

Agricultural mechanization strategies for sustainable production intensification: concepts and cases from (and for) sub-Saharan Africa

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1. Introduction

Farm mechanization seems to have become, to a certain extent, the neglected waif of agricultural and rural development. As an essential input, mechanization can transform farm family economies by facilitating increased output and reducing the drudgery of hand-powered production. Mechanization, when carefully selected and appropriate to the task, is also capable of protecting natural capital and the environment whilst boosting food production (Kienzle *et al.*, 2013).

However we have seen in recent years that consideration of mechanization as a vital input, in need of research and development, has been frequently neglected. Indeed, and as an example, the UK Government's 2011 Foresight Report (Foresight: The Future of Food and Farming: Challenges and choices for global sustainability¹) barely mentioned the role of agricultural engineering. Following a meeting with the Government Chief Scientist, the UK's Institution of Agricultural Engineers was invited to respond to this deficiency and, as a result, produced, in 2012, the document 'Agricultural Engineering: a key discipline enabling agriculture to deliver global food security'². Agricultural engineering departments in the CGIAR's³ international research centres have been wound down and closed and the availability of world-class undergraduate training is also in serious decline. Why this should be the case is a mystery when careful studies have made it abundantly clear just how crucial an input mechanization is in the pursuit of global sustainable crop production intensification and improved rural livelihoods (for example see the deliberations of the 2009 FAO, Rome forum on how to feed the world in 2050⁴). In FAO itself the resources invested in the selection of appropriate mechanization options have been declining, although the vital role of rural mechanization is recognized as a vehicle for raising rural incomes through high quality service provision on the farm, for road transport and in the development of entrepreneurial enterprise in the agricultural product value addition chain (Sims *et al.*, 2011).

2. Mechanization

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

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

- increased productivity per unit area due to improved timeliness of farm operations;
- an expansion of the area under cultivation where land is available, as it often is in sub-Saharan Africa (SSA);
- accomplishment of tasks that are difficult to perform without mechanical aids;

¹ <http://www.bis.gov.uk/assets/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf>

² http://www.iagre.org/sites/iagre.org/files/repository/IAgrEglobal_Food_Security_WEB.pdf

³ Consortium on International Research

⁴ <http://www.fao.org/wsfs/forum2050/wsfs-background-documents/hlef-issues-briefs/en>

- improvement of the quality of work and products;
- a reduction of drudgery in farming activities, thereby making farm work less unattractive.

3. The current status of agricultural mechanization in sub-Saharan Africa

In SSA the total cultivated land area is about 2 455 million ha of which 173 million ha are under annual cultivation. The principle farming systems, in terms of areas cultivated are: cereal-root crop mixed; maize mixed; and agro-pastoral millet/sorghum (Dixon *et al.*, 2001). Farming systems in SSA are dominated by small-holder peasant farmers which in most cases are based on subsistence farming. The average landholding of farmers is less than 2 hectares.

The average number of persons in the family varies greatly but with an average of about five members. These family members constitute the main source of labour, however, it is often the case that not all members are available for farm work all of the time. In particular the younger generation, in order to earn off-farm income and to seek a better life, are increasingly migrating from rural areas to urban centres and elsewhere.

Fertilizer use is far less in SSA than it is in the rest of the world. For example, in 2007 average fertilizer use was only 13 kg per hectare, compared with 208 kg in Asia and Latin America (**Table 1**). The area under irrigation in SSA accounts for only five percent of cultivated area, compared to more than 38 percent in a selection of other countries in Asia and Latin America (**Table 1**).

Generally, crop yields in SSA are very low when compared with other regions in the world. For example, average cereals yields of about 1000 kg/ha in SSA are only about one third of average cereal yields in other countries in Asia and Latin America (**Table 1**). Another problem is the losses that occur during harvest, transport, and storage; losses in both quantity and quality are common. Several factors contribute to these low levels of production.

Some of the reasons for low productivity are technical (low fertilizer use, poor seed, poor crop husbandry, low levels of irrigation, poor storage etc.); others reasons relate to the prevailing physical and socio-economic environment.

Studies show that SSA remains the region in the world with the lowest power usage (manual, animal and mechanical) and the lowest level of farm mechanization. In SSA the general average number of tractors is about 28 per 1 000 ha whereas it is about 241 tractors in other regions (**Table 1**). Low labour productivity on smallholder farms reflects both the high amounts of labour used and the technologies applied. **Figure 1** shows that in many countries both large and small farms make a limited use of mechanized technologies and improved seeds. However the use is particularly limited on smallholder farms and there is much scope for increasing agricultural productivity by promoting greater profitable use of mechanization and other technologies and processes (FAO, 2014).

In SSA the principal power source is humans who dig, by hand, between 50 percent and 80 percent of the area under cultivation (Clarke, 1997). The use of manual power dominates in Central Africa whereas in Western and Eastern Africa more use is made of draught animals. In SSA, tractor usage is highest in Southern Africa (**Figure 2**).

4. Factors leading to the low level of agricultural mechanization

In order to explain the low levels and lack of growth in the use of mechanization, an analysis of the relationships between the different determinants was carried out (Houmy *et al.*, 2013). This analysis clearly indicates that conditions exist in SSA which have led to the creation of a restrictive environment, which has held back the development of mechanization (**Figure 3**).

The first and most crucial element represents demand for agricultural mechanization. Most agricultural systems in African countries, especially in SSA, are based on subsistence farming and the cash incomes of farmers remain relatively low (1). This is not only due to low production and productivity but also to other factors such as the lack of added value to crops that are sold. Therefore there is very little surplus cash generation in these subsistence farming situations (2).

One of the consequences of this is that there is a very low potential to invest in inputs. Inputs, apart from seed and fertilizer, also include agricultural machinery and therefore demand for tools and machinery remains low (3). This lack of investment in production enhancing technologies has resulted in very low levels of productivity (4) which again leads to a continuing situation of low farm incomes (1).

The lack of demand for mechanization drives another debilitating element: the supply side. This is represented by the bottom half of **Figure 3**. The low supply of tools equipment and power sources (limited choice and low sales volumes) tends to lead to higher costs of agricultural mechanization (6) which in turn leads to higher ownership and running costs (7). Finally, this high cost of farm machinery use leads back to the low demand in a vicious circle.

These inter-related factors illustrate the structural constraints to the increased use of mechanized methods of farming faced by most African countries. They also demonstrate the inter-dependent relationship between the demand and supply sides of agricultural mechanization inputs. However, they also give some indication as to how debilitating factors might be converted to enabling ones.

Nevertheless, these weakening factors provide only a partial explanation of the problems surrounding the development of agricultural mechanization. Other factors are present and these also have to be considered. This can be achieved by further analysis of both the determinants and the main constraints in the farm machinery sub sector.

5. Determinants of Agricultural Mechanization: Low Demand

Farmers at, or close to, subsistence levels face several major problems which prevent them generating sufficient income for investment in mechanization. Even though each country has its own unique constraints, some general common problem areas can be identified.

5.1 Unfavourable physical environment

The different agro-ecological zones across the region determine the local farming systems. For example, the Niger rain-fed zone, which lies between the 200 to 300 mm isohyets, covers more than two thirds of all the cultivated land and is the most important agricultural production area. The rainy season determines that all operations must be carried out within a period of three to four months. Crop yields, dominated by millet, remain very low (FAO, 2011a). Also in the humid zone of Cameroon, despite a high crop production potential, yields remain low and the possibilities to use tractors are restricted due to the lack of areas suitable for mechanization (FAO, 2011b). Soil degradation in tropical climates is also another major concern and is increasingly affecting crop production in many regions. Nutrient depletion, soil erosion, soil salinity, overgrazing, and deforestation are major issues in African agriculture and are leading to declining soil fertility and constraining crop yields. This is becoming a critical issue in Africa, particularly in the arid and semi-arid regions.

5.2 Unfavourable commercial environment

Unfortunately the business environment in which farmers are operating deprives farmers of economic incentives to invest in inputs, including farm machinery. Social, political, economic, regulatory, tax, cultural, legal, and technological factors are contributing to this poor business environment. Some of these are discussed in more detail below.

Farm gate price issues

Private sector led input and output markets have not developed as quickly as expected and farmers are constrained by a lack of free competition in these markets, resulting in high prices for agricultural inputs as well as lower farm gate prices for produce than in other regions of the world. The consequent reduction in farm incomes has led to an overall decline in the level of investment in agriculture. At the same time farmer organizations have not generally been effective in assisting smallholders to improve their access to markets and public services.

Land tenure regulation discouraging investment

Land tenure is one of the most important issues in agriculture and in many countries is the one which most hinders investment in the agricultural sector. For a successful transition from semi-subsistence farming to profitable, productive agriculture, land tenure must be secure and guaranteed by the state as well as by local laws and traditions. This will give farmers the security and confidence to invest in mechanization and other production enhancing inputs. Several countries have attempted to organize land tenure by the establishment of regulations and laws but these have often not met with much success. For example, customary common land ownership by clans and extended families makes it difficult to commercialize farming. It is also very difficult to change these traditional patterns of land ownership. In many countries despite the introduction of national legislation, no “secure” land transaction can take place without the participation of the traditional chiefs. Any investor always has to provide “gifts” at the beginning of the change of title procedure as well as later when farming commences. Other issues such as ‘land-grabbing’ are becoming more widespread and serious as world population grows and climate change adds uncertainty to agricultural production (Pearce, 2012).

5.3 Inadequate and insufficient infrastructure

The existence of adequate infrastructure is also a very important determinant of agricultural mechanization development. For example, in the Democratic Republic of the Congo (DRC), one of the reasons for the high cost of tractor use is the lack of roads to access rural areas and farms. Another constraint is the scarcity of fuel stations (FAO, 2011c). This lack of access to rural areas also has a negative effect on transport costs of commodities out of the areas. In some cases, the transport costs in SSA have been found to be as high as 77 percent of the value of exports (Economic Commission for Africa, 2004). In Latin America, rural roads amount to 0.017 km per hectare compared to 0.007 km per hectare in SSA. In addition to a lack of transport, another serious problem in Africa is reported to be bribes demanded by police and other officials at border posts and road blocks. All of these factors demonstrate how crucial it is to develop a strategic plan and how essential it is to take these broader issues into account when planning and programming agricultural mechanization developments.

5.4 Lack of farmer skills

Although African farmers have a great deal of traditional knowledge and experience accumulated over generations, access to new knowledge remains largely limited. Mostly the level of training for farmers is relatively low and the opportunities for further training are limited. Another problem is that a large proportion of rural farming populations are illiterate. This situation stands in the way of improving agricultural production and productivity as well as general levels of farm management. For example, in many SSA countries only land preparation and transportation are carried out by tractors. Other operations such as seeding and harvesting are still mostly carried out manually. This is due to a lack of knowledge by farmers about suitable equipment and a lack of skills in operating such equipment (Ashburner & Kienzle, 2011). Where machines are used, the lack of both farmer knowledge and skills leads to misuse and mismanagement of machinery; especially more sophisticated machines.

6. Constraints to the private sector

The whole of the farm machinery sub-sector, which encompasses manufacturers, importers, distributors, and retailers, faces several constraints which hinder its development. Although low demand is mostly caused by lack of development, these other constraints should nevertheless be taken into account.

6.1 Agricultural machinery importation and distribution

There are several ways in which farm machinery is imported and distributed (see **Figure 4**). Some of these ways are more successful and sustainable than others. The following options are in practice:

Specialist private importers of agricultural machinery

These are usually companies which have a franchise to sell and import a selected and commonly limited number of brands. The franchise is given to them by the company manufacturing the machines. These companies are usually located in the capital city and may sometimes have branches in other major cities and towns. Traditionally they have represented one of the major western agricultural machinery manufacturers but more recently, Asian and Latin American manufacturers have moved into these markets. Unfortunately in almost all markets in SSA, sales of major items of equipment (tractors and combine harvesters) are still very low. This has led these franchise companies to diversify their activities into other types and makes of equipment.

Occasional private importers

These tend to be general traders with no specialist knowledge or experience of farm machinery. It is usual for these companies to import a batch of machines and once they are sold there is no further obligation to provide either spare parts or service for them. The next batch of machines to be sold might well come from a different manufacturer. The farmers who purchase from these companies are mostly inexperienced and often do not realize that there may be later problems with spare parts and repair services.

State institutions

In some countries state institutions as well as aid agencies become involved in the importation of farm machinery. Also, several African countries have created local tractor assembly plants in a mistaken effort to promote agricultural mechanization or with the objective of providing lower cost machinery. The batch importation of farm machinery (in a similar manner to the occasional importation by private traders) also occurs when governments and aid agencies issue tenders for purchasing large quantities of farm machinery (see **Box 1**). In such a situation the imported machinery generally bypasses the local distributor who subsequently has no obligation to provide spare parts or service for the machines. These tenders are almost always evaluated on the basis of price and the winning bidder may well have no representation in the country nor have any possibilities or interest in supporting the machines. Machines purchased in such a manner tend to end up as “orphans” with no spare parts or backup services and, as a result, tend to have a very short operating life. They may be cheap initially but end up being very expensive.

Donations of agricultural machinery

Many African countries have over the years received donations of tractors and implements from many different countries. Unfortunately almost all of these, no doubt well intentioned, programmes have failed to produce the desired results. This is due to a number of reasons, the main ones being a lack of compatibility between products manufactured in donor countries and machines that are already on the market. Very often there has been no dealer or spare parts available to support the operation of the equipment. The machines that have been donated quickly become “orphans” with no support and once the first breakdowns occur the machines cannot be repaired. In many countries “graveyards” of such machinery are still to be found.

Direct importation

Large farmers and agro-industrial companies often import machinery directly from abroad. This is the case when large orders attract high discounts or when the company or farm has sufficient resources to stock their own spare parts as well as to carry out their own maintenance and repairs. It also occurs when particular specialized machinery is required e.g. sugar cane harvesters.

Importation of used equipment

In some countries the importation of used machinery, particularly tractors, combine harvesters and other specialized machinery offers farmers an alternative source of cheaper machinery and offers an additional way to meet demand. However, whether farmers can benefit from this cheap source of machinery depends upon whether the importer is serious in offering a service to farmers including the provision of spare parts and repair services. Importation and sale of used machinery occurs mainly in countries where there are technicians who have a relatively high level of skills and knowledge but where the costs of labour are low. As is the case with new machinery, it is often tempting for the public sector to become involved in the importation of used machinery, however, without specialized knowledge of agricultural machinery these schemes usually end up with disastrous consequences.

Box 1: Another rush towards tractorization

In recent years many African countries have directly imported tractors or have established tractor assembly plants. Some examples:

- assembly of tractors by Chinese companies has been undertaken in Mali and Chad and by Indian companies in Cameroon;
- assembly plants in Nigeria, Ethiopia and Tanzania although these closed some time ago;
- importing 800 tractors to Niger;
- importing around 700 tractors to the Democratic Republic of the Congo.
- importing over 1000 tractors to South Sudan following a bilateral government deal with India.



Government-led two-wheel tractor imports
Ghana



Government led importation of tractors into South
Sudan

The reasons given for this are:

- to decrease food imports by increasing food production in order to achieve food security;
- to exploit “tractorization” as a political objective since this can be claimed to be “modernization”;
- it is claimed that private sector tractor importation leads to high prices and profiteering and that the public sector can import and manufacture more cheaply;
- to comply with the achievement of the Millennium Development Goals (MDGs).

Some of these projects have been carried out without any prior preparation and where the use of tractors is not yet suitable or appropriate. It seems that the same mistakes that were made during the seventies are being repeated!

Source: Houmy *et al.*, 2013

6.2 Manufacturing of farm tools and machinery

The manufacturing industries in SSA countries produce a wide range of hand tools, farm implements, and processing equipment. However, there is a wide variation in the facilities to be found in different countries. In some countries only the simplest of hand tools are made mostly in the artisan (blacksmith) sector; in other countries sophisticated manufacturing facilities exist. At various times farm tool and machinery manufacturing has also been supported through bilateral and multilateral cooperation. Unfortunately the sustainability of the manufacturing industry has often been problematic, because of erratic raw material supplies, fluctuating demand, issues of quality as well as problems caused by bulk ordering from projects. Currently three different kinds of manufacturer are found: state owned and operated companies; private industrial companies; and the informal artisan level.

6.3 Maintenance and repair services

In general the maintenance and repair of hand tools and animal traction implements is not a problem

as it is mostly carried out at a local level by small workshops. The situation has been improved in some countries by the standardization of spare parts, facilitating inter-changeability between tools sourced from different manufacturers. However, for motorized farm machinery and equipment many problems still remain, particularly for tractors. This is mostly caused by poor maintenance facilities and a critical lack of spare parts. This situation leads to long down times, and a consequent under-utilization of equipment and eventually to premature write off. Many years ago, emphasis was given to public sector programmes and projects which developed agricultural mechanization maintenance and repair centres. However, these were not very successful and many have since fallen into disuse.

6.4 Hire services

A wide range of operations can be covered by machinery hire services. In addition to crop operations such as soil tillage, planting, and spraying, other hire services such as threshing, shelling, and transport are also offered. Similarly, it is important to note that hire services are not only limited to motorized operations but also to operations where the source of power is animal draught.

After independence several countries established public sector operated farm machinery hire services in an attempt to include small farmers into growing markets for high-value commodities. Most of these schemes, which were mainly for the provision of tractor hire services, failed. There are some remaining vestiges of them which only continue to exist through the provision of government subsidies, but the remainder have disappeared (See **Box 2**). There were many reasons for the failure of these schemes but the main ones were small fields with long travel distances, unaffordable hire charges, problems of non-payment, inflexible and inefficient public sector administration, lack of operator and mechanic incentives, breakdowns, and the non-sustainability of the subsidies that were required to keep the service running. These experiences demonstrated that public sector tractor hire services are not sustainable. Unfortunately, these catastrophes were mainly responsible for giving farm mechanization a bad name; a situation which still widely exists today, particularly among aid agencies and donors.

Box 2: Hire Services in Cameroon

One of the most important institutions involved in hire services in Cameroon is the Centre National d'Etudes et d'Experimentation du Machinisme Agricole (CENEEMA). This state centre, created in 1974, provides services for small producers (less than 10 ha) as well as for agro-industrial complexes. A wide range of activities such as land clearing, ploughing, sowing, harvesting and road construction are carried out.

In addition to these activities, CENEEMA also undertakes training, testing and prototype development. CENEEMA has played a key role particularly during the economic crisis of 1987 to 1993 which allowed Cameroon to re-establish agriculture as a major economic activity.

However, during this period, the stations in Bambui, Garoua and Nanga Eboko were closed with only Yaounde remaining open. Reasons for the closures were:

- Management problems
- Inadequate infrastructure, especially accessibility
- Climatic conditions

Unfortunately the private sector did not take over these activities apart from a few services established in the Northwest region of Cameroon. Here, twenty private contractors with tractors are active, usually operating with second hand machines and mainly offering tillage services. The extent of the services on offer, however, remains marginal when compared to the demand. One of the main issues is the cost of services which are seen as high in relation to farmers' incomes.

Source: Houmy *et al.*, 2013

In many countries, the private sector has always been involved in the provision of hire services; mostly on a very small scale and mostly in situations where tractor owners have spare capacity and hire out their machines to generate income and to assist in covering costs. In most cases their clientele are neighbouring farmers who the owner knows and can be confident that he will receive payment for the work carried out. In some cases payment is in kind. In fewer cases, but increasingly, local entrepreneurs are investing in two or three machines and running small scale contractor businesses. This again occurs mainly in communities where the contractor knows his clientele.

One way to improve the profitability of tractor hire services is to diversify the number of operations offered and thus ensure that the services can be marketed continually throughout the year rather than having to concentrate on the seasonal period for land preparation. The question thus arises as to whether such a year-round market exists for other on- or off-farm activities (Sims *et al.*, 2011).

7. New opportunities for agricultural mechanization development

In many African countries, despite the constraints listed above, the situation for the foreseeable future presents numerous opportunities. After decades of decline in per capita food production, a new climate of optimism exists. In the future, the agriculture sector is projected to be economically sustainable because of the rapid expansion of urban centres and the associated demand for agricultural products and also the increases in international food commodity prices. There are many reasons why the new situation will provide opportunities for the adoption and expansion of agricultural mechanization. The main ones are:

7.1 Increasing agricultural wages

The development and expansion of off-farm employment and the disenchantment of rural youth with arduous agricultural work (hard physical labour and drudgery) have triggered a rural–urban migration of young people. This has led to a shortage of manual labour, particularly at peak times which has led to increasing levels of rural wages.

7.2 New sources of farm machinery more suitable for African conditions

Western technology, which was a very important source of farm machinery in the past, has become increasingly more sophisticated and has become less suitable and affordable by small farmers in Africa. However, the newly emergent industrial economies such as India, China and Brazil have stepped in and have provided new sources of farm machinery which is continually coming on to local markets. This machinery is often more suitable for African conditions and is considerably cheaper than machinery manufactured in Western Europe or North America.

7.3 Need for more innovative and energy efficient sustainable mechanization concepts in line with the FAO 'Save and Grow' paradigm

African countries will have to adapt to the world energy crisis and to new energy saving technologies. New ideas on energy efficiency and the use of other energy sources will have to be further developed and adopted. With such a large potential for the utilization of solar energy, the continent has been the subject of particular interest regarding the development and use of solar power. Many technologies have already been developed for drying vegetables and fruits as well as for pumping water and the provision of electrical energy. The FAO Save and Grow Concept is leading the way for sustainable crop production intensification with leaner and more precise and energy efficient production technologies such as reduced and no-tillage/direct seeding practices (FAO, 2011).

7.4 Climate Smart / Conservation Agriculture – a new need for environmentally sustainable mechanization

Major international donors and world leaders' plead for new agricultural concepts that are more climate-smart (FAO *et al.*, 2014). The use of agricultural machinery has sometimes been criticized for the negative effects it can have on the environment. At the same time it is clear that developing new machines and techniques which are more precise and protective of the environment is the key to climate-smart agriculture. One powerful concept is conservation agriculture which maintains a permanent cover on the soil and uses direct seeding through the vegetative cover. At no time is the fragile soil exposed directly to solar radiation and high intensity precipitation. This has only been made possible by the development of specialized equipment. Similar developments or technologies can also be expected in the future in order to tackle other emerging environmental problems.

7.5 New need for sustainable business models for mechanization in Africa

The development and expansion of agricultural mechanization will take place only within a favourable economic environment. SSA still remains largely undeveloped in terms of economic activities and therefore great possibilities exist for the development and adoption of new ideas for business models adapted to the prevailing conditions.

8. Suggested Interventions to achieve Sustainable Mechanization Strategies

Any intervention in support of mechanization development will have to either support the demand side or the supply side of mechanization. Moreover there are also some overall suggestions for interventions to be made by donors or global UN agencies such as FAO. FAO has attempted in the past to formulate those interventions through a comprehensive strategy exercise for mechanization. However, in practice and with the increasingly acknowledged perception that only very integrated sector and cross sectorial concepts may lead to true sustainable intensification of agriculture, the interventions listed below may also be applied as appropriate in broader agricultural programmes for sustainable intensification.

8.1 Interventions to assist the farmers (the demand side of mechanization)

- Remove policies and regulations which restrict the choice of farm machinery by the purchaser;
- Any state supported leasing or credit programmes should allow the farmers to purchase or lease imported machinery as well as domestically produced machines;
- Consumer protection legislation should be introduced particularly for contracts and credit and to protect consumers against being sold faulty or inappropriate or un-safe and potentially dangerous machines;
- Government programmes should concentrate on providing information for farmers and farm businesses to enable better choices to be made that consider both technical and business issues.

8.2 Approaches to improve the supply side (private sector machinery industry)

- Suggest the **removal** of policies which protect local industries. Such policies include subsidized finance, favourable tax exemptions for domestically manufactured machinery, protective tariffs on imported machinery and barriers to foreign investment.
- Free up the market for the importation of foreign machinery, including removal of unreasonable testing and certification requirements.
- Privatize state owned and operated farm machinery stations. Reduce bureaucracy and barriers to business development; create an environment which eases the development of businesses including such measures as easing import restrictions, creating a level playing field for foreign

businesses, reducing taxation and easing restrictions on leasing of property and capital equipment.

- Any subsidized programme operated by the state should have a pre-defined period of operation after which it would be privatized.
- Introduce training and education programmes for commercial development as well as technician training (scope for donor support).
- Lending for the purchase of farm machinery as well as for emerging service providers can be a risky business for private banks and it is for this reason that credit from private banks is often unobtainable or expensive. Donors should consider supporting the farming and agricultural machinery sector by underwriting credit for these purposes. Such programmes could include business and technical training elements.

8.3 Interventions to support efficient, lean and environmentally sound and sustainable mechanization

- Introduce so-called smart subsidies for mechanization inputs that are in line with sustainable mechanization and concepts such as ‘Save and Grow’ and ‘Climate-Smart Agriculture’ as described above.
- Develop precision agriculture applications as an integrated tool within the sustainable agricultural intensification concept or within the ‘Save and Grow’ concept.
- At global policy level: work on global agreements for good practices in the procurement and supply of agricultural equipment and mechanization inputs. By good practices we mean avoiding short-sighted politically-motivated arrangements with no after-sales support and with equipment levels that are not appropriate to the level of training of the recipient countries.
- Accept FAO together with other bodies such as UNIDO and OECD, as international bodies that can provide a neutral platform for private and public sectors to work in harmony to develop and implement sustainable mechanization strategies for the benefit of farmers and rural enterprises in developing regions and in particular in sub Saharan Africa.

9. Conclusions

Sustainable agricultural mechanization strategies and subsequent interventions at policy and field levels are in high demand especially for Africa. However, these interventions have to be holistic, broad in scope, and recognize all three pillars of sustainability with economic, social and environmental dimensions.

For decades mechanization was blamed for being a potential cause of environmental and social disasters. It was characterized as an example of a large-scale solely profit-oriented capitalistic approach, or as something that private sector suppliers should take care of on their own with no support from the public sector.

Only recently, in the aftermath of the 2007/2008 financial, energy and basic food price crisis, and with increasing evidence that the world’s resources including land, clean water, energy and subsequent food supplies are not limitless, have opinions shifted. Combined with the increasing evidence for negative climate change impacts on agricultural production among other phenomena such as the massive rural-urban migration of youth from the agricultural sector, have given support to the idea that the role and place of mechanization must be given a fresh appraisal, especially in the context of the African continent which risks being increasingly left behind in the world

development scenario.

Joint efforts of public and private sectors, of academia and development managers, of smallholders and commercial farmers, of consumers and producers, are required to energize the emergence of truly sustainable and profitable mechanization and technology interventions which are so urgently needed to enable Africa to realize and release its potential for sustainable crop production in the decades to come.

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Figure 1. Shares of farms using selected modern farming technologies, by farm size

Source: FAO, 2014

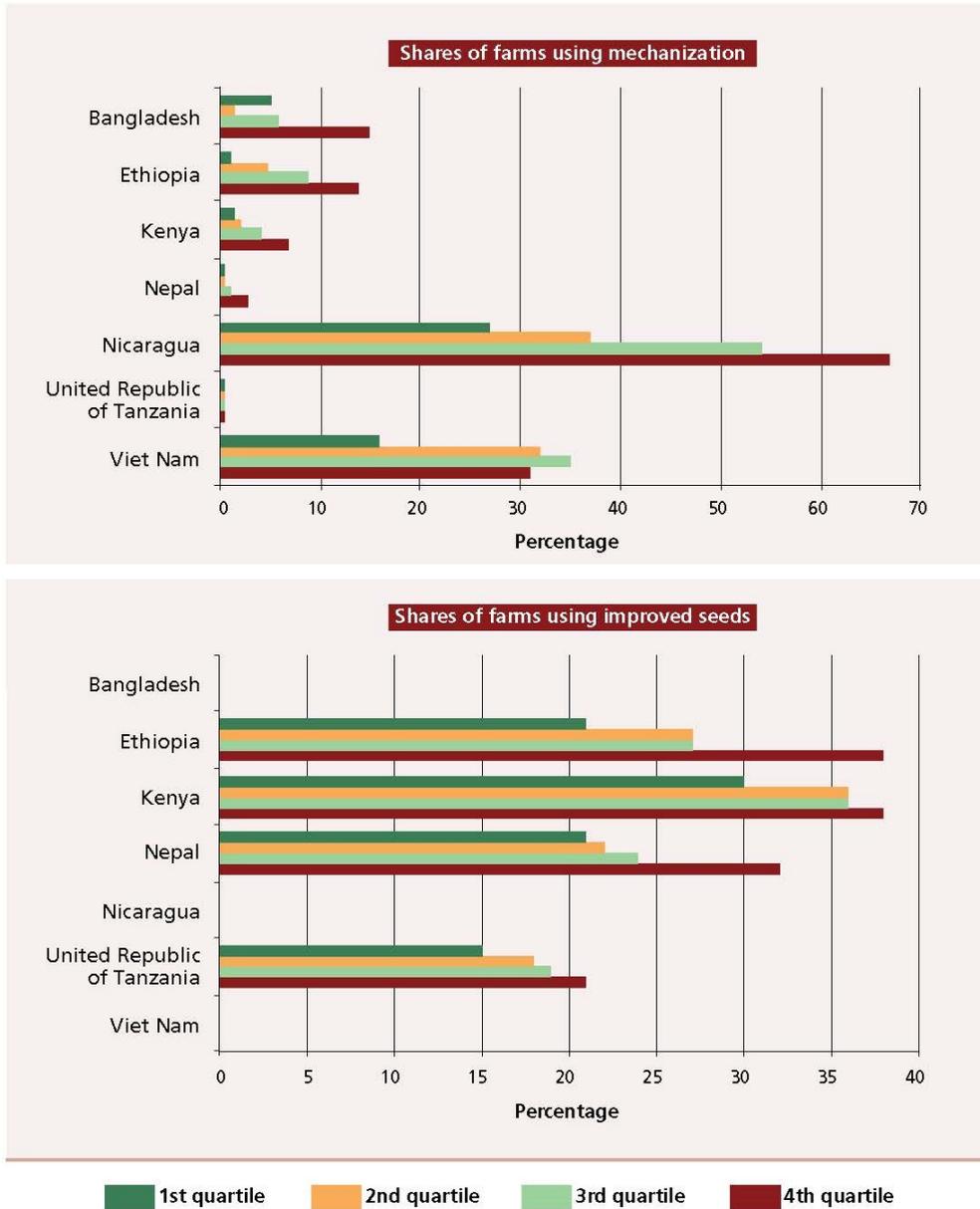


Figure 2. Percentage use of different sources of power in agriculture in four regions in Africa

Source: Clarke, FAO, 1997

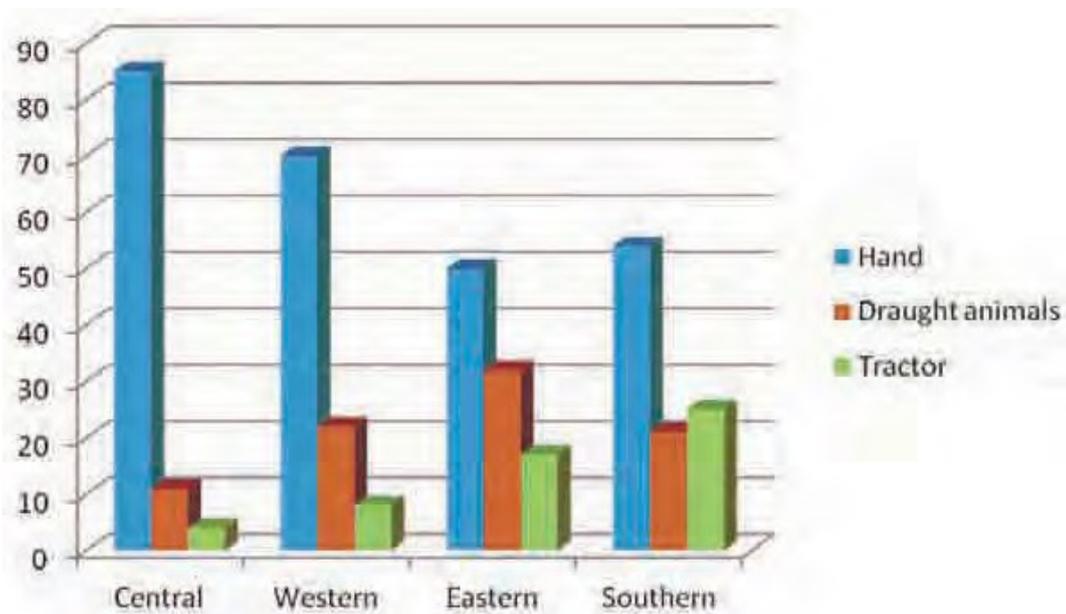


Figure 3. Factors weakening the demand and supply of agricultural mechanization

Source: Houmy *et al.*, 2013

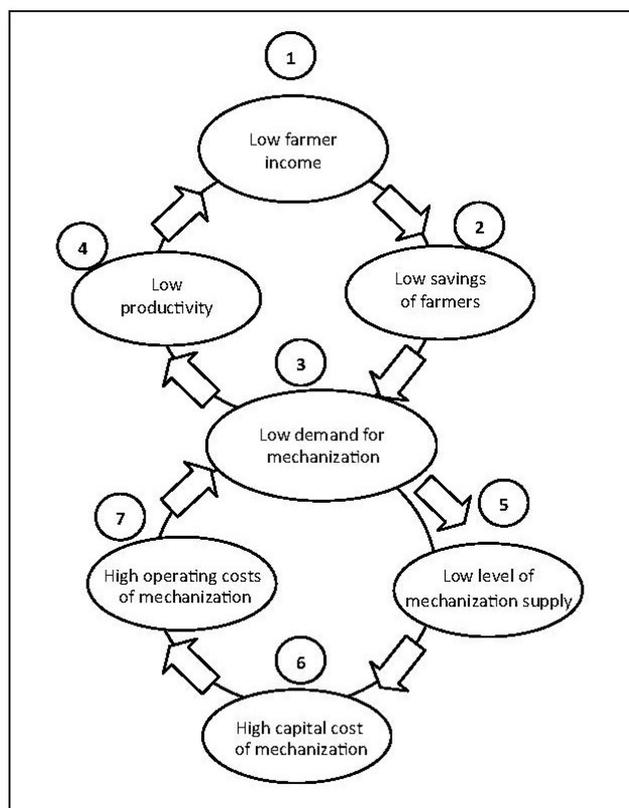


Figure 4. Agricultural machinery importation and distribution

Source: Houmy *et al.*, 2013

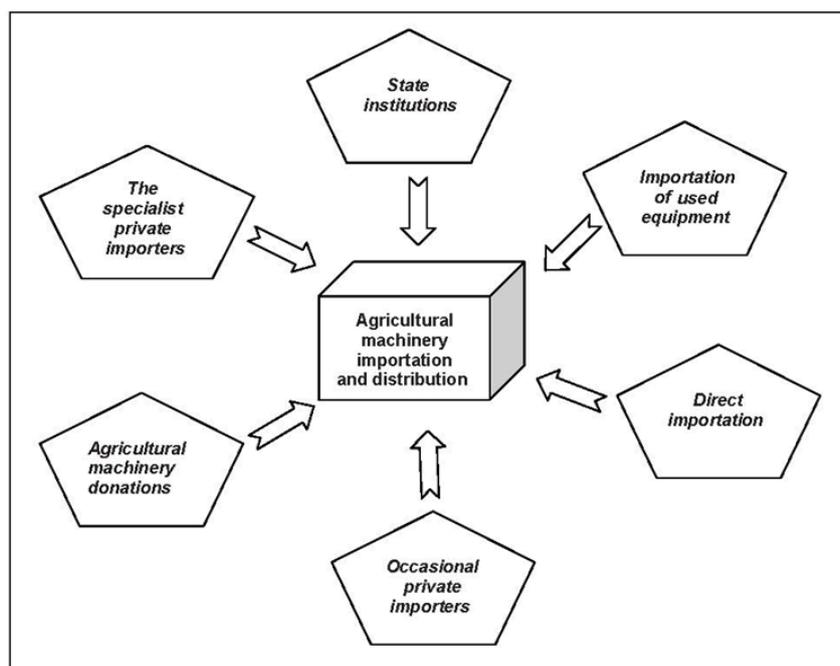


Table 1: How Africa compares with other developing regions

REGION	CEREAL YIELD [Kg/ha]	FERTILIZER USE [kg/ha]	IRRIGATION PERCENTAGE OF ARABLE LAND	TRACTORS PER 1000 ha
Africa ⁵	1040	13	5	28
Average of 9 ⁶ selected countries	3348	208	38	241

Source: The World Bank (2007) as cited by FAO and UNIDO (2008).

⁵ Africa less Egypt and Mauritania

⁶ Bangladesh, Brazil, China, India, Korean Rep., Pakistan, Philippines, Thailand, Viet Nam

Summary

Agricultural mechanization is the neglected waif amongst essential farm inputs. Mechanization includes all tools, implements and machinery and can use human, animal or motorized power sources. It is a key component for increased productivity, accomplishment of difficult or unpleasant tasks and to improve product quality. The state of smallholder mechanization and the factors leading to low levels of application are discussed from a global perspective. Determinants of the level of mechanization include low demand and constraints to the private sector. Factors affecting these determinants are considered in some detail. The development of private sector machinery hire service provision is seen as a particularly hopeful strategy. There are new opportunities for mechanization as a result of rural-urban migration, increasing demand for food and technological progress, particularly in the area of climate-smart agriculture. Both the public and private sectors should work in harmony with global development organizations such as FAO to smooth the way towards effective, efficient and profitable mechanization strategies.