than other work animals, such as cattle. They are very well adapted to pack transport in the mountains but they can also pull carts and light cultivators. Larger donkey types can be used for riding, and donkeys can be harnessed in teams to pull large loads. Because donkeys are generally inexpensive, with meat of low value, donkeys are less likely to be stolen than cattle. In semi-arid areas, donkeys seldom get sick and may live for 20 years. However they do not thrive in humid conditions and their range tends to be restricted to mountains and semi-arid areas.

Mules are sterile animals that are created by crossing a male donkey with a female horse, and this tends to make them relatively rare and/or expensive. They are large, strong, robust, long-lived and excellent for transport purposes in mountains (packing, riding) as well as for pulling wagons. Because of their cost and their behaviour characteristics (they are best kept in regular work), they are mainly used for transport operations by contractors and medium-scale farmers. In some countries, such as Mexico, they are also important for ploughing.

Camels are tall, strong and walk fast. They have large feet and are well-adapted to long-distance transport in arid conditions. They can also pull carts and ploughs. Their large size makes them expensive to own, and like mules they tend to be the animals of choice for transport contractors rather than small-scale farmers.

Other work animals

Most other work animals are restricted to particular geographical areas or to very specialized types of work. They may be locally important, but they do not have the same international significance as the other work animals. Yaks (and their crosses with cattle) are used for packing and other work in the Himalayas. Banteng (Bali cattle) are similar to cattle and are found in Indonesia. Llamas are used for pack transport in the Andes. Elephants are used for logging, ceremonial work and/or tourism in parts of Asia and Africa. Goats, sheep, dogs and reindeer can be harnessed to carts or sledges and/or used for pack transport.

USES OF ANIMALS FOR WORK AND CROP PRODUCTION

Ploughing and tillage, harvesting, post-harvest

The main use of work animals in farming systems is for primary soil tillage. This may be ploughing, ridging or tine-tillage (including furrow opening for conservation agriculture). Many traditional implements (long-beam ards) provide tine tillage and/or ridging operations, while mouldboard ploughs are designed to invert soils. Animals may also pull harrows of various types to produce a seedbed. In irrigated rice systems, animals may be used for ploughing, puddling and levelling. Planting may be done behind a plough or furrow-opener, or with a purpose built seeder or planter. Inter-row weeding can be achieved with weeding tines and/or ploughs or ridgers. In all cases, the main advantages are speed of operation and labour productivity, with soil protection an important benefit with some cropping systems. Using animals and appropriate implements, farmers can cultivate more land and in a more timely way than they could using only hand labour. This leads to greater yields per unit of human labour. The overall effect is often extensification (larger area but lower yield per unit area). Tractors may lead to greater extensification (an even larger area but a lower yield per area, for the same inputs), but even higher labour productivity. Many people incorrectly assume that tractors invariably increase the yield of fields: high production mainly comes from associated fertiliser use. Maximum production per unit area is actually achieved by intensive manual cultivation (small gardens are highly productive – but they are small).

Animals can be used to raise root crops (eg, potatoes) and groundnuts. While mowing, reaping and harvesting machines can be pulled by horses, these are operations that benefit most from motorization. Similarly, animals can power threshing and grinding machines, raise water from wells and even generate electricity. However stationary animal-powered machines are relatively easy to substitute with more productive motor power. Very many longstanding, traditional animal-powered stationary machines and irrigation systems in the world have been replaced, including most irrigation systems in India and 'trapiche' sugar cane crushers in Central America. One stationary system that is still spreading in some areas is the use of animal power for oil extraction (slow speed, high torque grinding). In the past decade, small numbers of camel-powered oil mills have been spreading from Sudan into northern Ethiopia.

Photo: Paul Starkey

Figure 1 Oxen ploughing in Ethiopia: tillage with oxen is the basis for most agriculture in Ethiopia

Photo: Anne Pearson

Figure 2 Crossbred cow ploughing in Indonesia: most work animals in Indonesia are multipurpose females

Transport for livelihoods, marketing, harvest, residues, manures

Animal-powered transport can offer particular social and economic benefits, both for farmers using multipurpose animals and for transport entrepreneurs using animals for livelihoods. Rural and urban women, men and children require access to supplies, services, facilities and opportunities for survival and a good quality of life. People need access to water, power/fuel,

food, health services, education, employment and livelihoods options. Access depends on infrastructure, proximity and transport options. Animal power involving riding, pack transport or carts can increase the transport capacity for rural families and reduce drudgery at a relatively low cost. Men, women, children and disadvantaged people can use animal power to increase access, reduce poverty and isolation and enhance social and economic development. Animal transport can be complementary to human transport (for small loads over short distances) and motorized transport (for larger loads over longer distances).

As farmers and traders, both women and men, are freed from the limitations of head loading, more is produced and traded, increasing profits and overall economic activity. Farmers with animal transport, either carts or pack animals, have wider contacts with traders. The resulting enhanced market access allows them to increase their production and also their profit. With animal transport greater use is made of manure and crop residues, and this increases overall farm production. Animal power can provide important efficient local 'feeder' transport between farms and roads, to complement motorized road transport systems. Such systems often develop spontaneously, but transport authorities are seldom sympathetic to animal transport, and may legislate against animal transport encroaching on public roads (Fectu, 2008; Colombia, 2009).

Photo: Paul Starkey

Figure 3 Donkey pulling cart in Burkina Faso: in the 1970s there were there were no donkeys in this area but by 2010 most farming households owned a donkey cart.

Figure 4 Ox cart in India: oxen remain extremely important for transport and agriculture in India

MECHANIZATION DEBATE

Comparative advantages of manual, animal and motorized options

Animals and motors both help to reduce human drudgery and allow people to achieve more with their time. Motor power, where available and affordable, can achieve the greatest savings in time and labour. Many smallholder farmers would like to benefit from tractor power, but such aspirations are often unrealistic. Motor power tends to be most appropriate for large-scale farming and long-distance transport. For small-scale farming and local transport, animals may be more affordable and appropriate. Tractors require fossil fuel and may cause soil compaction: animals that eat local plants and provide organic manure may be more appropriate in fragile environments.

Individual tractor ownership is seldom possible for farmers with small areas of cultivation, unless they have high-value crops, irrigation and/or multiple cropping. Tractor hire (public or private) has seldom proved viable when aimed at smallholders farmers in rain-fed food-production systems. The success of power tillers for smallholders in some Asian countries has been associated with sequential irrigated rice crops (often three-crops a year), low-cost supplies, multiple uses of motors and the establishment of a critical mass of artisanal mechanics.

Work animals and motors (tractors, trucks and pick-ups) can coexist in the same area - even on the same farm. Tractors may be best for power-intensive operations (eg, ploughing) and on large areas of land. Animals may be more appropriate and affordable for control-intensive operations (eg, weeding, levelling) and on small areas of land. Produce may be transported from the fields with animals, and then to the towns on trucks.

Increase in tractors and power tillers

Agricultural mechanization increases the area that one person or family can farm. With animals, farmers can cultivate more land, and with tractors, even more. Historically, in many countries, the adoption of animals and tractors has been associated with increasing the size of land holding. Where there is plenty of available land, mechanized farms can expand into unused terrain. Where land is already owned and used, farmers can buy, rent or acquire neighbouring land. Depending

on land tenure and political systems, the success of larger farmers has often been associated with the failure of smaller farmers and gradual rural depopulation. In some areas of the world with low rural population densities, continuing land availability allows mechanization using animals or tractors to take place without displacing people. In areas of higher population density, mechanization with animals or tractors leads to changes in labour patterns, with some unemployment, some adjustments to the local economy and often greater economic disparity. With the growth of tractor and power tillers, there is need for fuel supplies, spare parts suppliers and repair workshops. These require very different skills to animal-traction support (farriers, harness makers, blacksmiths, animal health services). While animal power equipment used to be made by local, rural blacksmiths, most steel implements are now made in urban-based workshops. This can lead to supply problems within villages, particularly as urban workshops may find the profitable and consistent market for other products (window frames, burglar bars) is more attractive than the very seasonal and erratic (harvest dependent) market for animal-drawn implements.

Photo: Paul Starkey

Figure 5 Oxen and power tillers working in rice fields in Sri Lanka: while power tillers are relacing animals, the technologies can be complementary.

Photo: Paul Starkey

Figure 6 Horse-drawn taxis (gharries) in Ethiopia: these forms of public transport are increasingly replaced with motorized three-wheelers.

Desire for mechanization and modernization

In much of the world, people (particularly the younger generation) aspire to machines that are prestigious, labour-saving and modern. Politicians often promise greater access to modern machines. Aid agencies have found that provision of tractors is popular with people and politicians, and facilitates rapid disbursement of funds with clearly visible short-term results. The combination of aspiration and political expediency has often speeded up the process of tractorization although this has not always led to long-term economic viability. Once tractors have started to be used in farming systems, it is difficult to promote the advantages of animal power. Interesting exceptions to this general rule occur in the USA, where Amish and Mennonite communities have maintained and further developed profitable farming systems based on animal power. In Cuba, at the time of economic crisis when the Comecon block disintegrated, political will ensured that work animals were effectively re-introduced to farms where tractors had long been employed.

In Southern Africa, tractors have long been used on large-scale farms (historically the 'white' sector), and they have also been promoted for the small-scale sector. To date, no economically sustainable model has been developed for providing tractor services for small-scale farmers growing rain-fed crops. However large amounts of money have been spent on subsidized tractor schemes operating in competition with non-subsidized animal traction. Individuals have purchased tractors with non-agricultural income (trading stores, pensions, aid subsidies) but have not been able to replace them through profits. Some farmers have been using remittance income to pay more in hire fees than the value of their harvest. Illogical economic decisions are made owing to the high status of tractors and the actual or perceived decline in animal traction options in the face of increasing tractorization.

Photo: Paul Starkey

Figure 7 An Amish man cultivating with a horse in USA: the area of Amish land cultivated by animal power is increasing in USA

Photo: Paul Starkey

Figure 8 Weeding with oxen in Cuba: the Cuban policy of encouraging animal power has led to increased numbers of oxen in agriculture

CROP-LIVESTOCK INTERACTIONS AND FOOD SECURITY

Timeliness, yields, security, residue use, manure use, marketing

Relative to hand labour, animal traction can lead to yield increases owing to improved timeliness in cultivation, planting and weeding. This is particularly true in semi-arid areas, where the time of planting after the first rains is critical. In theory, greater timeliness can come from tractors; in practice this is only true for the first person who uses the tractor. When many smallholder farmers own animals, they can all plough their fields at the same optimum time. This has long been the case in Ethiopia and can now be seen in parts of Senegal and Mali. Farmers that do not own their animals arrange paid or in-kind services from their neighbours: generally the animal owners till their own land first. Ownership of work animals provides security for timely operations, for unless there are many tractors or manual workers in an area, it is risky to rely on external power sources.

Work animals create great synergy within farming and marketing systems, leading to higher production, enhanced food security and greater incomes. Crop-livestock integration and nutrient cycling is encouraged by the use of animal-drawn carts or pack transport. With animal transport, it is easier to carry green fodder, hay or stover to be used as feed for animals on the farm or sold for income. Similarly animal transport makes it easier to carry manure and compost back to the fields. Animal transport also makes it easier to bring in products from the field and take them to market.

Photo: Paul Starkey

Figure 9 Direct seeding with a donkey in Senegal: the timeliness benefits achieved with seeders have encouraged the on-going expansion of their use in West Africa

Multipurpose animals: production and products from work animals

Work animals tend to grow during the time that they are kept for work and this can lead to important gains in meat production, food security and incomes. In some countries oxen are used for just three or four years, and then sold on for meat, often being sold at twice the weight and price as at the start of training. Oxen can be used for eight years or more, and this allows excellent farmer-animal relations and reduces the need for retraining. However meat production and 'capital gains' are maximized by replacing animals every two to four years.

If animals are well-fed, the use of work cows, including buffalo cows, is particularly productive, but it requires high levels of animal husbandry. In those parts of Europe, where the use of cattle

for work has persisted, most farmers now use multipurpose cows. Cows are also common in some other smallholder production systems such as rice-farming in Indonesia and Viet Nam and potato production in the Altiplana of the Andes. Both these examples are characterized by insufficient feed resources to justify maintaining non-reproductive animals.

Risks to animals: theft, disease, drought

Three of the main problems for animal traction are stock theft, disease and drought. Very few smallholder livestock are insured. Animal loss can be devastating and adversely affect food security. Work oxen are particularly vulnerable to theft, as they can be rapidly converted into anonymous meat for disposal. One of the reasons given for the increasing use of donkeys in all regions of the world is that they are more resistant to drought and less likely to be stolen. Farmers prefer the strength of large oxen, but value the lower risk of small donkeys. Similarly, farmers often prefer local breeds to exotic animals and their crossbreds. Indigenous types are usually more resistant to diseases and local environmental conditions. The overall range of donkeys is spreading and as farmers move donkeys away from their natural range there are large risks that un-adapted donkeys may die. Farmers are often aware of the health problems and short life expectancy of donkeys in more humid areas, but they may still take risks because of the large benefits that the donkeys could bring if they were to survive.

SOCIAL, ECONOMIC AND POLITICAL ISSUES

Changing institutional context

In the 1960s and 1970s and 1980s, researchers in many countries were looking at animal traction, although there was a tendency not to look at the system as a whole, but to concentrate on either the implements or the animals. The last few decades have seen a reduction in public sector institutional support to agricultural extension, research and knowledge dissemination, at both national and international levels. This has affected animal traction in various ways. Several internationally-orientated agricultural mechanization institutions or departments have been closed or severely reduced through institutional re-structuring. This has directly affected the number of people and projects actively engaged in supporting animal traction and related information dissemination. Specific examples include the international agricultural engineering sections of the British Silsoe Research Institute, the French Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical (CEEMAT), the Dutch Instituut voor Mechanisatie (IMAG), the German Gesellschaft für Technische Zusammenarbeit (GTZ) and agricultural engineering sections of FAO, the International Livestock Research Institute (ILRI) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

In the 1980s and 1990s, several publications and networking events relating to work animals were supported by a variety of donor agencies and internationally-oriented institutions, including the Australian Centre for International Agricultural Research (ACIAR), the French Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), the British Department for International Development (DFID), the Dutch Directorate General for International Cooperation (DGIS), FAO, GTZ, the International Livestock Centre for Africa (ILCA, which became part of ILRI) and Swiss Development Cooperation (SDC). In the past decade however, it has been increasingly difficult to find funds to support networking and publications relating to animal traction. Even the low-cost, informal publication 'Draught Animal News'[2], aimed at people investigating or promoting animal traction and has been published regularly since 1982 has recently had to stop owing to lack of funding (Pearson, 2010).

In many countries where animal traction remains very important, the national research services are not actively engaged in supporting or monitoring the use of work animals. Universities

[2] http://www.link.vet.ed.ac.uk/ctvm/Welcome page/Publications/dan/danfp.htm

similarly have little research or teaching related to animal traction. For example, in the Paraná State of Brazil, where animal power is very important for livelihoods and food production (perhaps half of all local food production is grown using working horses and mules), the universities offer no courses that cover work animals. Similar examples could be given from all continents. This means that there is a small and decreasing pool of graduates with tertiary training relating to animal traction. National policies and research strategies are therefore drifting without informed debate or serious consideration. This is compounded by the urbanization and 'modernization' issues that tend to regard animal traction as an historic technology that will soon disappear.

Access and issues of gender, age and family labour

Animal power can benefit all members of society, including marginalized groups, if access to animal power is widespread. Access may be through animal ownership, which allows greatest timeliness. Poor people often lack the resources to buy and maintain animals and purchase the necessary equipment and support services. Appropriate credit is seldom available to them. However, many communities have systems for borrowing or hiring animal power, so spreading some of the costs and benefits.

Historically, men have tended to control many animal power technologies, including ploughing and transport. In recent years, women have had increased access to work animals in many countries. Women, as major carriers of water, fuel wood, food grains and agricultural products can benefit particularly from transport animals. Donkeys are efficient and easily-managed transport animals that can be of special benefit to women, and donkeys have fewer associations with masculine power than most other work animals. Women are increasingly involved in controlling animals for agricultural operations, such as ploughing and weeding. Nevertheless, in most countries women still have less access to work animals and related support services than men.

In many parts of the world, the average age of farmers is rising. This is partly owing to greater longevity, with older farmers retaining their rights to work the land. Small farms cannot support several adults and grown-up children may be forced by economics to work elsewhere. Increasingly, the children of farmers prefer to work in other professions, and the children of successful farmers are more likely to have the educational and economic opportunities to allow this. HIV/AIDS has also affected the age profile of farmers. The younger generation increasingly associates farming with old people and consider animal traction and its supporting services as being old-fashioned, a view strongly reinforced by the media.

By controlling work animals, children can contribute to household tasks and family production without excessive physical strain. However, as children attend schools, certain traditional animal-management practices are no longer practicable without exploiting children. Partial urban migration of male workers and the HIV/AIDS pandemic have also influenced labour availability for agricultural operations. Appropriate low-cost alternative animal management and grazing systems are needed to suit changing family labour profiles.

Urbanization and 'modernization'

Urbanization is a major ongoing trend in most countries. Fifty years ago, there were many countries where most people lived in rural areas, with economies dominated by agriculture and supporting services. As an increasing proportion of the population lives in towns, many countries now have more than half their population based in town and cities. This affects the economy, the national policy and the perceptions of ordinary people and decision makers.

People in towns have greater access to, and contact with, 'modern' technologies, including electricity, motor power, television, mobile phones and advertising. Most young people, in urban and rural areas, aspire to modern technologies. Animal traction, whether in its rural or urban settings, is seldom portrayed as modern. Young people in towns have become more familiar with the international image of tractorized agriculture they see on the television than with the animal traction currently being used in their own rural areas. This process has been going on for many years, and some of these young people have now become politicians and decision makers. They

not only have urban backgrounds and perceptions, but they may also lack real understanding of the smallholder farming systems of their own countries. The ongoing process of urbanization is directly and indirectly affecting both people's perceptions of animal traction and also the overall policy environment.

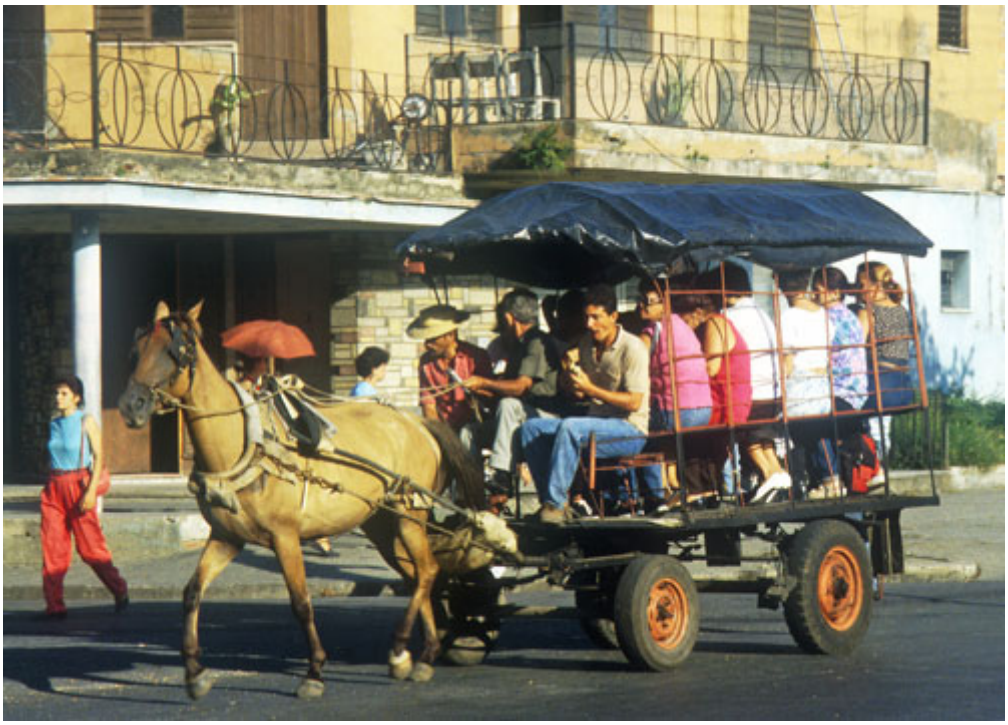

Photo: Paul Starkey

Figure 10 Horse bus in Cuba: horses provide public transport in several towns in Cuba.

Photo: Paul Starkey

Figure 11 Horse cart in Colombia: legislation has been passed to ban horse carts from Colombian towns

Ethical and animal welfare issues

Throughout the world, there are people who maintain excellent relations with their work animals and look after them well. It is in the interests of users that their animals are in good condition

and can work with enthusiasm. Animal operators often develop close relations with their animals, talking to them, grooming them and giving them rewards. Few people that have watched such animals preparing for work would doubt that they appear to 'enjoy' a reasonable work schedule. Most work animals are adequately or well-maintained.

However, there are also cases throughout the world where work animals are made to suffer through excessive workloads, poor harnessing and hitching, insufficient feeding, lack of adequate health care and physical beating. In some circumstances, the people responsible for the poor animal welfare are operating in societies where humans also suffer from excessive work, poor equipment, inadequate nutrition and health care, and physical violence. Even so, it should be in people's best interest to care for their animals. In many countries, there are both NGOs and government services that counteract animal cruelty through education, training and legal enforcement.

Many international NGOs support such work throughout the world,. NGOs provide targeted support in many countries, however, no matter how committed they can be, they can affect a relatively small proportion of the work animals in these countries, unless their interventions are coupled with more substantial and widespread policy interventions. Several international animal welfare NGOs have been supporting international networking and publications relating to horses, mules and donkeys (Fielding and Pearson 1991; Bakkoury and Prentis, 1994; Arriaga Jordan *et al.*, 1998; Pearson, Fielding and Tabbaa, 2003; Pearson, Muir and Farrow, 2007). In the past decade some NGOs have been adopting participative processes that should, in time, lead to more wide-spread influence in the target populations of animals and humans (Brooke, 2010).

World distribution and current trends

INFORMATION SOURCES, RELIABILITY, PERCEPTIONS, UNDERSTANDING

There is no authoritative estimate of the number of work animals in the world. Very little data is collected on the levels of animal traction use. FAO has a database containing numbers of tractors, but there are no equivalent numbers of work animals. Few national governments maintain or make public information on the use of work animals. For some animal types, notably mules and donkeys, it is reasonable to link overall populations to work animals. However this is more difficult for horses, which have recreational and breeding as well as work uses, and camels, also kept for meat and milk production.

Most cattle and buffaloes are maintained primarily for meat or milk and so it is impossible to estimate the number of work animals from the national populations of cattle and buffaloes. To estimate the numbers of working cattle and buffaloes, it is necessary to have observational information or survey data on the proportion of households that own and/or use animal power. Even then, the diversity of farming systems (e.g. ranching or pastoralism contrasting with smallholder mixed farming) makes it difficult to estimate the proportion of the national herd engaged in work, unless there is good data disaggregated for farming systems. A number of countries maintain some information on work animals, based on census or household survey data, agricultural or tax returns and even slaughterhouse records. The reliability of such information is variable, and it is seldom easily accessible. Some valuable data relating to work animals in specific target areas is maintained by NGOs and regional projects, although these tend to concentrate on their achievements (animals trained, implements sold or resulting benefits) rather than objective situation assessments.

In the early 1980s, N.S. Ramaswamy prepared a report on draught animal power for FAO and other United Nations agencies (Ramaswamy, 1983). This was not finalized for publication, but some copies were informally circulated. The report contained a table on the estimated number of work animals in various countries. There were few indications of the sources of these estimates and there were also some notable inaccuracies. However versions of this table were then repeated in various other documents including Ramaswamy (1986) and Ramaswamy (1988). Table 1 illustrates the estimates used at this time.

Ramaswamy's tables contained various inaccuracies and omissions and did not include Europe. However, they were the best estimates available at that time and were influential. Starkey (1988) compiled estimates of work animals in all African countries. In the subsequent two decades, it was generally assumed in relevant publications that there were about 300-400 million work animals in the world. As will be made apparent in the subsequent sections of this document, in recent years there has been ongoing expansion in sub-Saharan Africa, and contraction (at different speeds) in Asia and Europe, with a mixture of expansion and contraction in the Americas. An updated 'guestimate' might put the present world population of work animals at about 200-250 million.

Table 1 Some estimates of draft animal populations around 1980[1]

Country [2]	*Cattle*	*Buffaloes*	*Horses*	*Mules*	*Donkeys*	*Camelids*	*Totals*
India [3]	110.0	16.0	1.0	0.1	1.0	1.7	**129.8**
China [4]	53.0	17.0	11.0	4.0	7.4	1.1	**93.5**
Mexico	2.8		6.5	3.2	3.2		**15.7**
Ethiopia	6.0		1.5	1.4	3.9	1.0	**13.8**
Pakistan	7.0	0.5	0.5	0.1	2.3	0.8	**11.2**
Bangladesh	10.0	1.0					**11.0**
Brazil [5]	2.6		2.0	1.7	1.7		**8.0**
Thailand	3.0	5.0					**8.0**
Indonesia	3.5	2.0					**5.5**
Myanmar	4.0	1.0					**5.0**
Nepal	2.8	2.0					**4.8**
Turkey	2.5		0.6	0.3	1.4		**4.8**
Philippines	0.6	3.0	0.3				**3.9**
Colombia	1.3		1.0	0.6	0.6		**3.5**
Peru [6]	0.1		0.4	0.2	0.5	1.2	**2.4**
Tanzania	1.0				0.2		**1.2**
Egypt [5]	1.0						**1.0**
	211.2	**47.5**	**24.8**	**11.6**	**22.2**	**5.8**	**323.1**

Source: After Ramaswamy, 1983, 1986 and 1988

Notes:
1. This table is included for historical reasons only as it includes many inaccuracies
2. Countries ranked by estimated total work animals (totals were not on original tables)
3. The cattle figure for India, taken from Ramaswamy (1986) was said to include young stock.
4. The cattle figure for China, taken from Ramaswamy (1986) was said to include young stock and included yaks. The camelids were said to be llamas.
5. It was implied there were working buffaloes in Brazil and Egypt but there were no estimates available
6. In Ramaswamy (1986) the camelids were said to include yaks

Recent publications and accurate information often come from projects in areas of ongoing expansion and research. These refer to recent adoption by a few hundred or a few thousand farmers. While this may represent life-changing and poverty reducing trends for the affected families, the total numbers are often very low, compared with areas of long-standing, traditional use. The total numbers of work animals in the world is highly dependent on the estimates for China and India, each of which may have confidence ranges of 10 million animals. This possible 'error' is greater than most national figures. In Africa, the estimates for Ethiopia may well have a confidence range of one million work animals, giving a potential 'error' that is higher than many national totals. While it may not be possible to rely too much on quantitative estimates, there is much evidence for the food security and poverty-reduction implications of the changes that are taking place in the various regions. There are some new initiatives to improve the collection of relevant livestock data, including the Livestock Data Innovation in Africa Project, a consortium including FAO, World Bank, ILRI, Africa Union and the Gates Foundation (Livestock Data, 2010). It is important that work animal information is included in such programmes.

Some information relating to animal populations have been taken from the FAOSTAT databases. These may not accurately reflect the actual situation. Population estimates (by FAO staff or

national livestock services) may not be based on 'on-the-ground' appraisals. Few countries keep accurate data on donkey populations. Population 'stability' may be a result of always using last-year's figures in the absence of survey information.

AFRICA

Photo: Paul Starkey

Figure 12 Cows ploughing in Egypt: few oxen are used in North Africa.

Photo: Paul Starkey

Figure 13 Women weeding with donkeys in Tanzania: weeding, donkeys and women's use of animals are all increasing in Tanzania.

Photo: Paul Starkey

Figure 14 Demonstration of training techniques for weeding using N'Dama oxen in an area of animal traction expansion in Guinea.

North Africa

Work animals have traditionally been used in North Africa for thousands of years. A wide range of animal types (horses, donkeys, mules, camels, cows and buffaloes) have been used for agriculture, transport, post harvest operations and water raising. All large-scale farms and major transporters now use motor power. Motorization has been assisted by oil wealth and the political desire for modernization. The continued importance of animal power in some sectors may be denied and/or ignored by the authorities and planners. Accurate data on the numbers of work animals is not available. Horses and donkeys remain locally important for both urban and rural transport in Egypt, Morocco and Tunisia, with more minor employment Algeria and Libya. The size and stability of the donkey populations in the past decade is noteworthy in Egypt (3 million), Morocco (one million) and Tunisia (230 000), illustrating the continuing importance of donkeys for small-scale transport in the region. Transport of fodder for dairy animals is important in Egypt. Animals assist with the transport of smallholder crop harvests in Egypt and Morocco and Tunisia. Tillage with multipurpose dairy cows and dairy buffaloes remains important for some smallholder farmers in Egypt. In Morocco, some smallholder farmers use multipurpose transport horses and/or donkeys for tillage work. Camels may sometimes be worked with other animals. Work oxen are seldom, if ever, employed in the region. While there is some use of animals for water raising and crop processing, this is becoming rarer.

Northeast Africa

Animal power has been used for agriculture and transport in Northeast Africa for thousands of years. The traditional maresha ard plough pulled by oxen is used very widely in the highlands of Ethiopia and Eritrea. Despite the promotion of tractors and alternative animal power technologies in recent decades, tractorization is quite limited and the majority of land is tilled by oxen using traditional technologies. It is estimated there are 7-8 million oxen in use in Ethiopia (Alemu, 1998). There is little evidence that this will change rapidly in the coming decade. There are about five million donkeys in Ethiopia, and they are very widely used for pack transport. There is an increasing trend to use donkey carts, notably in the Rift Valley. Horses (population 1.7 million) are widely used for riding and have been used for pulling horse taxis (gharries) in towns. In the past decade, the use of gharries has been declining rapidly in the face of competition from motorized three-wheelers. This trend, supported by some authorities, seems

likely to continue and urban transport using gharries is likely to decline and possibly disappear. There is some use of camels for pack transport and for extraction of oil from seeds.

Sudan, Somaliland and Somalia are more arid and there is less intensive use of animal power for agriculture. There are some major irrigation schemes with tractors, but small family plots are often tilled by hand or by animals (oxen, donkeys, horses or camels). South Sudan is not an area of traditional use of animals for ploughing, and could be an area for the expansion of animal traction technologies in the coming decade.

East Africa and Madagascar

Animal traction is gradually increasing in East Africa, notably in Tanzania, with over one million work animals, and Uganda with many fewer. Numbers of work oxen are increasing in those districts where animal traction has long been well established (e.g., Shinyanga District in Tanzania). It is also spreading to some new areas (such as Rukwa District in Tanzania). It is slowly spreading (from a very low base) into Rwanda, the Democratic Republic of Congo and Southern Sudan. Oxen are the main work animals, and these are used for ploughing and pulling carts. The use of oxen for pulling weeders is still very limited, although some farmers do weed using their ploughs. There is some adoption of ripper tines that have been promoted for conservation tillage, in place of conventional mouldboard ploughs. The drought of 2006 killed large numbers of animals in the region, including many work oxen, and set back the growth of animal power. The small size of land holdings is considered a problem, notably in Kenya, as many farms are too small to justify large animals. Another issue is the relatively old age of farmers, notably in Kenya, with young men reluctant to start farming with work animals. Four-wheel tractors, with hire services, have become established in some areas (e.g., Arusha District) and these reduce the need for work animals. While 2-wheel tractors have not yet had a major impact in the region, recent large importations (5000 in Tanzania) may lead to the local development of a critical mass of this technology. However the impact on animal traction may be limited if they are mainly used for rice production as most work oxen are used for rain-fed crops. Donkeys have traditionally been used as pack animals by pastoralists in East Africa, and they are increasingly used for cart transport, notably in Kenya, and for light tillage.

Zebu cattle have traditionally been used in Madagascar to puddle rice fields with their feet. Since the nineteenth century, they have been used for pulling wooden-wheeled ox carts. Caravans of ox carts still engage in long-distance marketing, although this is decreasing slowly. The use of pneumatic tyres on carts is slowly increasing. The use of oxen to pull ploughs was not traditional in Madagascar. It was promoted in the 1980s but adoption is still quite low. There are a small number of horses and donkeys that pull carts. Although the potential for power tillers appears high, they are only beginning to have an impact (Rakotoarimanana *et al.*, 2009). National instability and issues of governance have affected most development initiatives in recent years, including those related to animal traction.

West and Central Africa

The use of camels, horses, donkeys and cattle for traditional transport in West Africa dates back many hundreds of years. The colonial powers further developed the use of animal power for wheeled transport around the ports of West Africa. Animal traction for agriculture was introduced early in the twentieth century, and is still spreading in some areas. The main areas of increase are in the Sahelian zone, where animal traction, primarily with oxen, can be profitably used for growing cotton, groundnuts, maize and millet. Zebu oxen are the main work animals used for agriculture, but bulls are used in some countries (Chad, Niger, Nigeria) and smaller N'Dama animals are used in Guinea and neighbouring countries. Cotton companies have been, and remain, important for promoting animal traction technology and providing credit to allow investment in animals and equipment. Adoption has also been assisted by the establishment of implement factories (notably Sicoma/Sismar in Sengal) selling a range of ploughs, cultivators, seeders and carts. For example, from 1960 to 1995, the number of donkey carts in Mauritania increased from fewer than 1000 to over 75 000 mainly owing to informal importations from Senegal (Starkey, 1996).

An example of the recent growth of animal traction has been documented from Mali (Mali, 2005). In 1964, nine percent of the cropped area was cultivated using animal traction. That had increased to 35 percent in 2002, with about 800 000 work oxen, 170 000 donkeys, 50 000 horses and 1000 camels. Equipment used included 350 000 ploughs, 250 000 cultivators, 100 000 seeders and 230 000 carts (Mali, 2005). Comparable rapid growth was reported at the end of the twentieth century in Senegal and several other countries in francophone West Africa. The number of working oxen in these countries was estimated to have increased over five-fold from 350 000 in 1965 to 1,900 000 in 1995 (Havard, 1997). Another rough estimate of about 4 million work oxen in West Africa was provided by Sims and Kienzle (2006). The growth of animal traction in West Africa is still continuing (Havard, Vall and Lhoste, 2009), but with some areas of Senegal, Mali and Burkina Faso now having 90 percent of farmers using animal power, further increase in numbers in such zones is difficult. The ongoing increases will be mainly in other areas and some (but not all) of these could be less favourable to animal traction. One interesting social observation in areas of adoption (including Mali and Burkina Faso), is that ownership of work animals and a cart has become an important criterion for marriage eligibility. Figure 15 (from Havard, Vall and Lhoste, 2009) is a map of West Africa showing the main zones of animal traction adoption, and also the rainfall isohyets that influence the distribution of work animal species and the 'donkey line'.

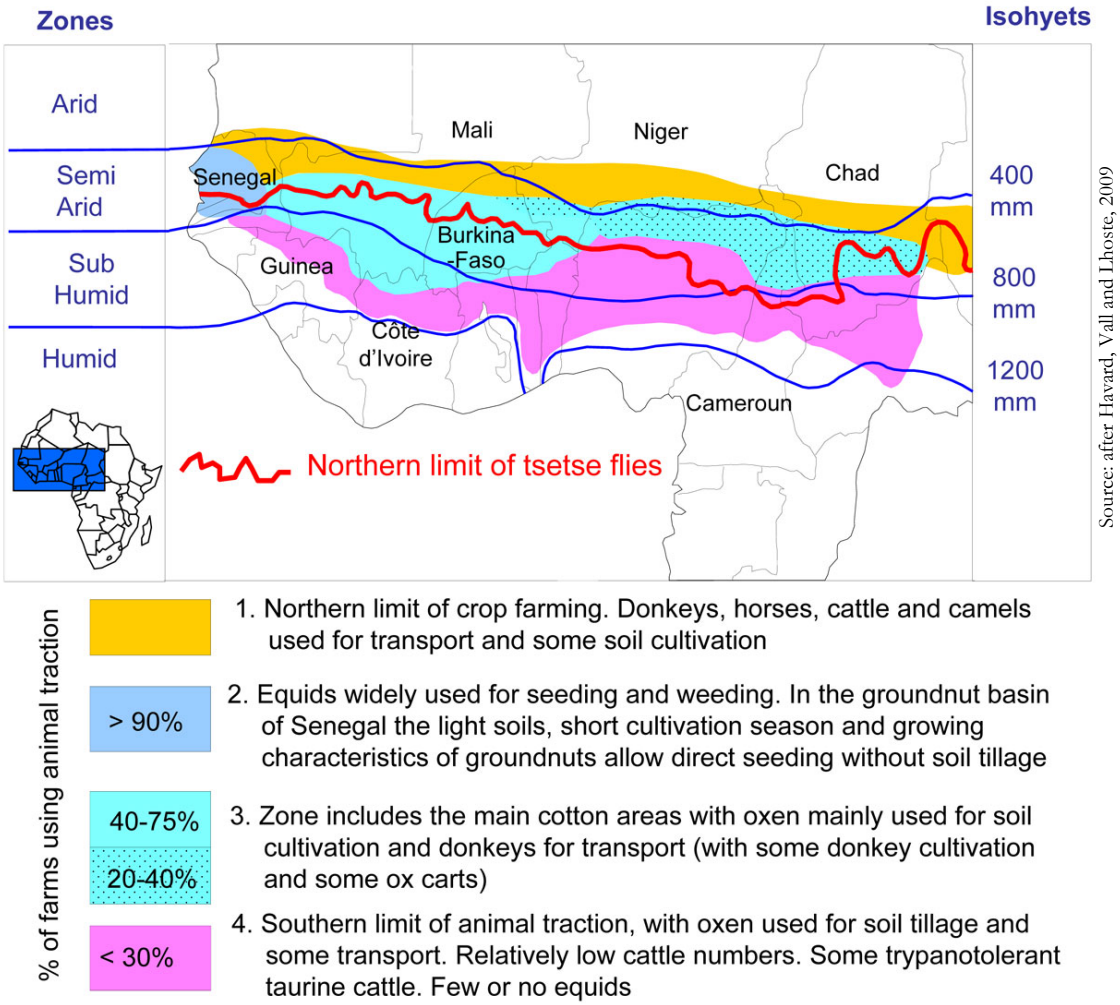

Figure 15 Map of West Africa showing main animal traction zones

The use of oxen is gradually spreading southwards in most countries in the region (from Guinea to Central African Republic), often following initial deforestation for hoe-based farming. In Guinea, the Réseau Guinéen pour la Traction Animale (RGTA) is an active NGO that, with the support of various projects, has been training farmers, trainers and blacksmiths. Over 10 000 pairs of N'Dama work oxen were trained with RGTA support between 1997 and 2010 and there is said to be sustainable ongoing expansion, with new on-farm training run by self-financed master-trainers (RGTA-DI, 2010). There are few cattle in the higher rainfall areas to the south of West Africa, and in this zone pilot farmers face high risk of animal loss through disease or theft. Despite the constraints, some national authorities and NGOs are assisting new adoption in the more humid zone, with new interest extending as far as the Democratic Republic of Congo (Ngongo, 2010).

Long-distance transport with camels largely has been superseded by truck transport. Some camels are used for ploughing, notably in Niger and Nigeria. Short-distance transport with horses, oxen and donkeys is stable in many areas and increasing in some. In West Africa, donkeys are used for pulling carts, pack transport and soil cultivation. Donkeys are increasing and spreading. The 'donkey line' (Starkey, 1994) is the southern limit to the range of West African donkeys that runs east-west at the edge of the savannah zone. This has been moving southwards in the past few decades and continues to do so. In the 1960s, the donkey line was north of The Gambia. During the 1980s, the line passed through the Gambia and donkeys became the dominant work animal there (Starkey, 1987). Donkeys continued to move into Casamance (southern Senegal) with comparable movements in Mali and Burkina Faso. In western Burkina Faso, there were no donkeys twenty years ago but now very many rural families own donkeys and donkey carts. Between 1998 and 2008, the population of donkeys in Burkina Faso increased from 700 000 to

1.2 million, while in Mali it increased from 800 000 to 1.8 million. Most West African countries with similar ecological conditions also have increasing donkey populations, although the growth has been less dramatic. The overall West African donkey population increased from 4.5 million to 6.3 million in the past decade (FAOSTAT, 2010).

Knowledge of the past and present trends and issues in West Africa has been shared in recent years through various networking initiatives and regional workshops. The West Africa Animal Traction Network effectively linked both Anglophone and Francophone countries between 1985 and 1995, organising bilingual regional workshops and resource publications (Starkey and Ndiamé, 1988; Starkey and Faye, 1990; Lawrence *et al.*, 1993). Many of the links formed at that time are still in operation, and the Guinean RGTA-DI (an NGO formed from a networking initiative) is particularly active (RGTA-DI, 2010). Subsequent regional networking has mainly linked francophone countries, with researchers from CIRAD playing active roles. A regional workshop on the effects on animal traction of the changing role of the state and public sector services was held in Burkina Faso in 2003, and has led to a various resource publications and follow-up initiatives (CIRDES, 2004. REMVT, 2004). In 2009, many experiences of animal traction and mechanization in francophone West Africa were brought together by the Inter-réseaux development network in a special edition of the electronic publication Bulletin de veille on agricultural mechanization (Inter-réseaux, 2009).

Southern Africa

In Southern Africa, pastoralists have used cattle as transport animals for centuries. The use of animal traction for agriculture and the use of equids started with settlers in the seventeenth century. It gradually spread in the region, assisted by promotion by missionaries in the nineteenth century and by extension programmes in the twentieth century. Animal traction for agriculture became an integral part of smallholder systems, but was constrained by many socio-economic factors, including migratory labour, racial divisions, limited access to land and/or animals and wars (Angola, Mozambique, Namibia and Zimbabwe). Large numbers of smallholders use work oxen or donkeys, with some use of transport horses. A small number of farmers in South Africa use heavy horses (Dommett, 2006). The main small-farm tillage implements are mouldboard ploughs, most of which used to be made in South Africa by the Safim company. In the 1990s, private sector implement manufacture channels became dominated by Zimbabwe producers. In South Africa there may be about 400 000 work oxen and 150 000 donkeys in use. In Mozambique there are about 100 000 work oxen, found mainly in the south (INE, 2009). The national figure of 13 percent of farmers using animal traction is based on high use in the south (49 percent in Gaza) to minimal use the north where there are few cattle (INE, 2001). There is now gradual expansion, after the animal losses during the war and subsequent droughts.

Throughout the region, particularly in South Africa and neighbouring countries, there have been numerous schemes to promote tractor use by smallholder farmers. Such schemes, which have occurred in all decades since the 1950s, have proved economically unsustainable. Nevertheless, throughout the region they have been repeated for socio-political reasons. A recent Government of Swaziland document noted that the use of tractors on small, fragmented pieces of land was uneconomic, and it was therefore government policy to evaluate draft animal power (Mhazo *et al.*, 2011).

Cattle and donkey populations are very low in the more humid parts of the region, including southern Malawi, north/central Mozambique and northern Zambia and Angola. Elsewhere, serious droughts have affected livestock ownership and increased the importance of donkeys, as drought-resistant animals.

In the past decade, donkey populations have been slowly increasing in most countries in the region, with gradual expansion into new areas in Mozambique, Malawi, Zambia and Angola. There are areas of ongoing adoption, expansion and diversification (use of donkeys, use for weeding) in Malawi, Zambia and Mozambique (Kumwenda, 2004; Muswema, 2011; Armanda Cavane, 2010).

In several countries in the region, there is clear policy support for animal traction with some research and extension services relevant to animal traction. In Malawi, 13 percent of all farmers use animal power, with a much higher percentage in the north of the country where there is gradual expansion and ongoing promotion (Kumwenda, 2004). In Namibia, a EU-backed project has been promoting animal power in the north of the country, providing training for farmers and animals (Chigariro, 2009; DAPAP2, 2010). Surveys in several districts showed the majority of farmers (60-70 percent) used animal power (oxen and donkeys) for crop production (Mudamburi, 2009). Surveys also demonstrated that although there seemed to be many donkeys in the area (excessive numbers and 'overstocking' according to some authorities), the farmers thought there was a shortage of donkeys, as they had fewer work animals than they would have liked (Mudamburi *et al.*, 2003). The project trained 4500 farmers in nine regions to use animal traction and found that 89 percent of the trained farmers continued to farm with work animals in the following years (DAPAP2, 2010). While there has been little adoption of animal power equipment for conservation agriculture, there is extension interest and support for this and local fabrication facilities will be established (Mudamburi and Namalambo, 2011).

In recent years, there have been several national and regional workshops to link people working on animal traction. The Animal Traction Network for Eastern and Southern Africa (ATNESA) was formed in 1990 and has organized many regional workshops and published many resource books including Starkey, Mwenya and Stares, 1994; Jones, 1997; Starkey and Kaumbutho, 1999; Pearson *et al.*, 1999; Kaumbutho, Pearson and Simalenga, 2000; Joubert, 2002; Pearson, Simalenga and Krecek, 2003; Simalenga and Pearson, 2003; Fielding and Starkey, 2004; Ashburner, Bwalya and Odogola, 2005. Numerous papers and publications are available on the ATNESA website. The latest ATNESA workshop was held in Arusha, Tanzania, in July 2010. Participants from nine SADC countries prepared papers and discussed key issues relating to animal power in conservation agriculture (Jones, Mudamburi and Nengomasha, 2011). There have also been many national workshops relating to animal traction issues, including Ethiopia, Lesotho, Mozambique, Namibia, South Africa, Tanzania and Zambia (EARO-ILRI, 1998, Mattick, 2000, Simalenga and Joubert, 2004; Simalenga, Joubert and Ntlokwana, 2007).

ASIA AND THE PACIFIC

Photo: Paul Starkey

Figure 16 Pack donkey in Pakistan: the donkey populations have been increasing in Pakistan and Afghanistan.

Photo: Anne Pearson

Figure 17 Buffalo cows levelling a rice field in Viet Nam: with limited grazing resources, smallholder farmers keep multipurpose females for work and animal production.

Photo: Paul Starkey

Figure 18 Camels pulling carts in India: camels are used for transport and agriculture in Rajasthan.

China and East Asia

China has a very long tradition of using a wide range of work animals, with large numbers of animals in use. In the southeast, water buffaloes are used in agriculture. In the central areas of the country, oxen are more common. In the northern and western areas, horses, donkeys and mules are the main work animals. In the Himalayas, relatively small numbers of yaks and their crosses with cattle are used for pack transport and agricultural operations. Some camels are employed in

the northwest. With urbanization, industrialization and mechanization, there are some areas where animal traction has been declining quite rapidly, but it is still very well established in the more remote parts of the country. Power tillers and 4-wheel tractors have been increasing rapidly, reducing the need for work animals in irrigated rice zones and in the larger rain-fed fields. This has reduced the use of buffaloes and oxen. Rapid expansion of the number of three-wheeler motor vehicles and power-tillers with trailers has reduced the need for animal-drawn carts. For reasons of traffic congestion, safety and modernization, animal-drawn carts have been prohibited from some urban areas. These trends have greatly reduced the visibility of animal power to urban people and inter-urban travellers. However, away from main roads, in the rural areas, tens of millions of farmers depend on animal power for agricultural production, on-farm transport and local marketing. The donkey population, still the highest in the world, has been decreasing from a peak of 11 million in 1993 to 7 million in 2008 (FAOSTAT, 2010), in response to the greater availability of small motor vehicles. In the same period mules declined from 5 million to 3 million, horses from 10 to 7 million and camels from about 350 000 to 250 000 (FAOSTAT, 2010). Buffalo and cattle populations have been more stable, as the majority of these are maintained for non-work purposes.

In the twentieth century, animal traction was largely replaced by motor power in Japan. South Korea has been following a similar pattern of urbanization, industrialization and mechanization. North Korea endeavoured to 'modernise' its agriculture and mechanize all farms. While, for a time, tractors became the dominant technology in the flatter areas, animal power persisted in the more remote and hilly areas. Subsequent economic problems and fuel shortages led to an increasing importance of animal power in many farming systems, as well as for local transport. The North Korean authorities have recently been researching the potential for conservation tillage systems involving animal power (Ahn, 2005).

South Asia

South Asia has a long history of animal traction, with one of the most widespread and diverse employment of animals and technologies in the world. Work oxen are the main work animals and throughout the region commonly used with traditional ard ploughs and a wide range of local ox carts (Ramaswamy and Narasimhan, 1985). Smaller numbers of water buffaloes are used throughout the region (from Sri Lanka to the Himalayas). Horses, donkeys and mules are mainly found in the drier and higher areas (notably in Pakistan, Afghanistan and Iran). Camels are used in the arid areas (Rajasthan, Pakistan) and yaks are used in the highlands of Nepal. Small numbers of elephants employed for logging and for ceremonial purposes in several countries.

While animal traction is highly persistent in much of south Asia, its use is generally decreasing because of tractorization and greater access to affordable motorized transport. However, animal traction remains extremely important in many countries, with tens of millions of people benefiting. India is estimated to have 68 million work animals, most of which are oxen (Yadava, 2002). There are more than 10 million animal-drawn carts. While India has large numbers of four-wheel tractors (nearly three million), notably in the Punjab, it is likely that draft oxen still cultivate a larger total area (55 percent of arable land, according to Phaniraja and Panchasara, 2009). Two-wheel tractors have been rapidly spreading in several South Asian countries, including Sri Lanka and Bangladesh, and these, together with three-wheeler transport, have replaced many work animals. Bangladesh is now said to have one of the most mechanized and labour-intensive agricultural sectors in South Asia, owing primarily to the recent rapid adoption of two-wheel tractors powered by Chinese diesel engines. There are thought to be three times more two-wheeled tractors in Bangladesh than the whole of India (Biggs and Justice, 2010). While working oxen and buffaloes still exist in Sri Lanka, they are minority technologies.

The relatively small horse and mule populations of south Asia remain fairly constant (horses used for some urban transport, rural carting, recreation and military functions), the number of donkeys in Pakistan has been rising in recent years from 3.6 million in 1998 to 4.4 million in 2008 (FAOSTAT, 2010). The donkey population of Afghanistan has also been rising (0.8 to 1.2 million) while in Iran it has remained stable at about 1.6 million. The donkeys are mainly used

for transport (goods, water, agricultural produce, animal feed, manure) but also undertake light tillage work in small plots.

Throughout the region, work animals are most rapidly being replaced in those places with good roads and large level land areas, where a critical mass of tractors, small-motorized vehicles and support services now exist. They remain highly persistent and extremely important in the remoter and hillier areas.

Southeast Asia

Animal traction has been part of many traditional Southeast Asian farming and transport systems. Work oxen have been the most important work animal by number, but water buffaloes have been closely associated with rice production systems in the region, notably in Indonesia and The Philippines. Small horses (ponies) have been used for transport in many countries, pulling carts (and taxis) in some peri-urban areas and as pack animals in the hills. Following the pattern of some other regions, tractors and power tillers have become widely used for rice production, notably in large flat areas. Thus in the deltas and coastal areas of Viet Nam and the large rice-production areas of the Mekong basin in Laos, Cambodia and Thailand, most tillage involves two- or four-wheel tractors. However, buffaloes and working cattle remain extremely important in the hillier and more remote areas. In Viet Nam, the population of buffaloes in the coastal and delta regions has declined (owing to competition with power tillers), while in the hillier regions use of the buffalo is growing (Ly, 2001). One recent study in Viet Nam (Nha, Thu and Preston, 2008) suggested that in the delta regions, buffaloes remained important for tillage in the wettest and muddiest fields and that their role in the transport of rice from the fields (often by sledges) was actually increasing and saving human labour. Buffaloes were more profitable for rice production than power tillers, mainly owing to the breakdowns of power tillers. Moreover, farmers reported that buffaloes took the same amount of time as power tillers, but were more relaxing to use, owing to the lack of noise and vibrations (Nha, Thu and Preston, 2008). In some countries, notably Indonesia, most of the animals working on smallholder plots are females (buffaloes or cows). Feed resources are very limited and maintaining male animals for work is much less profitable than using female animals for milk, reproduction and some work. Similarly, the use of female buffaloes is also an increasing trend in those more isolated and/or upland areas of Viet Nam and Cambodia where smallholders still use animal power. Even some power-tiller using farmers in these countries employ their female buffaloes (maintained for animal production) for final puddling and levelling, claiming it reduces tillage pans and increases yields (Pearson, 2010).

During the 1980s, the Australian Centre for International Agricultural Research (ACIAR) was asked to support animal traction research projects in Southeast Asia, including Indonesia. In order to gain ideas and then to share initial research findings, ACIAR arranged two international workshops. This stimulated some animal traction networking in the region, including the circulation of the Draught Animal Bulletin, which published animal traction articles and research findings from Indonesia and several other South and Southeast Asian countries (DAP, 1987-1990; DAP, 1991). The proceedings were published and circulated as resource documents (Copland, 1985; Hoffman, Nari and Petheram, 1989). More recently the SIDA-supported project for Research Cooperation for Livestock-Based Sustainable Farming Systems in the Lower Mekong Basin (known as MEKARN) has included some work on animal power in its research and training programmes and the Masters degree courses it has sponsored (MEKARN, 2010).

The Pacific

Animals suitable for work are not indigenous to the Pacific region and the use of work animals is not traditional on any islands. Colonialists have brought various animals for work, primarily transport), including horses, donkeys, mules, cattle and buffaloes. Some oxen and buffaloes have been used for soil tillage, including in Papua New Guinea and Fiji. In the World Wars, the opposing armies made use transport animals (notably horses and mules) in several countries, including Papua New Guinea, Fiji and the Solomon Islands, proving that such animals can be used for remote rural transport in the mountainous areas of the region. The use of both buffaloes and horses by smallholder farmers for preparing rice fields in Timor Leste (Asia/Pacific

interface) shows the technology has potential, and could be introduced to comparable areas in West Papua and Papua New Guinea. Total numbers of work animals in the region are low and fairly static, with some interest in increasing animal power for rural transport and agriculture in Papua New Guinea (Starkey, 2006).

North and Central Asia

Agriculture in Russia and Central Asia was highly mechanized during the period of the Soviet Union, and large fleets of tractors remain in use. Work animals are mainly used for transport in the more remote areas with significant populations of donkeys and horses and much smaller populations of camels. The estimated populations of donkeys have been increasing in the past decade in Tajikistan (90 000 to 170 000) and Uzbekistan (200 000 to 290 000) according to FAOSTAT (2010). The horse populations of the region reflect traditional uses for riding and for meat and milk production.

West Asia

Animal traction has been a traditional technology for agriculture and transport in West Asia and 'the Middle East', having been developed by the very early civilizations of the region. Oxen have mainly been used for ploughing, with some use of the main transport animals (donkeys, horses, mules, camels) for farming operations. Oxen have been used for pulling carts, but this is now quite rare. While motor power has replaced animals for much agricultural and transport work, transport animals (notably donkeys, horses and mules) remain very persistent in most countries in the region. Some transport animals (horses and donkeys) are used for tilling small plots. According to FAOSTAT (2010), estimates of the significant donkey populations of Yemen (500 000) and Iraq (380 000) have not been declining in recent years. However, some donkey population estimates have halved in the past ten years: Turkey (700 000 to 300 000), Syria (230 000 to 115 000) and Jordan (20 000 to 10 000). Because donkeys are seldom maintained if they are not used, such estimated figures illustrate the continuing importance of donkeys in the region.

THE AMERICAS AND THE CARIBBEAN

Photo: Paul Starkey

Figure 19 Cows ploughing in Brazil: large numbers of farmers in Brazil use animal power but this is not reflected in the educational systems.

Photo: Paul Starkey

Figure 20 Mules ploughing in Mexico: large numbers of work animals are employed in Mexico including horses, mules, donkeys, oxen and cows.

Photo: Paul Starkey

Figure 21 Horse pulling innovative metal seeder for terrace cultivation in Honduras

Central America

Animal traction was introduced into Central America by the Conquistadores. Its use in the region is quite widespread, particularly in the more remote areas. Oxen are mainly used for ploughing, with long-beam ard ploughs, and pulling heavy carts. Horses are used for riding, including for ranching, and pulling light carts and carriages, including some urban transport in Nicaragua. Small numbers of donkeys are used for pack transport and breeding mules. Mules are employed for riding and cart transport. A small number of goats are used to pull carts to carry water or fire

wood. Large scale farms are mainly mechanized, although these may use horses for on-farm transport. The main countries in the region for animal traction are Honduras and Nicaragua. There is now little animal traction in Costa Rica and the more urbanized or industrialized parts of El Salvador and Panama. However in the more remote areas of these countries, oxen, donkeys, horses and mules are all employed on a local basis for agriculture and transport. In the 1980s and 1990s, the Programa Regional de Fomento de la Tracción Animal (FOMENTA) promoted the use of alternative equipment, including locally-produced plough-mounted seeders and small-terraced-based hill-farming techniques. Its impact was increased by the formation of a regional network (RELATA) which promoted information exchange through its colour magazine 'El Yuntero' and a series of regional workshops (Mejía Gómez and Granda Jimbo, 1996; RELATA, 1997; RELATA, 1999, RELATA, 2002). The effects of these are still being felt, with gradual expansion of these animal traction technologies in Honduras, Nicaragua and Guatemala. The use of oxen for road maintenance has also been promoted on a small scale (Montiel, 2002).

North America

Animal traction was extremely important for North America in the nineteenth century, but declined through the twentieth century, as tractors and motor vehicles took over most of the tasks formerly performed by animals. At the beginning of the twenty-first century, animal traction was almost absent from large-scale farming, but persists in several niche situations. In some parts of the United States, there are a large number of farms cultivated by Amish and Mennonite people using animal traction (mainly horses). In some US counties, half the land area is profitably farmed with animal power (Bender, 2001). There are about 250 000 Amish living in USA, and their resource-efficient, profitable and sustainable farming systems provide a valuable example of the potential benefits of animal power (Kendell, 2005). The Amish population is rising, with increasing numbers of people engaged in fulltime farming using work animals. The total area farmed with work animals is growing and the numbers of working horses are increasing. For example, in Michigan, the numbers of working horses increased from 5500 to 8500 between 1984 and 1991 and further increased to 12 600 by 2007 (Kendell, 2010). This doubling of work horse numbers was in contrast to overall declines in the numbers of horses kept for pleasure and shows. Much of the equipment used by Amish and other users of animal traction equipment is of modern design. Horse Progress Days provide opportunities to demonstrate innovations in equipment and techniques for serious modern users (Horse Progress, 2010; Rural Heritage, 2010).

In Mexico, the large-scale farms use tractors and there is a large population of relatively wealthy people who own motorcars. However there is also a large population of smallholder farmers and relatively poor rural people. Many of these make use of oxen, mules or horses for ploughing (Velázquez-Beltrán *et al.*, 2011). Donkeys, mules and horses are widely used for transport, including for riding, pack transport and pulling carts. Despite a rapidly rising number of motor vehicles in Mexico, the population of just over three million donkeys and three million mules has remained fairly constant over the past thirty years (FAOSTAT, 2010). This is because there remain an important number of people without access to affordable motor transport.

South America

The very long-standing use of llamas for pack transport in the Andes is now quite limited. The use of oxen (or bulls), horses and donkeys was introduced by the Conquistadores and subsequent settlers, and spread throughout the continent. Oxen are used by small-scale farmers for soil preparation (mainly with long-beamed ard ploughs) in hill-farming systems in Colombia, Ecuador, Peru, Bolivia, Paraguay and parts of Brazil. In flatter areas they may also pull carts. In these countries there are also large-scale farms using tractor power. Horses are used for riding, pulling carts, and for some ploughing. In several countries, horses are employed for small freight transport in and around towns (and some rubbish collection). In Colombia, the national transport authorities have proposed removing horse carts from the roads and replacing them with modern, motorized transport (Colombia, 2009). Horses were the ploughing animals of choice in the southern half of the continent, and some remain in use in southern Brazil and Chile. Most farms in Uruguay and Argentina now use tractors for soil tillage, but riding horses are

widely used for on-farm transport. Donkeys are important for small-scale rural transport in the northern Andean countries (Venezuela, Colombia, Ecuador, Peru, Bolivia) and parts of Brazil. Donkeys are also used for pulling carts in some urban and peri-urban areas. Mules are quite widely used for riding, pack transport in the mountains, pulling carts and some ploughing (including parts of Brazil and Chile). Mules and donkeys used to be employed for the long-distance transport of potatoes and other produce in the Andes. This is now mainly done by trucks, with mules and donkeys remaining important for shorter distance field-to-village transport. The overall population of about 6 million donkeys and mules in South America has remained fairly constant over the past decade (FAOSTAT, 2010).

Historically, in most of South America, there was a major gulf between the perceptions of the urban elites (who tend to dominate policy making) and the needs of poor people in both urban and rural areas. Elections in several countries have returned politicians more in tune with rural people, but many administrations remain dominated by urban elites. While animal traction is often appreciated for its historical and 'macho' associations, there is little policy support for present users. Indeed, there may be denial that animals still have a place in modern-day countries. Urban and road authorities tend to marginalize people using animal-drawn carts (Colombia, 2009).

There is little or no training offered in schools, colleges and universities relating to animal traction technologies. In Paraná State in Brazil, it is estimated that half the farmers and half the food production depend on animal power, but students taking degrees in agriculture or veterinary science receive no courses relating to the use of animals for work. Although animal power has a very low profile in universities and research centres, there is some research interest in enhancing animal traction technologies in several countries including Colombia (Cortés Marín, undated). Various conservation agriculture technologies have been developed in Brazil by the private sector (farmers, implement producers, agrochemical firms) with public sector research inputs (Bolliger *et al.*, 2006). Several of these are based on animal power, and relatively large areas of Brazil are now farmed using animal power and conservation tillage systems. This is a source of interest to several countries in Africa, including Kenya, Tanzania, Uganda and South Africa, and FAO has been supporting international collaboration in this aspect of animal power (Kaumbutho and Kienzle, 2007; Nyende *et al.*, 2007; Shetto and Owenya, 2007).

The Caribbean

Cuba provides a fascinating example of animal traction in recent times. Cuba illustrates that declines in animal traction can be reversed if there is a political will and a population prepared to re-engage with work animals. Animal power had been introduced by the colonialists and was the main source of agricultural power in the nineteenth century. During the twentieth century, the mainly plantation-based agriculture gradually mechanized, with 7000 tractors, 500 000 oxen and 700 000 horses in 1960. Following the revolution in 1959 and support from the Soviet bloc, Cuba rapidly increased its tractor fleet to 70 000 and numbers of work oxen had dropped to 160 000 in 1990, with horses down to 235 000 (Ríos and Cárdenas, 2003a and 2003b; Starkey *et al.*, 2003). Then, in 1990s, with the end of the Soviet bloc, the country entered the Special Period of economic problems with shortages of fuel and spare parts. The country made a policy decision to encourage sustainable animal power in its farming systems and actively supported the use of oxen, mules and horses. By 2003 there were about 400 000 oxen, 300 000 horses, 30 000 mules and 5000 donkeys in use in Cuba. Now, tractors and work animals often operate in complementary ways on the same farm (tractors for ploughing, oxen for weeding). The work animal population in Cuba is firmly established but probably has now peaked. It may be gradually declining owing mainly to social reasons such as livestock theft and an aging farm population (Starkey and Sims, 2003).

On the neighbouring island of Hispaniola, animal power is widely used for agriculture and transport in both Haiti and the Dominican Republic. Oxen and some cows are used for cultivation, often in complementary systems with tractors for ploughing and oxen for puddling or weeding (Starkey, 1995a). Horses, mules and donkeys are important for transport, with 850 000 horses and 600 000 donkeys and mules in the island. There has been an increase in motorcycles

in recent years, and these will probably lead to a reduction in the use of donkeys. Recent trials with power tillers in Haiti are likely to be followed by major importations using post-earthquake funds (Justice, 2010). This may well reduce the demand for work animals in the coming years although it is too early to be sure.

Elsewhere in the Caribbean, numbers of work animals are quite small. Jamaica is the only other island with a significant numbers of donkeys and mules (30 000). In most islands there are persistent but gradually declining uses of donkeys and horses, and relatively few oxen, as tractors and motorized transport become more accessible to the increasingly affluent populations.

EUROPE

Photo: Paul Starkey

Figure 22 Haymaking with horse in Lithuania: animal power in Eastern Europe is widespread but declining.

Photo: Paul Starkey

Figure 23 Horses logging in Romania: animal power remains widely used for logging in Europe.

Photo: Paul Starkey

Figure 24 Cow pulling a cart in Portugal: most work animals in Europe are now either cows or equids.

Western Europe

For millennia, animal power was essential for the agricultural and transport systems of Western Europe. Tractors, stationary engines and motor vehicles gradually replaced most work animals during the twentieth century. Historically, oxen were the main agricultural animals, but they were replaced in Northern Europe by horses that had greater speed and acceleration. Stationary machines operated by animals were replaced early in the process, with transport uses among the last replacements. It is noteworthy that the last widespread uses in Western Europe were for

small-scale agriculture (often in remote hilly areas including Spain and France), for urban transport (deliveries, scrap collection) and rural transport where people did not have easy access to motor vehicles (e.g. donkey use in Ireland and Italy).

The decline of donkey populations in Europe illustrates an important trend (Starkey and Starkey, 1994; FAOSTAT, 2010). In some of the richer countries of Europe, including UK, donkey populations declined to low levels before the second world war (WW2), as traditional donkey carts were replaced by motor vehicles (motorcycles, cars and pickups). In France and Ireland, with more small-scale farmers, the decline came later. The donkey population of France fell from 185 000 in 1938 to 41 000 in 1968 (and down to 15 000 in 2008). In Ireland donkeys decreased from 148 000 in 1938 to 64 000 in 1968 (down to 6000 in 2008). The donkey population in Italy halved between 1938 and 1968 (790 000 to 324 000) and by 2008 it was down to 24 000, a decline of 97 percent since WW2. There was a similar trend in Spain. The donkeys had been replaced by affordable motor vehicles. In contrast, the donkey populations of Greece (400 000) and Bulgaria (300 000) were relatively stable between 1938 and 1968. These countries had many rural people living in remote and hilly areas who could not afford motor vehicles. However, with rising rural affluence, donkey populations have declined, with Greece falling steeply to 40 000 in 2008 (down 90 percent in the past 40 years), and Bulgaria falling more slowly to 130 000 in 2008 (down 57 percent in the past 40 years). These figures suggest that rural people will retain donkeys as long as they are important for transport but will switch from donkey power to motor power, when motorcycles, cars and pickups become readily available and affordable. The slower decline and persistence of donkeys in some countries was not a reflection of average national wealth, but the fact that there were still very many rural people who did not have access to motor transport to replace their donkeys. The donkey population in Cyprus has similarly crashed since WW2, as farmers have replaced their donkeys with pickups. In contrast to Cyprus, in nearby Syria and Egypt, there are still large populations of donkeys, because many rural people cannot yet afford to buy pickups. One exception to the trend that 'proves the rule' is the island of Hydra in Greece, where, to date, no private motor vehicles have been allowed to operate. Mules, horses and donkeys have been retained and are currently used for all major transport functions, including carrying goods from the ferries to the supermarkets.

Throughout Western Europe, small numbers of animals remain in use for specialised operations including forestry, organic farming and the transport of tourists. Some people prefer to use animals for religious, historic, ecological or practical reasons. One estimate suggested that in many Western European countries there are several hundred horses regularly employed in agriculture (Sieffert, 2004). The number of serious users of modern animal traction technology in Western Europe is now increasing (Herold, 2010). The number of work oxen is lower than that of horses, but there are 170 farms in France have one or more pairs of work oxen (or cows) in regular use (Avon, 2004).

While there are some traditional and heritage uses of animal power in Europe (some of which are linked to living history museums) most of the existing animal power use is definitely modern, with new equipment designs, techniques and materials (Herold, Jung and Scharnhölz 2009). There are private companies developing and selling new animal traction designs, including those of the late Jean Nolle (Prommata, 2010) and Charlie Pinney (Carthorse, 2010). These are often demonstrated at farming shows, including the PferdeStark draught horse meetings in Germany. This biennial meeting attracts animal traction users and equipment makers from all over Europe. In 2009, the prize for equipment innovation went to a new Italian design of horse-drawn toolcarrier (Herold, 2009). Sustainable agriculture courses at Eberswalde and Kassel Universities in Germany now include modules orientated to modern European uses of animal traction (Herold, 2010).

Work animals have comparative advantage in some special ecological situations (logging, hill farming, transport in national parks). There are several thousand horses employed in commercial logging in Europe, with national horse-logging associations in many countries (Maijala, 1999; Schlechter *et al.*, 2006; Dugast, 2008; Herold, Jung and Scharnhölz, 2009). In recent years, at least 70 cities have introduced horse-pulled wagons for municipal collections and park work (Herold, 2010). There are networks and associations of people actively involved with animal traction in

several European countries. These have the important function of linking people working in various specialized fields, and they provide information, support and recognition. The various associations and networks hold national and international workshops and meetings from time to time, sometimes linking people addressing animal traction from different perspectives, including modern farming and logging, historical traditions, scientific studies and international development (Dalin, 1999; Manceau, 2004; Bourrigaud et Sigaut, 2007).

In some countries of Europe, notably in UK, animal rights campaigners are vocal and influential: a proposal to introduce horse-drawn vehicles for tourists in Oxford was refused after animal rights activists campaigned against the idea (Animal Aid, 2001).

Eastern Europe

Eastern Europe had quite similar experiences to Western Europe, but the transition to motorized alternatives in the smallholder farming and transport sectors was significantly slower, probably reflecting different levels of affluence. Thus, at the end of the twentieth century, there were still large numbers of work animals in countries of the soviet bloc, such as Romania, Bulgaria and Poland. Large horses were the main work animals, with donkeys important in Bulgaria and working cows (multipurpose animals) used by smallholders in several countries.

In the past decade, as many countries have become fully integrated into the European Union, the transition away from animal power accelerated, partly because of the availability of credit and subsidies to enable the purchase of tractors and motor vehicles. Local and road authorities made it increasingly difficult to operate horse-drawn vehicles on public roads. In 2007, a law was passed in Romania banning horse carts from national roads. There are said to be 900 000 work horses in Romania, and while farmers and transporters prefer to use tracks and local roads without traffic, it is often necessary to use national roads to access these (FECTU, 2008). In addition, supporting artisans (harness makers, wheelwrights, blacksmiths) have found their markets disappearing and young people have been reluctant to become apprentices in apparently backward occupations. This is contributing to the ongoing downward spiral of disappearing 'critical mass', when there are no longer enough support services to maintain animal power, and not enough animal power users to sustain support services. Families on small farms have found the time required to maintain animals an increasing constraint. Often one adult has off-farm employment and there are fewer children and old people than in previous generations. People find it is more convenient to maintain a tractor and/or pickup that does not require daily attention.

In 2010, there are still many work animals (mainly horses) employed in Eastern Europe, but numbers are declining quite rapidly. They are most persistent in the more remote and often hillier areas where there is smallholder farming. Rural and urban transport uses also persist where there is no adverse legislation. Niche applications, including tourism and forestry logging, are likely to continue, provided there are appropriate artisanal support services available.

FECTU (Fédération Européenne du Cheval de Trait pour la promotion de son Utilization) is a Europe-wide network linking many national associations concerned with current and modern uses of work animals. These include horse loggers in France, Belgium, Poland, Finland and Sweden, and people using horses for organic farming in Germany, France and elsewhere (Herold, Schlechter and Scharnhölz, 2008). In addition to linking groups actively engaged in using work animals, FECTU campaigns for a policy environment more sympathetic to the modern needs of people using horses for their livelihoods (FECTU, 2008).

Conclusions and policy implications

KEY TRENDS AND INFLUENCING FACTORS

Animal power is widely used around the world, with various areas of stability, expansion and decline. At the present time, hundreds of millions of people are benefitting from the use of work animals. Most of the influential media in the world is produced in modern studios and offices by urban-based people in cities lacking positive examples of animal power. Hollywood and Bollywood films, international TV series, international and local radio stations and national newspapers generally portray animal power as an out-dated, historical technology. This greatly influences young people, fashion and policy makers concerned with modernization. Animal power is often portrayed in the context of poverty, yet in all regions of the world, the poor cannot afford work animals: animal traction is actually a technology for people with resources.

In many situations, despite the rising cost of fossil fuels, the availability of affordable tractors and vehicles is leading to a decline in animal power use. However there are large areas of new year-on-year adoption in sub-Saharan Africa. There are smaller areas of adoption and diversification in the Americas, Asia and Pacific regions. There are recent examples of special conditions leading to the growth of sustainable animal power in Cuba and the USA. There are very many parts of the world, where work animals, notably donkeys, assist with rural transport on a daily basis, often with growing populations of work animals.

One clear trend is that people will replace human-powered tillage and transport with the use of animals, when this is available, affordable, profitable and socially acceptable. This trend explains the current situation in the animal traction growth areas of sub-Saharan Africa and other localized growth areas.

Another clear trend over the past two centuries is that most people will replace work animals with motor power when it is available, affordable, profitable and socially acceptable (the final condition includes the Amish in this trend). This trend explains the current situation in most industrialized countries including Europe, USA and Japan.

A third dominant trend is that people will retain labour-saving animal power, where it is profitable and socially acceptable and there are no easy alternatives available. This explains the high persistence of animal power in much of the world, including the rapidly industrialising countries of Brazil, Mexico, China, India, Indonesia and Viet Nam. It also explains the post-WW2 persistence of donkeys in some European countries. Social acceptability is often crucial, and young people are particularly affected by apparent status and perceptions. In all regions of the world, farmers talk of the reluctance of some young people to work with animals and traditional support services. In some areas, including Southern Africa, people have made 'illogical' (unprofitable) investment decisions because tractor ownership and use was considered to have high status in the community.

A fourth trend involves relatively small numbers of animals (thousands rather than millions) but is potentially very significant. Individuals and organizations in many countries choose to adopt animal traction because they believe it is environmentally or socially more appropriate than motorized alternatives. There are examples in all continents where animals have been adopted as the power source of choice for organic and conservation farming, forestry, tourism, park amenities, urban transport (including waste collection), recreation and various therapy applications. These applications are often associated with positive images and high status situations.

In parallel to the various changes in animal power use, there is a fifth global trend concerning public sector investment in animal traction research, education, training and promotion. This has declined significantly in the past twenty-five years. There is little or no ongoing international research related to animal traction in the institutes of the Consultative Group on International

Agricultural Research (CGIAR), the United Nations, internationally-orientated national institutes or major universities. Indeed, many departments and institutes that had worked on animal traction in the past have recently been scaled down or closed. In the 1980s and 1990s there were various donor-assisted programmes and projects promoting or investigating animal traction. These were mainly in sub-Saharan Africa, but there were some in Central America and Southeast Asia. Most of these have long-since closed and the staff dispersed. The only areas with noticeable ongoing public sector investment in animal traction are francophone West Africa and Eastern and Southern Africa (areas of animal traction expansion). However these programmes are mainly low-level extension support, with little financial investment.

A sixth worldwide trend is the tendency for growing urban populations, policy makers and the media to view animal traction as old-fashioned and of little relevance to the modern world. This may be the most important and critical issue, since changing perceptions and policy environments can directly affect all the other trends.

IMPLICATIONS

The agricultural and food security implications of the main trends are complex. In areas of animal traction adoption, increased farm power, crop-livestock integration and transport capacity should lead to higher overall quantities of harvested and stored farm produce. With animals available to transport both animal feed (forage, stover, groundnut hay) and animal manure, there should be greater and more sustainable crop-livestock production. There may be increased vulnerability to livestock theft and/or animal diseases. There is ample evidence that adopting work animals for agriculture and transport can lead to improved incomes and better quality of life for the farming families.

In areas of adoption of motorization, additional farm power may lead to higher harvested yields for those farmers with sufficient land suitable for tractor cultivation. However they may suffer with greater vulnerability to fossil fuel prices and possible failures in the supply system for fuel and spare parts. Moving from animal power to motor power generally means changing from local input supplies and employment to imported input supplies (fuel, equipment) with employment implications in the local and national supply chains. Money and foreign exchange will flow out of the area unless production and external sales rise to counteract this. If livestock continue to be maintained, organic manures may be available for agricultural fertility and/or for fuel purposes. If the keeping of large animals stops, then there may need to be replacement fertilisers and/or domestic fuel.

The climate-change implications are also complex. Motorization generally leads to greater energy consumption, higher carbon dioxide emissions and lower use of renewable resources compared with the use of multipurpose work animals (Pretty and Ball, 2001). The risk of climate change causing catastrophic failures within farming systems is generally greatest in systems with low bio-diversity and high dependence on external inputs, which is typical of large-scale farming systems. However large-scale farmers may have the resources, insurance and technology to reduce their vulnerability. Multi-cropped, integrated crop-livestock farming systems may have the diversity to allow greater tolerance of climatic fluctuations, but not necessarily the resources to cope with disasters attributable to climate change. Vulnerability to external factors such as climate change increases with the adoption of animal traction and even more with the adoption of motorization. In the medium to long term, climate change will affect which types of work animal are most suited to particular areas. Already drought-resistant animals (notably donkeys) are becoming increasingly appreciated in the drought-affected areas of southern, eastern and western Africa. One characteristic of recent disasters (floods, earthquakes and wars) is that local work animals often prove invaluable for moving people out of danger and distributing medicines and supplies.

The implications of the low levels of public sector investment are significant, particularly in regions with potential for growth, such as sub-Saharan Africa. Once animal traction becomes a 'traditional' practice, the private sector (often small-scale artisans and the informal sector) can generally maintain animal traction and allow its continued use and gradual expansion (as is

happening in parts of sub-Saharan Africa). Farmers will modify implements and practices and develop their farming systems. However, there is good evidence that in areas of introduction, there is important need for public sector (or parastatal company) support. The successful promotion of sustainable animal traction use in Africa has generally been associated with development projects and/or commodity companies ensuring there were suitable implement supplies, appropriate credit products, animal health care and training schemes. Gaining the virtuous spiral of a critical mass of users benefiting from appropriate support services has required 'priming the pump'. This has been achieved with strategic support and promotional services of governments, NGOs and parastatal corporations. Animal traction is unlikely to spread further in the face of a major reduction in public-sector and international investment.

DEFAULT 'LAISSEZ-FAIRE' POLICY AND IMPLICATIONS

Animal traction is very resilient. Even in the absence of a supporting policy environment, in the short term there will be few major changes to the world situation. There will be much stable, ongoing use. There will be growth in those places with current adoption. There will be continuing decline where people can afford motorized alternatives.

In the absence of a positive policy environment, fewer and fewer people will receive education and training relating to animal traction and its roles and needs. This will make it more and more difficult to develop appropriate policies and strategies. The image of animal traction as an outmoded technology will strengthen, affecting young people in particular. This will slow growth and speed up the rejection of animal traction and supporting industries. Urban-based policy makers, with little understanding of the benefits of animal power, will increasingly marginalize animal traction users in various ways. Animal-drawn carts will be banned rather than appropriate animal power routes being designated. Incentives and subsidies will be given to 'modern' mechanized technologies in development projects and schemes. Support services appropriate to animal power (e.g. medium-term credit for cart purchases or improved security against stock theft) will not be introduced or retained.

It will become increasingly difficult to maintain animal traction technologies, which may start the downward spiral of inadequate support services contributing to an insufficient market to maintain them. This may cause an unremitting decline of animal traction, albeit a slow one, in most areas.

One danger of the mechanization and modernization debate is that it encourages thinking in terms of progression up a mechanical ladder, with animals initially helping people, but then tractors and motor vehicles providing additional help. This has some validity in rich countries with little poverty. Seeing a former horseman 'tying up' his pickup under the shade of a tree illustrates a comforting economic and technological progression. However, watching a woman carry a heavy burden for miles or watching someone hand hoeing a smallholding illustrates the ongoing problem of poverty in very many countries. It is these people who might benefit from adopting work animals to assist them. Such poor people will exist in the foreseeable future: they may be prevented from benefiting from animals owing to their extreme poverty (they may not be able to afford to buy and maintain animals). However, they may also be prevented because the relevant development agencies are not promoting and facilitating the option of using animals for agriculture and transport. Poverty-reducing adoption of animal traction may not be possible where the authorities are not providing a positive policy environment and relevant credit, training and support. With 'laissez-faire' policies poor people will not automatically acquire the services of tractors and motor transport. They will probably have to continue to use human energy for farming and transport and they will forego the potential economic and livelihood benefits of adopting animal power. The key poverty-focussed debate should not be about middle-income farmers replacing animals with motors, it should be about assisting poor people to benefit from animals in appropriate ways and suitable areas.

In a particular case, a book about empowering rural communities was produced and the cover photo showed a smiling woman entrepreneur with a donkey carrying two drums of water

(Starkey, 1995b). A politician described this as an insulting, negative image: the community should have tapped water, not donkey transport. The politician's aspiration for reticulated water pipes was very reasonable, but the negative dismissal of the existing solution was inappropriate. The politician failed to understand and appreciate the immediate advantage to that woman and her community of animal power. In the existing circumstances, if the woman had no donkey, she would lose her livelihood as a transporter and/or be forced to carry water herself. The donkey power was beneficial, and in no way did it prevent the authorities from investing in a water system that could eventually replace the donkey transport of water.

Laissez-faire policies will fail to achieve important development goals, particularly if there is no change in the attitudes of authorities to the existing and future roles of animal power. To achieve poverty reduction, there is an ongoing need to consider proactive ways in which animals can help reduce poverty for individuals and communities.

POSSIBLE STRATEGIC SUPPORT AND IMPLICATIONS

One of biggest advantages of animal power is that it reduces the drudgery and increases the productivity of poor, smallholder farmers. It is extremely important to focus on poor people and how they could benefit from animal power in a realistic timescale. Unfortunately, the poverty focus is often lost as animal power is widely perceived as old-fashioned and outmoded. As countries urbanize and industrialize, national figures and even provincial politicians fail to see the value to local people of using work animals. Politicians, advisors, government officials, NGOs and aid donors can all gain popularity by offering modernization and tractorization. The playing field is seldom level to allow a fair analysis and choice of technologies based on agricultural, economic and technical appropriateness to particular conditions.

One of the main constraints to animal traction in the world is its poor, outmoded image. This is preventing national authorities and aid agencies from seriously considering animal traction as a modern, developmental option that could reduce poverty and increase economic well-being. Animal traction is not 'the answer' but it is one neglected option that should be promoted and facilitated as well as motorized and human-powered options.

One of the major impacts that intergovernmental organizations such as FAO could play is to raise awareness, provide information and technical inputs to national authorities, universities, NGOs, aid donors, educational systems and the private-sector media to provide a positive, progressive and modern image of animal traction. It is important to publicise the fact that animal power can provide present and future benefits to individuals and to communities as well as the importance of animal health and welfare. Increasing knowledge and understanding about work animals and raising their profile should allow animal traction use to continue where it remains valuable and should allow further expansion and diversification where this is appropriate.

National and regional networks concerned with animal traction have proved effective at sharing information, generating the critical mass needed for influence and policy change and providing recognition, status and professional support to the small number of technical experts in this area. Much of the information obtained for this paper was only available because of past network publications and present networking exchanges. Networks are particularly appropriate as they can effectively link people working in different disciplines, countries and organizations and at different levels. They require little start-up resources and can effectively build on a very wide range of expertise and experience in different countries.

Identification of future interventions can often be delegated to networks, that can jointly examine limiting factors and potential solutions, drawing on lessons from other experiences. Such approaches can be applied to adaptive research, equipment design and production systems, credit products and promotion schemes, animal welfare needs and policy requirements for integrating agricultural and transport technologies. All of these options may allow animal traction to help reduce poverty, but none are likely to be implemented if the first limiting factor (lack of a favourable policy environment at national and international levels) is not also addressed.

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