AGRICULTURAL
AND FOOD
ENGINEERING
TECHNICAL REPORT

3

ISSN 1814-1137

Farm power and mechanization for small farms in sub-Saharan Africa

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Farm power and mechanization for small farms in sub-Saharan Africa

by
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and

Josef Kienzle

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2006

The Agricultural and Food Engineering Technical Reports bring to a broad audience the results of studies and field experience related to agricultural and food engineering within agrifood systems. The reports help us take stock of what we know and clearly identify what we do not know; and in so doing they provide information to both the public and private sectors. The Agricultural and Food Engineering Technical Reports serve to direct further work within agrifood systems. The views expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations.

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Foreword

In the past, many of the publications concerned with mechanization, draught animal power, hand-tool technology, etc. tended to be rather mono-topical, dealing with only one aspect of the subject. Farm power and mechanization also tended to be separated from the actual processes of crop production and processing; it was a topic created by engineers and was dealt with by engineers. As a result, there is a widespread lack of understanding of the subject, and there are many widely held misconceptions with regard to the essential contribution of farm power and mechanization to small farmers' productivity and livelihoods.

In recent years, the Farm Power and Mechanization Group in FAO has broken away from this rather narrow approach and has put the different sources of farm power, mechanization, machinery, equipment and tools into a much broader context. We have looked at farm power from the perspective of rural livelihoods and farming systems, as well as the critical area of labour saving in HIV/AIDS and migration-affected populations. We have purposely avoided taking rigid positions with regard to any one particular type of technology; instead, we have adopted a much wider brief and have been concerned to identify appropriate solutions for a range of situations.

As a result, we have produced this manual, which provides an overview of options for farm power and technologies that could be suitable for small and medium-sized farmers who are faced with making decisions about the different types of farm power sources available. The manual also lays out the importance of the farming systems and the economic context within which the mechanization takes place. Special emphasis is also given to the financial implications of farm power, as well as to the environmental impact of mechanization that may be inappropriate to the conditions.

Many practitioners, both from FAO and from countries in sub-Saharan Africa, were involved in preparing and commenting on this document, all of whom have long experience with the different technologies and farming systems to be found there. The contributors are mentioned in the Acknowledgements.

We hope that whoever reads this manual, whether out of general interest or to solve some particular development problem, will put it down with a greater level of knowledge and understanding. If we can provide any other information or answer any queries our contact the Agricultural and Food Engineering Technologies Service of FAO.

Acknowledgements

This publication is a result of the teamwork of many people, beginning with those who carried out field studies and provided the information on which it is based, and those who contributed to its writing, reviewing and preparation.

The main authors were Brian Sims (Consultant) and Josef Kienzle (Agricultural Engineer, Agricultural and Food Engineering Technologies Service – AGST), with important inputs from Jennifer Heney, Rural Finance Officer (Agricultural Management, Marketing and Finance Service – AGSF) and from David Barton (Consultant) for the chapter on financial and economic aspects of mechanization. Bill Hancox (Consultant) contributed to the section on tractor maintenance and replacement parts. Josef Kienzle coordinated the production with FAO's 'Enhancing Small Farmer Livelihoods' Programme, in the Agricultural Support Services Division (AGS). John Dixon, the leader of that programme and former Senior Farming Systems Officer (AGSF) provided guidance and support, especially for the sections covering farming systems, while Doyle Baker, Chief of AGSF, assisted with aspects of rural livelihoods and mechanization. Lawrence Clarke, Senior Officer and Agricultural Engineering group leader (AGST) provided overall guidance throughout the production of the publication.

Many people reviewed and revised the publication at various stages, beginning with Timothy Simalenga of the South African Agricultural Research Council (ARC) and Calvin Miller, Senior Rural Finance Officer, FAO. The main reviewer was Clare Bishop-Sambrook, (Consultant) and the author of the Agricultural and Food Engineering Technical Report 2 (*Contribution of farm power to smallholder livelihoods in sub-Saharan Africa*). She made numerous, very valuable, suggestions.

A first major building block in the series of field studies that made this publication possible (Agricultural and Food Engineering Technical Report 3) and its companion Technical Report 2, mentioned above, was the 1998 IFAD/FAO study in five countries of sub-Saharan Africa on agricultural implements used by women. Colin Fraser (Consultant) led that participatory study in the field and also revised and edited this publication.

It is particularly important to note that the field work for all of the studies that provided the material for these publications could not have been conducted without the whole-hearted participation of thousands of poor rural people in sub-Saharan Africa. They willingly gave of their time and were forthright in expressing their ideas and opinions. The work could not have been done without them, and it is therefore to be hoped that there will be intensified efforts by governments and development agencies to improve their livelihoods through solving the farm power and labour shortage problems they face – problems that are contributing to keeping them locked in poverty and malnutrition.

Last but not least we would like to thank Louise Newton and Larissa D'Aquilio for their efficient support with editorial issues and the desktop publishing.

List of abbreviations

AGS	Agricultural Support Services Division (FAO)
AGSF	Agricultural Management, Marketing, and Finance Service (FAO)
AGST	Agricultural and Food Engineering Technologies Service (FAO)
ARC	Agricultural Research Council, South Africa
AU	African Union
CA	Conservation Agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
DAP	Draught animal power
FFS	Farmer Field Schools
FSD	Farming Systems Development (FAO)
ha	Hectare
HIV/AIDS	Human immunodeficiency virus/acquired immunodeficiency syndrome
IFAD	International Fund for Agricultural Development
Kg	Kilogram
LSP	Livelihood Support Programme (FAO)
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organization
SEAGA	Socio-economic and Gender Analysis Programme (FAO)
SSA	Sub-Saharan Africa

Executive summary

CONTEXT AND BACKGROUND

According to the New Partnership for Africa's Development (NEPAD), 200 million people in Africa, or 28 percent of the continent's population, were chronically hungry in 1997–99. By the end the 1990s, only ten countries had been able to reduce their numbers of hungry people in that decade. Food imports have been rising since the 1960s, and Africa became a net agricultural importer in 1980. The agriculture sector now provides only 20 percent of the continent's exports, whereas it provided 50 percent in the 1960s.

NEPAD makes agriculture one of its main priorities "as the engine of NEPAD-inspired growth". It stresses three aspects: improving the livelihoods of people in rural areas; achieving food security; and increasing exports of agricultural products.

None of these aims can be achieved without giving serious attention to family farm power in small-scale agriculture in sub-Saharan Africa (SSA). Farm power is a vitally important component of small farm assets. A shortage of farm power seriously constrains increases in agricultural productivity, with a resultant stagnation in farm family income and the danger of a further slide towards poverty and hunger.

Studies in SSA in 2003 and 2004 have revealed in a graphic manner that unless the issue of farm power is addressed in a practical way, with solutions that are accessible to small farmers, the region is at risk of increasing poverty and hunger. The Millennium Development Goal of halving the proportion of people suffering extreme poverty by 2015, and the similar goal of the World Food Summit in 1996 to reduce the *number* of starving people by half, are now unlikely to be attainable in SSA until well into the 21st century.

The review and guidelines presented in this publication are the result of several recent studies of the power situation of farm families in small-scale agriculture in SSA. These reports reconfirm that the farm power situation is deficient almost everywhere, and that urgent measures are needed to correct it if the widely promoted goals of raising the productivity of the sector, reducing poverty, and achieving food security are to be achieved.

Another serious concern in SSA is that of soil degradation. The level of degradation varies considerably across the region and is difficult to quantify. However, some figures for soil erosion in Ethiopia were documented in 1988; they ranged from 16 to 300 tonnes of soil per year being washed away, with an average for the country of over 40 tonnes/year on cultivated land. An FAO/World Bank Ethiopian Highlands Reclamation Study some four years earlier estimated that 1 900 million tonnes of soil a year were being washed away from the cultivated land in the Highlands, equivalent to about 100 tonnes per ha. Even if the erosion rate were halved, there would still be a 2 percent per year reduction in total grain production in the Highlands. It is true that erosion and soil degradation in Ethiopia are particularly severe, but in many other parts of Africa there is abundant anecdotal evidence from smallholders themselves who state that they are obtaining much smaller yields from a particular plot than were being obtained by their fathers and grandfathers.

There can be little doubt that conventional methods of farming, with much soil disturbance for seedbed preparation, exacerbate erosion. This and the depletion of soil organic matter and nutrients contribute to soil degradation. Any interventions concerning farm power and farming systems need to take into account the issue of soil degradation; at the very least, they must contribute to halting the degradation process, or better still, reversing it.

MECHANIZATION

The term "mechanization" is used to describe tools, implements and machinery applied to improving the productivity of farm labour and of land; it may use either human, animal or motorized power, or a combination of these. In practice, therefore, it involves the provision and use of all forms of power sources and mechanical assistance to agriculture, from simple hand tools, to draught animal power and to mechanical power technologies.

Mechanization is a key input in any farming system. It aims to achieve the following:

- increased productivity per unit area due to improved timeliness of farm operations;
- an expansion of the area under cultivation where land is available, as it often is in SSA;
- accomplishment of tasks that are difficult to perform without mechanical aids;
- improvement of the quality of work and products;
- a reduction of drudgery in farming activities, thereby making farm work more attractive.

Mechanization systems are categorized into human, animal and mechanical technologies. Based on the source of power, the technological levels of mechanization have been broadly classified as hand-tool technology, draught animal technology and mechanical power technology.

AN OVERVIEW OF FARM POWER IN SUB-SAHARAN AFRICA

A series of studies on farm power conducted by FAO in SSA in the years 2002–2004 have shown that the principal labour-demand peaks in the farming cycle are for land preparation and subsequent weeding. The constraints to increased farm production are due, to a large extent, to three factors:

- an excessive reliance on human power;
- the low productivity of human labour;
- a decrease in the labour available.

Human power: With human power, productivity is generally low because of the lack of physical energy available and the limited range of hand tools. The situation has been exacerbated by the HIV/AIDS pandemic and other factors, such as migration, which reduce the numbers of young, healthy people available for farm work..

Draught animal power (DAP): Draught animal power is generally considered to be an affordable and sustainable source of power for small scale-farmers. Oxen and sometimes cows are the animals of choice, but in some African cultures it is unacceptable for women to use bovines. Donkeys and horses are increasingly being used, as are camels and mules in some areas. Apart from tillage, transport and other field operations, work animals can also be used for logging, pond excavation, and rural road maintenance.

Tractor power: Government-run tractor hire schemes in SSA, never widely effective, are now in a state of collapse following a reduction in government expenditure on services that could, theoretically, be provided by the private sector. Private sector tractors have been profitable on large landholdings, but they have seldom proved viable for the smallholder sector in SSA, whether in individual or group ownership, or in private hire services.

CONSTRAINTS AND OPPORTUNITIES OF DIFFERENT POWER SOURCES

Human muscles still contribute about 65 percent of the power for land preparation in SSA. A typical farm family that is reliant solely on human power can only cultivate in the region of 1.5 ha per year. This will rise to 4 ha if DAP is available, and to over 8 ha if tractor power can be accessed. It is quite common to combine available power sources in order to increase the area farmed, or to reduce the burden on humans.

Tractors or draught animals can be hired for primary tillage and subsequent planting, and weeding can also be done with a combination of power sources and technologies. Application of these alternative power sources can relieve pressure on human labour at critical times of heavy demand.

Making more efficient use of human power, together with the efficient application of draught animal power, provides the best immediate strategy for reducing the problem of farm power shortage in SSA, thereby increasing agricultural productivity and improving the livelihoods of millions of families in the shortest time.

DIVERSIFICATION AND EXPANSION IN THE USE OF DRAUGHT ANIMAL POWER

The power available for farm use can be increased by diversifying the type of work to which power sources are applied, for this makes them more affordable and can further enhance their potential for improving productivity and livelihoods. There is a great potential for diversifying and expanding the use of draught animals. Such diversification and expansion can be brought about in some of the following ways:

- Widening the scope of the number of jobs that animals can do. This can include more crop production jobs, but can also mean water lifting, milling and other stationary power activities.
- Using single rather than multiple animals, and providing them with appropriate (usually lighter) equipment.
- Using animals that have hitherto not been used for farm work. This could include horses, donkeys and mules, even if they have to be restricted to transport.
- Using animals for non-farm work (e.g. road maintenance or dam construction).

Perhaps the greatest potential for diversification is in transport. Farm work tends to take place intensively for short periods. For example, ploughing may be done in a week, and then the animals are not needed for a few weeks until the first weeding, and so on through the farming year. This makes the cost of these operations very high because the investment in draught animals and equipment is not spread over a range of activities and time. Adding transport to the portfolio of activities performed opens the opportunity for year-round work.

Transport is a daily grind for millions of women in SSA; they are responsible for bringing water and fuel wood to the homestead and, frequently, they also have to carry produce to market, all as head loads. The diversification of animals into transport has the potential to ease, or even eliminate, this burden.

OPTIONS IN FARM POWER AND TECHNOLOGY

A study in seven SSA countries in late 2001 and early 2002 examined the crucial role of farm power in increasing production and improving livelihoods[1]. In these countries, despite attempts to increase the use of DAP and tractors, human muscle still constituted the most important power source – with some 65 percent of agricultural land prepared and weeded by hand in the seven countries. The study found that with the omnipresent threat to the ability of families to provide sufficient labour, the cultivated area declines, nutrition suffers, and the spectre of increased hunger and poverty looms over the homestead. (Box 1).

Work in the United Republic of Tanzania in 2003 and 2004 led to the view that, although increasing the supply of farm power to labour-deficient families would be one way to alleviate the stress; another way would be to reduce the requirement for labour in agricultural production. Of course, this would need to be done without compromising family food security. The work was preliminary in nature, but it

[1] The term 'livelihood' has caused some difficulties of interpretation recently, principally as a result of its misuse by some development agencies. In this publication it is taken to mean simply the means of making a living. This involves the application of a range of assets in productive processes.

BOX 1
Impact of labour shortages on agricultural production

Many households respond to power shortages by scaling down their activities, reducing the area under cultivation and growing a limited range of less labour-intensive crops. They struggle to keep pace with the seasonal calendar, which results in delayed or incomplete operations in one season, with adverse effects on the next. Food security falls, nutritional status declines and household members are increasingly susceptible to infection thus becoming less productive. Households become increasingly vulnerable to external shocks, such as poor weather. Their ability to recover and secure a living is compromised by the often irreversible strategies they have adopted in previous seasons to meet short-term needs.

The challenge, in part, is to identify and support opportunities that relieve the burden of labour shortages and enable households to withstand shocks better e.g. from AIDS-related illness and death.

examined the potential for reduced tillage through the use of DAP rippers, followed by direct (zero tillage) planters, using either DAP or human power.

Hand tools: Hand tools are the most important implements for smallholder farmers throughout SSA. They are used everywhere for land clearing and primary soil tillage, and thereafter for a variety of agricultural jobs, from weeding to harvest to tree felling.

There is a severe constraint on the area that can be prepared by hoe; more than 60 person-days per hectare are generally required for the job.

Weeding is an absolutely critical operation in the cropping cycle. The penalty in crop yield for late weed control is heavy: more than 30 percent of yield is commonly lost because of weed infestation. Weeding is generally performed by women, who consider it to be their most onerous task, for it is both extremely time consuming and physically taxing. Some crops require more than 50 person-days per hectare for weeding.

Draught animal power: The ard (*maresha* in Ethiopia) and mouldboard plough are the two main primary tillage implements used with DAP. The mouldboard plough is good for weed control, but it does not have a great deal more to recommend it. It leaves the soil surface loose and unprotected, which makes it vulnerable to erosion while also accelerating the oxidation of organic matter. It is probably the greatest cause of soil degradation and crop yield decline in SSA. Nevertheless it remains a very popular and widespread implement, and its demise is not imminent.

Narrow-tined chisel ploughs, or rippers, have a mode of action very similar to that of the ard. They are able to burst the soil in a narrow furrow and leave the remainder of the soil protected with surface organic matter. Their use, although still not widespread, is generating interest for its dual attributes of saving energy and time, and of reducing soil erosion.

Ridgers are used for shaping soil into ridges or for earthing up a crop grown on the ridge as a weed control measure. Cultivators are commonly used in many SSA countries, mainly for inter-row weeding of a crop that has been planted in lines.

Tractor power: It will generally not be economically feasible for a smallholder farmer, with a typical land holding of up to 5 ha, to own a tractor. As a rule, government run tractor hire schemes have not been viable and have not helped to alleviate poverty or to increase farm production. On the other hand, the concept of a rental market for privately owned and operated tractors has possibilities that may increase in the future.

In the past – and sadly sometimes today – the application of tractors and heavy mechanization in unsuitable situations has led to heavy financial losses, lower agricultural production, and environmental degradation. In these circumstances, tractor mechanization can easily become a burden to national economies, and to individuals, rather than being an essential input with the potential to increase productivity.

TECHNOLOGY OPTIONS FOR REDUCING THE NEED FOR FARM POWER

Bearing in mind that farm power must be an essential ingredient of agricultural productivity and livelihoods strategies, two approaches to satisfying the need can be considered: on the one hand, increasing the supply of farm power, and on the other, reducing the need for it.

Examinations of the demand for farm power clearly show that the greatest demand comes from land preparation, and as has been indicated, this is also the source of greatest environmental degradation. However, there is now crucially important evidence that traditional land preparation methods may not be necessary and that conservation tillage, including zero tillage, can provide an alternative that is economically and ecologically sustainable. The system is known as conservation agriculture.

CONSERVATION AGRICULTURE

A principal component of conservation agriculture (CA) is the reduction of soil manipulation to maximise the vegetative soil cover that will protect the soil surface. Tillage can be reduced with the use of rippers. Even greater reductions in energy needs can be made with direct sowing into the stubble of the previous crop, and options exist for this to be done by hand, DAP, or tractor.

The practice of 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. In addition to reducing farm power requirements, it contributes to environmental protection as well as to enhanced and sustained agricultural production. It can be thought of as resource-efficient/resource-effective agriculture.

CA is an alternative to traditional land use and management. It is a practical method to reduce soil erosion, restore organic matter, and conserve soil moisture and soil fertility. The method is based on the following:

- maintaining a permanent or semi-permanent organic soil cover to protect the soil physically from sun, rain and wind and to feed soil biota;
- zero tillage (or minimum tillage). The principle is to eliminate mechanical tillage in order not to disturb the activities of soil micro-organisms and soil fauna;

TABLE 1
Issues and challenges to the adoption of different forms of mechanization

Hand tools	DAP	Tractors
• labour availability • availability of manufacturers and suitable tools • socio-cultural traditions	• animal diseases • limited tradition of using DAP • security (likelihood of theft) Availability of: • suitable animals • animal husbandry skills • feed/pasture • veterinary services • implements and spare parts • artisans/blacksmiths • extension services for training • timber for yokes • harness makers • financial services • socio-cultural traditions	Availability of: • appropriate tractors, machines and implements • repair and maintenance services, spare parts • trained operators • supplies of fuel, lubricants etc. • implements for weeding and harvesting • financial services Other factors include: • suitable plot sizes • reasonable access to fields • shape of fields • reasonable distances between fields

- crop rotations to reduce disease and pest problems, to explore different soil strata for water and nutrients, and for biological tillage (e.g. to break hardpans).

Unfortunately, short-term solutions and immediate benefits always attract farmers whereas the full technical and economic advantages of CA can only be seen over a medium to long-term period, when its principles of no-tillage, permanent cover crop and crop rotation have become well established within the farming system.

In fact, if the two systems of conventional and CA are applied in two plots with the same agro-ecological and fertility conditions, no great differences in productivity are generally seen during the first years. Indeed, there may even be a yield reduction with the CA treatment in the first year. However, after cultivating the same crops in the same areas for several years, the positive effects of CA usually become evident.

Especially in areas where family labour is becoming a constraint, because of factors such as migration, HIV/AIDS and other diseases, CA could be a good option for farmers. The reduction in on-farm labour requirement allows farmers to:

- extend the cultivated area;
- hire themselves out in off-farm employment;
- diversify their activities, including processing of agricultural products;
- reduce the cultivated area – made possible because of increased yields – and allow marginal areas of poor fertility to regenerate.

ROW PLANTING

Although CA can certainly offer the greatest reduction in farm power needs, even the relatively simple introduction of row planting in conventional farming systems can bring important reductions. For as long as seed is broadcast, all weeding must be done manually (usually with hand hoes). The high labour demand for weeding can, and does, limit the area sown to crops. If, however, crops can be sown in rows, draught animals can be used to pull a cultivator along the inter-row space. There will still be the need for some manual weeding within the row, but the total time taken for weeding will be very much shorter.

THE ECONOMIC VIABILITY OF TECHNOLOGIES UNDER DIFFERENT LEVELS OF MECHANIZATION

Implements, machines and hand tools are different from most other inputs used in agricultural production because they require an initial investment in fixed capital. Variable inputs such as seed and fertilizer are used in a single cropping season, while machines and implements require servicing and maintenance to prolong their useful life. Tractors require fuel and draught animals require fodder and veterinary services; and tractors, implements and hand tools require maintenance and spare parts in the event of wear or breakdown.

Agricultural mechanization will not be successful if the local economy is unable to deliver servicing, fuel and spare parts for both imported or domestically produced machines and implements. This failure often occurs when markets for these items are fragmented or unevenly developed, when transport infrastructure breaks down, or when new models or different makes of machine are imported without considering the need for spare parts.

Mechanization inputs and other farm technologies will only be viable in SSA if they contribute to the following:

- An increase in the productivity of labour. A family relying totally on hoe technology is severely restricted in the area that can be cropped and cared for. Similarly, post-harvest processing tasks are often time-consuming, labour intensive and repetitive. The addition of animal or engine power to agriculture significantly increases the output derived from the human energy expended in crop production and processing.

BOX 2
Advantages and benefits of conservation agriculture

Conservation agriculture offers several important advantages in the context of farm power and environmental protection, these include:

- direct planting with no tillage saves energy;
- weed control with cover crops and herbicides saves energy;
- soil erosion is practically eliminated;
- leguminous cover crops fix atmospheric N and so fertilize the following crop, reducing the need for adding additional fertilizer and so saving labour;
- permanent soil cover conserves surface soil moisture, which can make the crop more resistant to spells of drought;
- yields, and livelihoods, are improved, with less risk.

- An increase in the area under cultivation. Where land is available, the addition of animal power to the farming system should normally allow a larger area to be cultivated with the same amount of labour. Larger areas under cultivation imply higher total yields, but they also increase the labour demands for weeding, harvest, and post harvest processing. Thus, in the longer term, enhanced power sources for these operations will also be required.
- An increase in land productivity by facilitating the timeliness and quality of cultivation. For example, improved land productivity or higher yields will result when timely land preparation and weeding are carried out.
- An increase in profitability from increased crop production and reduced costs of cultivation, transport and processing by reducing expenditure on labour. If the costs of all farm operations can be reduced with the introduction of animal or tractor power, this will lead to improved returns and profitability.
- A reduction of the drudgery associated with human powered farming, transport and processing. For example, ploughing with draught animals requires about 60 hours/hectare of human labour compared with 500 hours if the operation is undertaken entirely by hand.

PARTICIPATORY MECHANIZATION PLANNING AND EVALUATION

The participatory research concept has its roots in the recognition that if smallholder farmers do not perceive the relevance of the results of research to their own situation, they will not adopt them. Participatory research transfers the initiative and the power of decision to farmers who, in the final analysis, have significant advantages over scientists because they have detailed and practical knowledge of their own production systems.

Participatory planning involves the active participation of all stakeholders in planning and implementing mechanization strategies, with the role of farmers taking on paramount importance. Participatory planning builds upon the indigenous knowledge that already exists in the community and blends it with the ideas and knowledge of other stakeholders e.g. researchers, policy makers, private sector, etc.

Agricultural extension and advisory efforts are essential for the success of any mechanization and sustainable farming system. However, the conventional "top-down" approach to extension has not generally yielded positive results, whereas participatory extension approaches are a way of improving the effectiveness of extension efforts. They aim to empower farmers to plan, manage and implement agreed activities. In essence, the modern participatory approach tries to ensure that projects – from planning, through implementation, and evaluation stages – should be participatory, consultative with all stakeholders, flexible, empowering, gender-sensitive, and sustainable.

THE PROCESS OF MECHANIZATION PLANNING AND STRATEGY FORMULATION

The main purpose of mechanization strategy formulation is to create an environment in which agricultural mechanization will develop from the existing situation to a desired future state. The strategy is formulated paying specific attention to the roles of government and the private sector. The output (Figure 1) is a suite of policy and institutional recommendations, supported by programmes and projects when appropriate.

THE PROCESS OF TECHNOLOGY DEVELOPMENT

Development programmes often include technology that is novel to people in the target region. There may be a strong temptation to make decisions about the "most appropriate" technology without involving the stakeholders who will be affected by the adoption of new practices or equipment. The process of participatory technology development guides the people involved in development programmes to resist the temptation to impose, and it includes the other stakeholders from the earliest possible point in the programme.

In the context of farm power and the development of mechanization technology, the process followed will generally be in line with the following sequence:

- technical specialists and farmers working as partners;
- identifying the problem;
- selection of possible technical solutions;
- construction of prototypes;
- on-farm evaluation of the technological options;
- an iterative process of technology development;
- pre-production prototype;
- final field tests;
- first commercial batch production;
- batch production.

Local circumstances may sometimes call for the process to be modified. For example, technical transfer from one industrially developing country to another (south – south cooperation), facilitated by a development agency, may be a possibility. The formation of strong coalitions that promote rural change by means of research and development of technology are more important than the specific method applied.

ERGONOMICS IN DEVELOPMENT OF TECHNOLOGY

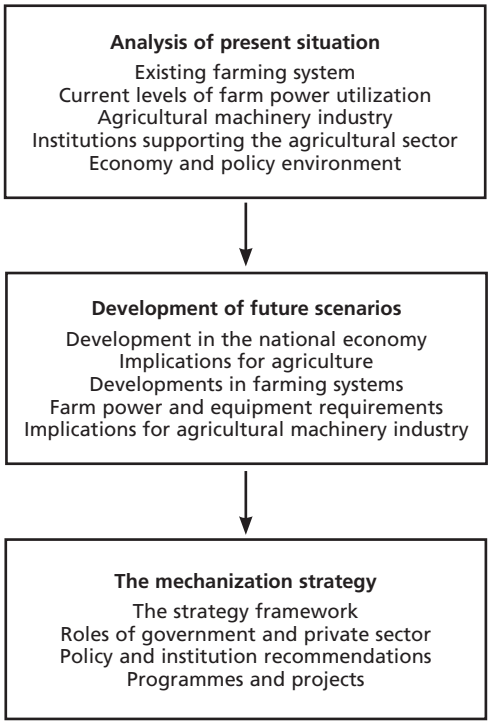
Improvements in the design of hand tools, made possible by fairly simple and ergonomically sensible changes, could make a big difference to the productivity and health of farm families. This is particularly true in the case of women, who are bent double for hours and days on end while they weed the family's crops.

Manual operations such as hoeing are physically demanding because of their energy and postural requirements and are considered sources of great drudgery. Approaches to identifying ergonometric problems and producing solutions – if genuinely participatory and inclusive of all stakeholders, especially of women – may hold the key to breaking out of cultural ruts and reducing unnecessary drudgery.

Essential ergonomic concepts that need to be considered are:

- work and work intensity
- physical work capacity
- comparative work intensity
- how hard people can work
- measurement of workload
- gender specific effects of agricultural work
- the concept of fatigue
- avoidance or reduction of fatigue and its effects.

FIGURE 1
Stages in mechanization strategy formulation



TECHNICAL AND ECONOMIC EVALUATION WITH FARMERS

The latter half of the last century saw a tremendous investment in research and development aimed at producing equipment for smallholder farmers. Regrettably, however, adoption by farmers was often disappointing to the developers, and numerous items of 'improved' equipment have ended up on the scrap heap. This emphasizes the importance of the participation of farmers in the whole process of technology development.

From an engineering point of view, on-farm evaluation by farmers is not the same as technical evaluation or testing. FAO's Agricultural Services Bulletin 110 on testing and evaluation of agricultural machinery and equipment gives detailed procedures for testing a wide range of implements, including hand hoes.

Technical evaluation and testing should be conducted during a technology development programme; it should be undertaken by trained technical staff. Conscientious and thorough testing is important because it can lead to improvements in performance, durability and ease of use.

Economic evaluation of technology involves costing its acquisition and use. The main points that need to be considered are:

- whether the technology is viable;
- an estimation of costs and benefits;
- implications of scale;
- effect on household cash flows;
- how to select the best option.

POLICY IMPLICATIONS AND THE ROLES OF THE GOVERNMENT AND PRIVATE SECTORS

NEPAD has a Comprehensive Africa Agriculture Development Programme (CAADP) that seeks to reverse Africa's agricultural crises through rapidly increasing productivity and efficiency in the sector. The case has been made in this Executive Summary – and it is also made in the main part of the publication – for the need to improve the farm power and mechanization options to smallholder farms in order to reach the goals outlined by NEPAD. NEPAD is an initiative by African leaders, so it can be assumed that there is a high level of political commitment to its goals. This needs to translate into mechanization strategies as an integral part of all agricultural development plans.

The principal role of government is to provide the conditions (i.e. enabling environment) for a largely self-sustaining development of the agricultural engineering sector. With the widespread move towards market economies, policies must be aimed at removing the most damaging forms of market restrictions, leaving market forces to operate where they can be effective in promoting both growth and rural poverty alleviation. For example, in some countries, high government import duty on steel has been a major factor hindering the local and economical production of farm implements. The import duties are levied across-the-board on the assumption that the steel it is destined for building construction, a relatively prosperous sector compared to small-scale agriculture. Governments could consider a system of rebates of import duty for manufacturers of agricultural tools and implements when they can show how they used the steel. It would, however, be important to eliminate any potential for corruption in such a scheme.

Many of the activities to promote and develop mechanization will take place in the private sector. The main role of this sector is to facilitate the delivery of inputs and services. Other roles will include providing necessary information and training and participating in networking activities to achieve an efficient balance between supply and demand. Efforts are required to ensure that this sector can function effectively, supported by appropriate training, extension, favourable fiscal policies, and research.

It cannot be repeated too often that farm power is critical to a better future for the people of sub-Saharan Africa. It is hoped that this Executive Summary will provide basic information to policy makers about the needs and options in farm power in that region, while the rest of the document provides greater detail for the actual planning and implementation of farm power strategies.