Effects of Draught and Transport Animals on Rural Livelihoods and the Natural Environment in Tigray National Regional State, Ethiopia

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Abstract

Cattle, camels and equines are widely employed to provide energy for agricultural operations and for transport in the Ethiopian Highlands. Their use is promoted by many Government and non Government agencies. They are generally considered to be beneficial in reducing the drudgery of many agricultural and transport activities, in raising food output, and in contributing to household incomes and food security. Human welfare is thus considered to be enhanced. The negative effects of the need for and use of animals to provide energy and power are rarely considered. Such effects include reduced output from other livestock functions such as milk and meat. There is also a need for additional labour to support and care for work animals during prolonged periods when they are not producing any output. Work animals also exert negative effects on the environment. These include their contribution to the expansion of arable areas on to lands unsuitable for this type of production and over and excessive use of and competition for limited natural feed resources. They are directly responsible for a major part of erosion in general and the creation of gullies in particular along their tracks. This paper provides an overview of the benefits and costs of the use of domestic livestock as providers of rural and urban energy in Tigray.

Keywords: Livestock herd age and sex composition, household income, food security, degradation

Introduction

In much of the Developing World animal power on and off the farm is considered essential to people's survival. Livestock furnish energy for draught and transport, help relieve the drudgery of arduous and repetitive tasks and contribute to larger cultivated areas and higher crop yields. They may create additional income that can be used for a variety of purposes including contributing to food security and assisting in payment of taxes and other expenses. Draught and transport animals in Tigray National Regional State (TNRS) and in its neighbouring states are implicated in most if not all of these functions (Wilson, 1975; Wilson et al, 2002; Mengistu et al 2005). So what is the problem?

The problem is that positive effects must be balanced -- as in all nature -- against associated negative ones which are rarely considered by proponents of animal power. In livestock production *per se* negative effects include reduced output from other components of the enterprise and the need for extra labour to feed and care for work animals. In human well being the have nots (those without animal power or with only a limited amount) are generally exploited – often shamefully – by the haves (those who do have it or have a surplus of it). In the environment and in sustainable production draught and transport animals consume enormous amounts of feed and contribute to and cause sheet and gully erosion in much the same way as do other classes of large livestock. This paper first calculates the number of draught and transport animals in TNRS, presents some of the pros and cons of this class of animal and then looks at their effect on the environment.

Draught and transport animal numbers

Cattle, camel, donkey, horse and mule are draught and transport animals in TNRS. In 2004-2005 the region was home to more than 3 million of these species (Table 1, CSA, 2006). Some 32.6 per cent of cattle were under 3 years, 62.8 per cent were aged 3-10 years and 4.4 per cent were over 10 years of age. In the group 3-10 years, 46.6 per cent of cattle or 766 600 head were used for draught compared to
16.9 per cent (278 000 head) for milk with 33.2 per cent (546 146 head) described as "breeding" animals and only 0.8 per cent (13 160 head) were kept for beef production. The total of three-quarters of a million draught cattle (which are mainly oxen of 3-10 years) does not provide the true picture as these are animals actually in work but 50 per cent (426 985 head) of the under 3-year olds are also being reared for draught and most animals over 10 years (amounting to about 55 000 head) plus about 8500 adult cows are also used for draught. The total of "draught" cattle is therefore of the order of 1.2 million head. Not all of theses are native to Tigray as in order to meet the demand for power additional oxen have to be imported from the neighbouring lowland areas. This very high proportion of work animals has negative effects on other aspects of output including low herd reproductive performance and reduced outputs of meat and milk. This results from competition for grazing and for crop residues used as feed as well as from fewer young (especially cattle) being born due to the low percentage of breeding females in the total herd.

The CSA census indicated that 90.1 per cent of camels over four years old were used for transport and 3.5 per cent for draught purposes. For camels, therefore, and in contrast to cattle, females as well as males are used for work. The total number of work camels (including those of both sexes under four years old) is therefore about 37 500.

Equines are mainly used for transport and to a lesser extent for draught. For donkeys 69.8 per cent are used for transport and 27.2 per cent for draught purposes leading to a

total number of 391 410 working animals. Horses are mostly used for transport (85.3 per cent) and to a lesser extent (8.3 per cent) for draught to give a total of 7370 animals actually being used or reared for work. Similar proportions of mules, as for horses, are work animals with 89.6 per cent used for transport and 8.6 per cent for draught to give a total of 16 120 work animals across all age groups.

Table 1. Estimated number of livestock and numbers of draught and transport animals in Tigray National Regional State, 2004/2005

Livestock species	Whole population	Animals for draught and transport
Cattle	2 619 540	1 200 000
Camel	39 791	37 500
Donkey	403 517	391 410
Horse	7 598	7 370
Mule	16 418	16 120
Total	3 086 864	1 652 400

Source: adapted from CSA (2006)

Table 2. Biomass (kg live weight) of work and non work animals in Tigray National Regional State

Livestock species	Mean population weight (kg)	Working animals		Non working animals		All animals	
		Number	Total biomass (kg)	Number	Total biomass (kg)	Number	Total biomass (kg)
Cattle	220	1 200 000	264 000 000	1 420 000	312 400 000	2 620 000	576 400 000
Camel	300	37 500	11 250 000	2 300	690 000	39 500	11 940 000
Donkey	90	391 400	35 226 000	12 100	1 089 000	403 500	36 315 000
Horse	200	73 700	14 740 000	230	46 000	37 930	14 786 000
Mule	200	16 120	3 224 000	300	60 000	16 420	3 284 000
Sheep	18	0	0	687 200	12 369 600	687 200	12 369 000
Goat	18	0	0	1 760 000	31 680 000	1 760 000	31 680 000
Total			328 400 000		358 334 600		682 734 600

Source: Author's calculations

In sum 1.2 million cattle, 37 500 camels and 414 900 equines are work animals. The total of approximately 1.65 million work animals means that there is one of these beasts for every 2.5 people -- the human population of TNRS is put at just over 4.2 million (CSA, 2006). In addition to the larger species of domestic herbivores used for draught there are 687 212 sheep in Tigray as well as 1 759 126 goats. The total number of quadruped livestock is therefore 5.53 million of which work animals constitute 29.8 per cent. Numbers alone are not, however, very helpful in this context as it is the biomass of animals that is important in calculating the use they make of resources. Based on population structure and weight for age a rough assessment of the weight of the "average" bovine in the regional herd is 220 kg, of camel 300 kg, of donkey 90 kg, of horse and mule 200 kg and of sheep and goat 18 kg (calculated from author's personal observations and empirical data collected in Tigray and elsewhere). Calculated in this

way work animals constitute 48 per cent of the total biomass of domestic animals in TNRS (Table 2) and can be expected in general to consume that proportion of all the feed eaten.

Benefits

Using oxen for ploughing is often seen as implying "integration" of livestock and crops in a farming system (Goe, 1987). Others see the use of animal power as a means of "intensification" (Astatke and Mohamed-Saleem, 1996; Mohamed Saleem and Astatke, 1996). Both of these pathways lead -- at least in theory -- to increased crop output either by increasing the area cultivated or contributing to higher yields. In the latter case yields are lifted mainly because of the more timely cultivation and planting than can be achieved with animal draught than with human labour. In Ethiopia using oxen to construct broad raised beds intersected with drainage furrows on heavy black cotton soils led to increases in both grain and straw yields with yields of the former apparently being double after constructing beds than what they had been before (Astatke and Mohamed-Saleem, 1998).

Crop yields are also considered to be increased through the production of manure and nutrient recycling (de Leeuw et al., 1994; Powell et al., 2004). There is a further belief in some quarters that grazing is of importance in maintaining or even enhancing diversity by dispersion of seeds in time and in space via deposition of dung (Zerihun and Mohammed, 2000). If this is actually the case, work animals would be major contributors to biodiversity as they travel more widely than other types of livestock.

Another source of income from draught oxen as well as from transport animals is the possibility of hiring out. This is clearly beneficial for those with animals and may be so for those without if it enables them to plant a larger area and at an earlier date than would otherwise be possible. There do not appear to be any quantitative data on the percentage of owners that hire out animals of different types but several types of arrangements are known (Beck and van Waveren, 2002). These vary depending on draught need and the availability of feed and labour. Common arrangements include provision of all inputs by the animal owner in exchange for a proportion of the yield after threshing, payment by the land owner of part of the harvest or provision by the land owner to the draught owner of two days' labour for each day's draught use.

Disadvantages

A major negative effect of large numbers of work oxen is that of reduced production from other elements of the cattle herd. There is clearly competition for feed resources which results in reduced growth rates for young animals, lesser milk yields by lactating cows, lowered reproductive performance of breeding females and higher

morbidity and mortality in the herd as a whole. These simple and straightforward consequences are compounded by the effects on herd structure so there is a multiplier effect of poor overall performance by a smaller number of (non draught) animals. "Draught" herds evidently have a smaller percentage of females than non draught herds. In herds with mixed production objectives of meat and milk, as for example the Borana of southern Ethiopia, females constitute about 70 per cent of the herd, as indeed they do in many other parts of Africa (de Leeuw and Wilson 1987). In herds that make considerable use of draught, as in Tigray, the female portion is reduced to 50 per cent or less. In East Shewa in the early 1990s females were only 46 per cent of the herd and in Illubabor they were only 43 per cent (GRM, 1994). In Tigray in the mid 1970s male animals in some of the "Rural Development Units" of the time were 70 per cent of the herd because they were fed the few resources there were as a result of the drought to the detriment of females (Wilson, 1975). To use another livestock metaphor this is putting all your eggs in one basket because if crops fail there is no fall back position in the sale of other animals or animal products from which the cash can be used to procure food.

It is difficult to condemn a fair rent or a fair hire charge for provision of a fair service. In much of highland Ethiopia, however, it seems rare that the party without or with insufficient draught or transport animals gets a fair deal. In all three arrangements described as being profitable for animal owners an adjunct to the rent is that they also receive all or most of the straw from arable related activities. Indeed this may be a prime consideration in hiring out by owners. In contrast, it has a further strongly negative effect on the person hiring if he or she has other cattle or other species of livestock to feed. On fertile soils, where higher yields might be expected, half the grain (as well as up to all the straw) might be demanded of the person hiring by the owner of the draught animals. On less fertile soils two-thirds or even three-quarters may be demanded (SCF-UK, 2001). In these transactions there are net disadvantages to the land owner or land user that represent income foregone and decreased household food security.

Labour requirements are not always absolutely decreased as a result of the use of animal power. Unless all operations are mechanized – not only ploughing but sowing, weeding and harvesting among others – labour requirements may actually increase. It is possible, however, that there is an increase in the productivity of the labour associated with crop activities. Some or all of this productivity is nonetheless offset by the need for additional labour for herding and for feeding and watering the livestock although this labour is seldom if ever considered when calculating the benefits that accrue from the use of animal traction.

The use of draught and transport animals may not be and usually is not gender neutral. Women are almost always expected to do much of the work associated with planting, weeding and harvesting. Seldom, however, do they receive rewards commensurate with

the extra effort they put in due to larger crop areas and higher total output. In Ethiopia women can gain access to draught power whereby they exchange their labour for hire of animals but the "payment" they make may be more than the returns they receive (SCF-UK, 2001) with a resultant negative impact on their livlihoods.

In Ethiopia the possibility of increasing the size of the cattle herd is further proscribed by the large number of equines – most unusual in Africa – that are kept for transport and compete for use of the natural resource base. Concomitant with the need to keep oxen to advanced ages is reduced commercial offtake of animals for beef as is evident from the fact that only 0.8 per cent of cattle in Tigray are kept with this production objective. In Zimbabwe in production systems where draught is also a priority market offtake is 2-5 per cent compared to probably 8-10 per cent in other traditional systems of production and 15-20 per cent in larger scale commercial operations (Wilson, 2000). The negative effects on reduced offtake for beef are not only internal to the system but also external to it. Thus because the Tigray herds are not self sustaining they import younger males from the lowlands -- the Afar herds are only 11 per cent male in the 3-10 year age group (CSA, 2006) -- which otherwise would have been grown on for beef and probably made a higher price. Even imports of animals may not be sufficient to provide the required power and lead to unusual combinations of a draught pair such as a camel and a donkey or an ox and a mule (Figure 1).

Figure 1. Ox and mule as a plough pair in Tigray in 1970 (the long horns and small cervico-thoracic hump indicate this is an Afar animal imported into Tigray from the lowlands) (photograph by the author)

Environmental effects

Over several hundreds of years the natural vegetation of Tigray has been gradually transformed under anthropic influences by the direct and indirect actions of man and by those of his animals. In the early 21st century much of the area has been completely cleared of natural vegetation and put under cereal and other food crops. Pressure on the remaining areas mainly for fuel wood (Figure 2), building materials and animal feed has resulted in the extinction of much of the original vegetation although remnants do remain in usually small and isolated areas. Some major plant species have disappeared and many others are present only as stunted specimens. Other vegetative species have benefited from man's interference and expanded greatly in the area they cover. In general this latter group comprises noxious plants that are not useful to man and are not eaten by his animals. In short plant biodiversity has been compromised and probably greatly reduced. Animal biodiversity has also been affected in a negative manner with many species of mammals, birds, reptiles, arthropods and other taxa disappearing or now present in the area in very low numbers and in very circumscribed areas. Further negative effects result from exposure of the substrate to the direct action of wind and rain with attendant and continued erosion of the chemical and physical properties of the already depleted soil base.

Figure 2. Fuel wood brought to market by donkey pack and cart (photo by the author)

In more practical terms for the livestock subsector, however, the main result has been that the resources potentially available as animal feed are greatly reduced over most of the area for most of the time. In many places only sparse scrubby and

unpalatable vegetation remains. Fluctuations in available feed occur not only within years (production is highly seasonal in relation to the annual rainfall pattern) but also across years. Fluctuations across years are, however, only relative under the prevailing low if considerably variable rainfall regime. In this context it appears unfortunate that owners of livestock do not recognize the problem of feed supply and nutrition. In one study in which farmers were questioned about feed deficits (WBISPP, 2003) they considered that major deficits in feed availability occurred in only two or three months of the year from February to May. In fact the inverse is the case as feed is available in sufficient quantities to provide more than minimal maintenance for only two to three months in most years (WBISPP, 2003). The natural environment is so degraded that only 40-50 per cent of livestock feed is obtained from the rangelands with the remainder deriving from arable stubbles and crop residues (WBISPP, 2003).

Global warming is perceived as a major problem at the beginning of the 21st century. Annual global emissions of methane from agriculture were estimated at 165 million tonnes in the early 1990s (IPCC, 1992). Draught and beef cattle contribute 50 per cent of this amount (Leng, 1993). Animals on low quality feed -- as in Tigray -- consume 15-18 per cent of all livestock energy intake but produce 75 per cent of the methane. Draught animals are used very inefficiently throughout their lives. In Ethiopia they have a very long maturation period during which they consume feed and produce methane. Training does not start until they are well into the fifth year of life (NEDECO/DHV, 1998). Even when mature they are used very inefficiently working for about 120 days a year of which 93 are for ploughing, 21 threshing, 5 transport and 1 other work (Figure 3). A “day” is not very long although it may be exhausting for an undernourished ox in a debilitated condition. In Tigray in the 1970s at the height of the ploughing season and over an 11-day period oxen were in the field only 4.7 hours per day and there were 6 hours 46 minutes of rest in the 45 hours 7 minutes of working time (Wilson, 1975). An area of 19 990 m^2 took 26.4 hours to plough equivalent to 5.62 working days per hectare per ox (that is, 11.24 total ox days for the pair).

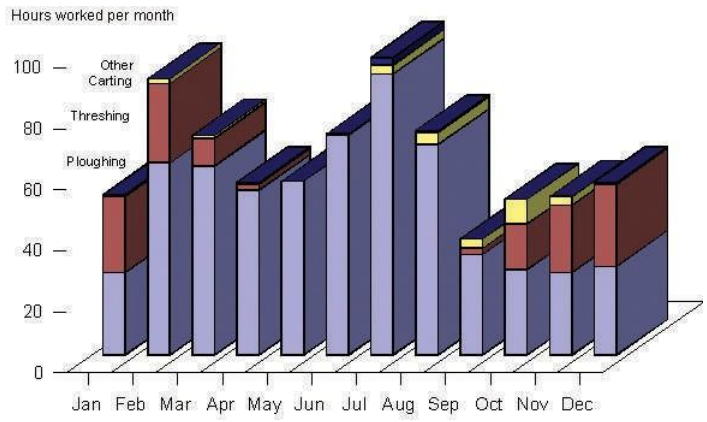

Figure 3. Number of work hours per ox per month in Ethiopia by type of work (GRM, 1994)

It is not only in ploughing that work oxen are used inefficiently. The use of capstans for seed decorticating, oil milling, lifting water and threshing would greatly increase output. The traditional method of threshing by trampling is very expensive in terms of both human and oxen power (Wilson, 1991). Modest use of technology such as a sled would halve the "cost" of threshing and use of a thresher would reduce it even further (Table 3).

Table 3. Time expenditure and costs of three methods of animal threshing

Method	Power source				Batch (kg)	Cost/100 kg (relative currency units)
	Human		Oxen			
	Number	Hours	Number	Hours		
Trampling	3	9	6	18	200	68
Sled	3	7	4	10	300	37
Thresher	2	4	4	8	400	28

Source: Wilson (1991)

Donkeys are used as equally inefficiently as oxen. In the Debre Berhan area of Amhara State they are used for about 433 hours per year or 8.3 hours per week on average. This work comprises 39 hours for transport of crops from field to farm, 46 hours for threshing, 40 hours for transport of hay and 308 hours for market transport (ILCA, 1988). These figures are considered to be above the national average (Crassly, 1991). There is thus a massive surplus of donkeys in the country. Further efficiencies would accrue if donkeys were used in carts which would enable them to move perhaps 10 times as much as by pack alone (Wilson, 1991).

One of the supposed benefits of integration of crops and livestock is the cycling of nutrients. In the case of draught animals much of this supposed cycling is nutrient transfer and a not inconsiderable amount of nutrient depletion takes place. Transfers of nutrients are from natural grazing lands -- as if there were not already enough problems there -- to the crop lands as draught and transport animals usually graze farther away from the homesteads than younger stock and sheep and goats. As an example of this transfer there is the case of West Africa where "Natural forages from rangelands and fallow lands provide important livestock feeds, and through manure, nutrients for cropland" (Powell et al., 2004). It is not, however, a one to one transfer as some nutrients are used by the animal in its metabolism and, as is clear from the preceding paragraph a lot of nutrients are dissipated as global warming gases. Further nutrients are removed from the grazing areas if they are enclosed and hay is made and then carted back to the farm. So transfer equates to mining. Mining of nutrients is also axiomatic in higher yields although this point again seems to have escaped the notice of or is ignored by the promoters of animal power. In the Kenya coastal area, for example, farmers without cattle suffered a net outflow of nitrogen from grazing of crop residues by the animals of others (Reynolds and De Leeuw, 1993). Manure is said to increase

not only soil fertility but also soil structure but this claim too rests on dubious premises. There is virtually no straw or other fibrous organic matter in the dung of Ethiopian livestock -- it is not farmyard manure in the generally understood sense of a mixture of dung or faeces and urine and fibrous material -- as such straws and materials are mainly eaten by the animals. The dung that goes on the soil is either fresh material or a dry fine powder from which many of the nutrients have already been leached. Not all of the dung does go back on the land as much of it is burned for heating and cooking and for plastering of buildings. In addition to home use there is a veritable cottage industry in dung fuel in the Ethiopian highlands (Figure 4). Burning dung does confer a small advantage in that it reduces the need, but perhaps not by much, for wood to be collected from the already denuded and eroded hillsides.

Figure 4. Dung dried for fuel and crop residues for animal feed for home use and for sale in local markets (in both cases plant nutrients are removed from the land) (photo by the author)

Negative environmental effects resulting from the need for and use of animals for draught are not confined to the mixed crop livestock systems of the highlands. In many areas highland cattle herds are unable to maintain themselves from internal resources due to the low proportion of breeding females and their poor reproductive performance. Work oxen or young males to be reared for work thus have to be imported from the lowland pastoral areas (see Figure 1 for an “Afar” ox ploughing in Tigray) . These extra animals add further stress to the highland systems. There is also a negative effect on the lowland systems as there are fewer animals to produce meat for the home or export markets: the example of only 11 per cent of male cattle of 3-10 years in Afar Regional State that has already been cited (CSA, 2006) is eloquent testimony to this.

Discussion

Working animals receive priority in supplementary feeding in that they are the first class of stock to be fed hay and crop residues. The amounts available, however, are inadequate to mitigate the stress resulting from the under and malnutrition that is compounded by subclinical disease and the presence of internal and external parasites. Draught oxen in particular are most debilitated at the time of year they are needed for work. This reduces further their already limited power output due to low body weights as output is directly proportional to body weight. Inefficiency in conversion of feed resources is further compounded by the fact that the average working day for an ox is little over five hours but effective time is reduced by frequent stoppages. In addition to the biological constraints there are social ones associated in particular with the culture and tradition of the region. Under this scenario even during peak periods no productive work is performed on several days of holidays enforced for religious reasons. Greater use of cows for work would also increase the efficiency of the whole herd.

Tigray is the archetypal highland Ethiopia where work animals are crucial to agriculture. Increases in the human population and therefore density leads to greater -- and unsuitable for the purpose -- areas being taken into cultivation. This creates a need for yet more draught power. Cattle herd composition is such that for much of the year it is non productive in both abstract and literal senses. This is because the oxen that constitute almost half of the cattle herd in numbers and in live biomass are used for only about a quarter of the potential working time and are idle for long periods. A similar scenario applies to equines.

A definition of sustainability is that “it meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). In addition to higher crop output, increased income and improved food security, afficionados of animal power emphasise that integration of crops and livestock contributes to sustainable production. Integration may be as much fallacy as fact as it is applied mainly to oxen whose demands on the supposedly holistic system may be greater than the supply that is given in return (Wilson, 2003).

Conclusions

Do, then, animals used as power and energy sources contribute to a sustainable ecosystem? If animals and their owners cannot be induced to work a great deal more efficiently than using only 24-27 per cent of the total time available that is now the norm and if the feed used for maintenance of draught animals remains at 85 per cent leaving as little as 15 per cent for productive work the answer is almost certainly no. The solution to the problems facing livestock and range production cannot be

achieved in isolation. Crop production and soil conservation are intimately linked to the livestock sector. Degradation of large areas of already lower quality land results from nutrient transfer and nutrient depletion. Sustainable crop agriculture may be being achieved at the expense of unsustainable animal agriculture.

There is no doubt that it is very expensive in terms of global warming to cultivate land in the Ethiopian highlands. An integrated approach is the only way to which long term development can be achieved.

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