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Animal power for crop production: new tillage or no tillage Benefits and challenges in sub Saharan Africa

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Summary
Many developing regions, especially sub Saharan Africa (SSA) are highly dependant on human labour for power use. Labour productivity is low and decreasing due to the effects of land degradation and HIV/AIDS especially in SSA. At the same time the potential productivity of draft animals is not being realised. Conservation agriculture offers a "win-win" scenario through eliminating the need for primary tillage in crop production, increasing labour productivity and allowing draft animals to be used more productively for transport, milk and meat, and at the same time providing environmental benefits as well as giving poorer households opportunity to benefit. Although there are a number of challenges to be addressed, the potential benefits of conservation agriculture provide opportunity for reversing the declining productivity in developing regions, especially Sub-Saharan Africa.

Introduction
During the 1990s overall investment in agriculture by donors and national governments halved, while the number of people in need of food aid doubled (FAO, 2001, World Bank 2003). With the most severe and intractable poverty in the world being in sub Saharan Africa (SSA), nearly half of the people live in absolute poverty subsisting on incomes of less than a dollar a day. On present trends, two of the fundamental Millennium Development Goals set by the United Nations, halving the number of people living in absolute poverty and halving the proportion of people suffering from hunger will not be met in SSA by the target year of 2015. In these areas, tackling poverty means boosting smallholder agriculture and recognising that this is the best way of driving broad-based economic growth and poverty reduction.

The role of draft animals
Alternative power sources
Statistics show that human power still predominates over much of the developing world, contributing over 70% of power requirements (Twomlow *et al,* 2002). At the same time draft animals contribute nearly a quarter of power needs and tractors only 6% (Table 1).

Table 1: Proportional contribution to total power use in selected regions-(%)

Region	Human	Animal	Tractor
N Africa	16	17	14
sub-Saharan Africa	89	10	1
Asia (excl China)	68	28	4
Latin America	59	19	22
Overall	**71**	**23**	**6**

Certainly in SSA, most rural households are dependant on human or animal power for their tillage operations. Hand tillage is hard, back-breaking work providing very low returns to labour. Not surprisingly it remains unpopular and a major reason why younger people do not want to work in

agriculture. At the same time most hand tillage, especially weeding, is often undertaken by women. Unfortunately HIV/Aids is further reducing labour productivity with sick people being unable to undertake hard physical work and able-bodied adults, often women, caring for those infected.

Two important questions need to be addressed, "*Can energy use/power requirements be reduced to ensure higher productivity for agriculture, and can the poorest benefit?*"

The importance of cattle and donkeys as a power source

Although there may be great demand for increased availability and use of tractors, the realities of capital availability, productivity and infrastructure requirements have made mechanisation problematical, especially for the small scale farm sector. For this reason draft animals are likely to remain widely used in transport and for tillage for many years.

Surveys, in Zimbabwe for instance (Barrett, 1992, Muvirimi, 1997), have shown that the greatest value of both cattle and donkeys is in the provision of draft power: in the case of cattle, 64% of their value and in the case of donkeys, over 90%. Unfortunately tillage, especially ploughing requires the most energy, often at a time when animals are in poorest condition, after a long dry season. Not only are animals least able to undertake this heavy work, but many households have inadequate animals to make up a tillage team.

Ownership of draft animals

At the same time, ownership of draft animals is highly skewed with the poorest 40% of households having no draft animals, even if they posses some DAP implements. Access to other resources and production is also skewed (Table 2)

Table 2: Access to resources and productivity of households in Masvingo Province, Zimbabwe (n=750)

	RG1	**RG2**	**RG3**	**RG4**
% of households	22%	38%	25%	15%
Livestock owned				
Cattle	9.9	3.2	0.3	0
Donkeys	2.0	1.1	0	0
Implements owned	Full range	Plough	Plough	None
Arable area (ha)	2.9	2.4	2.1	1.7
Income from crop (US$ pa)	51	21	11	3

RG1=Well resourced, RG2=Average resourced, RG3=Poorly resourced and RG4=Very poorly resourced households. ***Source:*** *Derived from Ellis-Jones, 1999*

This effectively means that only better resourced households have sufficient draft power for their own purposes. Others are almost totally dependent on hiring or some form of reciprocal arrangement. Where there are sufficient oxen, DAP is supplied by oxen, but as numbers decrease, the burden of DAP may be shared between oxen, cows and donkeys.

Interestingly better resourced households will often plough up to three times in a single season (Ellis-Jones *et al*., 2001).

- Immediately after harvest for moisture conservation and to capture any late rains.
- During the middle of the dry season (especially if some rain falls) for weed control.
- Just prior to planting, usually after the first rains, to control early weeds and to prepare a seedbed.

In addition ploughs are often used for weeding, for instance in maize when the crop is knee high the plough can be used for both weeding and making ridges as a means of moisture and soil conservation.

The evolution of primary tillage methods

The intensive and continuous use of the plough (or conventional tillage) is often regarded as synonymous with successful crop production. However the plough's use is being increasingly

criticised, even though, it remains the most widely practised form of tillage in many parts of the world. There are both advantages and disadvantages to using conventional primary tillage (Table 3).

Table 3: Advantages and disadvantages associated with conventional tillage

Advantages	Disadvantages
• Well known, simple, reliable, trusted and tested technology • Provides sub soil moisture conservation if undertaken at the right time. • Means of controlling weeds • Provides good seed bed for planting • Land preparation can be combined with planting	• Inadequate draft power, especially in poorer households • Non availability of ploughs, reliance on hand hoes • Reciprocal labour arrangements for weeding in return for often late ploughing • Development of a plough pan (often at less than 10cm) • Increased run-off, reduced soil moisture • Declining soil organic matter, loss of soil structure • Increased soil erosion due to poor soil cover • Declining soil fertility, land degradation • Increased fertiliser use, if funds permit • Stagnating or declining yields

Researchers have for considerable period advocated the use of reduced or conservation tillage, that often involves planting directly into rip lines or after harrowing or a light discing. At the same time, land degradation and the consequential drop in productivity associated with conventional ploughing, has led to increased enthusiasm for growing green manure crops, such as *Mucuna*, *Canivalia* or sunhemp as a means of improving soil fertility, improving soil moisture, reducing weeds and as a result increasing productivity. Green manures can either be incorporated by plough, hoe or left as surface mulch, more especially in the humid tropics and higher potential areas. The management of green manures is, however, more problematic in semi-arid areas.

Conservation agriculture

Conservation agriculture (CA) is now increasingly seen as the way forward. CA aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It can also be referred to as resource-efficient / resource effective agriculture (FAO, 2004). CA involves a paradigm shift, which does not involve the plough, often a symbol of agriculture. This normally involves zero-tillage with direct seeding through a permanent soil cover, created through the use of green manure cover crops, or by leaving at least 30% of the last crop as residues on the soil surface to form a permanent or semi-permanent organic soil cover. The function of this cover is to protect the soil physically from sun, rain and wind and to feed soil biota. The soil micro-organisms and soil fauna take over the tillage function and mediate the soil nutrient supply. Mechanical tillage disturbs this process. Therefore, zero or minimum tillage and direct seeding are important elements of CA. At the same time, CA increasingly involves the use of crop rotations (usually cereal-legume), with in-field and between field soil and water conservation measures. It involves a change in the agricultural system, and as such has many benefits, but with a number of challenges (Table 4).

Rather than incorporating biomass such as green manure crops, cover crops or crop residues, in CA this is left on the soil surface. The dead biomass serves to protect the surface of the soil and as substrate for the soil fauna. In this way rapid and wasteful mineralization is reduced and suitable soil levels of organic matter are built up and maintained.

Table 4: Benefits and challenges disadvantages associated with conservation tillage

Benefits	Challenges
• Saving in labour • Reduction in draft power requirement • Poorer households can benefit • Longer period available for planting • Timeliness less critical in relation to make or break interventions such as ploughing • Increased water infiltration • Better soil moisture conservation • Reduced moisture evaporation • Less water run-off and soil erosion • Increases in soil organic matter • Increases in nutrient availability • Greater biological pest control • Resistance to mid season droughts • Improved soil organic matter, soil structure and build up in soil fertility, less erosion and reduced land degradation • Reduction in production costs • Increased yields and productivity • Potential sequestration of carbon and contribution to national GHG emission reduction targets	• Need to build up a permanent cover with green manure or crop residues • Problematic in drier areas or where crop residues are required for fodder, or are consumed by termites • Where land/food is scarce, households may be unwilling to grow a green manure. A food legume (soybean, cowpea, ground or bambara nut) may be more suitable grown in rotation with cereals • Problems of weed control • Need to use herbicides, possibly in initial stages (3 years) • Build up in crop pests, especially when a rotation is not used • Increased stem borer and cutworm in maize • Need to destroy crop residues, especially cotton • Reduced tillage is often undertaken only because insufficient draft animals are available • Risk of crop failure

The potential advantages associated with conservation agriculture make it extremely attractive with wide application. Generally CA is seen a win-win situation. That does not mean that there are no problems. Problems associated with management of the component technologies tend to be are very site-specific. The major challenges are seen as: competition for residues, especially with animals (livestock and wild) and destruction by termites; equipment for seeding and spraying; weed control; nitrogen fertilization and availability and distribution of inputs, as well as awareness and knowledge dissemination. CA may require the application of herbicides in the case of heavy weed infestation. During the transition phase certain soil borne pests or pathogens may create new problems due to the change in the biological equilibrium. However once the CA environment has stabilized it tends to be more stable than conventional agriculture.

It would be totally inappropriate for research and/or extension systems to develop "technology packages" for all farmer situations. Activities need to be based on farmer experimentation, community learning and capacity building with scaling-up based on farmer-to-farmer exchange. Agro-ecosystems are highly varied with a high proportion of land constrained by low soil fertility and erratic and changing climatic conditions. Such conditions demand a range of technological solution, even across small areas. Although basic yield enhancing technologies are available for most crops, including maize, further research is needed to adapt them to local conditions and ensure that they are economically and environmentally sustainable. The best way to achieve this is through farmer-led research because when many farmers are involved in setting the research agenda and in monitoring and evaluating different technologies, there is greater assurance of uptake (Peacock *et al*., 2004).

Conservation Agriculture is now practised on about 67 million ha (Table 5), mostly in South and North America. Its use is growing exponentially on small and large farms in South America, due to economic and environmental pressures. Farmers practising CA in South America are highly organized (in regional, national and local farmers organizations), and are supported by institutions from North and South America.

In many of these areas CA is associated with use of transgenic crops, particularly soybean, maize and cotton that provide tolerance to use of herbicides, particularly glyphosate. If transgenic volunteers persist in soil, removing these may add to the challenges faced in CA.

Table 5: Use of conservation agriculture in selected countries.

Lead countries	Area (million ha)	% of total
USA	42.8	63
Argentina	13.9	21
Canada	4.4	7
Brazil	3.0	4
China	2.8	4
South Africa	0.4	1
India	0.1	<1
Other	0.3	<1
Total	**67.7**	**100**

Source: *Derived from James, 2003 and FAO, 2004.*

Conclusion

The process of reduction of draft power requirements for primary tillage and weeding allowing animals and humans to be used more productively can only be a beneficial step that increases productivity and improves the environment. Animals can be used more productively for transport, milk, and meat. Reduced labour input will increase labour productivity and provide time for other activities as well as helping to mitigate some of the effects of HIV/Aids pandemic.

Challenges that remain include:

- Identifying green manures and legume that can provide food, fodder, biomass and weed control;
- Reducing weed competition and pest damage through improving the effectiveness of herbicides with reduced applications and safer products.
- Establishing multi purpose control systems such as push-pull (Napier and *Desmodium* for stemborer, *Striga* and soil fertility
- Considering the role for transgenic crops.

References

Barrett, J. C., 1992. The economic role of cattle in communal farming systems in communal farming systems in Zimbabwe. ODI Pastoral Development Network. Network paper 32b.

Ellis-Jones J., 1999. *Small dams and community resources management project. Baseline socio-economic survey*. Descriptive statistics. Silsoe Research Institute and CARE.

Ellis-Jones J., Makunde G., Mavudzi Z., Mutambara J., Nyandoro R., and Sibanda S., 2001. Results from a household survey with emphasis on rural livelihoods and weed management undertaken in Lower Muzarabani District, Zambezi Valley, Zimbabwe. *Silsoe Research Institute, IDG/01/, November 2001*

James C., 2003. Global status of commercialised transgenic crops: 2003 ISAAA Brief No. 30: Preview. ISAAA, Ithaca, New York.

Muvirimi F, 1997. Current practices and characterisation of farmers using draught animals in semi-arid Zimbabwe: Interventions to improve the productivity of draught animals. Zimbabwe Farmers' Union. In Ellis-Jones, J, Ndlovu, LR, Pearson, RA and O'Neill, DH. 1997. Eds., Proceedings of Workshop on Improving the productivity of draught animal power in sub-Saharan Africa, 26-27 February, Harare, Zimbabwe

FAO, 2001. The applications of appropriate agricultural technology and practice s and their impact on food security and the eradication of poverty: lessons learnt from selected community based experiences. Rome, FAO committee on World Food Security.

FAO, 2004. Online at http://www.fao.org/ag/agse April 2004.

Peacock C., Jowett A., Dorward A., Poulton C., and I. Urey, 2004. Reaching to reach the poor: Investment in samllholder agriculture in sub-saharan Africa. FARM_Africa, Harvest Help and Imperial College London. ISBN 1-904029-01-9.

Twomlow S., O'Neill D., Sims B., Ellis-Jones J., and Jafry T., 2002. An engineering perspective on sustainable smallholder farming in developing countries. *Biosystems Enginering* 8193, 355-362.

World Bank, 2003. World Development Indicators. Washington DC.