

Farm equipment supply chains

Guidelines for policy-makers and service providers:
experiences from Kenya, Pakistan and Brazil



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by

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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.

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Foreword

There is a pressing need to liberate smallholder farmers in sub-Saharan Africa (SSA) from the back-breaking yoke of hand-hoe cultivation. Currently about 65 percent of the agricultural land in SSA is worked with hand labour and the hoe is the principal tool used, while in southern Asia this rate is 40 percent and in Latin America and the Caribbean, 25 percent. The low productivity of the human work force in Africa, frequently exacerbated by pandemics and rural-urban migration, makes it very unlikely that the UN Millennium Development goal of eradicating extreme poverty and hunger can be met by the 2015 target. Mechanization of agricultural tasks will raise labour and land productivity and is an urgent necessity to enable Africa to feed its people. Previous efforts to mechanize African farms, especially in the small- and medium-sized range, have not always been successful. What is clear from past experience is that a well-functioning supply chain is a basic prerequisite for successful mechanization to take place.

With this in mind, the FAO Rural Infrastructure and Agro-Industries Division commissioned three mechanization supply chain case studies in three continents. The studies were conducted in Kenya, Pakistan and Brazil, and the information contained in them has been used as the basis for the analysis presented in this Technical Report. What is clear is that all the stakeholders in farm machinery supply chains are vital links to ensure the smooth functioning of the chain as a whole. And also that all stakeholders must earn their livelihoods, totally or partially, from their activities in the provision of mechanization services to farmers.

Public sector efforts to supply mechanization services have often fallen short of their goals. However it is evident that the public sector does have a role to play in complementing the activities of the private sector in a synergistic partnership. The main role of the public sector is to have the vision of a national mechanization strategy and to cultivate an enabling environment that allows the private sector to operate effectively. One key possibility described in the Report is that of linking equipment supply chains across continents. This is exemplified by an account of the evolution of no-till (NT) technology in Brazil, which is now being successfully used by farmers in Asia and Africa. FAO, in conjunction with the international donor community, has been a key stakeholder in this supply chain development, being in a position to take a holistic view to encourage private sector actors and so disseminate profitable mechanization technologies from one continent to another.

The main recommendations of the Technical Report are aimed at policy-makers in the public sector, although there is plenty to interest other stakeholders, especially machinery suppliers and mechanization service providers. However the ultimate beneficiaries are small- and medium-scale farmers who are the recipients of the services provided.

Acronyms

ACT	African Conservation Tillage Network, Kenya
ADC	Agricultural Development Corporation, Kenya
AFC	Agricultural Finance Corporation, Government of Kenya
AGST	Agricultural and Food Engineering Technologies Service, FAO
AMRI	Agricultural Mechanization Research Institute, Pakistan
AMS	Agricultural Machinery Service, Government of Kenya
AS	Agriculture Secretary, Government of Kenya
BNDES	Banco Nacional de Desenvolvimento Econômico e Social (Brazilian Bank for Economic and Social Development)
CA	conservation agriculture
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology, the United Republic of Tanzania
EMATER	Empresa de Assistência Técnica e Extensão Rural (Brazilian technical assistance and extension corporation)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Corporation)
FAO	Food and Agriculture Organization of the United Nations
FEBRAPDP	Federação Brasileira de Plantio Direto na Palha (Brazilian No-Tillage Federation)
FFS	Farmer Field School
FINAME	Linha de Financiamento de Máquinas e Equipamentos do BNDES (Credit line – from BNDES – for agricultural machinery purchase)
FMD	Massey Ferguson Dealer in Kenya
FMI	Farm Machinery Institute, Pakistan
FOS	Farm Operation Services in Pakistan
FSK	Farming Systems of Kenya
GoB	Government of Brazil
GoK	Government of Kenya
GoP	Government of Pakistan
IAPAR	Instituto Agrônômico do Paraná (Paraná State Agricultural Research Institute, Brazil)
IPCC	Intergovernmental Panel on Climate Change, WMO UNEP
KENDAT	Kenya Network for Dissemination of Agricultural Technologies
KFA	Kenya Farmers' Association
Ksh	Kenyan shilling
MDG	Millennium Development Goal
MoA	Ministry of Agriculture, Brazil, Kenya, Pakistan
NAAIP	National Accelerated Agricultural Input Project, Kenya

NALEP	National Agriculture and Livestock Extension Programme, Kenya
NEPAD	The New Partnership for Africa's Development
NGO	non-governmental organization
NMK	Njaa Marufuku Kenya
NT	no-till
PARC	Pakistan Agricultural Research Council
PR	Paraná State, Brazil
PRONAF	Programa de Apoio a Agricultura Familiar (National family farmers support programme, Brazil)
PSQCA	Pakistan Standards Quality Control Authority
R&D	research and development
RS	Rio Grande do Sul State, Brazil
RTDC	Rural Technology Development Centre, Kenya
SARD	Sustainable Agriculture for Rural Development (a Government of Germany funded FAO project in East Africa)
SC	Santa Catarina State, Brazil
SCM	supply chain management
SSA	sub-Saharan Africa
UEMOA	Union Economique et Monétaire Ouest Africaine (West African Economic and Monetary Union)
UNEP	United Nations Environment Program
Ush	Ugandan shilling
UNIDO	United Nations Industrial Development Organization
VO	Village Organization, Pakistan
WMO	World Meteorological Organization

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Larissa D'Aquilio re-shaped and designed the figures, performed the photo search and undertook the desktop publishing. Special thanks are due to Edward Seidler for keeping the authors focussed on the central issue of machinery and equipment supply chains and how to make them work better for farmers, suppliers and service providers.

The Brazil country study was sponsored by the German Government through the German/FAO trust-fund project "Conservation Agriculture for SARD" in Brazil, Kenya and Tanzania. The project fosters the integration of inter-continental equipment supply chains with a focus on direct seeding equipment.

Executive summary

The guidelines resulting from this report are principally directed towards sub-Saharan Africa (SSA) where the lack of farm power and appropriate machinery is having a deleterious effect on rural livelihoods. The farm power and machinery supply chain¹ includes a range of stakeholders from manufacturers and importers through dealers, hire service providers, repairers and farmers. All stakeholders need to make a profit enabling the supply chain to be sustainable over time.

Environmental protection is a mandate as there is a current and urgent need to temper the potential damage caused by increased agricultural production and global warming. Conservation agriculture (CA) is a potential answer that has proved its worth in South America. However there is no panacea. Thoughtful mechanization strategies need to be formulated for each situation and context and, in addition to proposing profitable outcomes, they should have an inbuilt environmental protection mechanism.

The aim of this document is to provide national and regional policy-makers and would-be entrepreneurs with the knowledge and experiences of similar groups in three continents (Africa, Asia and America). The analysis and guidelines presented here will be relevant to the needs and aspirations of all stakeholders in the farm power and machinery input supply chain, be they manufacturers, importers or other vital service providers. The information is also aimed at helping farmers who are increasingly embracing the free market economy and are demanding positive results from the supply chain.

The main thrust of this Technical Report is to examine the farm machinery and equipment supply chains in three countries. Information from these cases can provide guidelines as a first step in national mechanization strategy formulation. However, a national strategy can only provide a framework for action. Implementation arrangements and agreements will have to be made and for this both private and public sectors have a set of roles and tasks to perform.

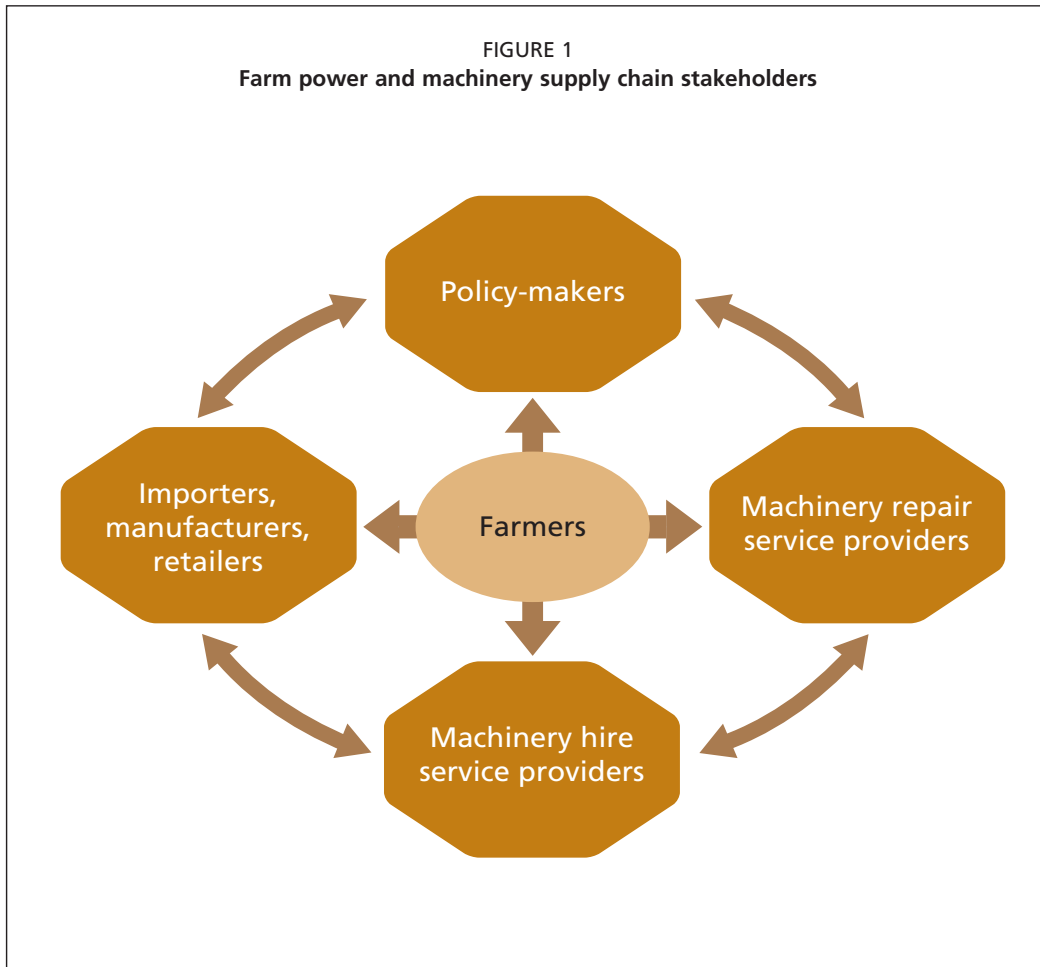
The report analyses the results of farm machinery supply chain case studies in Kenya, Pakistan and Brazil. Short summaries of each study are given and the roles of each stakeholder in the supply chain are described.

In Kenya, the small-scale farm sector is restricted to hand and draught animal powered equipment and the use of local artisans (*jua kali*) for repair work. Kenyan manufacturers are generally reluctant to manufacture for the small-scale farm sector as they see that it has little purchasing power. Efforts to train artisans are proving successful but funding is not always easy to obtain. Machinery hire services are thriving businesses although government funded services tend to undercut (and so undermine) private sector initiatives.

In Pakistan, agricultural machinery businesses are more self-contained (aiming at vertical integration) and outsourcing is kept to a minimum. Government incentives in the form of tax rebates for raw materials have greatly increased the number of manufacturers in recent years. Machinery repair services range from sophisticated services associated with main dealers, to roadside services operating on a shoestring. Farmers rely on machinery hire services, especially for expensive and infrequently used machines.

The Brazilian study focuses on the no-till (NT) case from the three southernmost states of the country. The farmers' requirements for NT machinery are catered for by a wide range of manufacturers from large-scale internationally active companies

¹ This chain supplies vital farm power and machinery inputs for agricultural production. Henceforth in this report the term "machinery supply chain" will be used. The machinery supply chain here refers to all power sources: human, animal and motorized.



to smaller-scale operations aimed at hand and draught animal powered equipment. State interventions through research and development (R&D) institutions have been a critical factor in developing NT systems and technology, and have greatly benefited the machinery industry. Financial interventions have also made farm machinery in general and NT machinery in particular more accessible to capital-poor farmers.

In the cases taken from these three countries, the business management practices of all stakeholders are examined and analysed. Business management in the supply chain ranges from the sophisticated Brazilian manufacturers with international markets to the rather inadequate family staffed service providers in Pakistan. The supply chain constraints are compared and contrasted with emphasis on Kenya and Pakistan given that the situation in Brazil would appear to be far more advanced at the moment. It seems that several years ago Brazil passed through the same situation now being experienced in Kenya and so may serve as a replicable model case.

A discussion on farm machinery testing is included and emphasizes that such a service should be offered in close collaboration with the manufacturing sector. In fact manufacturers should eventually be expected to finance fully any such service after, perhaps, an initial investment from the public sector. The comparative field testing of machines in Brazil is a good example of collaborative testing for the benefit of all stakeholders.

The guidelines developed from the case studies are aimed at five groups of stakeholders (Figure 1).

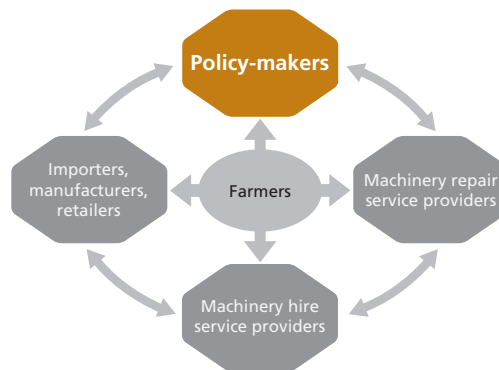
These guidelines suggest that the roles and activities of these stakeholders should include the following aspects:

POLICY-MAKERS:

- Formulation and updating of national mechanization strategies.
- Improvement of rural infrastructure.
- Facilitation of finance options.
- Coordination with other stakeholders.
- Tax relief on machinery and materials.
- Batch purchase of machines as an initial incentive.
- Testing services for machinery and materials.
- Participatory R&D in technology and machinery innovation.
- Training in technical and business management skills.
- Provision of quality extension services.



Plate 1
Policy-makers are updated on technical innovations

**IMPORTERS, MANUFACTURERS AND RETAILERS:**

- Coordination with other stakeholders.
- Demand creation.
- Synergistic associations.
- Machinery testing programmes.
- Improved business management.
- Staff training.
- Attainment of maximum competitive advantage.



Plate 2
Testing of a no-till planter by a manufacturer

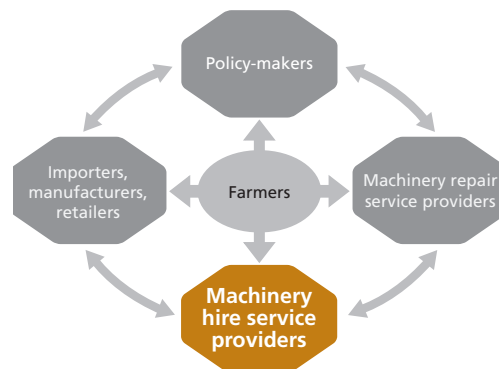


MACHINERY HIRE SERVICES:

- Coordination with other stakeholders.
- Business management.
- Quality control.
- Operator training.
- Maintenance and servicing.

**Plate 3**

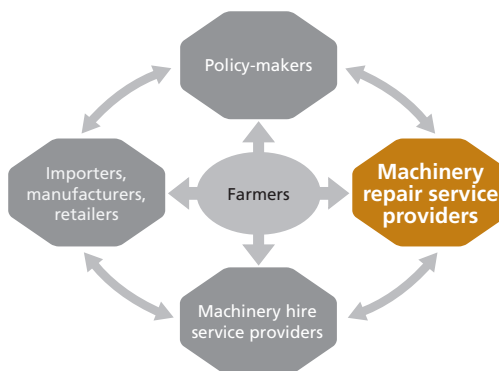
Machinery services for hire must closely follow farmers' needs

**MACHINERY REPAIR SERVICES:**

- Coordination with other stakeholders.
- Business management.
- Quality control.
- Technical training for staff.
- In-service operator training.
- Maintenance and servicing.
- Appreciation that these services include artisanal roadside repairers through to certified service agents for manufacturers and representatives.

**Plate 4**

Roadside repair of combine harvester

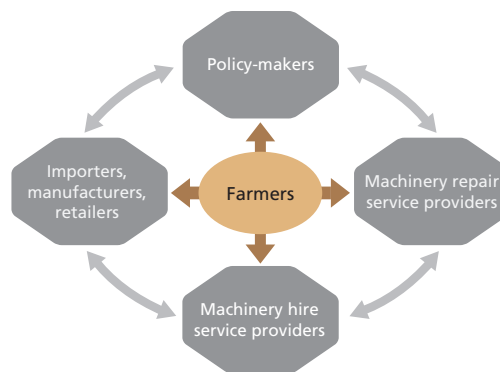


FARMERS' NEEDS:

- Coordination with other stakeholders.
- Functioning support systems.
- Improved business expertise.
- Access to knowledge on innovations.
- Formation of farmer groups.



Plate 5
Farmer field-testing of a prototype planter



Although these guidelines are aimed at many stakeholders, the central aim is to assist farmers, including smallholder farmers, to gain better access to agricultural equipment services in order to create better and improved linkages with markets and the commercial sector.

Chapter 1

Introduction and background

The lessons derived from this analysis of three machinery input supply chain case studies are mostly relevant for developing countries, especially in parts of Africa, where mechanization has still to fully take off. Despite decades of development efforts in SSA, the lack of a well functioning machinery input supply chain for small- and medium-sized farms has resulted in an acute farm power shortage. This is having a detrimental impact on agricultural production and rural livelihoods. Agriculture is the mainstay of many African economies and in a recent joint meeting on the future prospects for agricultural mechanization on the continent (FAO and UNIDO, 2008), it was recognized that current rates of progress are inadequate to keep pace with population growth (FAO and UNIDO, 2007b).

Investigations into the impact of farm power shortages have shown that it is a key component of inadequate livelihoods. A reduced availability of this vital input into agricultural production systems is a source of poverty in SSA (FAO, 2005). Solutions suggested to alleviate the immediate (and possible future) situation of poor farm families include: vouchers and grants for farm power services in times of dire need; securing the asset base of existing power sources (be they human or draught animal); managing farm power assets for maximum impact throughout the farming year (for example by diversifying into other sectors such as transport services – FAO, 2009); and adopting new power sources (e.g. motorized power) and more efficient, labour saving crop production systems (e.g. direct planting in CA systems).

The farm machinery supply chain is a sequence of (decision-making and execution) processes and (material, information and money) flows that aim to meet farmers' requirements and that take place within and between different stages along a continuum (FAO, 2007c). The links in the farm machinery supply chain start with the production of an appropriate technology. The chain then links manufacturers or importers through a dealer network to farmers. Other actors in the chain

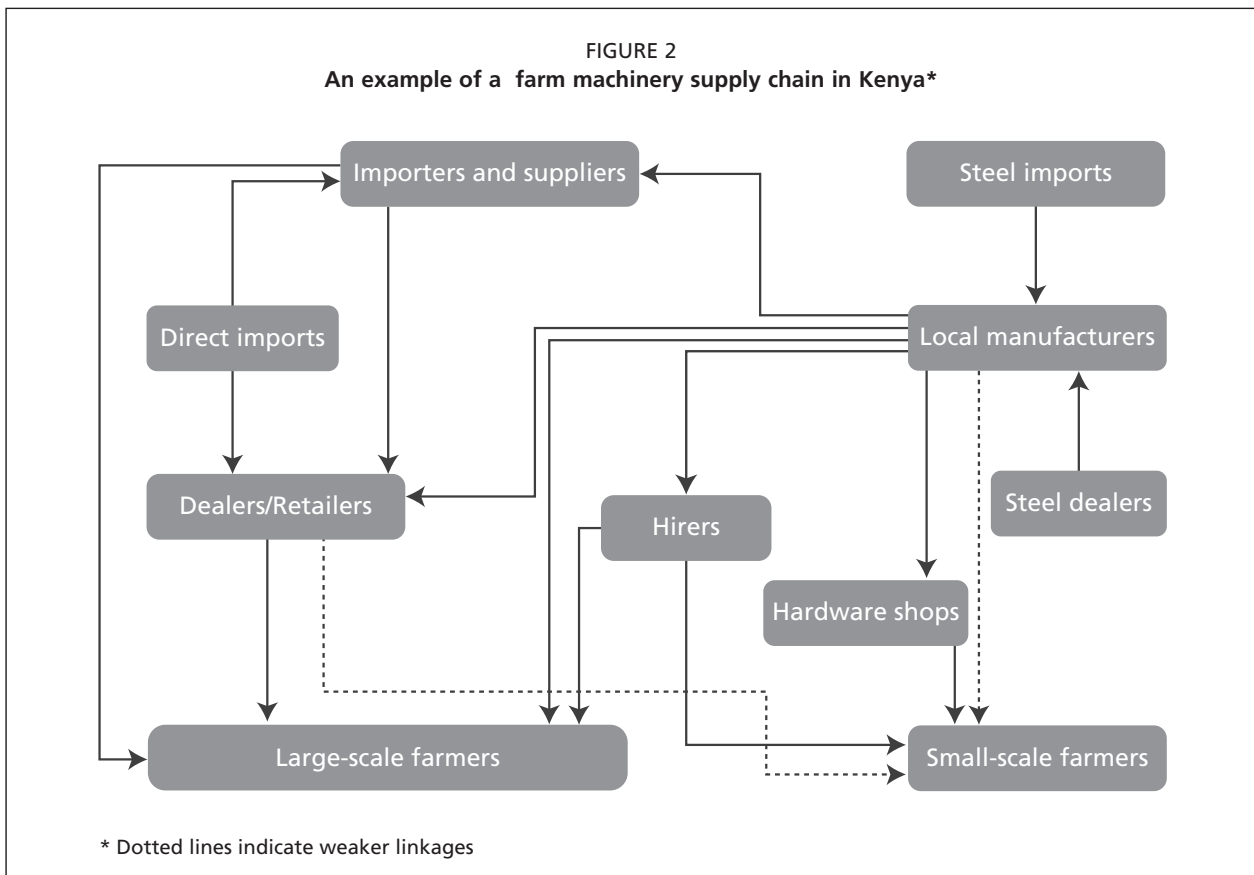
are machinery service providers that include machinery hirers and machinery maintenance and repair artisans. All these stakeholders will need to derive an adequate margin from their activities for the chain to be sustainable. The purpose of the input supply chain is to provide efficient mechanization services to farmers for agricultural production and processing.

Figure 2 shows that each participant in the supply chain network depends on various supply chains, i.e. can have multiple suppliers and customers. For example dealers and repairers can get their "inputs" from importers, directly import from abroad or source them from local manufacturers. In turn the dealer can provide services to large- and small-scale farmers.

Agriculture is the key driver to promoting growth in the African economy, and economic growth must be accelerated to prevent many African countries from falling even further behind the rest of the world. Currently the rate of growth in agricultural production (at around 2 percent per year) is not keeping pace with population growth which, despite the ravages of pandemics such as HIV/AIDS and malaria, is still over 3 percent per year.

Sustained economic growth would, on the face of it, appear to be a worthy goal, and in fact the New Partnership for Africa's Development (NEPAD) includes long-term economic growth as one of its principle objectives (NEPAD, 2008). Economic growth in Africa will certainly be needed to achieve the Millennium Development Goals (MDGs) (UN, 2008), especially MDG 1: eradication of extreme poverty and hunger in the region.

The drive to improve access to modern mechanization services for a wider range of farmers is a necessary and timely strategy; especially as this is a key ingredient for the development of the agricultural sector in many African countries. However it is pertinent to introduce a note of caution. The Intergovernmental Panel on Climate Change (IPCC) has warned that focussing on continued annual growth rates in national gross domestic product is having a deleterious impact



on global warming. Global carbon emissions by 2050 need to be cut to 15 percent of the year 2000 level. And this is probably a gross underestimate – a 90 percent cut is more likely to be the requirement in order to contain global temperature increases below 2 °C (Monbiot, 2007a & b). Growth rates in economic activity drive the current rise in carbon emissions, although the industrialized and industrializing economies carry the majority of the responsibility. The IPCC is already predicting that by 2020 African countries will experience increased water stress, crop yields reduced by 50 percent, and increased desertification and sea levels (IPCC, 2007).

Where does this leave us in the quest for increases in agricultural production that are necessary now and need to be accelerated to cope with the 50 percent increase in world population between now and 2050?

The answer must lie, in part at least, in the greater provision of effective tools for higher levels of agricultural production. Current mechanization technologies can be immensely damaging to the environment. Destroying soil structure by

ploughing, chiselling and disking, leads inevitably to loss of soil fertility and loss of the soil itself through accelerated erosion from wind and water. The declaration following a high-level conference on world food security (FAO, 2008c) confirmed the need for concerted action to support increased access to locally adapted agricultural inputs to increase agricultural production. These inputs include technical assistance and appropriate farm power and mechanization (FAO, 2008b).

Saner solutions are needed and one of the most important ones is NT farming, also CA. One very promising approach has been to look at the success of CA in putting a brake on natural resource degradation and providing sustainable and reliable increases in crop and livestock harvest among farmers (be they classed as small, medium or larger scale) in South America. Faced with declining soil fertility after forest felling, Brazilian farmers, researchers and private sector entrepreneurs developed an innovative integrated farming system that over time has been adopted on millions of hectares of farmland in South America (FAO, 2007b).

CA is a concept that involves the concurrent application of three basic principles: minimum soil disturbance, usually through direct seeding (hence

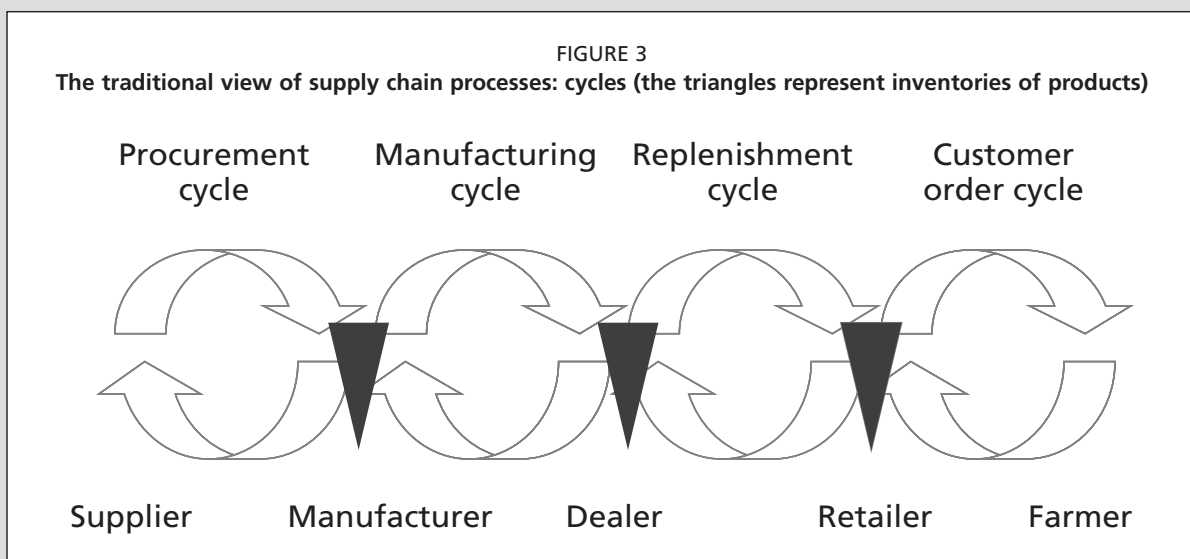
BOX 1

The "cycle-view" of the supply chain and supply chain management (SCM)

One traditional view of a supply chain is the so-called "cycle view". In this view, the processes in a supply chain are divided into a series of cycles, each performed at the interface between two successive stages (Figure 3). Each cycle is decoupled from other cycles via an inventory, so that it can function independently, optimize its own processes and is not hindered by "problems" in other cycles. As an example, we may think of a cycle where a hardware shop's inventories are replenished by products from a local manufacturer's end-product inventory. Another cycle takes care of replenishing the local manufacturer's inventory, e.g. steel from steel importers. A cycle view of the supply chain clearly defines the processes involved and the owners of each process and their roles and responsibilities (FAO, 2007c).

Properly functioning supply chains can improve the performance of interested stakeholders and reduce inefficiencies. Malfunctions reverse these effects. All too often, for example, spare parts are not available for farm machinery. This not only causes production and marketing problems to the farmer, but also increased costs and lost profits. Further, other stakeholders in the supply chain can also suffer, for instance repair service providers will be unable to repair the farmers' machinery and will not be able to sell their services.

Business management also involves managing the supply chain. SCM is the integrated planning, implementation, coordination and control of all business processes and activities necessary to produce and deliver, as efficiently as possible, products that satisfy market requirements. (For more information on the subject refer to FAO, 2007c and FAO, 2007d.)



Source: FAO 2007c

the alternative description of NT); permanent organic soil cover, often with cover crop establishment; and rotations of both main crops and cover crops to achieve enhanced soil fertility and better control of pests and diseases. The goal is to improve natural biological processes, both above and below the soil surface, and allow nature to produce abundant healthy and profitable crops and livestock fodder at no environmental cost.

Consequently it is not simply a question of improving access to mechanization services, but

improving the quality of the mechanization services being offered. The Brazilian example on NT technology coupled with permanent soil cover is one that merits greater attention in other regions of the world, and especially in SSA.

Appropriate agricultural mechanization strategies need to reinforce the entire supply chain for farm products so that farmers are facilitated to enter into commercial activity and become market players and demanders of farm power and mechanization technologies. Among other



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Plate 6

Direct planting through stubble maintains a permanent protective cover on the soil

stakeholders in the farm power supply chain are local manufacturers or importers, artisans, hire service providers, dealers and stockists of replacement parts. In a free market economy these stakeholders will be involved in offering a range of products to end users (usually farmers) who will decide the type of input best suited for their needs.

Agricultural mechanization strategy formulation (FAO, 1997) should aim to provide the basic conditions for a self-sustaining development of the input chain in the private sector. Typically formulation will follow a series of logical steps:

- A description of the existing situation.
- Identification of the policy issues impacting on the chain.
- An analysis of problem areas and constraints.
- A definition of the preferred future situation and the actions required to achieve it.
- A definition of follow-up actions and activities to assist policy-makers in carrying out the strategy.

The main thrust of the present document is to examine three contrasting scenarios of farm machinery and equipment supply chains in developing countries. A similar analysis could constitute an important first step in national strategy formulation.

However, a national mechanization strategy can only provide a framework for action. Implementation arrangements and agreements will have to be made, and for this both private

and public sectors have a set of roles and tasks. Governments and business actors now agree on the need for better coordination of each other's strategies and interventions in the agricultural sector (Wolter, 2008).

The public sector should provide the "enabling environment" for private sector initiatives. Minimum features of such an enabling environment include: appropriate macroeconomic policies, legal and regulatory frameworks and land ownership and tenure policies, among others. Creating an enabling environment for domestic and foreign investors is a major ongoing challenge that transcends agricultural investment, including investment in mechanization. Because the business sector in many developing countries is being rapidly transformed as a result of the free trade policies of international financial and trade institutions, an agricultural mechanization strategy also needs to be responsive and flexible in order to adjust to reality. Other public sector priorities are: training and human resources development, strengthening local organizations as well as R&D (FAO, 2008a).

The private sector (from small-scale farmers to large-scale machinery and services providers) is usually motivated by profit² and needs to make money in order to sustain the business. Making a living and sustaining livelihoods is crucial for any private sector business. If the public sector enacts policies in favour of market expansion and improved regulatory conditions to support private sector development, then the private sector will be enabled to enhance agricultural production and, in doing this, encourage the creation of rural employment on the farming, agricultural services and agro-industries sectors. Examples of required public sector investment to achieve these ends include infrastructure (roads, telecommunications, electricity) and tax incentives to draw in private investments.

1.1 BACKGROUND TO THE PRESENT STUDY

In 1994 FAO commissioned an occasional paper on agricultural machinery distributors, importers and dealers: their role, management and operation (FAO 1994a). The paper provided an overview of agricultural machinery distribution and service from a predominantly European perspective. There

² Often this may not apply to smallholder farmers. Bolliger *et al.* (2008) suggest that in parts of South Africa a smallholding is more a place to stay than a place to farm: smallholders with this mindset will not wish to break with tradition and are not motivated by profit.

is now a need for updated information relevant to the needs of entrepreneurs in developing countries who form a vital link in the supply chain of the inputs essential for putting many sustainable agricultural practices into effect. To date this link in the chain has been fairly weak, especially in many developing countries of SSA, with entrepreneurs uncertain of the future market and wary of making risky investments.

In 2006, the Agricultural and Food Engineering Technologies Service (AGST) of FAO commissioned two studies on the availability of farm equipment related services, one in Pakistan (Abbas, 2007) and the other in Kenya (Mbaka *et al.*, 2006). In 2007 a further study was commissioned in Brazil (Casão Junior and Guilherme de Araújo, 2008) in order to document the success of the sophisticated supply chain for CA inputs (specifically NT planters) in that country.

For the present analysis all four documents were studied to produce a comparison of the case studies and a synthesis of the main lessons learned.

The aim of this document is to make available, to national and regional policy-makers and would-be entrepreneurs, the distilled knowledge and experiences of similar groups in the three continents (Africa, Asia and America). The analysis and guidelines presented here will be relevant to the needs and aspirations of all stakeholders in the farm power and machinery input supply chain, be they manufacturers, importers or other vital service providers. The information is also aimed at helping farmers who are increasingly embracing the free market economy and are demanding positive results from the supply chain.

1.2 REPORT STRUCTURE

This report is structured in the following way: this Chapter provides the background to the comparative study and indicates the objective to be achieved. Chapter 2 reviews issues surrounding machinery supply chains with information on agro-industrial SCM, alternative approaches to reduce the need for farmers to overinvest in machinery and a comparative summary of supply chain constraints from the three in-country studies. It also discusses the need for a machinery testing service and offers suggestions for its organization. Chapter 3 brings together the salient points for each stakeholder group in the form of guidelines principally directed at policy-makers in SSA. Chapter 4 presents brief summaries of the three contributory case studies (in Kenya, Pakistan and Brazil). In each of the

three country studies farm machinery supply issues and the levels of and needs for improvements of business management skills for supply chain actors are discussed.

Chapter 2

Supply chain and machinery management issues and a summary of the constraints encountered

2.1 SUPPLY CHAIN FOCUS

Business or social justice focus

All stakeholders (manufacturers, retailers, machinery hire services and farmers) in the agricultural machinery supply chain will usually have to make a profit to provide for their livelihoods. There are possible exceptions to the rigorous application of the profit motive, but for long-term sustainability costs must be calculated by all stakeholders so that charging rates can be calculated and a profit, however modest, can be made. Exceptions to this situation encountered in the case studies include:

- State subsidized machinery hire services. The Agricultural Machinery Service (AMS) in Kenya is one example; AMS charge rates for machinery hire are typically one-third of the rates charged by private sector providers. Another example is that of municipal governments in Brazil that provide subsidized machinery services to small- and medium-sized farmers.
- Some family-run machinery retailing businesses in Pakistan may undercalculate their costs as family members are not considered to be paid employees and so their costs are not included in the overhead calculations.
- A similar situation arises with small-scale family-run farms where family labour, as opposed to hired labour, is typically not included in enterprise cost calculations.

The supply chain comprises both private and public actors with, sometimes, different objectives (business and economic in the first case and social justice and equity in the second). Good financial management is more important for those actors operating with a primarily business objective as that will be required to make sound business decisions. Public sector schemes with a less rigorous business

ethic will need to finance subsidized services from somewhere. This will usually be through tax revenues for which there will be multiple competing demands.

Financing farm machinery

One aspect of medium and smallholder farmers that is constantly mentioned by manufacturers and retailers is their limited ability to invest in agricultural equipment. The helpful provision of credit at moderate interest rates has been highlighted (in the case of Brazil) but the advantages of sharing machinery ownership would also repay further investigation, especially in the case of SSA.

Lander (2000) suggests a number of alternatives to maintain the efficiency of machinery use. Whereas sole ownership of a machine improves timeliness, equipment matching and maintenance assurance, there are also no costs for management or travelling, which may be incurred in the sharing possibilities discussed below. On the other hand the following options may offer lower cost solutions in given circumstances:

- **Hiring.** Hiring for a fixed term allows costs to be known in advance. Repair and maintenance will usually be the responsibility of the owner and so the fixed costs of ownership (Box 9) are avoided.
- **Contracting.** This is a traditional way for farmers to deal with work peaks. One drawback could be that timeliness of operations may suffer when demand outstrips supply. On the other hand the service may offer up-to-date equipment with skilled operators and so work quality can be very high.
- **Machinery syndicates.** These are mechanisms of joint ownership of agricultural machinery and may fall into three categories:

- **Informal groups** where two or more farmers agree to cooperate.
- **Formal groups** where a group of farmers reduce individual capital outlay by jointly investing in machinery. Management is formal and it is vital to establish operating rules at the time of establishing the syndicate.
- **Cooperatives** where farmers will be stakeholders in a business run by paid employees. Often a cooperative will be specific to an enterprise and will offer services throughout the cropping, processing and marketing cycles.
- **Machinery rings.** These are groups of farmers, some or all of whom periodically suffer imbalances of machinery capacity. The ring cooperates to use excess capacity on one farm to satisfy the demand on another. Rings need to be administered by a manager and are financed by subscriptions and levies on all transactions.

2.2. SUMMARY OF CONSTRAINTS

Stakeholder constraints

Table 1 summarizes the principal constraints encountered for each class of stakeholder in the three case study regions. The analysis is especially relevant to the Kenya and Pakistan cases as it would appear that Brazil has passed through these difficult stages several decades ago. Many of the currently successful NT equipment manufacturers in Brazil started out as family businesses offering repair and maintenance services to agricultural machinery users. As they gained experience, and with the advent of NT as a viable option for Brazilian farmers, they were able to adapt and exploit the new market with innovative designs suited to prevailing conditions and demand. However, with the reduction in public sector support for equipment purchase by small-scale farmers and the parallel move by small-scale farmers to change from draught animal to small tractor power, some machinery businesses are going out of production.

BOX 2

Agro-industrial supply chain management

Effective SCM implies a synergistic relationship between the customer and the chain of service provider stakeholders. In the case of farm machinery supply this could mean that the manufacturers and importers are supplying hardware relevant to their target customers' needs. Machinery distributors and service providers (e.g. operator training and the after sales services of repair and servicing) will be well trained and supplied in time for critical periods of demand. Machinery hire service providers will be in tune with farmers' requirements and financial situation and will be able to maintain their machinery pool in good working order so that it is capable of providing the quality of service demanded.

In the examples from Kenya, Pakistan and Brazil there are wide variations in the successful application of SCM to the different components of the farm machinery supply chain. World class actors such as Jacto in Brazil (Jacto, 2008) will use cutting edge technology and will continually innovate to satisfy customer requirements in an evermore sophisticated market. By contrast, rural artisans will have a much more intimate knowledge of their customers' needs but the supply of goods will be managed on a personal basis by word of mouth.



Plate 7

Sprayer production at the Jacto factory in Brazil. In Jacto's SCM all engine-driven sprayers are made to order to conform with the end user's specifications

TABLE 1
Summary of constraints for each category of stakeholders

Constraint	Country		
	Kenya	Pakistan	Brazil
Manufacturers and retailers			
<ul style="list-style-type: none"> Lack of confidence in small-scale farm market: <i>Machinery manufacturers in Kenya are not prepared to manufacture batches of equipment for small-scale farmers without a firm order. In fact most manufacturing and importation of agricultural machinery is in response to orders rather than for stock in the expectation of future markets.</i> 	√		√
<ul style="list-style-type: none"> Poor infrastructure, especially in rural areas: <i>Poor infrastructure increases delivery costs of machinery and services. Rural roads (and often main trunk roads) are frequently in a state of poor repair, which adds to distribution costs.</i> 	√		
<ul style="list-style-type: none"> Raw materials are subject to import duty whereas completely built-up units of agricultural machinery are imported duty-free: <i>Local manufacture of agricultural equipment in Kenya faces unfair competition from the duty-free imports of all agricultural equipment. Raw materials (principally steel) are subject to import duty in Kenya. In Pakistan all agricultural tractors and implements can be imported duty-free but at the same time local manufacture only uses nationally produced materials.</i> 	√		
<ul style="list-style-type: none"> Lack of quality control and product testing, especially for smaller-scale entrepreneurs: <i>Farmers are not protected from inferior products, nor are manufacturers (especially smaller-scale entrepreneurs producing for local markets) encouraged to maintain high levels of quality control. An independent authority, working closely with both manufacturers and end users, would offer benefits to farmers in improved quality of products; and manufacturers in design improvements and quality assurance. The Kenya Bureau of Standards is reported to be working towards this goal. The issue is discussed further in the Section 2.3 on machinery testing.</i> 	√	√	
<ul style="list-style-type: none"> Business skills not well developed: <i>There is a lack of ability for manufacturers to estimate precisely their operating costs and hence develop a healthy pricing policy.</i> 	√	√	
<ul style="list-style-type: none"> Manufacturers offer no training or technical literature: <i>Small-scale manufacturers do not train their dealers nor do they provide any service literature for repairers or even users. The situation seems to be particularly unsatisfactory in the Pakistan case study. On the other hand, poorly trained equipment servicing staff are unlikely to be able to follow technical service literature without thorough training.</i> 		√	
Repairers			
<ul style="list-style-type: none"> Business management is frequently poor: <i>Although local-level equipment repair service providers often provide a remarkable service under difficult constraints, their business management is often deficient. This means that wealthier clients are likely to be overcharged, and poorer clients are given credit until after crop harvest or until they can pay their debt in kind. In the case of Kenya, the need for improved management skills is principally felt by jua kali artisans at the basic level, as lack of competition at the top end of the market means that more sophisticated service providers can make a healthy profit with generous markups.</i> 	√	√	
<ul style="list-style-type: none"> Artisans have a raw material supply problem: <i>Raw material for artisans (jua kali in Kenya) is a problem in a country with no indigenous steel production capacity. Of necessity local sources of scrap are eventually depleted and artisans need to look further afield for their (increasingly expensive) supplies.</i> 	√		
<ul style="list-style-type: none"> There is no government sponsored technical training programme offered: <i>Workshops rely on self-training on-the-job. Also most businesses have a wish to expand into offering service for new equipment (especially combine harvesters). Workshop managers profess to be keen to avail themselves of any low-cost training schemes because at the moment the cost of available training is too high.</i> 		√	√
Hire service providers			
<ul style="list-style-type: none"> Business management is frequently poor: <i>The full costs of operating a machinery fleet are not always well understood and recapitalizing is jeopardized if fixed costs are not adequately covered. Transport costs on poorly maintained rural roads, large distances between clients and fragmented holdings will all add to operating costs.</i> 	√	√	
<ul style="list-style-type: none"> Machinery operators and mechanics need constant in-service training to operate machines effectively and efficiently and to avoid expensive downtime. 	√		
Farmers			
<ul style="list-style-type: none"> Small-scale farmers have severely limited purchasing power. 	√		
<ul style="list-style-type: none"> Land fragmentation exacerbates the purchasing power situation and is a factor preventing small-scale farmers entering the market economy. 	√		
<ul style="list-style-type: none"> Farmers, especially small- to medium-scale farmers may encounter some difficulty in making rational decisions between alternative investment options. Business management and especially financial literacy training would be a great asset to this group. 	√	√	√

2.3 TESTING AGRICULTURAL MACHINERY

At an international meeting in 2007³ to discuss options for mechanization in Africa it was agreed that agricultural mechanization is an essential input to lift African farmers out of the drudgery that is the inevitable result of systems associated with hand-tool agriculture, dominant on over 80 percent of the cultivated land in the continent (FAO and UNIDO, 2008).

At the same meeting there was consensus on the identification of the way forward. Emphasis must be on facilitating private sector involvement in the agricultural mechanization supply chain that includes the provision of agricultural machinery and mechanization services. This report has already made clear the message that motorized mechanization services will mainly be a profitable agricultural input in the commercial agricultural sector. And so a necessary prerequisite for a healthy farm power input supply chain is a buoyant commercial agricultural sector. This scenario does not, of course, preclude the extension of mechanization services to the smaller farm sector to assist it in intensifying production as it moves into the commercial sector. This group will have access to equipment hire services from larger farms or hire service providers, as is the case for example in Pakistan and Brazil. At the moment the situation of many small-scale farmers in southern Brazil is that they are in the process of transformation from animal power to small tractor power.

The private sector in the machinery input supply chain includes farm machinery manufacturers and importers. In order to help ensure that only high quality products enter the supply chain, there was a call at the Vienna meeting for the provision and application of standards to tractors and agricultural machinery. And it is in this technical area that government mechanization strategies, aimed at providing a facilitating environment for the private sector, can come into play.

Limbrey and Mukungu (FAO and UNIDO, 2007b) in describing their view of the way forward in the provision of farm mechanization services indicate that public sector institutions will be responsible for, among other services, standards, health and safety. This will involve impartial machinery testing and will primarily be a service to manufacturers. In the context of West Africa,

Fall (FAO and UNIDO, 2007a) recommends that UEMOA (West African Economic and Monetary Union) should be instrumental in setting up a regional centre for technical and economic evaluation of agricultural machinery. In India all imported farm machines, including tractors, must be tested at the Central Farm Machinery Training and Testing Institute in Budni (CFMT&TI, 2008) and must satisfy minimum performance standards guidelines (FAO and UNIDO, 2007e). In addition *all* machines must satisfy the same standards to qualify for finance from the national bank for agriculture and rural development.

Farm machinery testing can offer an invaluable service to the development of the manufacturing industry in a country. But only if the service offered is in close partnership between industry and the public sector funding department (the Ministry of Agriculture [MoA] for example). It will generally be the case that the public sector will be involved in establishing the service even if the long-term aim is to devolve responsibility to the manufacturers themselves.

Remember:

For an agricultural machinery testing institution to be in a position to offer a truly useful service to emerging manufacturers, it must be a partnership between manufacturers and the institution.

To establish a testing facility with the purpose of testing agricultural machinery in isolation from the manufacturers will only serve to produce the situation in the study area in the Punjab province in Pakistan where "hardly 2 to 3 percent of manufacturers" approach the appropriate agricultural R&D and testing centres (Farm Machinery Institute [FMI] or the Agricultural Mechanization Research Institute [AMRI]) for guidance.

Machinery testing has two major objectives (FAO, 1995): to assist in the development of the industrial sector through appropriate machinery manufacture; and of the agricultural sector through improved mechanization.

³ Agricultural Mechanization in Africa: time for a new look. Vienna, Austria 29–30 November 2007, UNIDO and FAO.

Testing can be for a range of distinct groups of stakeholders:

- **Manufacturers.** This group would also include importers and dealers who have an interest in supplying high quality products (Box 3).
- **Regulators** to ensure that machines reach established standards in terms of machine quality, output and safety.
- **Advisers,** principally front line extension agents who need to be able to provide impartial information to farmers.

The farm machinery testing facilities in Pakistan have been described by Amjad (2004). In Pakistan the FMI is a national entity under the Pakistan Agricultural Research Council (PARC). The AMRI is under the provincial administration of Punjab. Both FMI and AMRI are involved in testing and evaluation of both local and imported machines. The mandate of both institutions also includes rendering technical assistance to farm machinery manufacturers (although as we have seen this is not an offer that is currently attractive

BOX 3

Legitimate versus inferior hand-hoes

Cock brand hoes are made in the People's Republic of China in several factories and are of high quality. Because of their popularity, some unscrupulous manufacturers have produced fakes made of inferior materials. These are being exported to eastern and southern Africa.

It is difficult for farmers to distinguish between the genuine article and the fakes as, superficially, they are similar.

An official materials test by a reputable institution and the application of quality standards would ensure that the materials in imported equipment are fit for purpose.

Ensuring that only equipment of acceptable quality can be imported into a country will not only protect the consumer against inadequate tools but will also protect the indigenous manufacturing industry against unfair competition.

Source: FAO, 2006

to most manufacturers). Both institutes also devote effort to developing agricultural equipment for eventual commercial manufacture. However this will require close cooperation and collaboration between manufacturers and researchers and should also involve the active participation of potential end users from the outset.

Amjad (2004) continues with the assessment that testing is of paramount importance for Pakistan to maintain the quality of locally produced agricultural machinery and to assess the suitability of imported farm machines. Standardization is required to ensure the use of the right type of materials and to ensure the interchangeability of components and so facilitate the repair and maintenance of products. Testing farm machines before selling them to farmers is almost non-existent in Pakistan. Manufacturers have inadequate instrumentation and test facilities and both FMI and AMRI have very limited facilities.

The Pakistan Standards Quality Control Authority (PSQCA) is responsible for formulation of standards and has them for agricultural machinery. However they are not used to any practical extent because of three factors:

- they are not available in Urdu;
- there is no legislation to enforce their application;
- users do not understand the importance of test reports.

The situation in Kenya is that currently there is no effective collaborative agricultural machinery testing institution. In the past there has been public support for such a facility and the Agricultural Machinery Testing and Development Centre in Nakuru is an example of this. However its testing functions are now considerably reduced and it has now had its mandate expanded to embrace the Rural Technology Development Centre (RTDC). Manufacturers in Kenya really have no reliable authority to turn to for advice and assistance in farm machinery testing and standards. The R&D and testing environment in the region is constrained by limited laboratory and testing equipment and limited human capacity (FAO and UNIDO, 2007c).

The situation in Brazil is different again; there is now no official agricultural machinery testing service. Testing has taken place but often by state institutions with active support from manufacturers.

In the early 1980s the Brazilian Bank for Economic and Social Development (BNDES) offered a credit line (FINAME) for agricultural machinery purchase. And they insisted on testing and approving machinery before credit could be given.

More recently the Paraná State Agricultural Research Institute (IAPAR) has been active in field testing, through comparative trials, of a full range of commercial NT planters and seeders. The trials were made with crops sown 30 days before the public exhibition of the machines in work. This allowed farmers to compare the field performance of different machines and to judge the quality of seed placement and crop emergence (Plate 8).

The results of these evaluations were published with comparisons being made between factors such as machine specifications, depth of work, frequency of blockages, seed coverage and crop emergence (e.g. Casão Junior *et al.*, 2001; Siqueira and Casão Junior, 2002). In addition comparisons were made between ease of maintenance and machine adjustments for different field conditions and crop requirements.

The trials resulted in a marked improvement in planter performance and quality as positive elements were adopted more widely and less effective components eliminated. IAPAR was also instrumental in initiating on-farm testing of animal traction planters in collaboration with manufacturers.

It is the manufacturers themselves, however, who undertake their own testing as an integral part of the equipment development process. The study revealed that some manufacturers (nearly 40 percent) seek independent testing from national science and technology institutions.



Plate 8

Sfil SS 10000 planter at a dynamic evaluation event of no-till seeders in 2003 in Guaíra Paraná State, Brazil

Chapter 3

Guidelines and opportunities for agricultural machinery supply chain stakeholders

This Section draws together conclusions from the evidence gathered in the three case studies presented in Chapter 4. The aim is to offer some guidance for stakeholders or would-be stakeholders in the agricultural machinery supply chain. It focuses on information for policy-makers so that they may be guided towards creating a facilitating environment for supply chain entrepreneurs and so make an important contribution both to the supply of appropriate mechanization inputs into developing country agricultural sector producers (both farmers and processors) and also to the industrial sector via support for agricultural machinery manufacturers.

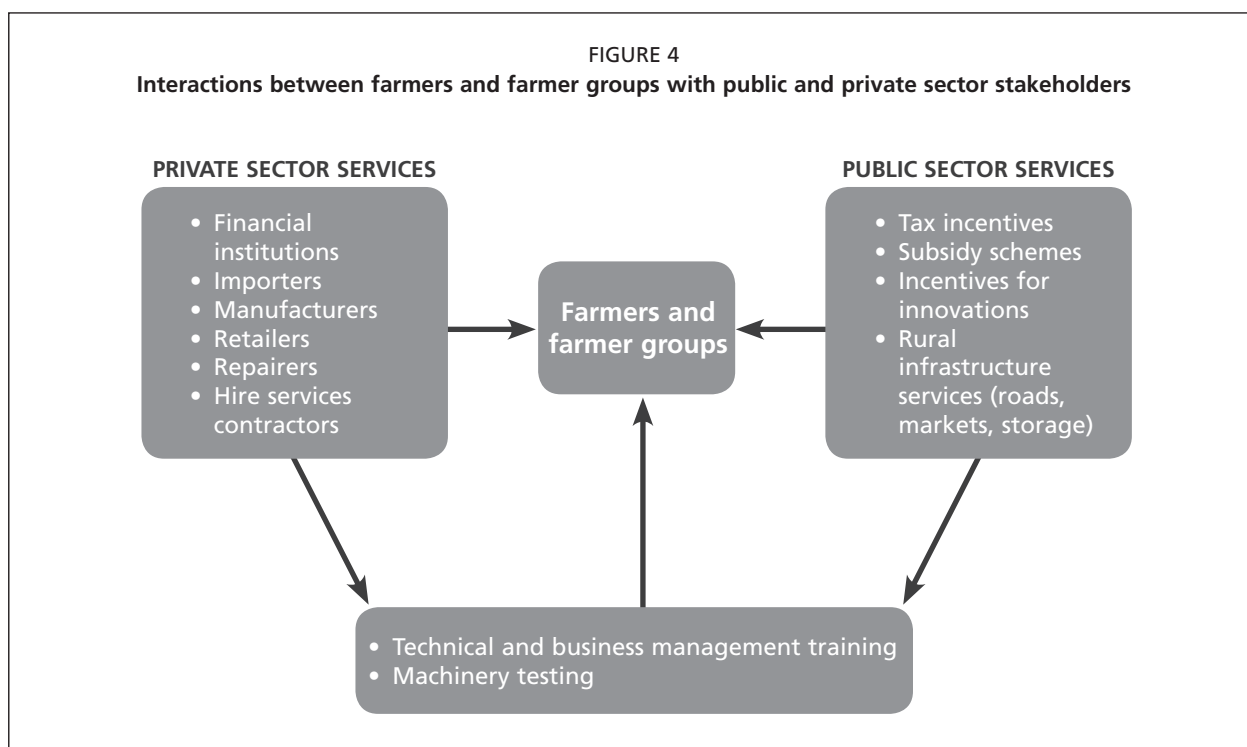
While reviewing the evidence that has been distilled from the three case studies, one point has emerged with particular clarity in that all the stakeholders in the machinery supply chain have vital roles to play and all of them are in the chain to ensure, partly or wholly, their own livelihoods.

These guidelines are clearly targeting the policy-makers, manufacturers and importers in the

equipment supply chain (plus, to a lesser degree, retailers, hirers and repairers). However, it should be clear that the ultimate clients or beneficiaries are the farmers and farmer groups. It must be a principal aim of all players in the equipment supply chain to equip small-, medium- and large-scale farmers with the range of equipment that they need for sustained and commercial agricultural production.

Public sector incentives for innovative technologies may be justified, especially if farm equipment will contribute to reducing drudgery for smallholders or if a significant contribution to a social environmental benefit can be expected. The private sector should be encouraged to take up such incentives.

Some of the important interactions between private and public sectors are shown in Figure 4. These synergistic activities contribute to the creation of an enabling environment for sustainable and profitable farm power and equipment acquisitions and employment.



3.1 POLICY-MAKERS

Formulation, revision and implementation of national mechanization strategies

FAO has, for many years, been promoting the importance of formulating and implementing national mechanization strategies. This has been done to enable the provision of farm power to the agricultural sector. The process should take place in a logical and ordered sequence with the best options available to all stakeholders in the supply chain (FAO, 2008b). The Kenyan case study draws attention to their Strategy for Revitalizing Agriculture, which includes a revised national agricultural mechanization strategy. This is a sound starting point, and it is the contention of this report that a national mechanization strategy is a necessary, but not sufficient on its own, starting point for facilitating access to farm power that will result in sustainable intensification of agricultural production. The following points indicate some of the main issues that would be likely to be relevant components of such a strategy:

Improvement of rural infrastructure

Poor rural infrastructure, particularly roads, is reported to be a major impediment to the free operation of markets. Poor infrastructure is a disincentive to market access and will always add to input prices. Infrastructure improvement (and especially improvements in rural transport and roads) is likely to form part of a wider national strategy for economic improvement (as was the case in Brazil), however its importance to farm power input supply is emphasized. One of the principal causes of failure for public sector machinery hire schemes has been the extraordinarily high cost of transport, both in terms of distances and time involved, access to fuel and services in remote areas, and the damage done to farm machinery during transportation.

Facilitation of financial options for machinery acquisition

In many countries the majority of measures taken to improve the supply of farm mechanization services take place in the private sector. The commercial banking sector has frequently been averse to extending financial credit to relatively resource-poor farmers. But experience has shown that investment in this sector can be profitable. This is especially the case for technologies with a lower capital cost and that demand a lower level of

management skills. Draught animal power options are a case in point (Hollinger *et al.*, 2007) where financial instruments could be extended by the private sector at relatively low risk. To make such schemes even more attractive some government guarantee, perhaps in the form of crop insurance, would shield smaller-scale farmers, working to emerge into the commercial sector, from the worst risks of crop failure and other catastrophes.

The Brazilian experience has been particularly illuminating with respect to financing. Early in the process of innovation in CA systems the government realized the need to extend attractive credit lines, especially to small- and medium-sized farms. Credit line programmes, such as FINAME from BNDES targeted resource poor farmers and allowed them to raise production and family livelihoods through the acquisition of farm power and equipment.

Given the experience in Pakistan with village organizations (VOs) and farmer field schools (FFSs) in East Africa, policy-makers should consider expanding access to credit by linking local organizations to local banks.

Tax and duty relief for agricultural machinery and raw material imports

Tractors and agricultural machinery are frequently given privileged status by governments actively promoting the development of their national agricultural sectors. Such equipment can be imported free of duty. However, sometimes (as in the case of Kenya) machinery parts and raw materials (principally steel) are excluded from this arrangement and this puts the national manufacture of agricultural machinery at a disadvantage. Few developing country governments would want to jeopardize the development of their national industrial sector in this way. One simple way of providing tax relief to national manufacturers would be to give them a rebate on the duty paid for materials that can verifiably be shown to have been used in agricultural machinery construction. The positive Pakistan experience is a useful model.

Batch purchase of agricultural machinery

Many people working to improve the development of the agricultural sector point to the need for a fresh impulse, such as the partnership between the private and public sectors of the economy (e.g. FAO and UNIDO, 2007d).

One way to do this and to motivate the private sector to manufacture for the smaller-scale farm sector is for the MoA (for example) to commission

batch production of equipment that would then be sold to farmers via the extension service or other outlets (Plate 9). This mechanism would be viable through the Kenya Farmers' Association (KFA) in Laikipia, Kenya, for example. In this way confidence in the market can be built and sustainable commercial production of agricultural machinery can become a more probable outcome.

Provision of impartial machinery and materials testing services

A mutually respectful collaboration between the public sector and the private sector would make it possible for the public sector to fund impartial machinery and materials testing centres in direct response to the needs of the manufacturing industry. Previous efforts in East Africa may have been too prescriptive and have not always offered a valued service to private sector manufacturers. The current situation in the Punjab in Pakistan is that extremely few manufacturers seek advice and guidance from public sector institutions set up to provide those services. A new approach must consider the needs of the industry from the outset. A strategy for sustainability of the service would be to phase out public sector support over a number of years so that the service is maintained by and for the private sector. It is by no means certain that manufacturers would consider such a service to be a worthwhile investment. Local manufacturers in the United Republic of Tanzania, for example, make no or little use of the testing institution (CAMARTEC) that is available to them. In Brazil manufacturers tend to do their own testing and may only outsource particular aspects that they believe can be done better outside. In Brazil the role of public sector institutions in organizing side by side comparative evaluations of NT planters has been a notable success in improving the technical quality of production machines.

R&D and facilitation of innovative technology provision

The public sector has historically not been notably successful in developing prototypes and moving them into commercial production via the public sector. R&D by researchers in isolation from other key stakeholders is a discredited paradigm. New models of collaborative participation are more likely to produce results that are capable of being manufactured locally at an affordable cost and at the same time would be technologies actively being sought by farming communities. A tripartite



©FAO/IG. SIMS

Plate 9

Batch orders placed with private sector manufacturers. This is one way that the public sector can reduce the risk for entrepreneurs and facilitate greater farmer access to mechanization inputs

arrangement, whereby the voices of farmers, manufacturers and researchers have equal value, is an activity that should be funded by the public sector, and its longevity should be dependant on the production of outputs valuable to all parties.

A further way that the public sector should be involved in the development of the machinery supply chain is by facilitating the introduction of valuable, farmer-proven technologies from other regions. Two examples of this approach are power tillers and draught animal power in East Africa (FAO and UNIDO, 2007c). Box 4 gives another example, the introduction of raised beds for crop production under controlled traffic conditions in Pakistan. Box 5 describes the initiative of the MoA in Kenya to introduce jab planters to increase crop yields.

The experience of IAPAR in Brazil in creating awareness and interest in draught animal powered NT planters is a useful example. Working with manufacturers and farmers, IAPAR was able to produce a planter that has served as the prototype for many lines of commercial production in the ensuing years.

Technical and business management training schemes

There appears to be a great need, as well as a hunger (especially in Kenya and Pakistan), for training programmes aimed at improving business skills and technical competence, particularly for tractor-based enterprise and farm businesses. Large-scale manufacturers, importers and dealers are, of course, fully conversant with the need for financial controls and with the tools needed for calculating costs and profits. Other actors in the supply chain

BOX 4

Tractor hire services for raised beds and reduced soil compaction

Keeping traffic (wheeled, animal hoof and pedestrian) to a minimum in CA systems is very important to reduce soil compaction. Confining traffic to permanent tracks or pathways and growing the crops on raised beds (1.2 m wide) between the pathways (0.6 m wide) can achieve this goal both under rainfed and irrigated conditions. Crops can then be produced under CA conditions on the raised beds where permanent cover can be maintained, crops of differing rooting depths rotated and crops sown with NT.

One of the main limitations to the uptake of CA in Africa and Asia is the scarcity of mechanization services. The establishment of the raised beds is a one-off operation and the practice could be more widely adopted if tractor hire services were equipped and trained to use the appropriate tools required (ridger, bed-maker, chisel plough for initial hardpan bursting and perhaps NT planters).

Such tractor hire services have worked well in Pakistan as part of an FAO food security programme. It is a good example of how farmers, machinery hire services and machinery suppliers can work together with international technical assistance programmes to raise agricultural production in a sustainable way.



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Plate 10
High density carrot crop on raised beds

Source: Fintan Scanlan, FAO. Personal communication

BOX 5

The Government of Kenya through the Ministry of Agriculture: getting serious with conservation agriculture

Food prices in 2008 reached unprecedented peaks in Kenya. These rises pushed additional millions of people, already at or below the poverty line, into worsening food insecurity. In a recent meeting between the Agriculture Secretary (AS), FAO and the African Conservation Tillage Network (ACT) representatives, the government enthused over the possibility of integrating CA with national agricultural extension initiatives, including: National Agriculture and Livestock Extension Programme (NALEP), National Accelerated Agricultural Input Project (NAAIP) and Njaa Marufuku Kenya (NMK). At this initial stage most interest was expressed in the introduction of job planters to the smallholder farmer for efficient and precise application and distribution of seed and fertilizer. The AS recognized that while the government was making efforts to provide subsidized seed and fertilizer to the farmers to counter the devastating effects of soaring food prices, their efficient application would substantially contribute to improvement in yield. This government strategy is highly likely to lead to scaling up of CA in the country.



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Plate 11
Smallholder farmers practise crop establishment with job planters

Source: Tom Apina, ACT. Personal communication

are sometimes less familiar with the methods required and are in need of orientation. These include small-scale manufacturers, hire service providers, machinery repair services and small- to medium-scale farmers.

Technical training is needed at many levels: from manufacturing skills needed by small-scale entrepreneurs, to servicing and repair requirements for new technology (for example, combine harvesters and power tillers) to training in new practices for farmers (for example, CA). Technical and managerial training courses and programmes are expensive for individuals and constitute an ideal and acceptable way for governments to demonstrate their commitment to development.

The policies of particular governments are crucial in this regard. The current administration in Brazil under President Luiz Inácio Lula da Silva is particularly keen to promote technology exchanges between his country and the African continent. This situation should be exploited by training African entrepreneurs in the technical and business skills needed for successful manufacture of productivity-enhancing agricultural equipment.

Provision of quality extension services in agricultural machinery

An active, motivated and well-trained extension service is a prerequisite for a progressive, developing agriculture sector. Agricultural extension does not belong wholly in the public sector, but elements of it do. For example, machinery demonstrators from larger-scale manufacturers, importers and dealers are part of the extension effort and the public sector service should liaise closely with their colleagues in the private sector. Experience has taught that, unfortunately, extension services have too frequently tended to be neglected, attracting poorly trained recruits who then are poorly rewarded and have nothing of great value to transfer to the farming community. The growing numbers of organized farmer groups (such as FFSs, earthworm clubs⁴, friends of the soil and NT clubs), which are proactive in the technical assistance that they demand, are a healthy sign that extension services will need to respond to a greater extent to farmers' requirements. The public sector has a key role to play here in ensuring that the extension service delivers high value information and training and in return is highly regarded by the farming community that it serves.

⁴ For example: *clubes da minhoca*; *clubes amigos da terra*; FEBRAPDP in Brazil.

3.2 MANUFACTURERS, IMPORTERS AND RETAILERS

Demand creation

Manufacturers, importers and dealers should be proactive in increasing the demand for agricultural machinery; they should not simply respond to demand but participate in its creation. This group is typically better educated than the majority of their potential farmer clients and they have access to more sources of information. They should take advantage of this to ensure that they keep abreast of current adoptable innovations in agricultural mechanization for similar agro-ecosystems around the world (Box 6). One good example of this would be the outstanding success of CA in Brazil and the current efforts to introduce farmers in several African countries to the benefit of this kind of labour saving crop production system. At the same time this group should make itself aware of current worldwide concern with climate change and the implications that this has for environmental protection. Again CA has an important role to fulfil.

The role of ACT exemplifies the kind of action required. ACT is an intermediary facilitator linking donors to the public and private sectors. In a sense ACT acts as a "lubricant" to create demand at the farmer level and to satisfy that demand by helping to channel appropriate technologies through the supply chain. Some of ACT's activities are indicated in Boxes 6 and 7.

Manufacturers who involve themselves with the vanguard of innovation introduction can expect to benefit from batch orders of equipment for pilot projects. These will usually be funded by governments or development organizations and can remove the risk associated with production for farmers who may have poor purchasing power and equally poor access to credit supplies. The experience gained from this kind of pilot activity puts both manufacturers and dealers in a good position to judge the farmer demand for the product. It also gives an excellent opportunity to master the manufacturing processes required and to cost the production process.

Although it is true that costs and benefits will be uppermost in manufacturers' minds, they are also capable of philanthropic actions. Technology transfer to African countries through in-house training is one example that has been proposed

BOX 6

Brazafric venture into conservation agriculture equipment

One consequence of the 2005 Third World Congress on CA held in Nairobi, Kenya, was the emergence of Brazafric (<http://brazafric.p0101.net>) as a private sector player in the importation of hand jab planters and animal drawn NT planters. The company was participating in a CA congress for the first time and recognized the opportunity and ordered its first consignment of equipment. This initiative was facilitated by the fact that the company, in addition to having a base in Nairobi, has another branch in Brazil which made it possible to procure Brazilian NT equipment more easily. Even though the company did not undertake any thorough initial market research, they were convinced that CA had a huge potential and sooner or later there was going to be large demand for CA equipment in East Africa. Indeed, although the first batch of equipment moved rather slowly, towards the end of 2006 the company started registering increased demand. Requests were mainly coming from projects and from a few farmers who were aware of the existence of the equipment.

The consignment in 2006 comprised 200 jab planters and 12 animal-drawn NT planters that were all sold locally in Kenya. The second consignment,

in 2007, comprised 200 jab and 12 animal-drawn NT planters, most of which have been sold to Uganda. The third consignment, which was made after FAO/ACT through the CA-SARDII project, supported one of Brazafric's managers on a tour of Brazilian CA equipment manufacturers, in May 2008, comprised 100 jab and 12 NT planters. The fact that the company has been able to empty their stock despite lack of commercial promotion indicates that CA awareness created by various projects and institutions involved is taking root.



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Plate 12

Two-row animal-drawn no-till planter of the type now being imported into East Africa from South America

Source: Tom Apina, ACT, personal communication

by Brazilian manufacturers⁵. It should, however, be pointed out that technology transfer in the form of joint venture manufacture in developing countries is only likely to be successful when a mature market demand has been built up for the technology in question. In the initial stages, groups of manufacturers in one region can collaborate to exchange ideas on innovative technologies (Box 7).

Synergistic associations

By associating with other stakeholders promoting relevant innovations (such as international development organizations like FAO and the International Fund for Agricultural Development [IFAD], trade associations, national extension services and rural finance institutions), manufacturers can take a lead in promotion and demand creation through participation in on-farm

trials and demonstrations, field days and other opportunities for practical demonstrations.

An excellent example of the synergistic relationship that can be built up between diverse stakeholders is the introduction of NT seed drilling into the rice-wheat systems of Pakistan (Box 8). In fact it seems to be the case that, wherever well-functioning collaborative associations among diverse stakeholders grow and flourish, then benefits in terms of greater demand for better equipment can be the result.

Participate in machinery testing programmes

Manufacturers are key stakeholders in programmes of farm machinery testing. As noted above with reference to policy-makers, manufacturers and importers must be included, along with end users, in any testing scheme. On-farm testing during the prototype development phase is an essential, but often underestimated, activity. By including representatives of farmer user groups at an early

⁵ During a three-day trade mission seminar with Brazilian and East African manufacturers in Londrina, PR, Brazil, May 2008 (www.act-africa.org).

BOX 7

Femo Works Engineering, Nairobi, Kenya

Simon Ngeru owns a small–medium-sized workshop (classed as up to 25 employees) located in Kiambu district some 30 km west of Nairobi. The enterprise was established in 1986 with an initial capital of Kenyan Shilling (Ksh) 1 000 (US\$15), which has since rocketed to over Ksh25 000 000 (US\$40 000) in capitalization. The workshop is equipped with the usual metal working machines and also plastic moulding machinery. Mr Ngeru is an accountant by profession but with a deep understanding of, and enthusiasm for, engineering principles. Consequently he has assembled a team of engineering designers who, in his words, are able to design and fabricate most of the less sophisticated product parts required for his market.

Mr Ngeru had never heard of CA until he landed an opportunity to visit Brazilian CA equipment manufacturers through the CA-SARDII project. Simon felt challenged with what he experienced in Brazil so that on his return he embarked on developing systems that could enable him to manufacture CA equipment using locally available materials. He believed that it was only through local production of CA equipment that the technology could be up-scaled by offering farmers quality products at competitive prices. While there was no CA equipment that was ready for sale at the time of compiling this report, the company had shown much optimism, and it was

only a matter of days before the Femo jab planter and a pedestrian-pulled sprayer were launched in the market. The company is also in consultation with other local CA manufacturers for the production of plastic parts. Such companies include Nandra in Moshi, Intermec in Morogoro and SEAZ in Mbeya, all of which are based in the United Republic of Tanzania. The company is working closely with ACT for the local field-testing of the products before the launch. The desire of Simon to venture into CA equipment is spurred on by the increasing demand of CA equipment and overreliance on imports from Brazil.



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Plate 13
Simon Ngeru explains the design of the Femo pedestrian-pulled sprayer

Source: Tom Apina, ACT, personal communication

stage of product development, it is more probable that the finished article will enjoy a higher level of acceptance than a product introduced without consultation and participation.

Improve business management

The business management of larger-scale manufacturers, importers and dealers is of high quality almost by definition as poor performance in this area would quickly lead to financial failure. However there is evidence that smaller scale actors are deficient in their financial management. Training in the subject is often necessary and this group should actively seek out sources of information. The most likely provider of appropriate services will be a government sponsored training centre, but non-governmental organizations (NGOs) and credit institutions may also play important roles in the supply of relevant orientation and training.

Staff training programmes

There is an increasing awareness on the part of many developing country governments of the crucial need for more and better mechanization services for farmers. This means that the technology available will become more sophisticated for many countries as their economies become increasingly integrated with the global market. In this situation, staff will need to have access to programmes of continuous training (both for production and sales personnel) to improve staff morale and keep them up to date with innovative techniques and practices.

Training needs also include the creation of a support system for farm equipment users in the form of effective and efficient repair and maintenance services. One way that this could be done would be to make use of the pool of roadside artisans who can be trained and used to supply this service for innovative products being supplied to

BOX 8

Rice–wheat systems in Pakistan

Rice–wheat and rice–rice systems are the most important cropping systems for food security in south Asia (Hobbs *et al.* 2008). Traditionally soil for rice was puddled to produce compaction layers and control weeds, and the soil was ploughed many times to force a seed bed for the subsequent winter wheat crop. Ploughing is time-consuming; it extends the turnaround time between crops and so reduces crop yields. The first innovation was to introduce NT wheat using *inverted T* coulters technology (FAO and CABI, 2007). Adoption has been accelerating and it is estimated that in 2005 two million hectares of NT wheat were sown worldwide by 425 000 farmers.

Both large- and small-scale farmers adopted the technology with the small-scale producers renting NT drills from hire service providers. The key to the rapid adoption has been the participation of farmers in the development process and the management of local machinery manufacturers to make affordable effective drills for the local market.

Development of machinery continues to allow good germination of both rice and wheat. Researchers are working in partnership with local manufacturers and farmers to produce new equipment at a price that will not be an obstacle to adoption and with provisions for after sales service and the supply of replacement parts.

It is anticipated that as machinery manufacturers keep pace with the demand for drills and as more farmers learn about the benefits of NT, this innovation will soon be used on the bulk of the wheat planted after rice in south Asia.

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Plate 14

Direct drilling wheat into rice stubble with a Brazilian no-till seed drill

the agricultural sector. Following on from this, it is also important to bear in mind the sophistication of the machinery support services available. A case in point would be the electronic control components on many modern tractors. These are not generally serviceable locally, at least in many parts of SSA, and should not feature in the design of machinery for such regions.

Attain and maintain competitive advantage

To achieve market share and competitive advantage, manufacturers need to pay attention to a series of factors (according to successful companies participating in the case studies). These include:

- Quality control, perhaps even to the extent of compliance with ISO 9000⁶ standards.
- Provision of technical assistance to dealers and users. In this context it is important to avoid "overselling" in the sense of selling more machines than can be accorded the needed technical backup in terms of training and replacement parts.
- Provision of clear and detailed technical literature with the machinery, written for the retailers, users and repairers.
- Good geographical coverage with the distribution network.
- Competitive pricing of the product.
- A policy of continuous product improvement.
- Investment in technology innovation.

3.3 MACHINERY HIRE SERVICES**Coordination with other stakeholders**

The business of providing machinery hire services should be developed in close coordination with other stakeholders (especially including the farmers) to define needs and select the most appropriate solutions. It makes little sense, for instance, for a machinery hire service to be offering disc ploughs and harrows when the extension service is recommending reduced cultivation to cut

⁶ Adherence to ISO 9000 standards does not of itself ensure product quality, but rather that consistent business processes are being applied (http://en.wikipedia.org/wiki/ISO_9000).

energy requirements for agricultural production and to protect the environment. Farmers cannot adopt new practices if the service is not available, so the hire service providers need to liaise with manufacturers and importers to have access to more profitable (for farmers) and more environmentally friendly technologies.

Business management

Public sector machinery hire services have proven to be notoriously unprofitable and therefore, in the long term, unsustainable. It is difficult, in the current free market climate, to endorse public sector machinery services. This means that the services offered must be profitable and the case studies have shown that the ability to calculate charging rates that reflect their real costs is often lacking. This is probably the most important aspect for private sector service providers, and they will need to be trained in this aspect just as is recommended for small-scale equipment manufacturers.

Quality control

Whereas there is some evidence that a number of farmers are satisfied with cheaper services of inferior quality, this is unlikely to be the best service to offer for long-term sustainability. Maintaining high standards of quality in the work done requires tight quality control and will also require rigorous operator training.

In-service training for operators

The need for continuous in-service operator training follows from the previous point. It is also important in the dynamic environment of changing and improving the technologies being demanded. New practices require new approaches and, often, novel machinery to implement them. It is not realistic to expect operators to reach acceptable levels of proficiency without appropriate training.

Maintenance and servicing

There is evidence of poor servicing at machinery hire centres and this is manifested in machines lying idle through breakages and lack of parts. Again, training is required in parts control and adherence to servicing schedules. This training alone however may not solve the fundamental problem that could concern managerial skills.

3.4 MACHINERY REPAIR SERVICES

Machinery repair services are frequently under-capitalized and operate out of inadequate premises with insufficient tools and equipment. Many of the points mentioned above in the case of hire service providers also apply to repair service providers. In particular, improvements are widely required in the following areas:

Business management

This is needed especially for the calculation of accurate operating costs and, therefore, profitable charging rates. Current practices tend to charge according to perceived ability to pay, or by comparison with prices charged by other service providers (which may also undervalue the costs of work done).

In-service training for technical staff

As has been mentioned in the cases of other stakeholders in the supply chain, a dynamic technological situation will give rise to specialist repair needs that are best acquired through thorough technical training rather than by trial and error. Manufacturers and importers may play a role in this process, but in most developing country situations there is likely to be a need for a partnership between these stakeholders and the public and NGO sectors for the provision of appropriate training.

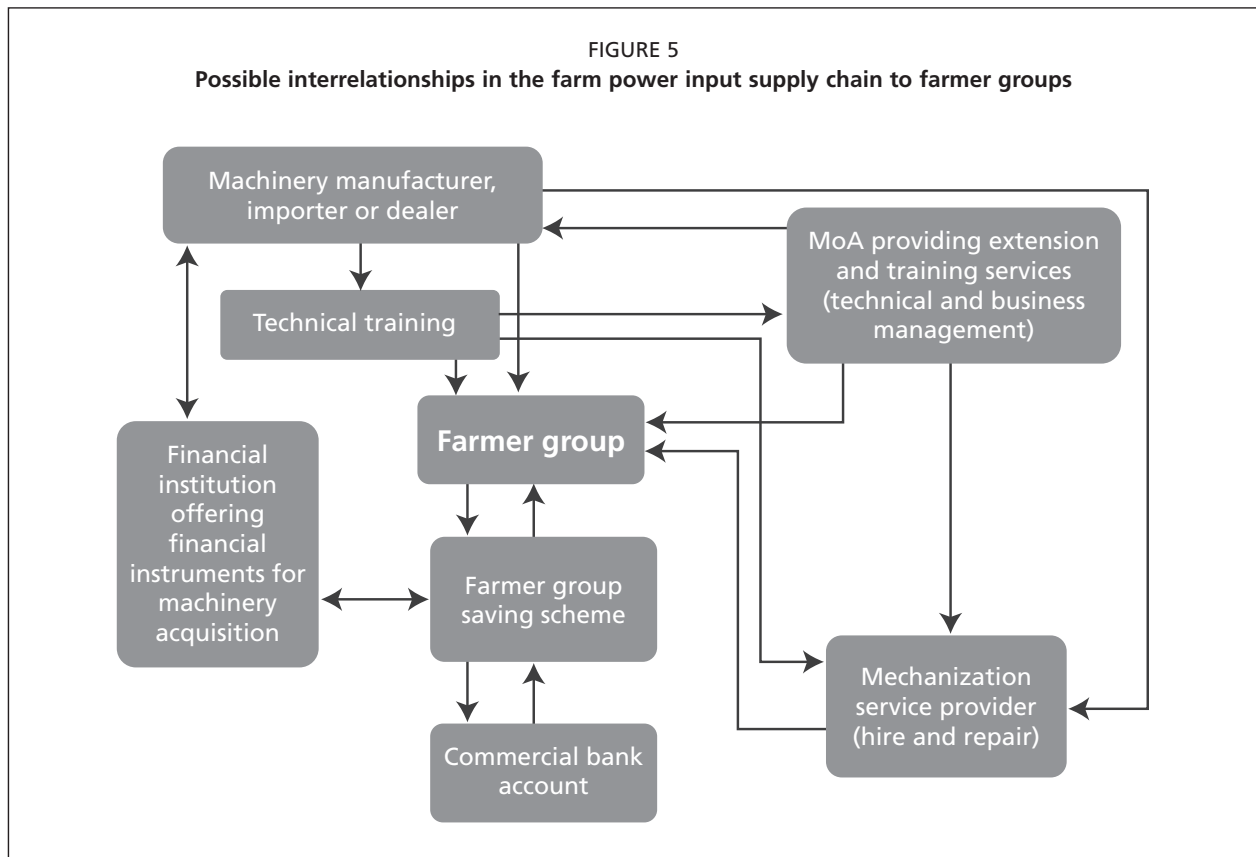
Support for fast moving parts

Engine-powered equipment brings a different level of sophistication for repair and maintenance services. Fast moving wearing parts, such as tyres, belts, filters and lubricants, are needed on a permanent basis for equipment, such as combines, tractors, pumps and mills.

Less sophisticated equipment (e.g. hand- and animal-powered machinery) is not very demanding in this respect and so repair and maintenance can be less sophisticated as a result.

3.5 FARMERS

Large-scale farmers (rather like the larger-scale manufacturers and importers) are quite capable of managing their finances, providing training for their operators, gaining access to credit lines, keeping abreast of innovations and are fully integrated into the commercial market. On the other hand, smaller-scale farmers may often require some assistance and orientation to become integrated into the market economy. In the process of becoming more



commercially oriented, many of these farmers will need to acquire mechanization services through hire or purchase.

Business expertise

Farmers need information on how to choose between machinery options, and for this they will need training in cost calculations, cash flow management and budgeting (especially partial budgeting).

Knowledge of innovations

Smaller-scale farmers will usually not have easy access to knowledge of innovations (via the internet for example). This knowledge has to be supplied by the extension service, by NGOs, by regional knowledge brokers, such as ACT, or through development projects funded by international organizations.

Farmer groups

When farmers organize themselves in groups they will usually find themselves in a better position to control their businesses in comparison with individual farmers working on their own. A farmer group with a bank account will clearly have better possibilities of gaining access to rural finance

providers. They will also be better placed to acquire technology for enhancing the value of their products (by the purchase of a mill, for example, or other processing technologies). However, group ownership of farm machinery that is highly seasonal in its use cannot always be recommended. A tractor and planter will be needed by all, or most, group members at the same time and allocating access to the equipment may be divisive. For this kind of technology, experience indicates that better service is provided by individual entrepreneurs (typically larger-scale farmers) who then offer a custom hire service.

How small-scale farmer groups might be integrated in the machinery input supply chain is shown in Figure 5. The Figure indicates how financial institutions may channel credit for farm power input acquisition via farmer group savings schemes (that could be supervised, for example, by VOs in the Pakistani situation, or by FFSs). The financial institution then links with the machinery supplier that can supply equipment directly to the farmer group, or via an equipment service provider. The appropriate extension messages, relevant to the proposed technology and delivered by competent, well-trained extensionists, are supplied to the machinery suppliers, service providers and

farmer groups. Care must always be taken to limit the risks of diversion of funds and deterioration of loans, and one way to do this would be to tap into the local banking structure by linking farmer groups to bank-like organizations (village banks, credit unions and other semi-formal arrangements).

Chapter 4

The case studies

4.1 INTRODUCTION

Three case studies were commissioned by AGST and were undertaken in selected regions of Kenya, Pakistan and Brazil. The reports have not been published, but have been used as a source of information for the synthesis contained within this document. This section analyses and summarizes the scope and main findings of each country study.

In Kenya, agriculture is the key economic activity in the two study districts of Nakuru and Laikipia where there is a growing demand for farm power and machinery. This holds true for both large-scale and smallholder farms, and the wide range of power sources and equipment found reflects this situation. The main thrust of the case study was to identify and describe the roles of actors in the supply chain.

In Pakistan, the study area was concentrated in two districts of the Punjab province, Rawalpindi and Sheikhpura, which reflect the situation of rainfed and irrigated farming systems. The focus was on machinery manufacture and supply and the related service industries for repairing and hiring agricultural machinery.

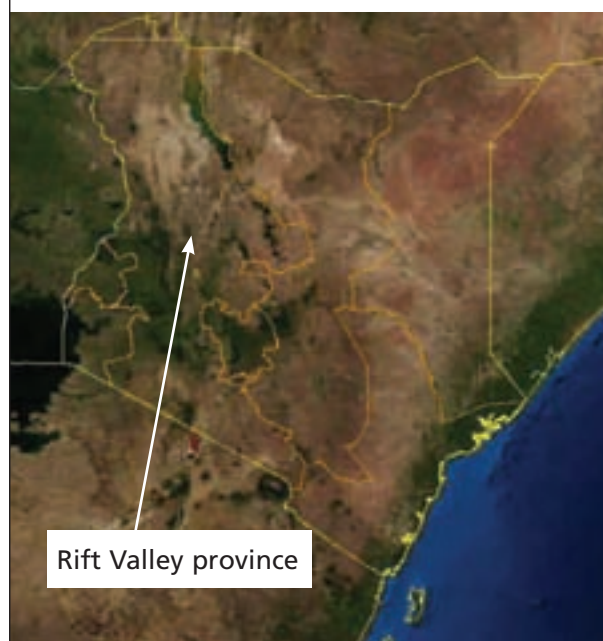
In contrast, the Brazil study focused on the development of the machinery and service industries for NT agriculture. The study traces the history of the sector's development, and this remarkable success story has benefited from the positive interventions of many actors including government sponsored programmes and state-level R&D and promotion initiatives. But fundamental to the process has been the innovative and entrepreneurial talent of the agricultural and manufacturing sectors.

4.2 KENYA

Overview

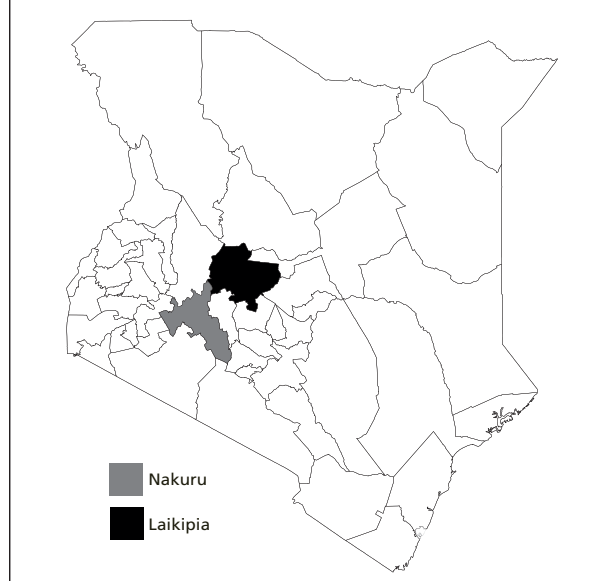
The Kenya study (Mbaka *et al.*, 2006) was conducted in two districts (Nakuru and Laikipia) of the greater Rift Valley province (Figures 6 and 7). The districts are both characterized by small- and large-scale farming, the main enterprises include: wheat, maize,

FIGURE 6
Location of Rift Valley province, Kenya



Source: FAO GeoNetwork

FIGURE 7
Location of Nakuru and Laikipia districts, Kenya



Source: adapted from <http://commons.wikimedia.org>

horticulture and dairy. There is a growing demand for agricultural equipment that offers opportunities for suppliers. Farmers in the two districts create a demand for the usual range of equipment associated with traditional agricultural techniques (earth movers, tractors, ploughs, harrows, harvesters, planters and choppers). The small-scale sector has a high demand for hired equipment, and this is fairly constant throughout the year as the maize and wheat crops are complementary (summer / winter) crops.

Farmer demand has produced an emergence of entrepreneurs (retailers, hirers, repairers and manufacturers) and also AMS, which is a government owned enterprise and offers a subsidized service that is most frequently accessed by medium- and large-scale farmers.

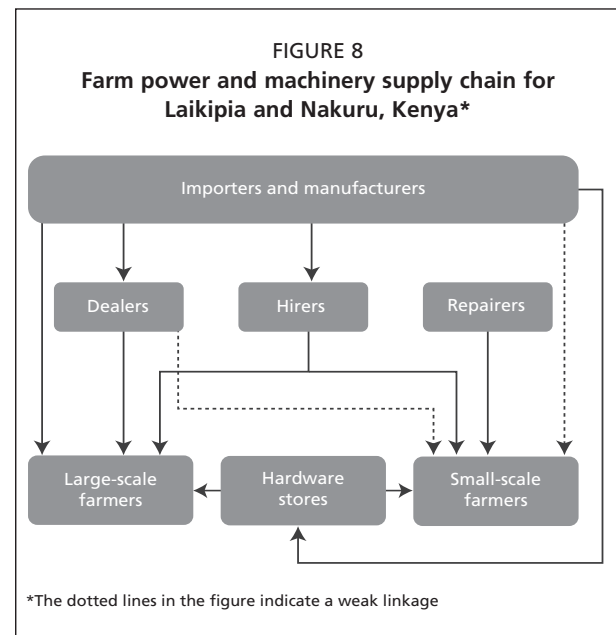
Manufacturers in the region include Ndume, Jalbert Engineering and KickStart (formerly known as ApproTec). Ndume is the largest manufacturer (with a technical staff of about 90 people), which makes a range of agricultural and non-agricultural equipment. Jalbert and KickStart are more involved with simpler technology for smaller farmers.

Farm equipment purchases are usually ordered through retailers (of which there are several, e.g. Holman Brothers in Nakuru, which imports larger-scale equipment from several countries). Occasionally groups of farmers will collaborate in a joint purchase although this is not common. Financial assistance is available (and is accessed) through the Agricultural Finance Corporation (AFC) and the KFA. Private sector sources of credit are generally considered to be too expensive, and hire purchase arrangements have suffered from payment defaults as a consequence of crop failure and are rarely offered.

Joint ownership of farm equipment has been challenged by the seasonality of demand, with all partners requiring the equipment at the same time. Owners offering equipment for hire is a more common situation and rates are competitive.

Farmers identified training as a pressing need. Farm equipment is often badly abused through the lack of knowledge of correct operational techniques, and training in appropriate usage, adjustment and maintenance, and repair is a requirement that emerged from the study.

There is a heavy demand for farm equipment hire services that are offered by both private and public sectors (including NGOs). The services are costed in a rather arbitrary way, and also prices will logically fluctuate with fuel costs and distances travelled. The service is then charged on a per acre



basis. Demand exceeds supply and this may be a contributory factor to the poor quality of work carried out⁷.

Local artisans (*jua kali*) are innovative but require training to be able to handle sophisticated agricultural equipment. This could possibly be supplied through local equipment fabricators who have an interest in educating and training local youth in technology development.

Generally there seems to be a lack of coordination between the principal stakeholders in the machinery input supply chain. The study concludes that farmers, artisans, retailers, manufacturers, importers, hirers and repairers lack information on each other's needs and objectives.

Farm machinery supply chain

The supply chain for the Laikipia and Nakuru regions is indicated in outline in Figure 8.

Both local manufacturers and importers service the agricultural community of the region. They supply directly to large-scale farmers, hire service providers and larger retailers (who can also be importers). The artisanal sector (which repairs and fabricates simple equipment) serves the small-scale

⁷ Poor quality in this context can cover a range of defective services. Untimely operations will usually lead to yield reductions. Poor spraying, by over- or under-dosing will be ineffective or inefficient; competent calibration of sprayers is vital. In the context of conventional tillage, poor quality ploughing can result in hardpans or inadequate weed control.

farming sector as do hardware stores. With this overall picture, the following sections analyse the chains for the major groups of stakeholders.

Equipment manufacturers and retailers

Figure 9 shows the input supply chain for local manufacturers and retailers.

There are a few local manufacturers, of which Ndume is the most important (Plate 15). The factory, established in 1965, has a staff of 90 people and produces a range of agricultural and industrial equipment (the full range can be seen on their website – Ndume 2008). The company manufactures to order and stocks are not kept. Because of the uncertainty of the farm equipment market, Ndume has diversified production and now supplies a wider clientele (including airport baggage handling equipment, for example). Their view is that manufacturing for the small-scale farm sector requires large-scale production to reduce unit costs. They also observe that the small-scale farmer has very limited purchasing power. Ndume justifies local manufacture, in spite of the import duty on materials and parts, by explaining that they manufacture for local conditions and are always available to customers for technical backup.

Other manufacturers include Jalbert Engineering and KickStart. Jalbert is a registered *jua kali* self-help group that aims to offer vocational training to

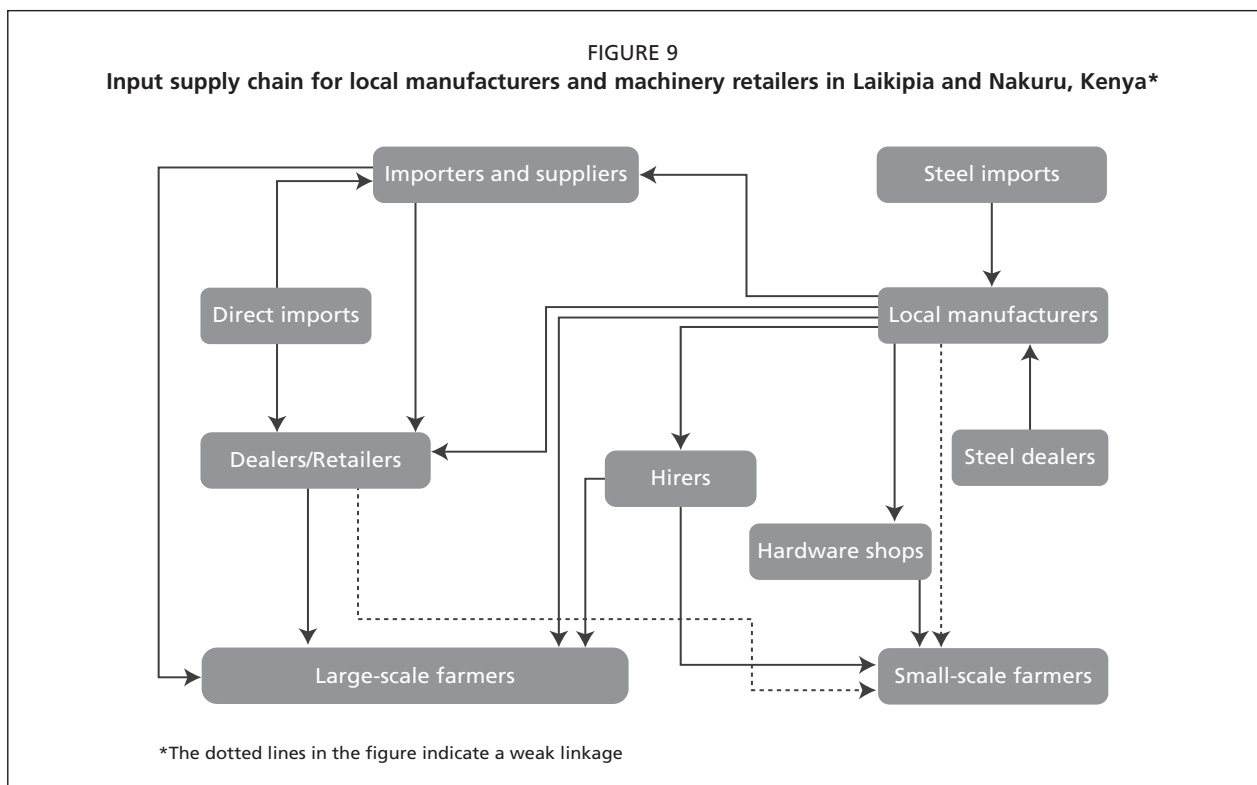


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Plate 15
The Ndume factory near to Nakuru manufactures heavy-duty agricultural equipment

young people to start them on a career of artisanal repair and manufacture. Jalbert experiences funding problems (principally because funding organizations need to share the vision of the value of such training), and the company is constantly seeking partners to help with the finances of this worthy venture.

KickStart is a non-profit organization that develops and markets new technologies in Africa. The designs for these low-cost technologies are bought by local entrepreneurs and used to establish profitable new small businesses. They create new jobs and wealth, enabling the poor to climb



out of their downward poverty spiral (KickStart, 2008). One example of the technology that they have produced and promoted is the Moneymaker treadle pump, which is commercially manufactured by several manufacturers in Kenya (Plate 16).

In Nairobi there are numerous small- and medium-scale manufacturers supplying the national market. Traditional tillage implements for small-scale farmers are generally not considered to constitute a very profitable manufacturing line, but value-adding technology (like hammer mills for instance) have a permanent market because they are used all year-round, not just for land preparation or harvest (Plate 17).

The Rural Technology Development Centre (RTDC) of the MoA in Nakuru has made some effort to supply better equipment to small-scale farmers with the design and manufacture of a range of tools and equipment. It is not clear how well RTDC advertises its products and penetrates the potential market, or how well the products are received by small-scale farmers. The equipment is displayed during agricultural shows and farmers' field days and in some instances equipment is taken to markets when farmers and local entrepreneurs visit on market days. This method has seen the adoption of ram press technology for value addition to vegetable oil processing at village level.

Retailers may import directly or may sell the products of locally manufactured machines and implements. Both private sector and public sector stakeholders are active in Kenya. However in the case study region the KFA – which is a public sector retailer – has seen its position decline in recent years caused by "financial and bureaucratic" constraints⁸. KFA imports implements directly through the Ministry of Cooperative Development for the agricultural sector. Other, private sector, retailers (e.g. FMD, Rift Valley Machinery, Holman Brothers, Hekima Engineering Works) are more active in the region (Plate 18). Generally the emphasis is on tractor-mounted equipment for larger-scale farmers. The retail farm equipment business is increasingly concentrated in the private sector with public sector actors withdrawing.

Farm machinery hire service providers

Hire services within the two Kenyan districts are offered by the public sector, private sector and NGOs. Figure 10 is a representation



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Plate 16
The KickStart Moneymaker pump being manufactured by a medium-scale manufacturer



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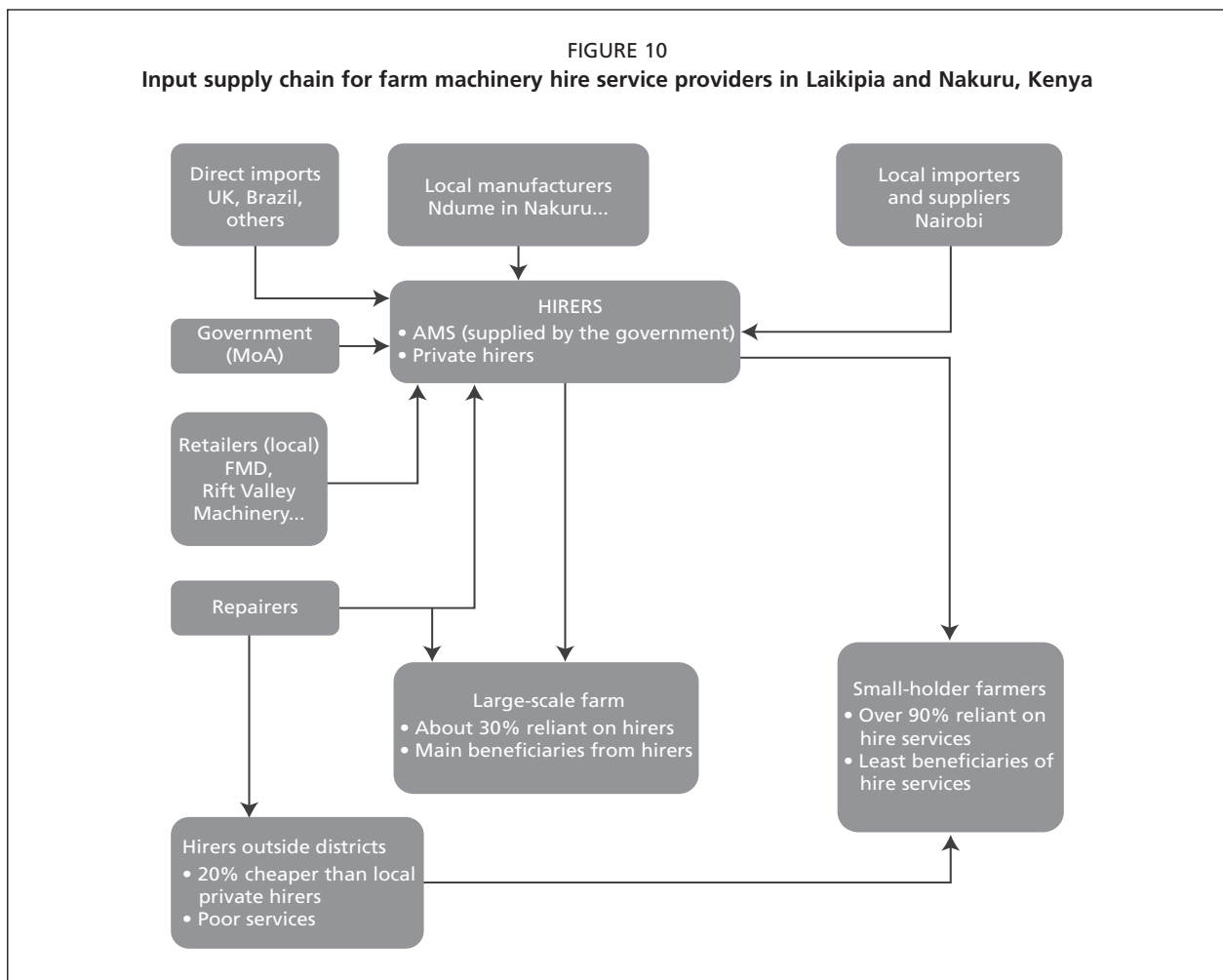
Plate 17
Hammer mill production in Nairobi, Kenya. (Making value-adding technology is attractive to manufacturers)



©FAO/R.G. SIMS

Plate 18
Holman Brothers imports machinery from Europe and Brazil and, in common with other retailers, caters for larger-scale farmers

⁸ In fact KFA has now closed (Mwamzali Shiriba, personal communication).



Source: adapted from Mbaka et al. 2006

of the supply chain for farm equipment hire service providers. The AMS of the MoA is well established in both districts and there has been a concerted Government of Kenya (GoK) effort to upgrade all the 23 AMS centres in Kenya with the acquisition of new machinery (FAO and UNIDO, 2007c). However, although their services had tended to concentrate on earth moving (for dam construction for example) and combine harvesting, this has recently changed when the government bought, from its own resources, a fleet of 50 farm tractors to offer the traditional services of soil tillage (ploughing and harrowing) and sometimes planting. In addition, the government has received a fleet of 60 agricultural tractors as a grant from the Italian Government to offer the same services, but this time through the Agricultural Development Corporation (ADC).

Farming Systems of Kenya (FSK) in Nakuru specifically offers limited services to small-scale farmers. Several large-scale farmers offer machinery

services to their neighbours after their own work has been completed.

In the private sector, charging rates are calculated on the basis of area covered, while AMS charges per hour⁹. However private sector charges used to be about three times more than those of AMS whose rates are determined remotely by the MoA and this would act as a strong disincentive for private sector entry into the market. Discounts are commonly offered by private sector operators for large areas of work in one block. Having said that, it must be borne in mind that AMS is a non-profit making MoA financed organization and is only required to cover its running costs each year. FSK, as an NGO, is not required to make a profit whereas other private sector service providers must necessarily cover their costs. The conclusion of the case study

⁹ This has recently changed and AMS now charges per hectare for agricultural services (Mwamzali Shiriba, personal communication). This is probably a response to excessive subsidy inherent in the AMS system.



Plate 19
Artisan training at RTDC, Nakuru

is that the hiring business is lucrative for those with the capital to buy the machinery. Service providers do have access to credit but they are not keen to borrow, being deterred by what they reported to be the unreasonably high interest rates offered.

Agricultural equipment repair services

All manufacturers and retailers offer warranties on the equipment that they make and sell and also offer repair and maintenance services outside of the warranty period. Technical staff generally receive on-the-job training and one company (Jalbert Engineering) in Laikipia also trains local people in the skills required for equipment servicing. RTDC in Nakuru also offers artisan training courses. The workshops managed by these operators are usually adequately equipped with basic fabrication and repair equipment (welders, lathes, milling machines). Figure 11 summarizes the main components in the equipment repair supply chain.

While most large-scale farmers in both districts have well equipped repair workshops to service their agricultural machinery, other, smaller-scale farmers rely on local artisan (*jua kali*) services. *Jua kali* artisans are usually rather undercapitalized with no access to machine tools. But the service that they offer is valued because they are local to the farmers and they can be easily accessed. They are able to repair and fabricate simple parts and even simple implements (such as the draught animal powered ripper) when they have access to the right jigs¹⁰ (Plate 19).

¹⁰ A jig is a template used in simple manufacturing processes to ensure precision and uniformity of the finished product.

Farming community

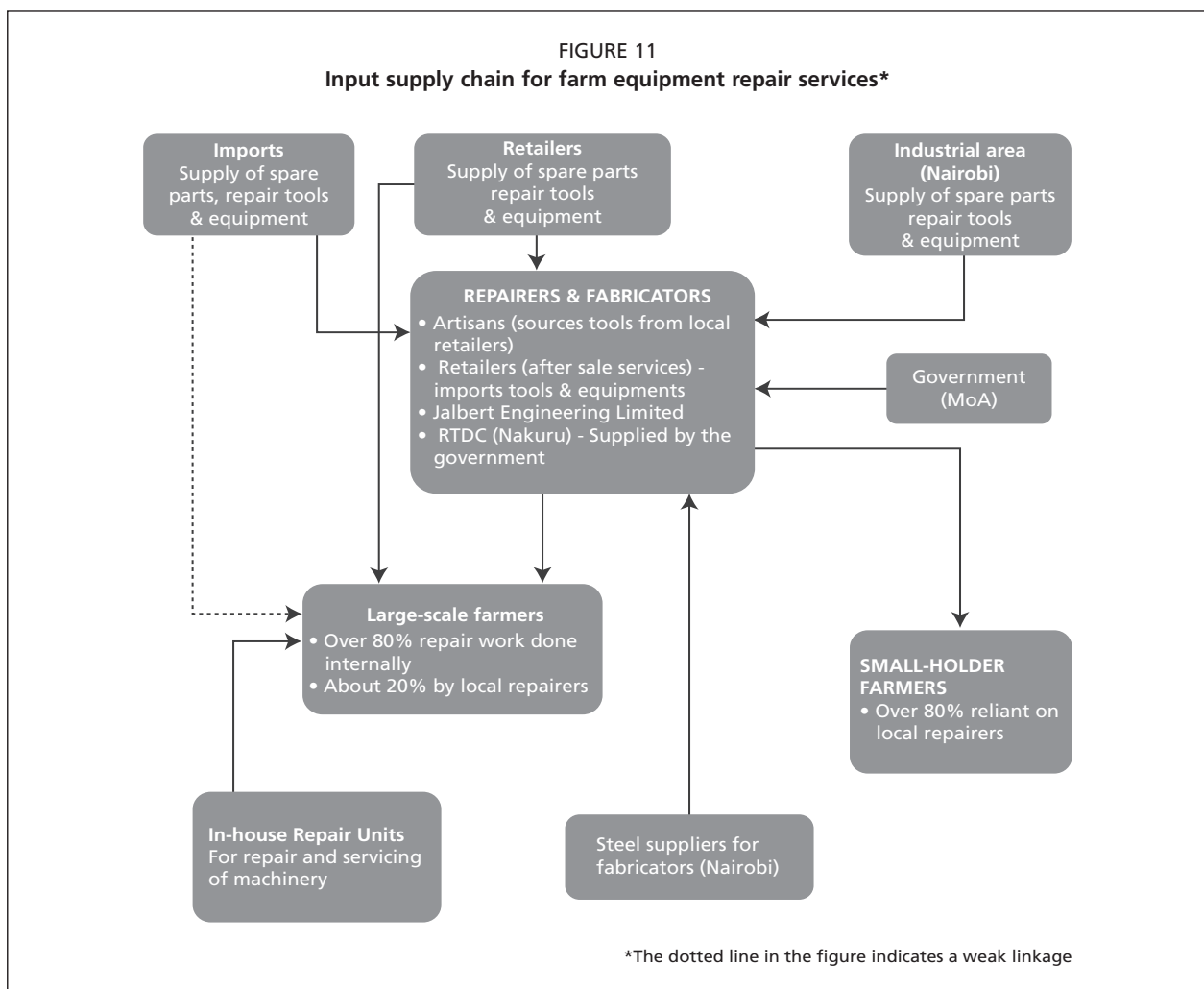
The great majority of farmers are small-scale operators characterized by a very limited purchasing power. This, naturally, has a marked impact on their access to most farm equipment and their related services. Typically their purchases from hardware outlets will be limited to a range of hand tools and draught animal equipment such as mouldboard ploughs. They will also make use of *jua kali* artisans for repair of the store-bought tools, but also for equipment that the *jua kali* are increasingly fabricating, albeit on a modest scale, such as draught animal powered rippers.

Inheritance customs have meant that family farmland tends to become fragmented as it is passed on, and shared out, from generation to generation. This situation further exacerbates the already acute purchasing power problem for small-scale farmers and so makes investment in machinery inputs even less attainable and viable.

Small-scale farmers' access to knowledge is also a limiting factor affecting the awareness of innovations and their subsequent trial and possible adoption. There is probably a major role for a more competent extension service in this regard. Farmers' participation in promotional events, such as field days where new technology is demonstrated practically, would be an important stimulus for a more progressive environment.

Because of the difficulty experienced by most small-scale farmers in acquiring their own agricultural machinery, hire services are popular. AMS is the favoured supplier because of its subsidized prices (as previously described in the hire service providers section). Access to other, private sector, service providers would be improved if farmers could enjoy some kind of credit arrangement.

Larger-scale, commercial farmers are, of course, already in the market economy and call on the services of manufacturers, retailers and repairers as frequently as required. Larger-scale farmers can also provide an important input supply service to neighbouring small-scale farms. One interesting example in Laikipia is a large-scale farmer purchasing herbicide in bulk at a reduced cost per litre. This is then sold on, at the same price, to local small-scale farmers and so represents an important saving for them. The widespread availability of mechanization services for small-scale farmers in SSA is likely to arise increasingly from service provision by medium-scale farmers in the future (FAO, 2008a).



Source: adapted from Mbaka et al. 2006

Business management skills and issues

Manufacturers and retailers

It is, of course, the case that major manufacturers and retailers, often with international supply chains, pay close attention to the calculation of costs and profitable charge rates. They have accounting departments to attend to such work. Accounts are computerized and specialist software is employed.

However in the case of small-scale manufacturers and retailers some deficiencies in business management skills have been reported. Most do not maintain detailed records, and financial management is usually the responsibility of the owner.

Demand for farm equipment tends to be seasonal, with the highest demand at land preparation and planting time: demand differential between the peak and the trough may be as high as 50 percent in sales volume. Some manufacturers (e.g. Ndume) adopt a product diversification strategy to even out demand

over the year and so enable continuous and profitable activity in the factory. Product diversification is, in fact, a commonly encountered response to market uncertainty and the seasonality of demand for agricultural implements (Figure 16).

Obtaining reliable information on sensitive financial matters such as profit margins is notoriously difficult, even if costs are precisely calculated. However, estimates of margins (probably lacking in reliability) varied from 5 to 30 percent.

Hire service providers

Private sector hire charge rates do not always reflect the full operational costs plus a profit margin. Rates are often determined by comparison with competitors and may not cover the full costs of depreciation of equipment. This will mean that re-capitalization at the end of the useful life of a machine will present difficulties. Of crucial importance in cost calculations are the costs associated with poor rural infrastructure, long

distances between clients and fragmented holdings. All of these items will dramatically increase the cost of operating the enterprise, and these costs must be calculated and recuperated to achieve sustainability.

Private sector farmers who offer tractor hire services may consider that the main purpose of the equipment is to work on the home farm. Service provision to other farmers is considered to be a secondary activity that may generate some cash and may only cover variable costs.

Independent machinery owners who provide mechanization services as a core business activity, based on commercial principles, recognize that business will fluctuate caused by machinery breakdowns, uncertain contracting opportunities, bad weather and delays in payments. The seasonality of agricultural work is again important in this context, and service providers try to diversify the range of services on offer to ensure year-round work and income streams.

Skilled tractor operators and mechanics are other essential ingredients of a successful machinery hire enterprise (Hollinger *et al.*, 2007). Shortage of such qualified human resources can seriously undermine the profitability of a hire service enterprise as it will result in poor work, more frequent breakdowns and this resulting in higher operating costs. Tractor operators and mechanics must be trained on existing and new machinery as an on-going, in-service activity (and therefore cost).

The larger machinery hire service providers (AMS and FSK) maintain good financial records electronically and so adjustments to costing would be quick and easy to include. Smaller, private sector operators do not always manage their data electronically and would benefit from an overhaul of their recording and costing data systems.

Access to working capital may be required because of the seasonality of the work. Most providers have access to financial institutions but are loath to borrow because of the perceived high interest rates charged.

Machinery repair businesses

Machinery repair in the region is generally considered to be a profitable business, but not so profitable as manufacturing according to one enterprise that does both (Jalbert Engineering). Although charges for repair work are negotiable, they should always reflect the costs of labour, materials and all overheads.

The repair business is profitable according to all the entrepreneurs taking part in the study. Profits of over 50 percent on the actual costs are reported (the exception being RTDC, which is financed

by MoA and reportedly only adds a markup of 6 percent over actual materials and labour costs).

None of the businesses felt that there was any competition as there are so few providers of this service in the region. This may explain, in part, why the entrepreneurs can charge such healthy markups over actual costs and why they do not seem to be in need of any orientation in terms of calculating costs and pricing regimes.

Jua kali artisanal fabricators and repairers offer an essential service at the lower end of the scale. Their overheads are minimal as they frequently do not have specialized premises, nor do they have a large inventory of tools or other capital equipment. However, in order to improve their business opportunities, technical and financial training would be of great benefit. They do receive some technical training at RTDC (via KENDAT, for example), but a thorough grounding in basic cost calculations would be of great benefit to many *jua kali*.

Farmers

The majority of farmers interviewed (especially smallholders) do not calculate the costs of their operations and investments. And when it comes to investing in agricultural machinery, or machinery services, the ability to make logical comparisons between possible alternatives is a basic necessity. The costs of owning and operating agricultural machinery are summarized in Box 9 where the difference between fixed and variable costs is noted. The Box also includes an illustration of the application of cost and benefit data to analyse the impact of a change in production system from conventional tillage to CA. The illustrative example is from a Ugandan study and so the costs and benefits are given in Ugandan shillings (USh).

Frequently farmers, and indeed equipment hire service providers, concentrate on recuperating the variable costs, whereas recuperation of fixed costs is essential for capital asset replacement at the end of its useful life. This situation is very common and can lead to farmers being unable to replace their machinery when necessary. It also has the potential to undermine machinery hire services which, in order to be sustainable and up to date, are obliged to charge rates that reflect the recovery of both fixed and variable costs. The fact that farmers will often keep their machines beyond the rational end of their useful life (i.e. when repair and maintenance costs become excessively expensive) can be partially explained by the fact that recapitalization is not possible because asset depreciation has not been taken into account.

BOX 9

Fixed and variable costs for operating agricultural machinery and an example of partial budgeting from Uganda

TABLE 2
Fixed and variable costs of operating agricultural machinery and draught animals

Fixed costs	Variable costs
Annual depreciation	Fuel, lubricants and filters
Annual interest	Operator's wages
Other possible costs incurred whether the machinery does any work or not. For example:	Repair and maintenance
Government taxes	Any other costs that are only incurred if the machinery or power source actually works. Such as veterinary and supplemental feed costs for draught animals
Insurance	
Shelter	
Prophylactic medicines for draught animals	

TABLE 3
Partial budgeting for the change over from conventional tillage to conservation agriculture
Assumption: 2 acres¹¹ of maize and beans, switching from conventional tillage and manual weeding to direct planting and chemical weed control

COSTS ¹²	BENEFITS
Annual additional costs	Annual costs avoided
Planter costs	Plough costs¹³
2.34 hours/acre × 2 acres × 2 (maize or beans + cover crop) × 2 seasons/year × USh2 529/hour =	2 acres × 8 hours/acre × 3 ploughings per year ¹⁴ × USh320/hr =
USh47 342	USh15 360
Sprayer costs	Labour for weeding
4.4 hours/acre × 2 acres × 2 seasons × USh1 475 =	2 acres × 2 seasons × 10 person-days/acre @ USh2 000/day =
USh25 960	USh80 000
Draught animals for planting	Draught animals for ploughing
Ugs15 000/acre × 2 acres × 2 crops × 2 seasons =	Ugs30 000/acre × 5 acres ¹⁴ =
USh120 000	USh150 000
Hired labour for spraying	Labour for planting
2 acres × 2 seasons × USh2 000/acre =	Assume family labour used =
USh8 000	USh0
Cover crop seeds	
USh4 000	
Herbicide	
1.6 litres/acre × 2 applications/year × 2 acres × USh 15 000/litre =	
USh96 000	
Labour for weed control	
Occasional hired labour for roguing and patch control. 5 person-days × 2 seasons × USh2 000 day =	
USh40 000	
Annual income foregone	Additional annual income
Assume a 5% drop in yield for the first 2–3 crops. Maize yield = 1 tonne/acre and farmgate price is USh150/kg. Loss =	Cover crop seed
USh15 000	300 kg/acre × 2 seasons × 2 acres × USh 200/kg =
	USh240 000
Bean yield = 0.8 tonne/acre and price =USh600/kg. Loss =	
USh24 000	
TOTAL COST	TOTAL BENEFIT
USh380 302	USh485 360
Net benefit/year = USh105 058	

11 1 acre = 4 000 m².

12 Exchange rate: 1 800 Ugandan shillings = US\$1.00.

13 An ox plough costs USh180 000, has a scrap value of USh18 000 and a useful life of 10 years. Total hourly costs are USh320 and output is 2 days (8 hours)/acre.

14 Land is commonly ploughed twice in the first season and once in the second.

It is not an easy task to estimate the future variable costs associated with machinery use. The best method is to refer to records of work performed previously by similar equipment under comparable conditions. However, these are very unlikely to be available and so, as a last resort, reference may need to be made to other local sources of data or to technical norms of the sort provided by FAO (FAO, 1972, FAO, 1990, FAO 1994b). It should be noted that local information is always preferable!

In view of this situation, raised financial awareness for agricultural communities is an apparent need. Mechanisms for promoting improved business management skills can start with financial education in schools; use of mass media; community meetings; self-help study groups and training courses (FAO and GTZ, 2000).

4.3 PAKISTAN

Overview

The Pakistan study (Abbas, 2007) was conducted in two districts of the Punjab province: Rawalpindi and Sheikhupura. Rawalpindi is in the northwest and Sheikhupura in the northcentral part of the province.

Rainfed areas (Rawalpindi) depend on hiring services whereas irrigated farms of over 25 acres (in Sheikhupura) will have their own tractors

and associated equipment. All farmers depend on contract combine harvesting. The principal crops grown on rainfed land are: lentil and wheat in the *rabi* season (October to April) and maize, groundnut, sorghum and millet in *kharif* season (May to September). Sheikhupura is entirely irrigated, with wheat grown in *rabi* and rice in *kharif*.

In the study area all machinery and tractors used (except combine harvesters) are manufactured and purchased locally. And from the manufacturers the input supply chain includes retailers, hirers, repair workshops and farmers. In the case of agricultural machinery retailers and machinery hiring businesses, business management is somewhat erratic with only 10 percent using computers for cash flow data management. Payment may also often be in kind in the form of grain at harvest. The concept of profitability is not well understood and the costs of operating farm machinery are not precisely calculated. Machinery sales have typical markups of 10–15 percent.

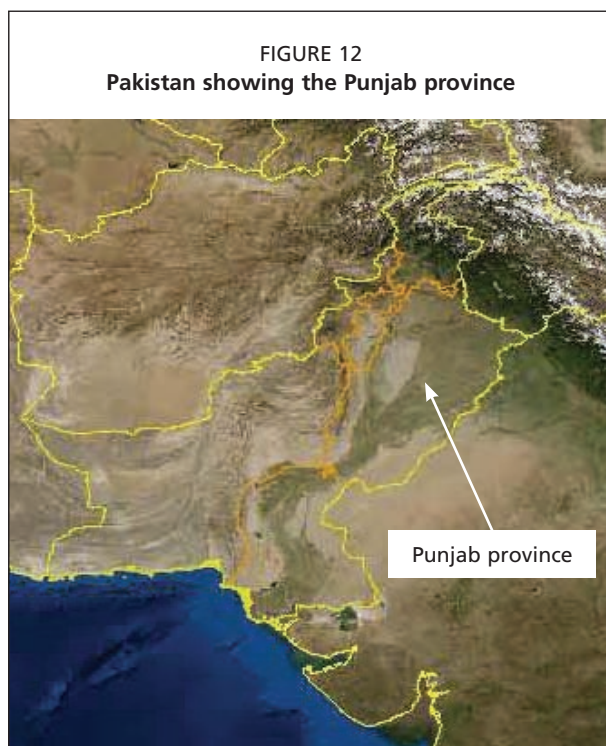
Manufacturers serving the region aim to be as self-contained as possible. They cast their own materials and only buy in parts (such as plastics) that need specialist skills. Manufacturers frequently stock implements and distribute through a national dealer network. Interestingly no training of any sort is provided to other supply chain actors by manufacturers and no parts or operation manuals are provided.

Hiring services in both rainfed and irrigated areas mainly offer rotary cultivators, ploughs, harrows, land leveling equipment, and combines and threshers. Demand is growing because farms are fragmented as a result of inheritance customs. There is also scope for improving repair workshop services to reduce downtime as a result of machinery failure.

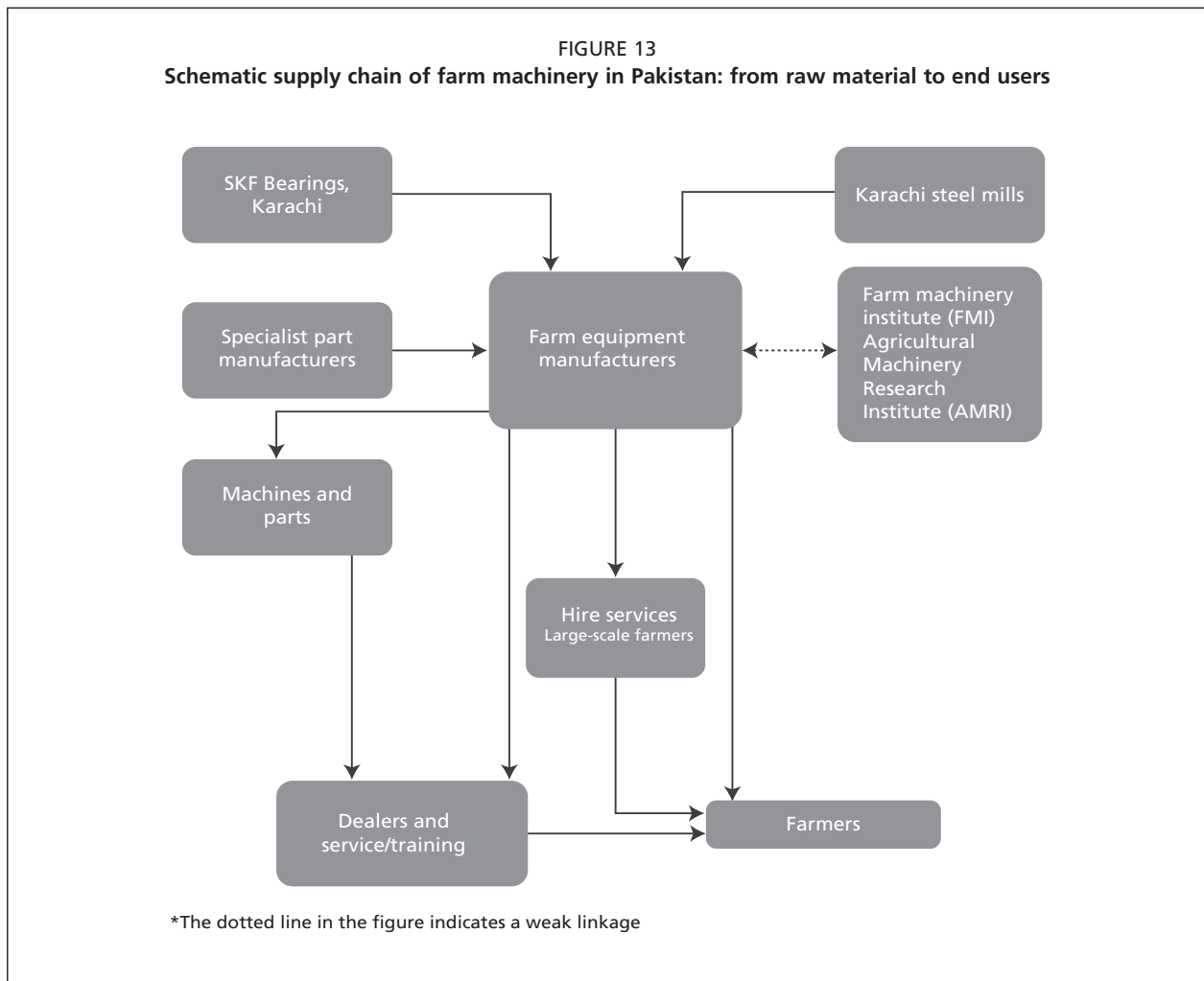
The needs emerging from the study focused on filling knowledge gaps. Technical training is recommended for repair workshop staff. But there is also a strong need for training in business skills to be able to calculate costs and profits as well as to understand the importance of healthy cash flows. The hiring business is flourishing, especially in the rainfed areas where farmers tend to be less wealthy, but again business management is generally poor.

Farm power and machinery supply chain

The information on the situation in Pakistan is more concise than that of the other countries and includes additional information from Gujranwala



Source: FAO GeoNetwork



and Sialkot districts (both in the Punjab province) as these are important centres for agricultural machinery manufacture and so are richer sources of relevant information. Figure 13 is a schematic representation of the supply chain to and from Pakistan's farm equipment manufacturers.

Equipment manufacturers and retailers

Generally agricultural machinery manufacturers (but not including tractor manufacturers) have self-contained businesses and cast their own parts (Plate 20). The exception to this is the supply of some specialist pieces, especially plastics, which are outsourced. Bearings are also outsourced from a Pakistani company in Karachi, SKF Bearings (SKF, 2008).

Steel is principally supplied by Pakistan Steel Mills in Karachi, and today no imported steel is used in the manufacture of farm equipment (as was previously the case). There is no government



Plate 20
Vertically integrated machinery manufacturers reduce outsourcing to a minimum

control on the pricing of products (in contrast to the situation with tractors).

Stocks of finished items and replacement parts are commonly held by all major manufacturers and these stocks are distributed to dealers as required. Surprisingly no training of any sort is provided by the manufacturers, and there is no technical literature supplied with the equipment (spare-parts, repair and operating manuals, specifications catalogue).

Little R&D takes place and few machines are tested by FMI and AMRI. Neither is there any official requirement for agricultural machinery to be subjected to testing before sale. New lines are the result of copying promising ideas from other manufacturers.

One interesting aspect of the consequences of enlightened government policy is that from 15 farm machinery manufacturers in Pakistan in 1959, there are now over 500. This is a result of the liberal government policy of giving these manufacturers a rebate of the import duty paid on raw materials (Amjad 2004).

Farm machinery hire service providers

In Rawalpindi, hire services are commonly provided by established larger-scale farmers and the most commonly offered services are for land preparation, crop planting and wheat threshing. In Sheikhpura both wheat and rice are harvested by hired combine harvesters. The clients for hired machinery are usually farmers in the vicinity of the service provider, with typically the number of clients for tractor services being approximately 25 and for combining services 50–60. The hire service operators are not specially trained, but tend to learn on the job.

Financial records of hire services appear to be inadequate to enable profit margins to be calculated. While on the other hand it seems that cash flow management is satisfactory. There is potential for expansion of the equipment hire market, and training in financial management skills would be a valued input that would allow greater accuracy in calculating operating costs and so enable a more precise pricing regime to be used in decision-making.

Agricultural equipment repair businesses

Repair facilities in the region are in two main categories. On the one hand there are major service providers authorized by tractor manufacturers (e.g. Massey Ferguson and Fiat) and incorporated into the dealerships. These enterprises are run by

trained personnel and offer a high-value service. On the other hand there are many small- to medium-scale operators often working in roadside premises and sometimes with barely adequate tools and technicians. This second category of service providers offers low cost service (standard tractor gearbox and engine overhauls costing US\$13 and US\$33 respectively). Other servicing work may be paid after harvest and in kind.

At the top end of the repair service scale are workshops that are well equipped with the basic tools needed to offer the service. Numbers of employees vary from 2 to 8 people and the number of customers may be 40 to 200 per year.

Again financial rigour is not usually applied and there is a lack of knowledge on how to calculate costs. Customers may be charged on their perceived capacity to pay. Smaller-scale customers will be allowed to wait until after harvest.

Staff training is on the job and there has been no programme (either in the public or private sectors) of training, either in technical or business skills.

Farming community

Farmers both offer and use machinery hire services. Farmers generally (70 percent of those interviewed) express their satisfaction with all levels of service providers although there is the usual request for a government run service offering subsidized machinery hire services. Such a service is very unlikely to be countenanced by government agencies in the current climate of neoliberal economic paradigms.

Machinery hire is one of the major services that farmers access in both districts. Most farmers own their tractors and land cultivation equipment. Other, less frequently employed equipment such as seed drills and threshers are commonly hired in Rawalpindi; whereas in Sheikhpura the demand is for combine harvesters. Machinery hire may typically cost individual farmers between US\$80 to US\$240 annually in Rawalpindi and up to US\$670 a year for combine service hire in Sheikhpura.

During a crop maximization project in Pakistan (which included the Punjab province) the preferred method of opening access to inputs for smallholder farmers was via the powerful VO. The VO supervises input purchase by the village as a group and ensures that 50 percent of the cost is charged and paid at the time of receipt and a further 50 percent at harvest. Farmers similarly shared the cost of the required agricultural implements¹⁵.

15 Fintan Scanlan, FAO, personal communication.

Business management skills and issues

Manufacturers and retailers

The information on agricultural machinery manufacturers in the case study is not as detailed as that for retailers, although of course the two are often the same (especially among smaller manufacturers).

Tractor and implement dealers in the region¹⁶ are well stocked and this is because they receive equipment on a credit basis and receive commission after sales. Information on the value of the commissions earned is not freely available but is a fixed amount per unit rather than a percentage of the selling price. Dealers benefit from an arrangement with the Agricultural Development Bank of Pakistan, which extends financing loans to farmers for agricultural equipment (especially tractors) provided that it is purchased via an accredited dealer.

Agricultural equipment retailers at the top of the range invest heavily in their premises, e.g. showrooms, workshops, stores, and their trained technical and administrative staff (Plate 21). They are well aware of the need to get a return on the investment made and so take special care with the financial management of their firms.

Medium- to small-scale retailers and manufacturers are less able to manage their financial affairs optimally. Typically they are entrepreneurs investing their own capital in purchasing raw materials to manufacture simple farm equipment (such as cultivators and seed drills). They tend to have poor record-keeping skills and thus are not inclined to maintain a well established and effective bookkeeping system. This hampers decision-making based on profit-loss accounting and cash flow. In spite of this situation, this sector appears to offer profitable services as their living standards attest. However they are reluctant to disclose detailed financial information as they fear fiscal reprisals.

An important aspect of the financial management of the smaller-scale manufacturing and retailing sector is that their cost calculations are frequently underestimated. An example is that employment of family members does not feature in cost analysis because the family lives as a unit and family labour is not factored into the accounts.



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Plate 21

Farm machinery dealer showroom in Punjab, Pakistan

Hire service providers

The services are all, by nature, seasonal. In Rawalpindi the main demand is from more progressive farmers and is for land preparation, seed drilling and wheat threshing. In Sheikhpura the main demand is for combine harvesters for the harvest of wheat and rice, although a full range of equipment is offered for hire. The most common situation is for farmers to offer a contract service in addition to running their own farming business. This means that most customers will be in the same neighbourhood.

The conclusion from the study is that business management skills in the area of record-keeping are inadequate. Although conversely, cash flow management appears to be satisfactory. Records are kept of machine hours, fuel and oil consumption (variable costs), and payments received. Profit calculations on this basis are likely to be overestimated, as fixed costs will be undervalued. This may go some way to explaining why most enterprises report financial constraints to enterprise expansion. Commercial loans at 9 percent per year are deemed to be too high.

Machinery repair businesses

A range of service providers are available. The top end of the scale is represented by the authorized dealers. This category of service providers maintains well kept records in order to analyse costs and determine prices for their services. Further down the scale are medium- to small-sized enterprises offering repair services for tractors and agricultural machinery in general. This latter category typically offers a roadside service with less than optimum technical staff and workshop machines and tools.

At times it would appear that financial management can be quite erratic. Prices for repair

¹⁶ Massey Ferguson, Fiat and New Holland tractor manufacturers are represented by the main dealers.

work are based on a general awareness of profitability but calculating profits is not a systematic process, and flexibility is a characteristic to meet the needs of a wide-ranging clientele. In some cases charges may be made on an assessment of how much a client would be able to pay; lower charges may be applied to perceived poorer customers. And in other cases payment may be deferred by offering credit until after harvest when the bills can be paid in cash or kind. In medium-scale enterprises the skills for cash flow management are usually satisfactory (if they weren't, presumably the enterprise would go out of business). However in smaller workshops good records of costs (labour input into each work order) are not well maintained.

Farmers

Machinery hire is one of the most important services that farmers access in both of the districts studied. The costs of machinery hire are an important expenditure item for many farmers and are in the region of US\$80–250 per year for seed drill and thresher hire in Rawalpindi and US\$250 per year for combine hire in Sheikhpura.

Improved business skills are required, especially for calculating costs and preparing partial budgets to compare options (e.g. between hiring and owning). Many of the comments made on the Kenya case are pertinent here too, although in Pakistan the farmers are clearly better equipped and the mechanization alternatives are likely to be more sophisticated.

4.4 BRAZIL

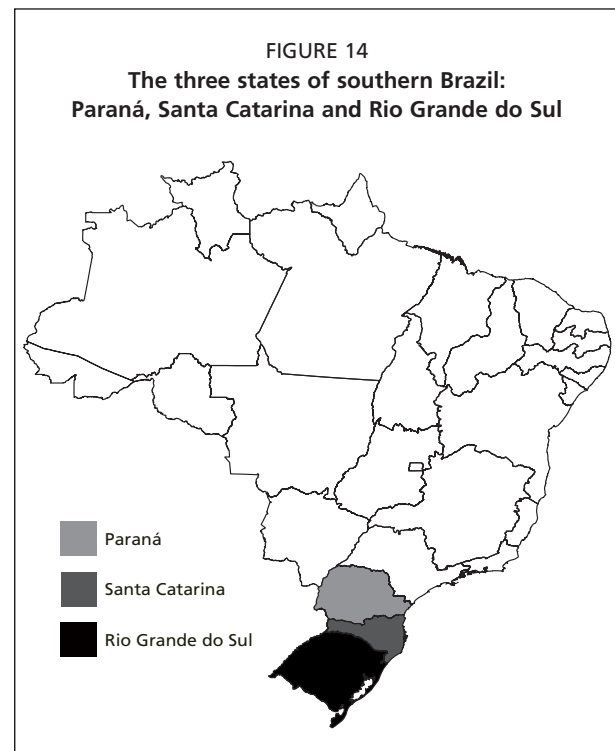
Overview

The Brazil study (Casão Junior and Guilherme de Araújo, 2008) was conducted in the three states of southern Brazil: Paraná (PR), Santa Catarina (SC) and Rio Grande do Sul (RS).

In southern Brazil the concern for natural resource conservation intensified in the 1970s. This was the period in which deforestation occurred for mechanized agriculture and problems associated with soil tillage arose. At the beginning, efforts were made by pioneer farmers and, after NT adoption had started, IAPAR¹⁷ and EMBRAPA¹⁸ began systematic research into NT. In RS, EMBRAPA concentrated on the development of soil tillage tines and set an example for the manufacturing industry that was starting to make the first machines. They

¹⁷ Paraná State Agricultural Research Institute.

¹⁸ National Agricultural Research Corporation.



Source: adapted from <http://commons.wikimedia.org>

made use of design features incorporated into the United Kingdom-made Bettinson-3D seed drill and the Canadian offset double disc systems for their first machines. Semeato was the industry leader at this time (1980) and arguably still is today.

The pioneering farmers and regional mechanical workshops in PR and RS were notable for their adaptations principally through their attempts to sow summer crops (especially soybean). In the 1970s the only available machine was the Rotacaster which, in addition to provoking too much soil movement, also had a low output. The 1980s was a decade of studies and there was no clear definition of the exact functions of a NT sowing machine. Farmers and workshops adapted conventional precision planters and drills for NT duty. Cutting discs and other devices were introduced for opening the furrow and depositing seeds and fertilizer. During this process, manufacturers were perfecting their products and at the same time were creating new precision NT planters.

The main setbacks to NT expansion in the 1980s were the lack of efficient herbicides (or knowledge about them). Also machines had still not been perfected, especially for clay soils, which had surface strata compacted in the first years after adoption of NT. With research work and farmers' experiences, the concepts of crop rotation and crop covers were

consolidated as well as the need to properly prepare the terrain before the application of NT.

With high fuel prices and increasing production costs, farmers were stimulated to adopt NT. Glyphosate (a non-selective systemic herbicide) production, first available in 1984, was produced by many companies and was offered at an accessible price. In 1992 mechanized NT was strengthened when several industries introduced and promoted new machines, especially precision planters. These paralleled the expansion of soybean production but were also used for other crops. The area under NT increased from 1 million hectares in 1992 to 25 million hectares in 2007.

In southern Brazil in the 1980s several natural resources management programmes were created and funded both nationally and internationally (e.g. by the World Bank). In addition, there were many other interventions integrated with multinational and national companies, extension, research and universities.

From the mid-1990s, the federal government financed agricultural equipment at low interest rates. These were mostly focused on small-scale farms as was the case with PRONAF¹⁹.

Many industries, workshops and farmers from different regions started to modify planter designs for NT. Tines well spaced from the cutting disc were used and this made sowing into clay soils a possibility. EMBRAPA and IAPAR evaluated NT planters from 1993 to 2003. This work promoted a positive research interaction between researchers and manufacturers. Today more than 300 different NT planter models are available on the Brazilian market for both animal and tractor power.

The manufacture, marketing and service provision for tractor-mounted NT planters and drills is now extremely well developed in Brazil and indeed has spawned a thriving export market. The increase in NT planting in smallholder farming has its origin in a PR state programme (1984) to promote animal traction. This was driven by the government's desire to improve the livelihoods of farm families in this sector. Various machines appropriate for small-scale farming were designed and evaluated alongside studies of soils poorly suited to NT and a programme of draught animal improvement. IAPAR was able to monitor the quality of the products and disseminate design parameters to manufacturers.

This work, supported by sound principles

developed over a long time (such as crop rotations, minimal soil movement and permanent soil cover) gave support to small farmers for easier adoption of NT using cover crops, principally cereals, legumes and deep-rooted species.

Today farmers are in a transition process; they are changing from animal power to tractor power, using small NT machines, renting services for animal powered planting and spraying equipment or simply renting crop management services and devoting themselves to other profitable activities. Throughout, this process has been assisted by the federal, state and municipal governments to finance research, dissemination and provide credit.

Several manufacturers of animal traction NT equipment appeared, mainly in the states of PR and RS. These included: Mafrense, Ryc, Buffalo, Triton, Werner, Fitarelli, Iadel, Knapik, Jahnel and Sgarbossa. Some, like Guarani and Scotton, specialized in sprayers and the traditional manufacturer Krupp in hand job planters. Some of them disappeared, others were amalgamated, leaving room for new companies to appear.

Farm power and machinery supply chain

The Brazilian study examined the situation of 20 agricultural engineering companies whose most important product line was equipment for CA and particularly NT. The analysis separates the manufacturers into two main groups: those producing machines for tractor powered agriculture and those predominantly focused on manual and animal traction powered equipment.

Manufacturers of tractor powered NT machinery

The majority of these manufacturers (Plate 22) established their businesses in the 1960s as the agricultural frontier expanded in southern Brazil.



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Plate 22

Sophisticated no-till tractor mounted planter produced by Sfil

¹⁹ National family farmers support programme.

Frequently their origins were as repair, maintenance and modification workshops. Ownership is, in some cases, still with the originating families although growth of the largest companies means that external directors must now play a major role.

Generally local markets are not of overriding importance to these manufacturers. Average figures show that about 30 percent of sales are in the home state, the majority in other Brazilian states and only 13 percent of production is exported. The export market does, however, represent about 25 percent of gross income.

Capital is normally sourced from within the companies (principally from profits) with a limited number (under 13 percent) depending on external financing from commercial banks. Only 10 percent of companies use loans to cover short-term working capital constraints.

The larger companies sell their products to machinery dealers (whom they train in the operation and maintenance of their products) and this will typically account for 75 percent of sales. Naturally, smaller, family companies will rely more on direct sales to their clients.

The process of product innovation shows interesting linkages between a range of actors. For the most part the development of innovative products is based on in-house studies of specific cases. But there is also a flow of knowledge from scientific institutions (such as EMBRAPA and IAPAR), and feedback from sales staff, dealers and users is also of fundamental importance. There is also awareness that products are copied by competitors once a definite technical advantage has been established and manifested through increased sales. Although 90 percent of manufacturers routinely patent their innovations, 70 percent admit that their ideas are copied by other companies. Figure 15 shows the interrelationships between stakeholders in the supply of tractor powered equipment to farmers.

Manufacturers of draught animal and human powered NT machines

There is still a thriving market in muscle-powered equipment for the smaller-scale farmers in Brazil (Plates 23 and 24). Indeed *all* farmers will have a *matraca* (or several) for re-seeding and for sowing seed in small and irregular plots.

The companies are usually family-owned and are well established (many have been in business for more than 50 years) having started out as repair and maintenance service providers. The main



©FAO/IG. SIMS

Plate 23
Matracas produced by the Krupp factory as its sole product line



©FAO/IG. SIMS

Plate 24
A hand operated sprayer being demonstrated by a Knapik company director at his factory

source of capital for operations and investment comes from the family, and typically there will be two family members as directors. Seventy-five percent of the businesses are classified as small and annual turnovers are in the range of US\$150 000 up to US\$6 million²⁰ for medium-sized firms. Many of the manufacturers have a diversified production portfolio (Figure 16) but the production of NT equipment is always prevalent and a priority.

It can be seen, from Figure 16, that diversification is a strategy widely adopted to minimize risk. Products are sold within the state of manufacture (38 percent) and regionally in other states (46 percent). This means that, to date, export has not been a major concern for most companies. However, 50 percent of companies do have some experience (and a few

²⁰ The dramatic collapse of the US\$ has meant that annual turnover (earned in Brazilian Reais) has increased when converted to dollars. In June 2008 the exchange rate was Reais 1.65 to the US\$.

FIGURE 15
Machinery supply chain for tractor powered equipment in southern Brazil

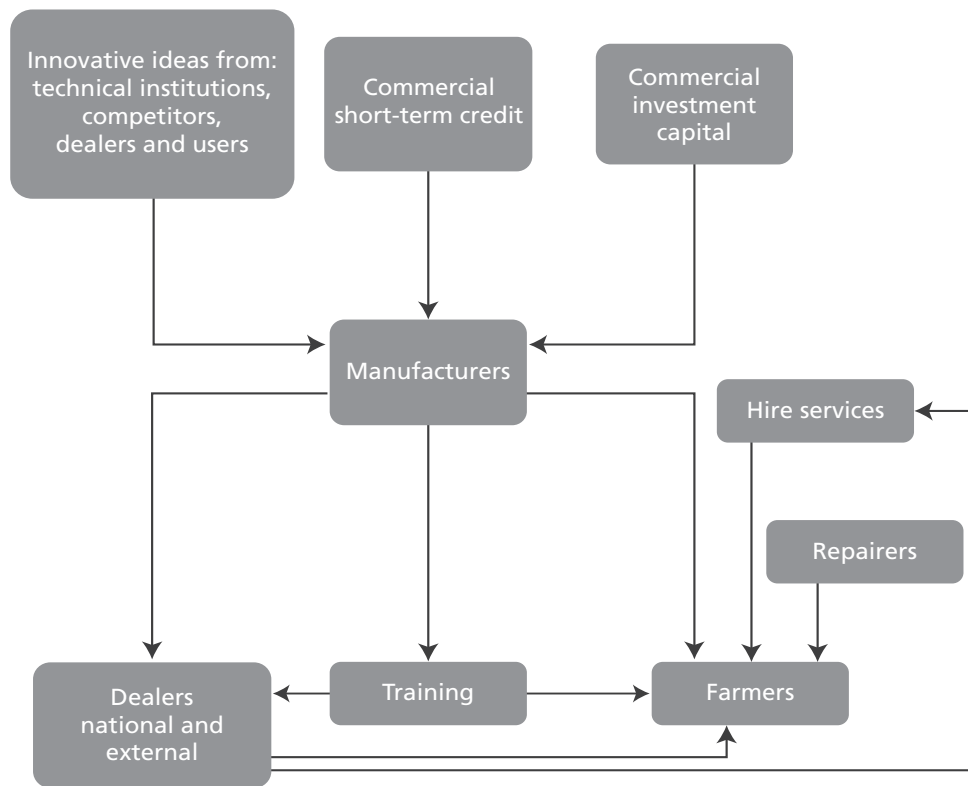
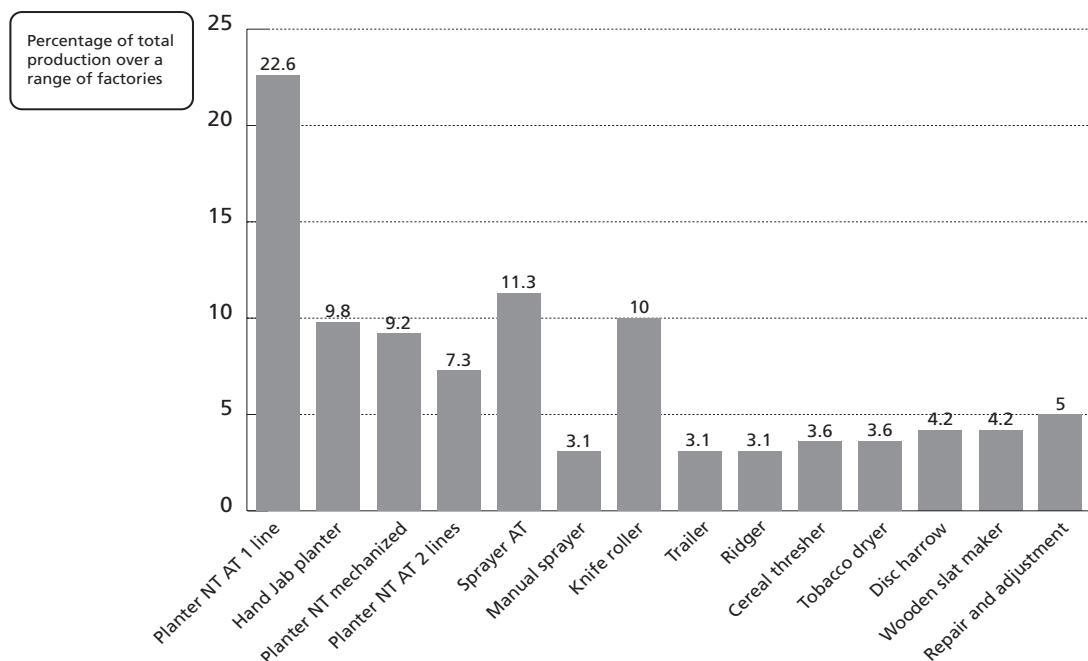
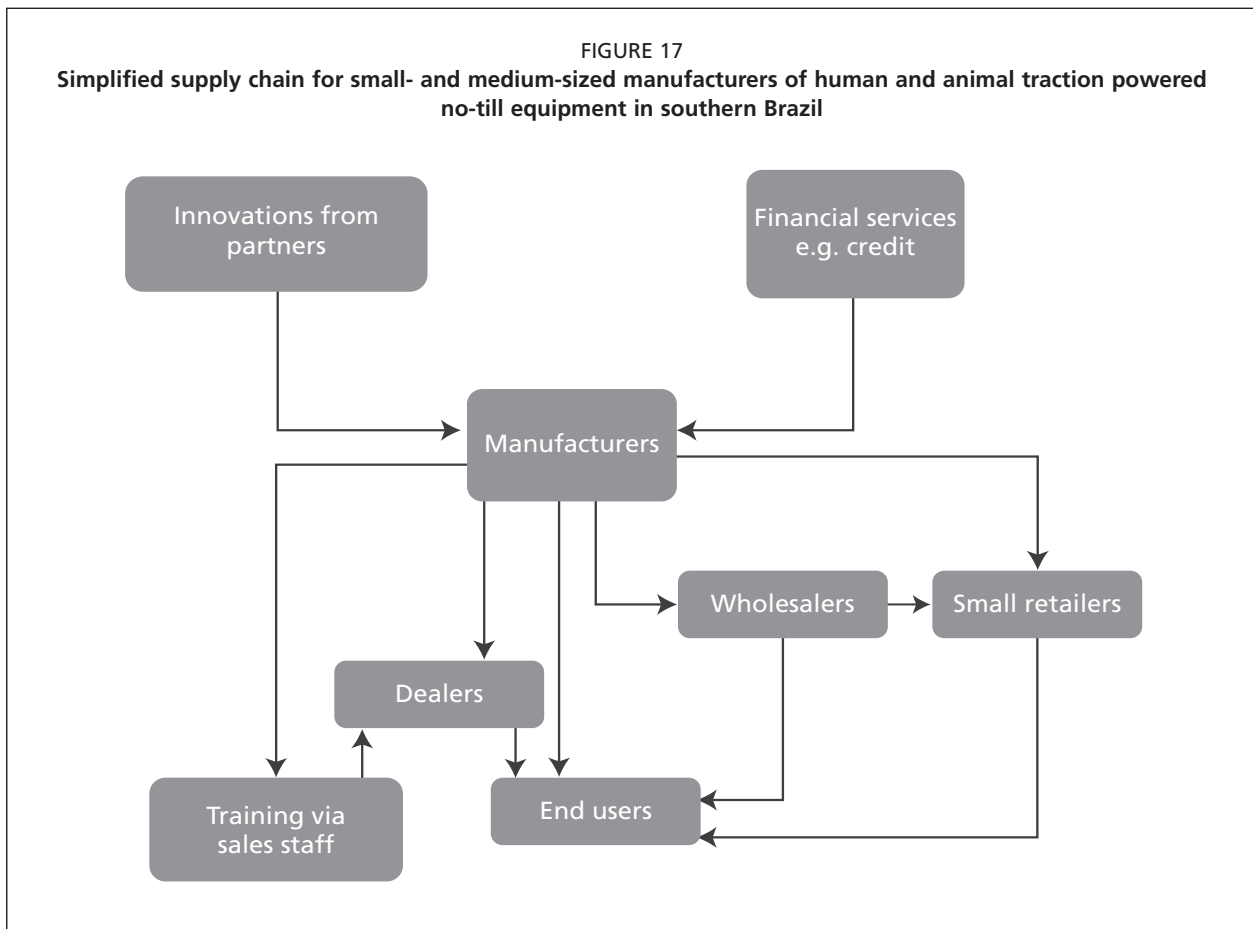


FIGURE 16
Production lines of a range of manufacturers of human and animal traction (AT) powered agricultural equipment



Source: adapted from Casão Junior & Guilherme de Araújo, 2008



have vast experience) of exporting; there is ample room for this market to be exploited further.

Almost half (46 percent) of production is sold via machinery dealers whereas 25 percent is sold directly to end users, wholesalers (13 percent) and small retailers (3 percent). Sales literature is produced but not all products have users' manuals and parts catalogues.

Most of the machines made are simple and training is normally carried out by sales representatives (who may not, of course, have direct access to end users). There is also a reported lack of technical training available for manufacturing staff. The average number of employees per manufacturer is 30, but many (more than 60 percent) do not have qualified engineers in their staff.

Innovation for product improvement is a major concern for all manufacturers, and 75 percent reported that they had introduced innovations in the past two years. This is in spite of the dearth of engineers already mentioned. Eighty-five percent produce innovations in-house while at the same time 50 percent employ technologies developed through outsourcing and partnerships. Product

quality control is emphasized through testing of production machines. Only the company with the largest turnover has submitted to the ISO 9000 certification process, compared to the 50 percent of manufacturers of tractor powered equipment.

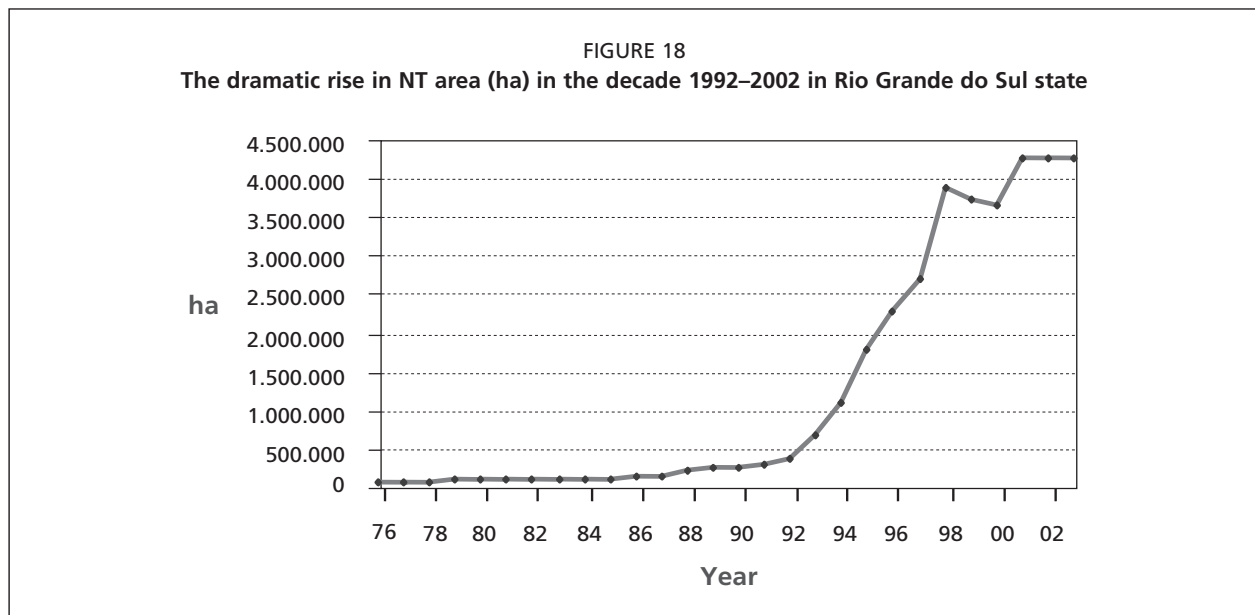
Figure 17 shows the simplified supply chain for manufacturers of human and animal powered NT equipment.

R&D institutions

Although it has been seen that all companies have their own innovative talent, state-funded R&D institutions have also played their part in generating NT technology in southern Brazil.

EMBRAPA and the Brazilian state's technical assistance and extension corporation (EMATER) played an important role in the development of NT systems in RS state (Kochhann and Denardin, 2008). The METAS²¹ project, in the early 1990s, resulted in a dramatic increase in NT adoption in RS from

²¹ The METAS project comprised a consortium of researchers (EMBRAPA); extensionists (EMATER); machinery manufacturer (Semeato); and herbicide, fertilizer and seed companies.



Source: adapted from Kochann & Denardin, 2008

<0.5 million hectares to >4.5 million hectares in a ten-year period. The success of this project was because of – in no small measure – the synergetic collaboration between state funded institutions and the private sector (Figure 18).

Another major player was IAPAR with its R&D focused specifically on the development of NT equipment for small-scale farmers. At the same time, parallel complementary research was needed to produce recommendations for cover crop species and management and crop rotations. One product of this research was the *Gralha azul* animal drawn NT planter in the mid-1980s, which eventually gave rise to a new generation of commercially produced animal traction NT planters (Plate 25).

IAPAR and EMBRAPA were also instrumental in popularizing NT through their organization of field demonstrations of a range of NT planters from different companies. Farmers could observe the machines in operation and also see the crops that had been previously sown by the same machines on display (Plate 8).

Extension institutions

Some of the work of EMATER has already been mentioned in the case of the METAS collaborative project. However it is very important to appreciate how EMATER was at the forefront of extending NT systems throughout southern Brazil in the critical days of early adoption. Working in conjunction with researchers and private sector stakeholders (machinery manufacturers and input suppliers) they were a crucial key component in the NT popularization process.



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Plate 25
The Gralha azul animal traction no-till planter and fertilizer applicator developed at IAPAR in the mid-1980s

Machinery dealers

Machinery dealers are important stakeholders in the machinery supply chain in Brazil. They stock the machines that farmers want and so have to be closely attuned to market demand. On the other hand the equipment that they stock will also have an impact on demand as their views are sought on the most appropriate machinery for a given region. Large-scale manufacturers of engine-powered machinery normally only manufacture to order, thus the client is identified from the initiation of the manufacturing process. The finished machine is transported to the dealer who gives the necessary training to the end user and, of course, receives commission for the service. Manufacturers of equipment for small-scale farmers usually have

personal contact with the dealer network and, in many cases the end users. Equipment is more often made for stock and delivered on consignment to dealers who pay when sales are made.

Dealers also fulfil the important function of training on machine use for farmers investing in NT equipment. And of course stocking replacement parts in sufficient variety and quantity is a fundamental activity of machinery dealers. In this sense dealers can be considered to be the most important link between manufacturers and farmers. The dealership is where farmers come to buy all their requirements to keep their machines in operation, as well as receive technical information.

Farmer groups

Farmer groups are commonly formed to reduce investment costs for individuals. Bank loans aimed specifically at such farmer groups have led to a stimulation of group ownership. With modern, well made and easy to service machinery, multi-use of farm equipment makes economic sense. To have a NT planter only working for eight days a year means that the hourly costs will be extremely high. Group ownership of other equipment that is only used in a short time frame includes knife rollers and forage harvesters.

Service providers

In southern Brazil there is a keen awareness from municipal governments for the need to give agricultural production an impulse, particularly for small- and medium-scale producers, through the provision of subsidized mechanization services. Typically, expensive machines such as planters will be offered with a 50 percent cost subsidy and the municipality takes care of repair and maintenance. Other equipment offered in this way includes tractors, combine harvesters and sprayers. The argument in favour of such an arrangement is that it raises productivity and wealth creation in the municipality, which ultimately benefits the entire population. See Box 10 for one example from RS that offers a 100 percent subsidy for agricultural equipment only required on specific occasions.

In a study on methods of acquiring agricultural machinery from "third parties" in Brazil, Laurenti (2000) found that a high proportion of farmers in all Brazilian states access machinery through some kind of rental service (in 1995 the figure was 40 percent of farmers accessing rented machinery). The author also found that there are four main access modalities:

- Entrepreneurial service providers. These will be owners of a range of agricultural equipment and will offer a rental service to the farming community.
- Neighbours. Some farmers will consider that they have an overinvestment in agricultural machinery and will offer a neighbourhood machinery rental service in order to defray ownership costs.
- Farmer groups. As discussed above, farmer groups frequently come to a mutually beneficial arrangement whereby two or more farmers will have a stake in a particular piece of machinery that is seasonal in use. Joint ownership of farm machinery also implies joint responsibility for maintenance, repair and storage. This is frequently an underestimated dimension and carries with it important cost responsibilities.
- A variation on the previous method is that farmers will manage their own lines of machinery that are complementary to those of their neighbours. Service provision is thereby deemed to be reliable but individual farmers do not have such a high investment burden as those who choose to invest in complete lines of equipment.

Even today the demands for hired equipment are mainly for soil preparation followed by harvesting (principally combine harvesters); for example 70 percent of soya (summer) / wheat (winter) farmers use rental services for combine harvesting. For the service provider this is an attractive prospect as the harvest can start in the north of the country and move south with the ripening crops. Other important areas for rental are for irrigation equipment and crop spraying.

There are, of course, some problems associated with a reliance on rented machinery. The first is timeliness as larger farmers will tend to receive the service before smaller-scale producers. Then there are concerns about the quality of work (especially important for spraying contracts). Rental service companies are now offering guarantees for the quality of their work.

Laurenti (2000) considers that outsourcing farm machinery requirements is particularly favourable for NT farmers. Soil tillage is eliminated so that investment in tillage equipment becomes redundant. For the rare occasions when soil

BOX 10

**Machinery supply to small-scale farmers
in Rio Grande do Sul, Brazil**

The municipality of Aratiba in the state of RS in southern Brazil is very keen to help smaller scale farmers (<20 ha) to access expensive agricultural machinery. To do this they have acquired tractor drawn manure spreaders (for lime and organic manures) and artesian well drilling equipment. One hundred percent of the costs are met by the mayor's office and are funded by local taxes.

To cover other needs such as combine harvesters, NT planters and spraying machines, the municipality invites bids from large-scale agricultural enterprises in the region. These contractors provide the services to small farmers who are subsidized with 50 percent of the commercial cost by the municipal government.

In this way the municipality promotes social harmony, increased local agricultural production and ensures that agricultural machinery services can be accessed by often capital-scarce smaller farmers.



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Plate 26

Fertilizer and lime distributor of the type offered free to small- and medium-scale farmers in Aratiba

Source: Interview with Gilberto Luiz Hedge, Aratiba Municipal Mayor, 14 May 2008

manipulation may be required (for instance for subsoiling), then renting equipment for the short period necessary makes financial sense. With the advent of ever larger NT planters with ever greater output, the problem of timeliness is reduced and so there is a growing confidence in machinery hire companies. The same applies to harvesting with the ever increasing output of large combine harvesters.

Financial institutions

PRONAF offers credit at attractive rates, which enables this group of farmers to invest in farm power (a pair of oxen for example) at annual interest rates of 4 percent and less. One result of the state support for extending credit to small farmers is that they have not only become much more interested in investing in NT technology, but also groups of farmers are collaborating to buy tractor powered equipment to replace their animal powered machines.

Almost any farmer now has access to bank credit at commercial rates that vary between 6 and 8 percent per year. To eliminate excessive exploitation of the farming community, the Central Bank is constantly monitoring the situation.

Business management skills and issues

It appears that financial management throughout the agricultural machinery supply chain is better developed than in the other two cases studied.

In the 1980s the Brazilian agricultural machinery industry felt itself to be in some financial difficulties, and the industry view was that it was the advent of interest in NT that helped to ameliorate the situation.

Innovation is seen to be the lifeblood of the industry, and the financial implications of investing in innovation for future income generation are well understood. Most (75 percent) of the industries covered in the case study had introduced innovations within the last two years. And in fact the development of, for example, a new model of NT planter is a process that will take two years or more. Investment in innovation is calculated to be necessary and viable.

All the manufacturers involved in the study have their own in-house accounting procedures and, of course, all the larger companies have a separate accounts department to track and analyse income and expenditure.

There may be a danger (albeit remote) that easily available credit, often at subsidized interest rates, could lure farmers, especially smaller-scale farmers, into making unsuitable investment decisions. On the other hand, the fact that credit is extended to all sectors of the farming community indicates a high level of confidence in their financial ability.

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Farm equipment supply chains

Guidelines for policy-makers and service providers:
experiences from Kenya, Pakistan and Brazil

Experience has shown that a basic prerequisite for successful mechanization of the agricultural sector requires a well-functioning supply chain. To draw lessons for achieving this goal, the FAO Rural Infrastructure and Agro-Industries Division commissioned three mechanization supply chain case studies. The studies were conducted in Kenya, Pakistan and Brazil, and the information contained in them has been used as the basis for the analysis presented in this Technical Report.

Historically, public sector efforts to supply mechanization services have often failed, as costs greatly exceeded income and the maintenance of ageing machinery fleets became too great a burden. However, it is evident that the public sector does have a role to play in complementing the activities of the private sector in a synergistic partnership. The main role of the public sector is to have the vision of a national mechanization strategy and to cultivate an enabling environment that allows the private sector to operate effectively. One key possibility described in the Report is that of linking equipment supply chains across continents. This is exemplified by an account of the evolution of no-till technology in Brazil, which is now being successfully used by farmers in Asia and Africa. A key stakeholder in this supply chain development has been FAO in conjunction with the international donor community, as they have been in a position to take a holistic view to encourage private sector actors and so disseminate profitable mechanization technologies from one continent to another.

The main recommendations of the Technical Report are aimed at policy-makers in the public sector, although there is plenty to interest other stakeholders, especially machinery suppliers and mechanization service providers. However, the ultimate beneficiaries are small- and medium-scale farmers who are the recipients of the services provided.

