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# Strategies for a Sustainable Intensification of Agricultural Production in Africa

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**Summary**

Over the next 40 years global population increase (to over 9 billion) will add urgency to the need for mechanized climate-smart agriculture. Agricultural intensification during the Green Revolution kick-started the shift to profitable farming and reduced malnourishment. But did not have a great impact in Africa. Globally smallholder farmers play a critical role in food production, especially in developing countries. Investment in agricultural mechanization will be a vital input if the world is to feed itself sustainably. Low levels of mechanization in Africa are due to low production which generates little cash surplus and so restricts the demand for mechanization (and other) inputs, leading to further low productivity. The reasons for low demand are examined in detail as are the constraints to mechanization provision from the private sector. The future will demand climate-smart mechanization adoption which sustainably intensifies crop production while protecting and conserving natural resources.

## 1. Introduction

### *1.1 Intensification in the past*

Over the next 40 years, world food security will be threatened by a number of developments, including an alarming increase in the number of people to be fed. The Earth's population is projected to increase from an estimated 7.3 billion at present to around 9.2 billion in 2050 and over 11 billion in 2100 [1, 2] with growth almost entirely in less developed regions. The highest growth rates are foreseen in the least developed countries. By 2050, about 70% of the global population will be urban, compared to 50% today and by 2030 the urban population of sub-Saharan Africa (SSA) is projected to reach 600 million, twice what it was in 2010 [3].

The history of agriculture can be seen as a long process of intensification [4], as people and societies sought to meet the ever growing needs for food, animal feed and fibre by raising crop productivity. Over millennia, farmers selected plants for cultivation that were higher yielding and more resistant to drought, pests and diseases. They have also shaped landscapes by clearing and demarcating fields and building water channels both for irrigation and drainage. In due course, in order to reduce the drudgery load, simple manually-operated tillage hoes were replaced with animal draught implements and soils had their fertility replenished with animal manure as fertilizer and pests were somewhat controlled with sulphur [2]. The process of intensification had started.

Globally agricultural intensification in the twentieth century represented a paradigm shift from traditional farming systems (which were based largely on the management of natural resources and ecosystems services) to the application of genetics, biochemistry and engineering to crop production. Following a similar model to that which had revolutionized manufacturing, agriculture in the industrialized world adopted mechanization, standardization, labour saving technologies and the use of agro-chemicals to feed and protect crops. In many parts of the world great increases in productivity have been achieved through the introduction of heavy farm equipment and machinery powered by fossil fuel, intensive tillage, high-yielding crop varieties, irrigation, manufactured

inputs, and ever increasing intensity of capital-use [5].

The intensification of crop production in the developing world accelerated in earnest with the Green Revolution. Beginning in the 1950s and expanding through the 1960s, changes were seen in crop varieties, and agricultural practices worldwide [6]. The production model, which focused initially on the introduction of genetically improved, higher-yielding varieties of wheat, rice and maize in high potential areas [7, 8] relied upon and promoted homogeneity using genetically uniform varieties grown with high levels of complementary inputs, such as irrigation, fertilizers and pesticides, which often replaced more environmentally friendly practices. Fertilizers replaced organic soil quality management, while herbicides and pesticides provided an alternative to crop rotations as a means of controlling weeds, pests and diseases [9].

The Green Revolution is credited, especially in Asia, with having kick-started the shift to profitable commercial farming, alleviating rural poverty, saving large areas of fragile land from conversion to extensive farming, and helping to avoid potential hunger threats in the face of the growing world population. Overall, the proportion of undernourished in the world population declined from 26% to 14% between 1969 and 2002 [10].

However, there have been serious negative consequences, it is now recognized that those enormous gains in agricultural production and productivity were often accompanied by deleterious impacts on the rural natural resource base, so serious that they have jeopardized the productive potential of agriculture in the future. Land degradation (through erosion and compaction), salinization of irrigated areas, over-extraction of groundwater, the build-up of pest resistance and the decline of biodiversity are some of the easily observable effects.

### *1.2. Agricultural intensification in Africa*

In Africa the Green Revolution has not had the same impact as it has in Asia. Mechanization and intensification levels, fertilizer use and use of other modern technologies have remained low throughout most of the continent to date (**Table 1**).

Also Africa still has relatively large areas that are not yet used for agriculture (although, in many parts, these are under threat from international 'land-grabbers' [11]). However, the African savannahs comprise very fragile ecosystems [12]. More than half of Africa's land surface is characterized by three types of soil: sandy soils (22%); shallow stony soils (17%); and young, weakly developed soils (11%). A healthy soil (with good structure and organic matter content) reduces the risk of floods and protects underground water supplies as soil organic matter can store more than ten times its weight of water. The soils in Africa store about 200 Giga tonnes of organic carbon – about 2.5 times the amount contained in the plant communities of the continent. One of the most important functions of soil is the recycling of nitrogen, phosphorus, carbon and other nutrients. The harvesting of conventionally cultivated crops from cultivated soils breaks the nutrient cycles, which then require additional external inputs for replenishment. In many parts of Africa, soils are losing nutrients at a very high rate, much greater than the levels of fertilizer inputs. Soils under tropical rainforests are not naturally fertile but depend instead on the high and constant supply of recycling organic matter from natural vegetation. Breaking this cycle (i.e. through deforestation) quickly reduces the productivity of the soil. Soil degradation (e.g. erosion, chemical and physical damage) affects about 65% of African farmlands [12].

Degraded lands are hence very common all over Africa and there are many reasons for this. One of them seems to be the over-population of livestock including small ruminants (goats and sheep) which causes overgrazing or eradication of many flora. Another one is the continuous use of the plough (or hand hoe) that leads to soil degradation, the creation of plough- or hoe-pans in the soil profile, and loss to fertile top soil. It is astonishing to see how far the reality of soil erosion has progressed in many regions of Africa considering the currently low level of mechanization level is.

However, looking to the future, if Africa should intensify and mechanize its agriculture on a large scale it must be done with care and in line with the principles of sustainable production intensification that FAO has summarized in its 'Save and Grow' guidelines and that has environmentally friendly and natural resource conserving CA mechanization at its heart [2].

### *1.3. The importance of smallholder farmers*

All over the world, but especially in Africa, it is the smallholder farmers that have a critical role to play in farming. Globally there are over 500 million family farms and smallholders produce 80% of food in developing countries. FAO projects that globally agricultural production must increase by 70% by 2050 and by 100% in developing countries [13].

Another phenomenon affecting many rural economies in the developing world but also in particular Africa is the drift of healthy young males to urban centres in search of more rewarding payment for their efforts. Fifty percent of the world's global population is urban today and this is projected to rise to 70% by 2050 [14]. This means that those being left behind to work on the farms are women, the elderly and children and the consequence is that farm power becomes an increasingly severe constraint. Seventy percent of the power source for smallholder farms in SSA is supplied by manual labour and less than 10% comes from engine-powered sources. The remaining 20–25% of farm power is supplied by draught animals [15]. If the supply of human labour emanates principally from women, the elderly and children, it is clear that supply constraints will have a negative impact on farm productivity.

For the foreseeable future, reducing poverty in Africa will depend largely on stimulating agricultural growth. Within agriculture, a powerful driver of growth is commercial farming which has the potential to develop along a number of pathways. Some crucial questions to be asked are [16]:

- To what extend can African countries with agroecological endowments similar to those of, for example, savannahs such as Brazil's *Cerrado* region and the northeast region of Thailand, become more locally, regionally, and globally competitive in selected agricultural economies?
- What sorts of investments, policy reforms, institutional changes, technological innovations, and type of intensification, would be necessary?
- Will commercialization of agriculture contribute significantly and substantially to reducing poverty in Africa?
- What are the potential environmental and social impacts of expanding commercial agriculture in Africa?

### *1.4. Mechanization for sustainable production intensification*

Farming systems for sustainable production intensification will offer a range of productivity, socio-economic and environmental benefits to producers and to society at large, including greater and more stable production and profitability; adaptation and reduced vulnerability to climate change; enhanced ecosystem functioning and services; and reductions in agricultural greenhouse gas emissions and 'carbon footprint'.

These proposed farming systems will be based on three technical principles:

- Simultaneous achievement of increased agricultural productivity and enhancement of natural capital and ecosystems services.
- Higher rates of efficiency in use of key inputs, including water, nutrients, pesticides, energy (including farm power), land and labour.

- Use of managed and natural biodiversity to build system resilience to abiotic, biotic and economic stresses.

The farming practices required to implement these principles will differ according to local conditions and needs. However, in all cases they will need to:

- Minimize soil disturbance by minimizing mechanical tillage in order to maintain soil organic matter, soil structure and overall soil health.
- Enhance and maintain a protective organic cover on the soil surface, using crops, cover crops or crop residues, in order to protect the soil surface, conserve water and nutrients, promote soil biological activity and contribute to integrated weed and pest management.
- Cultivate a wider range of species – both annuals and perennials – in associations, sequences and rotations that can include trees, shrubs, pastures and crops, in order to enhance crop nutrition and improve system resilience.

In practice this means applying conservation agriculture practices on a wide scale. This will require direct seeding, or at least low soil disturbance with the use of chisel-tined rippers and, if needed, subsoilers. Maintaining and managing soil organic cover will need crop residue management through the use of straw spreaders, knife rollers and agro-chemicals; whilst weed control can be achieved through mechanical, biological and agro-chemical means.

The remainder if this paper reviews the state of mechanization, especially sustainable and climate-smart mechanization in SSA and suggests positive approaches to alleviate the current paucity of services available to smallholder farmers.

## 2. Factors leading to the low level of agricultural mechanization in Africa

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 [17]. 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 1**).

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 (see 1 in **Figure 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 1**. 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.

## 3. 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.

### *3.1 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 in the country 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 [18]. 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 [19]. 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.

### *3.2 Unfavourable commercial environment*

Unfortunately the business environment in which farmers are operating deprives them 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 [11].

### *3.3 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 [20]. 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% of the value of exports [21]. 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.

### *3.4 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 [22]. Where machines are used, the lack of both farmer knowledge and skills leads to misuse and mismanagement of machinery; especially more sophisticated machines.

## 4. 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.

### *4.1 Agricultural machinery importation and distribution*

There are several ways in which farm machinery is imported and distributed (see **Figure 2**). 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. 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.

### *4.2 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, and 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.

### *4.3 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. A few decades back, emphasis was given to public sector programmes and projects which developed agricultural mechanization maintenance and repair centres. However, these were not very successful and most have since fallen into disuse.

### *4.4 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. 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.

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, known to the owner who 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.

## 5. 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:

### *5.1 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.

### *5.2 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.

### *5.3 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 [2].

### *5.4 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 [23]. 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.

### *5.5 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.

## 6. 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 realization 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. However, for mechanization to be truly sustainable it must be in the hands of the private sector; the public sector has the task of providing the positive environment that will incubate private sector initiatives.

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**Table 1. Nitrogen fertilizer use and cereal yields, 2002-9**

| | Nitrogen application, kg/ha | Cereal yield, kg/ha |
|---|---|---|
| Asia | 106.0 | 3404 |
| North America | 58.8 | 5723 |
| Central America | 38.6 | 2967 |
| South America | 36.6 | 3447 |
| Sub-Saharan Africa | 5.9 | 1274 |

**Source: Chirwa and Dorward, 2013 [24]**

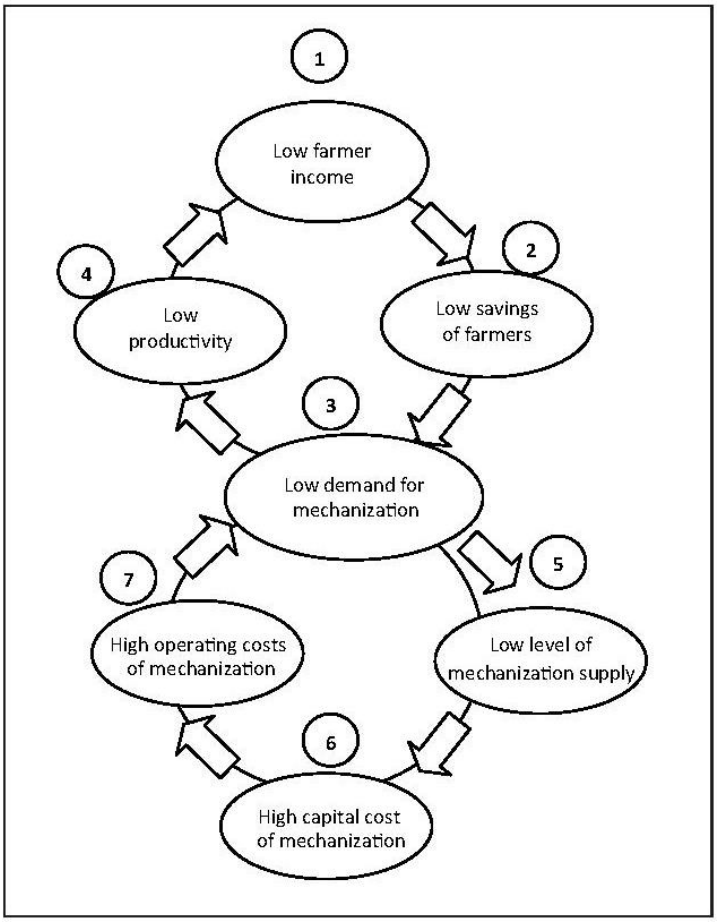


**Figure 1. Factors weakening the demand and supply of agricultural mechanization**
***Source: Houmy* et al*., 2013*** [17]

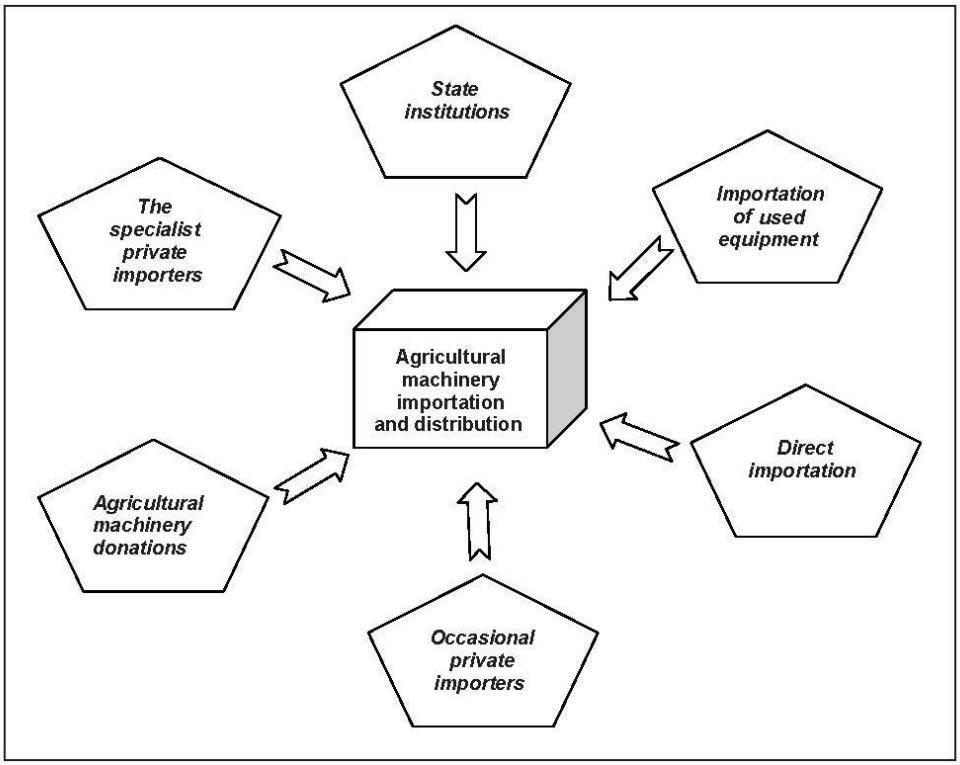


**Figure 2. Agricultural machinery importation and distribution**
***Source: Houmy* et al., *2013*** [17]