FACASI

Farm Mechanization and Conservation
Agriculture for Sustainable Intensification

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Agricultural Mechanization and Small-scale Agriculture: Case study

Evidence from Eastern and Southern Africa

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Agricultural Mechanization and Small-scale Agriculture: Case study Evidence from Eastern and Southern Africa

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Summary

This working paper highlights experiences in agricultural mechanization and small-scale agriculture from four African countries—Ethiopia, Kenya, Tanzania and Zimbabwe—where the Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project has been implemented over a three-year period. The project used the service provision and business model approach to examine how supportive the business and policy environments were to enable transformative change to small-scale mechanization among smallholder farmers. The working paper suggests that the introduction, successful adoption, adaptation and use of mechanical power on farms transiting from subsistence to small and medium scale commercial farming - especially in a developing country context - can be very challenging. Mechanization needs to be understood as a complex and dynamic process that cannot be appraised only from the standpoint of factor substitution or net contribution to production. Where mechanization has taken place worldwide, there have been fundamental and interlinked changes in the structure of agricultural sectors, in the nature and performance of agricultural support services, and in the livelihood strategies of farmers and rural entrepreneurs. A new perspective is required that views mechanization as part of a broader system that includes both public and private sector actors with the understanding that transformative change is required over a longer term horizon.

Keywords: Farm machinery, mechanization, Conservation Agriculture, business model, Africa

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Headquartered in Kenya, the **African Conservation Tillage Network** (ACT) is a pan-African not-for-profit organization that has evolved into an open platform for stimulating and facilitating the sharing of information and knowledge on experiences and lessons in promoting Conservation Agriculture (CA). ACT brings together stakeholders in the civil society and public and private and sectors dedicated to improving agricultural productivity and resilience through the sustainable use of production inputs and of natural resources of land, water and biodiversity in Africa's farming systems. The thrust of ACT is to add value to local, national and international efforts to introduce and scale up CA. It does this through strategic partnerships to identify, adapt, adopt and scale-up CA practices.

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About the FACASI Project

The Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project addresses the decline of farm power in Africa. The project works with smallholder farmers to deliver small mechanization based on inexpensive two-wheel tractors, and to introduce power-saving agricultural technologies such as conservation agriculture. The overall goal is to improve farm power balance, reduce the drudgery of labour, and minimize biomass trade-offs in eastern and southern Africa.

For more information visit www.facasi@act-africa.org

Abbreviations

ADMA	Agro-dealer Manufacturers Association
CA	Conservation Agriculture
FAO	Food and Agriculture Organization
MAFC	Ministry of Agriculture, Food Security and Cooperatives
4WT/2WT	Four-wheel tractor /two-wheel tractor
SSA	Sub-Saharan Africa
R & D	Research and Development

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1 Introduction: Food security, natural resource management and the role of the private sector

Global food security continues to be a major concern and in particular in sub-Saharan Africa (SSA) where most of the world's poor can be found. While SSA is rich in natural and human resources and economic growth is rapid, the challenge is to sustain this progress.

The increasing population growth rate in SSA is expected to result in the region maintaining the highest absolute number of the poor living below the poverty line. The last two decades have been a period of rapid change in Africa: globalization and market liberalization have occurred side by side with economic structural adjustment. With these trends, the public sector has been increasingly compelled to withdraw responsibility for providing agricultural support services and, in some cases, even rural infrastructure. The private sector has been taking over some of the functions for which governments in SSA have traditionally been responsible. The role of government has moved towards creating an enabling economic environment for private businesses to thrive (FAO, 1991; World Bank, 2006). These trends have occurred together with rapid population growth in the region and a rising rate of urbanization. The latter has been ascribed largely to rural–urban migration, which is draining the youthful labour force from rural areas. The root causes of this trend are poverty and the degraded natural resource base. A major consequence of this migration is a decreasing agricultural labour force that is both older and more feminized: more men than women are leaving the agricultural sector and the rural areas in search of remunerated jobs and better living conditions in the cities. The remaining rural population is burdened with the challenge of producing enough food for the increasing urban population.

Expanding agricultural production and productivity to meet the growing demand for food while contributing to poverty reduction puts increasing pressure on the natural resource base. The natural resources available for agricultural production in SSA are scarce and much of the natural resource base shows worrying signs of degradation. Climate change is adding to these concerns and increasingly it is becoming clear that agriculture within the region will suffer significantly. This situation has led to calls for more sustainable agricultural intensification, in ways that make the best possible use of natural resources and regenerate conditions (e.g. soil fertility, resilience of the ecosystem, water availability) for future production. Sustainable intensification is indispensable to increasing agricultural production and contributing to poverty alleviation. However, it also preserves and improves the limited natural resource base on which agriculture depends. This requires the introduction of new technologies including mechanization aimed at smallholder farming. Farmers must apply technologies and practices that lead to a combination of increasing production, improving incomes, ensuring natural resources are preserved, responding to climatic variability and uncertainty, and enhancing resilience. A key challenge is to ensure development, adaptation, adoption and scaling-up of practices that increase and improve the provision of goods and services in agricultural systems in a sustainable way. These trends and challenges have provided impetus for commercializing staples and the opportunity for mechanization to emerge as part of transformative change.

2 Mechanization and rural transformation

Trends in mechanization worldwide show strong correlations between economic growth and mechanization (Clarke and Bishop, 2002). Countries that have achieved unprecedented economic growth over the past four decades and succeeded in solving their food problems have also moved to higher levels of mechanizing their agriculture. Countries that have stagnated economically with significant numbers of their citizens steeped deeper in poverty have also lagged behind in agricultural mechanization.

This relationship has been well recognized in sub-Sahara Africa and it is acknowledged that agricultural mechanization has the potential to transform the rural economy into a viable engine of growth. As a response, many African countries after independence invested considerable resources to develop the sector through tractor imports (FAO, 1966).

Mechanization has the potential to increase the area under cultivation while freeing labour to concentrate on other aspects of farming, which in turn could enhance productivity (Irz et al., 2001). The resultant increased productivity should translate into increased employment, food security and poverty reduction, all things being equal (Mellor, 1999).

In the past, the main focus of support to small-scale farmers was to increase production and productivity while encouraging the marketing of food surpluses (FAO, 2013). Although notable gains have occurred, progress has been relatively slow as efforts have largely focused on incremental improvements rather than transformative change. Several reasons have been advanced in the farm mechanization literature for the failure of African governments and farmers to push mechanization to optimal levels. Infrastructural factors, capital constraints and the nature and choice sets of technologies available were some of the factors cited for such failures (Sims Kienzle and Cuevas, 2006). More importantly, the profitability of mechanizing agriculture is also critical. There were also debates about the intended and unintended outcomes of mechanization on employment (Biggs et al., 2002). Many writers argued that mechanization would leave rural farm labour unemployed; others argued that mechanization had the potential of improving productivity outcomes (Eicher and Baker, 1982). The debate became more focused on whether it was a good thing to mechanize instead of concentrating on which forms of mechanical technologies were viable (ILO, 1973). Proponents of mechanization argued that the use of tractors and draught animal could increase productivity of land through timeliness of farm activities, overcoming seasonal labour shortages, reducing farm drudgery and could also be used for other off-farm activities (FAO, 2011a).

Over the past four decades, efforts promoting the use of tractors, and especially on small farms, in SSA have not worked (Hatibu, 2013). Several policy initiatives by African governments assumed that the pathway to mechanization thinking was a linear process that required that prerequisites were in place before moving from one stage to another (Gass and Biggs, 1993; Biggs et al., 2011). This view resulted in a further slow-down in spending on mechanization (Starkey, 1998).

During the late 1970s and early 1980s, debates on mechanization were confounded with debates about transformation versus incremental change approaches to agricultural development in sub-Sahara Africa. Colonial and post-independence programmes that tried to introduce complete transformative packages generally failed, and by the early 1980s there was consensus—at least among experts working in Africa—that farmers adopt changes incrementally. More than 20 years of research in Africa went towards supporting client driven, staple food crops-oriented, incremental change of low-input farming systems (Collinson, 1999).

It is not entirely a coincidence that during these same two decades, agriculture in Africa stagnated with productivity gains falling well below population growth rates. Experiences in Africa with incremental change and continued reliance on low-input systems stand in stark contrast to the cropping systems approach in Southeast Asia that underpinned the shift to high input and high intensity multiple-cropping systems.

Many field studies were undertaken from the 1960s to the early 1980s to generate an empirical basis for resolving the ongoing debates on mechanization. The results of the field studies remain to some degree contentious but the weight of evidence indicated that the net productivity contributions of tractors were low or non-existent in many developing countries. The accumulating evidence, reinforced by synthesis appraisals for Asia (Binswanger, 1978) and Africa (Pingali et al., 1987), clearly tempered the enthusiasm of international, donor and financial agencies for mechanization and led to increased support for “appropriate technologies” in the form of draught animal technologies and specially designed small tractors. Given these deficiencies and the changing economic and rural environment in sub-Sahara Africa, proponents are now encouraging a more transformative approach to mechanization: investing not only in smallholder agriculture but in the development of the mechanization industry and supply chain as a whole to boost both agricultural production and productivity and value addition and employment as well.

3 Mechanization for smallholder production

Small farms remain at the centre of agriculture and rural development (FAO, 2014; IFAD, 2011). Rapid population growth in the rural areas of many sub-Saharan African countries has led to an increased number of landholders and, thus, a general decrease in average farm sizes, ranging from 1 to 3.7 hectares (Masters et al., 2013).

Smaller farms in turn tend to overuse labour and as a result the farming technologies applied are labour intensive resulting in low labour productivity (Larson et al., 2013; Barrett et al., 2010). Moreover, with the demographic shifts occurring in agriculture, labour is becoming increasingly scarce. Lack of availability and access to more modern forms of farm power by smallholder farmers is a key factor that continues to propel labour drudgery, particularly among women (in e.g. weeding, threshing, shelling and transport by head-loading), while impeding production and farm output. One of the main causes of low labour productivity in SSA is the lack of appropriate machinery that caters to and suits the requirements of small-scale farms. The scant adoption of mechanization among smallholders is a direct consequence of the unavailability of appropriate technologies. The challenge of increasing labour productivity among smallholder farmers suggests the importance of adapting mechanization technologies to farm characteristics.

Given the predominance of small-scale farms and their limited land sizes in SSA, the introduction of four-wheel tractors (4WT) is not economically viable. The choice of animal traction is threatened by the lack of land for fodder production due to shrinking land sizes, alongside the effects of drought and increased incidence of animal disease vulnerability. In this context, alternative and appropriate means of mechanization are essential if SSA will be in the position to emulate the experience of the Asian Green Revolution. In the Asian context, the Green Revolution occurred as a result of the adoption, use and dissemination of smaller scale equipment such as two-wheel tractors (2WT), shallow tube-wells, smaller scale low lift pumps, and 2-, 3- and 4-wheeled motor transportation vehicles (Biggs et al., 2014). The 2WT is particularly attractive given its versatility and ability to perform multiple functions that include planting, ripping, transporting, shelling, threshing and water lifting, which makes it the ideal candidate for mechanizing the various functions along the agricultural value chain. The use of Two wheel tractors, however, should be seen as a strategy of rural mechanization rather than of agricultural mechanization alone, because it is extremely difficult to separate mechanization for productive on-farm activities from other rural economic functions.

The benefits of the 2WT technologies are that they are more appropriate to match smallholding sizes, are better able to manoeuvre small fields and plots more efficiently, and are multi-functional. In addition, they are more appropriate to reduce on-farm drudgery, particularly for women. Two wheel tractors are also energy saving, which is essential to promote crop intensification in a sustainable manner and to make productivity gains with minimum environmental consequences. This approach is well articulated in sustainable agricultural literature (FAO, 2011b; Pretty et al., 2011), 'ecological intensification' (Cassman, 1999; Doré et al., 2011), or 'eco-efficient agriculture' (Keating et al., 2010). The commonality of this approach is the need for increased efficiency in the use of resources for farming and greater savings of energy. According to Baudron (2014), this can best be achieved by promoting Two wheel tractors that improve the farm power balance through increased power supply while concurrently adopting sustainable intensification principles that reduce power demand and increase power supply through appropriate mechanization. Sustainable intensification can only occur if the issue of declining farm power is adequately addressed.

Improving access to energy-saving mechanization can be seen as a form of 'smart mechanization'. As mentioned earlier, one of the triggers for the adoption and use of two wheel tractors is the challenges facing draught power. A shift from animal draught power to tractor power will generate additional benefits of reducing pressure on crop residues for animal fodder, and increase the portion available for surface mulching. The adoption of conservation agriculture practices is particularly important to mitigate soil degradation by eliminating soil inversion by minimum and zero tillage practices, and thereby reduce power needs. 2WT-based CA is most likely to enhance food security through reducing the costs of cultivating, improving yields (particularly in upland areas with small grains) and, as noted before, increasing labour productivity.

Some operations performed by two-wheel tractors are summarized:

Tillage: There are substantial economic benefits in using two-wheel tractors for land preparation, seeding, and tillage compared with both the hand hoe and draught livestock power, in terms of time and labour. A 2-wheel tractor can rip one hectare a day on sandy to loamy soils, using approximately 15 litres of diesel.

Shelling/threshing: Shelling and threshing is generally a tedious activity demanding a high labour input in post-harvest crop handling. Shelling/threshing is generally performed using human labour especially in maize, beans and pigeon

pea production. With the introduction of two-wheel tractors, shelling and threshing is quicker and more cost effective.

Pumping/irrigation: Two0wheel tractors can also be used for water lifting and irrigation especially for rice and vegetable production. The use of irrigation in maize production is increasing in some East and southern African countries because of the availability of furrow irrigation systems, but farmers require pumps and power to support the irrigation system and the 2WT is versatile in covering this operation.

Milling: Two-wheel tractors can also be used for milling rice and grain and, in a number of countries in SSA where two wheel tractors are more prevalent, its use in milling is rising as demand among farmers is high. The use of two-wheel tractors has efficiency gains as fuel utilization is relatively low.

Transportation: Two-wheel tractors are also used extensively as forms of transport for both productive and consumptive purposes. Tractors allow farmers to transport purchased inputs from dealers to the farm, and agricultural and non-farm produce to local markets. Transportation of inputs and fetching water traditionally use ox cart, motorcycle and bicycle but the demand for tractor transport in most countries is high.

It is important that any technology that is introduced is appropriate to address the real needs of farmers, can be used efficiently and effectively and is financially viable. Increasing levels of mechanization need not require large investments in tractors and accessories, but rather shifting to an alternative combination of the use of land, capital and labour that leads to improved farm income either by increasing output or by reducing costs, or through a combination of both.

4 Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project: Country case studies

Recognition of the potential benefits of small mechanization provided the background and rationale for an ACIAR-funded project—Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI)—that aims at improving smallholder farmers' access to 2WT-based mechanization technologies.

The project covers four East and southern African countries: Ethiopia, Kenya, Tanzania, and Zimbabwe. The concept is based largely on the successes of some Asian countries, in particular Bangladesh, where the possibility of delivering mechanization to smallholder farmers by promoting appropriate scale machines and involving the private sector has been demonstrated.

Studies were conducted in the four project countries on the status of mechanization for smallholder farmers. The experience in these countries, as well as others in SSA, over the past three decades has seen the collapse and failure of public sector-led tractorization schemes. More recently, mechanization, in general, has been picking up due to the involvement of the private sector, and clearer roles and responsibilities for public sector institutions. The farm machinery supply chain consists of public and private sector engagement, and comprises the sequence of (decision-making and execution) processes and (material, information and money) flows that aim to meet farmers' needs and that take place within and between different stages along a continuum (FAO and UNIDO, 2008). The purpose of the supply chain in supporting smallholder farming is to provide efficient mechanization services for agricultural production and processing. The links in the farm machinery supply chain start with importation or manufacture of a small engine and its accessories. The chain then links these actors through a dealer network to farmers. Other actors in the chain are machinery service providers who include machinery hirers and machinery maintenance and repair artisans. All these private sector stakeholders need to derive an adequate margin from their activities for the chain to be sustainable.

Conceptually, the supply chain can be divided into functional areas as represented in Table 1, covering a range of functions from research and development to after sales services.

Each actor in the supply chain network depends in turn on different supply chains with multiple suppliers and customers. For example, dealers and repairers can get their "inputs" from importers, import them directly from abroad or source them from local manufacturers. In turn the dealer can provide services to large- and small-scale farmers. While appreciating the relevance of the value chain approach, and characterizing the value chain in a generic form, findings from the four case studies suggest that there are particular variations and not all of the relationships along the chain are necessarily linear. In some contexts, a company may import agricultural machinery, warehouse them and resell to retailers or directly to the end users while providing a range of services (e.g. product information, estimates, technical support, and repair and maintenance, credit) to its customers.

The findings suggest that while opportunities exist for expansion and development of small mechanization, we are at an early stage of market development. A concerted strategy is needed to engage the private sector, and create awareness and promote small mechanization technologies. The market status and dynamics of the small tractor market and accessories for each of the four countries are described below.

Table 1: Agricultural mechanization value chain components

Value chain steps	***Objective for agricultural mechanization***
Research and technology development	Includes all aspects of understanding the needs of farmers and developing technologies that meet those needs
Import and manufacturing	Includes the supply and manufacturing of agricultural equipment, whether it is domestically or internationally sourced
Distribution	Includes the establishment and/ or functionality of upstream ecosystem of how technology is introduced and made accessible to the end user; as defined by the relationship between either the manufacturer/ distributor/ agent or operators but not to the end recipient
Promotion, purchase and usage	Includes the establishment and/ or functionality of downstream ecosystem of how technology is taken to farmers, including promoting benefits of the technology, physical usage and transaction support
After-sales services	Includes all services dedicated to the upkeep of and ensuring optimal functionality once the technologies have become operational

4.1 Tanzania: case study

The most recent data available in Tanzania collected by the Mechanization Department of the Ministry of Agriculture, Food Security and Cooperatives (MAFC) estimated that in 2011 there were 10,200 tractors in use in Tanzania, a country with 11.5 million hectares of arable land. Based on these figures, there are about 7 tractors per 100 sq. km of arable land, which represents just 5 percent of the farming households, most of which are smallholders. Most Tanzanian farmers (92%) continue to operate their smallholdings manually using hand hoes. The level of tractorization is low (14%) with hand hoes (62%) dominating the farming system. The use of animal traction is estimated at 24%. (See Figure 1.)

In the mechanization sector, the government has disengaged itself from direct commercial activities, opening doors for the private sector to import and distribute tractors. Over 40 companies are currently importing and distributing agricultural machinery including power tillers and tractors in Tanzania. Of these, 12 are very active in terms of quantities imported. While some of these companies have metamorphosed from state-owned enterprises into privatized firms, others are private companies that have existed for several years. In recent years, some companies have also sprung up in response to the national mechanization drive. Since 2009, there has been an upward trend in the number of tractors the private sector is importing as well as accessories such as threshers, disc ploughs and seeders. These power sources have been used in the main for the production of rice, maize, wheat and beans.

Two-wheel tractors (2WT) are a recent introduction in Tanzania, increasing from about 100 units in 2005 to over 9,000 units by 2015 (cumulatively). Figure 2 illustrates this rise. In 2005 there were only 100 two wheel tractors, but this number increased to a peak of 3,325 by 2010. Most Two wheel tractors are imported by the private sector; distribution is both privately and through government programs.

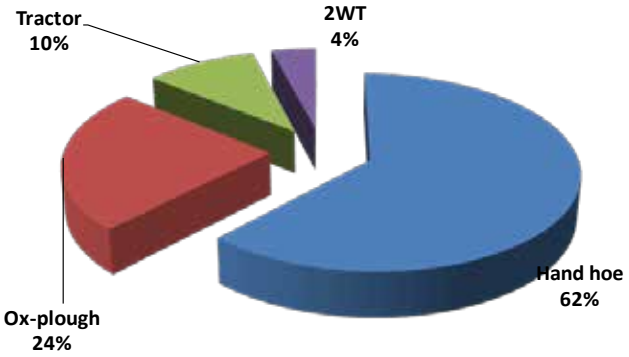

Figure 1: Level of mechanisation in Tanzania

The stimulus for the 2WT imports was the severe droughts of 2009 and 2010 that decimated 50 percent of the cattle in the country. The government promoted two wheel tractors as a substitute for draught oxen. The sharp drop in the number of tractors imported since 2011 can be explained by the erratic government support and the shifting policy of engaging the private sector in importation and delivery.

As of 2015 about 51% of the two wheel tractors were located in five regions (Mbeya 27%; Morogoro 7%; Iringa 6%; Ruvuma 6%; Lindi 5%) and the remaining 49% were spread over the rest of the 20 regions as illustrated in figure 3 below. In this regard, a poignant point is the fact that three (Mbeya, Iringa, and Ruvuma) of the five regions where most of the 2WT are found are also among the main grain surplus regions of Southern Tanzania. Surveys undertaken in Mbeya region (which has 27% of the total number of Two wheel tractors in the country) show that over 80% of the Two wheel tractors in the region are located in a single district—Mbarali—where they are used in rice and maize production and with considerable off-farm activities in transportation. Very few of the Two wheel tractors are being used to support CA. In short, most have been distributed to the rice cultivated areas as well as to other high potential cereal areas regarded as the breadbasket of the country.

Tanzania is developing a vibrant mechanization hire sector given the inability of smallholder farmers to purchase their own machines. However, farmers, who can afford to buy two wheel tractors provide

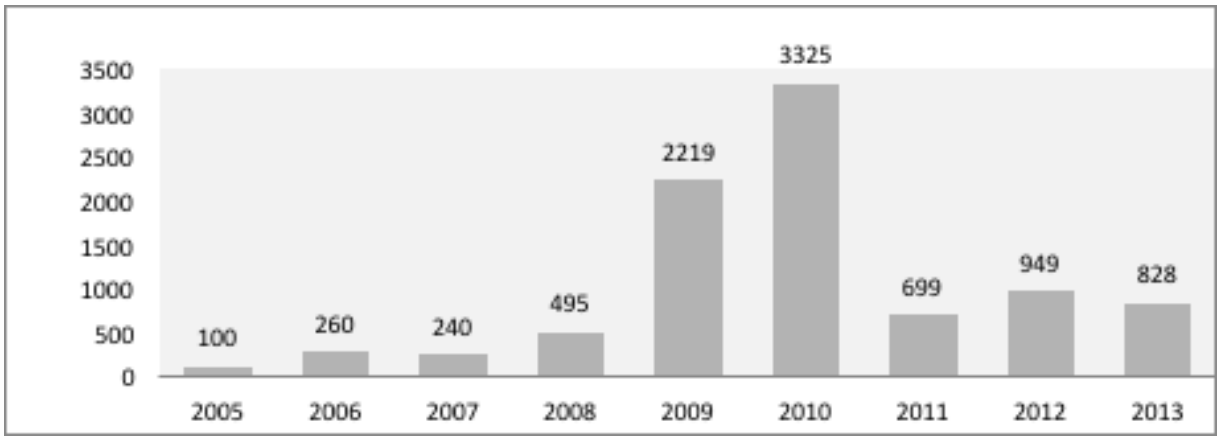

Figure 2. Growth in the number of Two wheel tractors in Tanzania

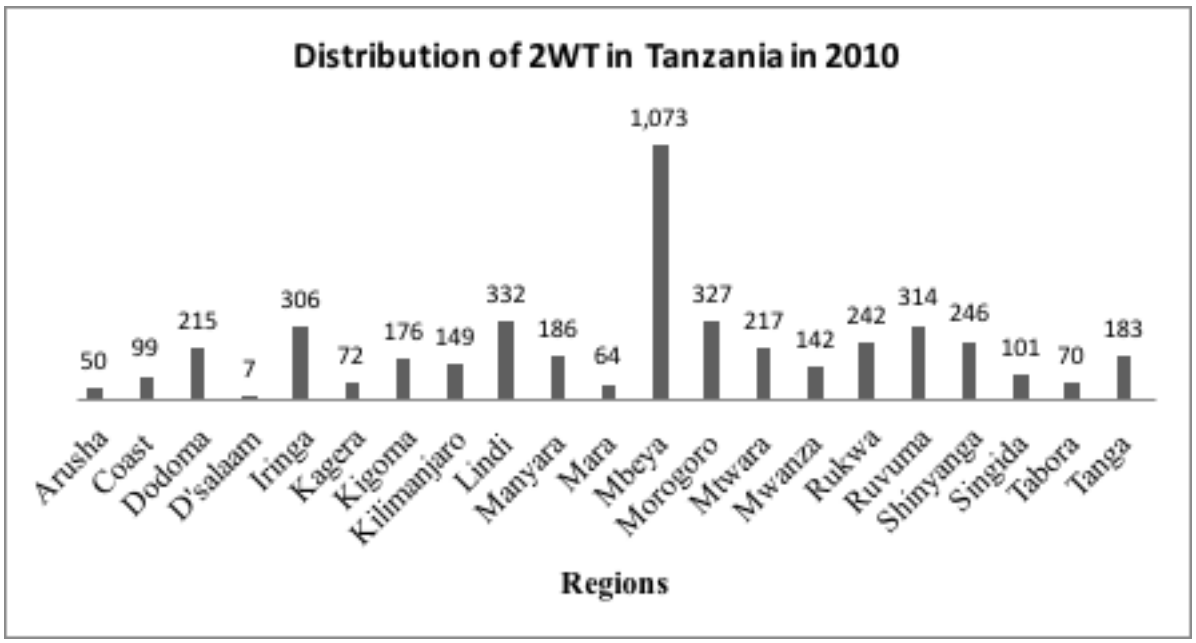

Figure 3. Number of 2WT in Tanzania, by region (2010)
Source: Ministry of Agriculture, Department of Agro-mechanization, 2010

part-time services to neighbouring farmers to enhance the viability of the capital purchase. Others have adopted a more entrepreneurial approach by setting up specialized tractor hire services to respond more effectively to seasonal demands. According to data collected from one of the project sites, Mbulu district, there are 16 2WT and 58 4WT service providers in the area. The findings suggest that demand for mechanization services is high.

The spread of two wheel tractors and ancillary equipment has been catalysed through government subsidies and a policy of government to waive VAT and tariffs on agricultural machinery. This has more recently encouraged private sector imports of two wheel tractors and implements. The dissemination of mechanization, although increasing rapidly, has been hampered by several factors including the low purchasing power of most small-scale farmers and the high cost of agricultural machinery. Other constraints are the lack of technically proven and high-quality appropriate machinery, low producer prices, lack of access to agricultural credit as well as a dearth of well-trained operators and mechanics.

4.2 Kenya: case study

The agricultural sector in Kenya faces innumerable challenges that could potentially provide opportunities for smallholder mechanization. Land tenure laws have encouraged a rapid degree of land fragmentation, with smallholders in the more densely populated areas cultivating on average less than one hectare of land. Mechanization levels among smallholder farmers are particularly low and only 512 units of two wheel tractors have been imported since 2005, with a peak of 106 units in 2010. However, most of the two wheel tractors are used in the horticultural industry to transport flowers from farms to pack-houses. The number of annual imports has since declined to only 68 units as dealers have cut back on imports owing to low market demand. This can largely be attributed to the relatively high cost of imports and low awareness among smallholder farmers.

In contrast, the 4WT market for more commercially oriented farmers has been rising gradually, albeit at a low rate. According to data available from the Kenya Revenue Authority (KRA), 4WT tractor sales in Kenya have risen very slowly since 1961 from 6,420 units to 12,840 units in 2002 and around 18,000 units by 2012. Over the last five years, annual imports of 4WTs have been in flux. In 2009 and 2010, some 1,432 and 1,174 units were imported, respectively, rising to 1,587 by 2012. In total, the inventory of imports over the period 2009–2012 is 5,600 units. With an estimated 3.5 million hectares of cropland, this suggests a ratio of one tractor per 195 hectares. Most of the 4WTs operating in the country are concentrated in large-scale commercial farms (both government and private) growing plantation and commercial crops: sugarcane, rice, wheat/barley, tea and maize crop enterprises.

The imported makes of two wheel tractors are largely Chinese Dongfeng and Japanese Kubotas. Some of the importers operate on a one-off basis. Once they see the low demand they stop importing the machines to avoid tying up capital in the machines and their storage. Few importers are willing to invest in creating demand, citing the low margins from the sale of two wheel tractors. Farmers sometimes shun Two wheel tractors because they perceive them to lack the status that comes with the larger 4WTs. Similar to other countries, experience with Two wheel tractors use in CA is limited. Although demand is low, the decreasing and fragmented nature of land sizes in Kenya's smallholder farming sector suggests there might be opportunity for this tractor type, but this would need a concerted campaign to expand the market.

The main field operation for tractor services is ploughing using a disc plough for 4WT power supplies, and a mouldboard plough for draught oxen. These implements

are mostly imported. With the introduction of CA, some farmers prefer rippers and some local manufacturers are now manufacturing them, though the market is not well developed. Mouldboard ploughs are used mainly by small-scale farmers and mechanization hire services. Most of the seeders in use in Kenya are drawn by 4WTs or with draught animal power. Farmers in the maize growing regions of Uasin Gishu, Trans Nzoia, Bungoma and Laikipia have been using maize shellers for some time now. The shellers are powered either by 4WTs or by movable engines. Some of these threshers and shellers are transported on motorbikes or on trailers attached to 4WTs as part of a hiring service business model.

The financial environment is conducive to the development of the sector but farmers and entrepreneurs typically need to provide 30 percent capital to avail funding. The government is preparing a policy for mechanization but the enabling environment is not conducive for private sector investment. Local manufacturers lack incentives: they are double taxed on importing sheet metal and for VAT for manufactured products.

4.3 Ethiopia: case study

Despite efforts made to introduce mechanization (4WT and 2WT), the country is characterized by the use of traditional farming implements and practices with very low energy requirements. All field and tillage operations among smallholder farmers are conducted with very simple farm tools—mainly human and animal power sources. In recent years, the use of tractor farm technology has increased as a substitute for draught oxen. While in the early 1970s only 4% of total smallholder farming households used tractors for ploughing, this figure rose dramatically to 17% by 1980 and to 39% in the 1990s.

Currently there are more than 12,500 four-wheel tractors in the country owned by both the private and public sectors, translating to 4 four-wheel tractors for every 100 sq. km of arable land. This steady increase in the number of tractors is primarily attributable to the growing number of foreign private investors engaged in large-scale commercial agriculture in Ethiopia, mainly from China, India, and Saudi Arabia.

Currently the country has about 4,100 two-wheel tractors. METEC, a government corporation owned by the Ministry of Defence, has imported 3,000 two-wheel tractors. The rest are imported by private importers and dealers. Most tractors imported by government and the private sector are not sold; demand is low due to lack of promotion, demonstration, and affordability. Most imported two wheel tractors have been from China and include Dongfeng and Sifang machines. The distribution of two wheel tractors in the country is scattered and none is used for CA. The government of Ethiopia is aware of the need to intensify agricultural production as part of the Growth and Transformation plan as well as the greater involvement of the private sector.

The number of farm and agricultural equipment/vehicles is on an increasing trend because farming and agricultural production are applying modern tools and techniques. Tractors are now in use in rural areas, mainly by commercial farmers and cooperative unions. One of the key elements that made this possible is the government's interest in involving the private sector in the farm privatization process as well as government-led 'mega' projects such as sugarcane production. A lot is expected from government to provide agricultural finance and leasing facilities to smallholders.

Notwithstanding these trends, there are a number of environmental constraints that impinge on the adoption of two wheel tractors. Rural entrepreneurs and farmers have poor access to effective forms of finance to purchase two wheel tractors and their accessories. At policy level, imports of farm machinery are tax exempt if cleared within six months, otherwise it appears a high tariff is imposed on imported agricultural machinery if it is not cleared within six months.

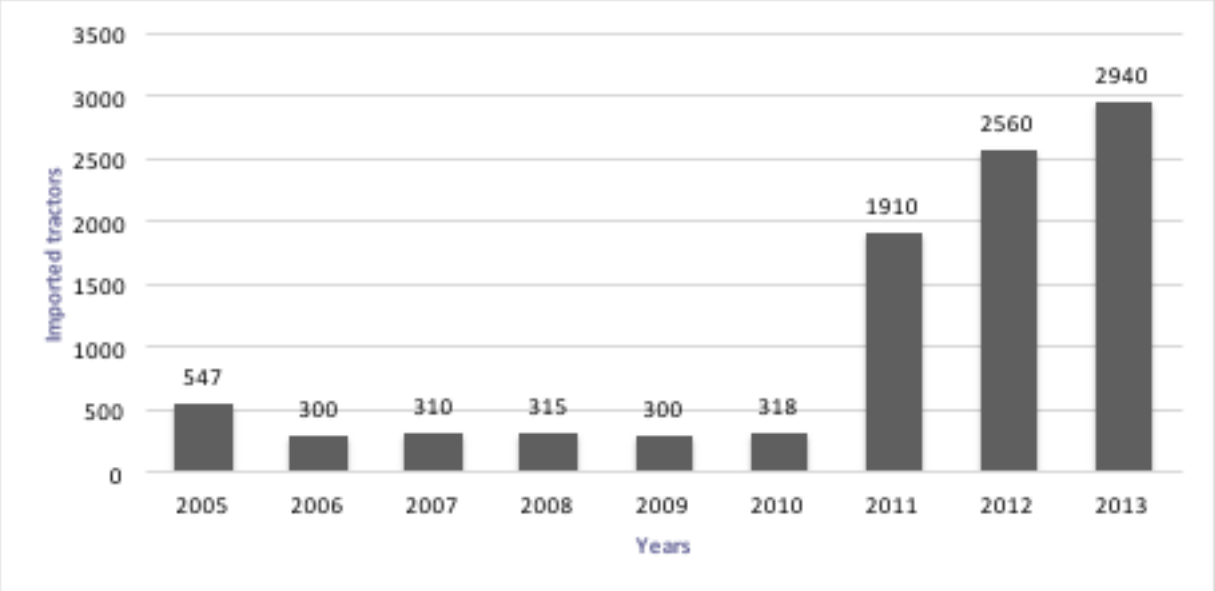

Figure 4: Trend in importation of 4 WTs in Ethiopia, 2005–2013

However, spare parts for tractors are tax free when imported together with the tractor machinery. The sector suffers inadequate supply of spare parts and poor maintenance of tractors. There is little incentive to set up a local manufacturing industry.

4.4 Zimbabwe: case study

Agricultural mechanization in Zimbabwe has evolved over time especially among smallholder farmers. The government's land reform policy has played a role in raising the demand for machinery. The reform policy categorizes farms according to size and machinery requirements. Officially, the land was divided into smallholder production, so-called A1 schemes, and commercial farms, called A2 schemes.[1] However, there is much overlap between the two categories.

Currently, the agricultural mechanization market is dominated by around 14,000 4WTs (ZIMSTAT, 2013). The tractors are used for multiple purposes, not only for agriculture. The total number of tractors currently available in the country falls below the national requirements of 40,000–50,000 tractor units needed to meet the agricultural production targets set (Simalenga, 2013). Over the past five years, the country has also been exporting agricultural machinery across Africa. Implements manufactured locally include ox-drawn and tractor-drawn equipment and equipment for use by human power. This suggests that the country has the capacity to manufacture the required accessories for imported power supplies.

Distribution of tractors is confined to high potential areas and to provinces such as Mashonaland West and Central, which are regarded as the grain basket of the country. The usage of agricultural machinery is skewed towards large-scale farms. In terms of tractor- and animal-drawn equipment there is variation in usage across the different farm categories. Tables 2 and 3 show the latest figures available for tractor and animal-drawn implements, respectively, across the different market segments. Smallholder farmers constitute about 75 percent of the total farming population in Zimbabwe and they

1 'A1' farms comprised about 150,000 plots of 6 hectares each allocated to smallholders following the division of the large white farms. The 'A2' model, in contrast, sought to create large black commercial farms by handing over much larger areas of land to about 23,000 farmers.

Table 2: Tractor ownership

Type of farmers	No. of tractors owned
Large-scale farmers	3,064
Small-scale farmers	601
Communal farmers	1,507
A2 farmers	6,575
A1 farmers	1,756
Resettlement farmers	778
Total number of tractors	14,281

Source: ZIMSTAT (2011)

Table 3. Tractor-drawn implements

	Tractor-drawn implements					
Category of farms	Plough	Cultivator	Planter	Harrow	Trailer	Water bowser
A1	1,196	365	182	581	1,038	306
A2	4,566	2,142	1,718	3,263	4,166	1,716
Communal	1,598	428	320	291	779	328
Small-scale commercial farmer	694	279	146	303	444	184
Large-scale commercial farmer	1,091	827	732	1,043	2,671	1,196
Old Resettlement	534	70	60	103	227	187
Total	9,679	4,111	3,158	5,584	9,325	3,917

Source: ZIMSTAT (2011)

Table 4. Animal-drawn implements

	Animal-drawn implements					
Category of farms	Plough	Cultivator	Planter	Harrow	Scotch cart	Water cart
A1	113,516	29,205	1,606	23,731	61,658	1,952
A2	3,075	17,116	8,085	1,173	7,691	8,822
Communal	813,618	179,804	6,377	134,829	364,060	15,085
Small-scale commercial farmer	–	12,858	7,457	1,504	6,286	6,723
Large-scale commercial farmer	719	394	198	362	474	12
Old resettlement	72,479	24,792	1,765	18,478	40,018	2,003
Total	1,003,407	264,169	25,488	180,077	480,187	34,597

Source: ZIMSTAT 2011

rely mainly on draught animal power (Koza, 2010). The concentration of animal-drawn implements is high among the smallholder sector because small scale farmers cannot afford to use more sophisticated motorized machinery and equipment 80 percent of smallholder farmers own at least an animal-drawn plough as illustrated in table 4 below.

The more commercial A2 farmers own a significant number of tractors, attributable largely to the government mechanization programme undertaken in 2007/08. In the past, the country received tractors as grants or concessionary loans from donors and government. The Reserve Bank of Zimbabwe (RBZ) run a major government programme and in 2007 imported and distributed agricultural equipment—1,247 tractors as well as combine harvesters and ploughs, harrows, planters, boom sprayers, and vicons—to boost commercial farming. However, the number of working machines available has since reduced considerably across provinces under the RBZ programme, due to lack of repairs and maintenance. Many of the tractors imported are not functioning. Proper strategies are needed to upgrade repairs and maintenance and thereby ensure better sustainability of the machinery.

Given the constraints that farmers face and lack of access to finance, the number of owned and imported 4WT has declined. During the 1990s the country imported about 2,000 tractor units per year. Current annual import figures are below 500 units. Demand for 4WT has dropped due to macro-economic conditions.

There is a dearth of information on 2WT imports and recent survey data suggests less than 200 units in total (personal contacts with importers). The 2WT provides services that range from ripping, planting, fertilizer application, boom spraying, and transportation to grass cutting, milling, shelling, threshing and water lifting. These machines, with varying horsepower capacity, are imported mainly from China. Since 2004 machinery imports have been declining due to the low productivity of the farming sector. The demand for two wheel tractors has been erratic and the main 2WT dealer imports 20 units per year.

Very little use is made two wheel tractors on farms; the machines are used mainly in the mining sector. However, the land reform process has created medium-sized (6–40 ha) farms that could provide an opportunity to introduce Two wheel tractors, if promoted with an appropriate package of accessories. The challenge in Zimbabwe is the use of 2WT for farming purposes and more so under CA. Other challenges relate to access to finance. The financial sector is facing liquidity challenges and few banks offer medium to long-term credit. Interest rates are high and all financial institutions require collateral guarantees.

Smallholder farmers have the highest number of ploughs: in 2011 the number of ploughs across the country was about 1 million. Mealie Brand is the main manufacturer of ploughs in Zimbabwe; the company exports a significant number to countries in the region. In 2010 the company manufactured 58,535 units and 74,113 in 2011. A number of local manufacturers Hastt, Mealie Brand and Grownet make seeders and planters. However, for CA operations seeders (direct seeders and jab planters) are imported from Brazil. The cost of a seeder is high yet imported equipment do not come with accompanying spares. Between 2013 and 2015, Hastt manufactured about 30 seeders/planters annually. Rippers are used mainly in CA and are manufactured locally by companies such as Hastt, Zimplow and Grownet. In 2013, Zimbabwe imported 5,280 units of threshers and 24 combine harvester threshers. ATA, Grownet and Hastt manufacture shellers (groundnut, maize shellers) locally at varying prices, depending on size and type of power source.

In all of the countries studied the most common use of 2WT is for transport with two-wheeled trailers. Clearly, commercializing two wheel tractors in these countries is fraught with challenges, requiring interventions in market development and business models for procurement and service provision.

5 Constraints and opportunities for small mechanization

Major constraints to small mechanization in the case study countries relate to lack of awareness of Two wheel tractors and their accessories, under-developed supply chains, inadequate knowledge and skills by smallholders and service providers in operating the machinery, and lack of a conducive enabling environment (access to finance, import policies, etc.) for mechanization (Table 5).

Factors that impede the adoption and use of machinery are shown in Figure 3. Service providers and farmers identified them as critical success factors.

Notwithstanding these constraints, opportunities exist for 2WT-based mechanization to find a niche in these countries. In Kenya, Tanzania and Zimbabwe, the private sector is active in importing 4WT. In Tanzania there is already a market for 2WT and in Zimbabwe the private sector is strongly set up with potential to move into small mechanization. These opportunities however are country specific.

In Kenya the national government and county administration provide political support to import new agricultural technologies. Rural areas seem to be well connected and the private sector has made inroads in setting up courier services and internet connectivity. Service providers and agro-dealers can deliver spare parts for machinery as long as there is demand.

In Zimbabwe, the government allows duty free imports of agricultural implements and tractors as a way of supporting the sector, however more work is needed to dialogue and lobby with government on ways to encourage the private sector to develop agricultural machinery for smallholder farmers. This is particularly prevalent as a way of providing support to smallholder farmers—the A1 category of farms that has not been adequately addressed. This market requires small-to-medium agricultural machinery to match its land holding size. Agricultural machinery with suitable packages of implements should be developed for that target market. Institutions in Zimbabwe seem to be well organized. Dealers and importers have come together to set up the Agro-dealer Manufacturers Association (ADMA), a

Table 5: Supply chain constraints and enabling environment

Supply chain constraints	Existing environment
Lack of efficient and effective distribution models for different agricultural mechanization technologies (KEN, ETH, ZIM)	Limited public sector resources allotted to Research and Development for mechanization (ETH/ KEN/ TAN)
Lack of farmer awareness of 2WT and accessories (ETH/ KEN/ ZIM) and its benefits	- Lack of support to develop a infant domestic manufacturing sector - Import tariffs drive up the cost of agricultural machinery - Agricultural machinery standards and testing have not been established (ETH, ZIM, KEN)
Lack of farmer awareness of CA based and post-harvest technologies (TAN)	Absence of mechanization policy (ETH, KEN, ZIM)
Affordability (KEN, ZIM); Low purchasing power (TAN)	Weak enabling environment to promote certification and quality/ safety standards of machines Standards dictating quality service provision (TAN, ETH)
Insufficient skills to operate machinery (technical and business); Shortage of skilled operators (ZIM)	Duty free imports (but need to sell within 6 months) otherwise tariffs are high Public sector involvement in importing and possible manufacturing (subsidized) crowding out the private sector (ETH)
Lack of available spare parts, maintenance and repair services (ETH, KEN, TAN, ZIM)	Duty free imported agricultural machinery Import duty applied to materials/spare parts = inhibit local manufacturing (ZIM/ TAN)
Topography and soil types (ETH, KEN)	Access to finance along the value chain (ETH, KEN, TAN) Long-term finance (ZIM) Lack of financial services to facilitate the use of agricultural mechanization services (ETH)

national coordination body. ADMA has a current membership of 14 organizations. Its role is to coordinate and lobby to create awareness of mechanization issues among public sector bodies. Similar to Kenya, Zimbabwe has a strong private sector-led distribution network in the rural areas stocking spare parts for tractor technologies. Some dealers provide back-up services for their customers including training in tractor operations, but largely for 4WT-based technologies.

Ethiopia has opportunities for the sector to develop. The government has a strong focus, with financial support from China and India to provide entry into the sector, of mechanization among smallholder farmers. The opportunity for mechanization is immense in Ethiopia with its large areas of underutilized arable land. The potential is huge for tractor sales to cooperatives and farmer groups, which could be realized once farmers are aware of the potential for small mechanization. However, there is limited knowledge and information about agricultural mechanization needs and requirements in the country.

In contrast, in *Tanzania* where two wheel tractors are more prevalent, the issue is largely the direction of expansion. Over 80 percent of its 40 million population live in rural areas and the government sees this as justification to support small mechanization. The demand for two wheel tractors is high and increasing but, more importantly, the demand for mechanized accessories such as mechanized shelling and threshing and transport in the maize and legume areas is also high. The private sector is encouraged to import machinery, and farmers and entrepreneurs see the opportunity to provide hiring services to farmers. In short, the government has made deliberate effort to support agricultural mechanization through a number of subsidized government programs. Government interventions include providing affordable loans through the Agricultural Inputs Trust Fund, supporting farmers to acquire farm machinery through District Agricultural Development Programs, and negotiating concessionary lines of credit from the Government of India to purchase Indian-manufactured machinery. The government has also established an agricultural window at the Tanzania Investment Bank and is in the process of establishing an agricultural bank to provide long-term credit to supply chain stakeholders. The Government of Tanzania has also been addressing policy constraints by enacting supportive policies for mechanization—waiving VAT and tariff charges on agricultural machinery to increase imports and availability for farmers.

6 Driving factors to support smallholder mechanization

6.1 Machinery supply chains

The availability of machinery, i.e. tractors, equipment, spare parts and other supplies is essential for the successful and sustainable spread of mechanization among smallholder farmers. Some activities require linkages with overseas manufacturers. Yet, emphasis should be placed on developing domestic supply chains for importing and distributing the more complex pieces of machinery and for manufacturing simple accessories and implements locally. Enterprises that make up the supply chain need to be supported by efficient and effective distribution channels for equipment, spare parts and repair services, and supplies such as fuel. For mechanization to develop within SSA, the entire supply chain must be strengthened.

Priority should be on establishing reliable and low-cost supplies of two wheel tractors and related equipment. A strategy being followed by the four case study countries is to establish supply chains for small mechanization machinery and spare parts imported from Asia. China, India and, particularly, Bangladesh have become important global suppliers of low-cost appropriate equipment. Most of the machinery available from the industrialized countries is expensive and complicated as well as of high-power rating more suitable for larger scale commercial farms. In contrast, India and China, among other developing countries, produce and export two wheel tractors and implements at prices that are a fraction of the prevailing prices of equipment imported from developed countries.

The advantage of developing local machinery manufacturing industries is that they will create alternative employment, reduce dependence on imports, save foreign exchange, and facilitate the supply of parts and services. This is the situation in Tanzania and Zimbabwe, although their focus is on manufacturing accessories and implements. In fact, implements that are specific to local conditions (agricultural conditions, soil types, etc.), which have the added benefit of reducing manufacturing and transportation costs, are best made by small-scale industries. This argument also applies to hand tools and animal draught implements.

The domestic manufacturing sector in all SSA countries is at 'infant stage'; substantial investment is needed to realize the benefits of a strong local manufacturing industry. Very few companies have in-house R&D capabilities necessary to develop the industry over the short term. Complex equipment that ensures a high degree of quality (engines, gears, etc.) is unlikely to be made locally. While ploughs, rippers, choppers, shellers, threshers and draught-powered equipment could be manufactured and serviced locally, the cost of local manufacturing can be reduced to competitive levels only if economies of scale are ensured by volumes. This in turn depends on market demand. Additionally, quality issues depend on the quality of materials used as well as the technical capacity of local manufacturers. To further complicate the current manufacturing sector's ability to grow, manufacturers of agricultural machinery need a downstream supply of basic metal and petrochemical materials to produce equipment locally. In addition, even if these companies have the required technical capacity, they may not have access to liquidity to finance machinery. As they also pay value addition and other taxes, they are less competitive when compared with importers who either do not pay taxes or pay little import taxes.

Caution is also needed in the event of rising costs of energy and oil. If this occurs, this may be a drawback to mechanization in the future just as it was in the 1970s, although at present the prognosis is favourable. Energy needs to be introduced as a criterion of efficiency in addition to land, labour, and capital efficiency. The price of fuel bears directly on the profitability of using mechanical power sources in agriculture. Consequently, it is important that the issue of energy is taken into consideration in the right context.

6.2 Enabling environment for mechanization

The enabling environment to support mechanization incorporates several essential elements. These are: i) fiscal and monetary control, ii) a regulatory framework supportive of mechanization, iii) basic infrastructure for private sector development, iv) delivery of public sector R&D and extension services, and v) an economic system that encourages competition and standards. This requires that a policy, regulatory and legal environment is in place and conditions are met to support private sector investment in mechanization and the establishment of support services. Among the most important of these policy conditions are:

- existence of suitable macro-economic conditions for 2WT replication
- formulation of policies affecting the cost of buying and operating machines, exchange rate regimes, credit subsidies, tariffs or tariff exemptions, taxation of parts or fuel
- policies affecting supply of machinery, spare parts, and fuels; foreign exchange regulations, quotas, preferential trade arrangements, credit rationing
- supportive and progressive legal and regulatory environment to allow the private sector to operate efficiently and effectively
- policies affecting the development of domestic industrial capacity
- patent laws, licensing and foreign collaboration, domestic content laws
- standardization; tariffs and regulations governing importation of machines, materials and parts; provision of transport and communications infrastructure
- development and introduction of regulations that are clear and transparent to private investors and that mechanization services are accountable
- removal of restrictions that impede the private sector mechanization stakeholders to compete in the market

- improved micro-economic capacity to promote mechanization
- provision of opportunities for private enterprises to develop management and entrepreneurial capabilities
- redefining of the role of government to bring about a shift from public sector lead in development of the mechanization sector towards private sector investment.

While these policy prerequisites are essential to developing the mechanization sector for smallholders, the experience of Asian countries (India, Bangladesh, China, Thailand, Korea) suggests that very often scaling-up mechanization follows a process of transitioning from a public sector-led initiative to private sector development. In the early stages of development, actors in the private sector may not have the expected knowledge and capacities to promote the development of mechanization. Ways are needed to create and develop partnerships: this is part of a dynamic process that requires time. The starting point as can be seen from those SSA countries that have embarked on a mechanization strategy—Tanzania, Ethiopia, Ghana, Zimbabwe—is for a strong public sector leadership, often with subsidies. It is unlikely at these early stages of development that the private sector will deliver R&D, extension and credit services to smallholders, especially to those located in remote areas, and the public sector may have to fill in (Eicher, 2004). The public sector has a role to ensure that the infant private sector is supported through key sectoral ministries.

For the private sector to invest in purchasing Two wheel tractors and accessories or establishing a mechanization hiring business, 'kick-start' incentives are often needed to set them up in business and generate the necessary competition (Gibson, 2001; Downing, 2001; Meyer-Stammer, 2006; Kahan, 2007; DFID and SDC, 2008). Examples abound globally of the public sector providing subsidies to develop the market for mechanization and later withdrawing and phasing them out after demand had been clearly demonstrated, allowing the private sector to take over (Tanburn, 2002; DFID and SDC, 2008). In Asia, government subsidies were used successfully to encourage private sector investment. Subsidies were used to help establish the link between machinery users and manufacturers to ensure that the most appropriate machines were made available in the local market. In most Asian countries, removal of subsidies after a sustained period did not interrupt the private investment that eventually developed a strong and sustainable private supply network. As the private sector recognizes the market for 2WT machinery, the incentive system should encourage private investors to participate in the machinery value chain. At this stage of development, the public sector still has a role to help private businesses by providing financial services and repealing any policies that might impede growth of the private sector. Such interventions could include eliminating restrictive import policies, licensing and tax disincentives and duties on mechanization. In this way, public resources can be used to foster and support the emergence of a sustainable private sector-led small mechanization sector.

6.3 Effective demand and profitability

Effective demand for agricultural produce creates both the need and the opportunity for mechanization (Clarke and Bishop, 2002). Mechanization among smallholder farmers should, as a priority, be linked to market-oriented enterprises to generate necessary cash flow to cover capital costs and make loan payments. Effective demand for products translates into effective demand for equipment and machinery services, but only if farming is profitable. Unfortunately, many African smallholders have only limited access to local, national, regional and international markets to provide them with inputs and to market their outputs. For farming to be profitable and, ultimately, to mechanize in these latter areas, farmers will first need opportunities to compete in a wider range of markets. In brief, for there to be sufficient and sustainable effective demand for mechanical technologies, efficient marketing and distribution systems need to be in place to ensure that whatever is produced on the farm can be transported, processed, packaged and marketed to consumers whether locally, in towns and cities, or through export.

Considering the low profitability of many small farms and the levels of investment required, 'better off' small-scale farmers are in the most favourable position to adopt mechanization. But even this category of smallholder farmer is likely to face many constraints that limit profitability and create difficulty in maintaining and replacing equipment. Increasing the profitability of smallholder farming can boost effective demand for mechanical technologies and augment the supply of tractor hire services to the more vulnerable small-scale farmers. There is a need to identify these farmers and encourage the development of viable commercial farming operations with potential to provide tractor services to small-scale farmers (Adams, 1988).

6.4 Access to finance

Without access to financial resources necessary for purchasing the technology and other inputs smallholder mechanization technologies are unlikely to be adopted. The availability of finance is a prerequisite for businesses to take advantage of the new 2WT technologies. Access to finance sets the pace and direction for scaling-up. Conditions (e.g., interest rate, repayment period, own finance, collateral) for availing finance influence the direction of 2WT development. Finance can come from various sources—loans and/or equity savings. However, loan packages are poorly designed and fail to cover shortfalls in cash flows. In the short term, cash is required almost daily to operate machinery throughout the growing season (e.g., fuel, oil, maintenance and repairs), while cash becomes available only after the crop has been sold. Deficits in the long-term cash flow are a more serious cause of repayment default. With time repair and maintenance expenditures sharply increase. Few tractor owners reserve funds for this purpose, and some end up in situations where cash earnings fail to cover the cash required for the operation, major repairs and maintenance, interest payment, and loan amortization. Appraising financial requirements depends first on

the profitability of the investment. Where the purchase and use of the farm machinery are certain to be lucrative, loan financing may not be a required precondition. Small farmers sometimes have the ability to raise money from within family resources, where high returns can be assured. The cost-effectiveness of using a 2WT system depends less on the financial package but on increasing the value of production, maintaining production while reducing costs or restructuring family resources to increase total productivity. It is thus important for investors to measure the profitability of their enterprises as well as the capacity to recover the costs of services being offered. This information can be used to improve performance and financial sustainability. Activities that narrow the overall profit margin must be identified and minimized, where necessary. Finally, access to finance is also required for the upstream actors of the supply chain to strengthen their existing businesses and set up new businesses for entrepreneurs willing to stock spare parts, establish workshops and manufacture implements.

6.5 Developing the demand for two wheel tractors and accessories

Findings of the country case studies highlighted the importance of creating awareness of the benefits of Two wheel tractors, and supporting mechanization as a first step towards market development. With the right products—appropriately sized, priced, and marketed—the private sector should be in a position to deliver new technologies to small farmers in a sustainable way. The private market place is arguably the most efficient mechanism for widespread distribution of technology to maximize its distribution and impact. The design process involves multi-disciplinary actions that seek not just to 'develop technologies' but to commercialize them as 'products'. This often requires a deep engagement with product engineers, technical specialists, marketing and branding experts, through a product design process where a particular solution is rapidly prototyped in a 'fail early and fail often' strategy. This process has been followed where demand for the product exists and the market is assured (Magistro et al., 2007). While the initiative for market development should lie with the private sector, this may require public sector involvement in creating awareness of new technologies.

In situations where market demand is weak, actions at market development are needed. These can take various forms that include (Mielbradt and Mc Vay, 2003):

- Conducting market assessments prior to project implementation
- Creating product awareness
- Designing an extension and demonstration strategy
- Organizing field days, trade fares and exhibits
- Promoting the products through mass media, and printed materials
- Designing matching grants and voucher schemes to 'kick-start' demand creation

In the case of the 2WT and its accessories, the market was weak in all the country cases, and as a prerequisite to market development the project conducted a product awareness campaign. However, in substantial segments of the farming community, the problem seems to be not so much one of localized market failure, but rather of a lack of appropriate market structures of any sort. Intermediary organizational involvement is likely to be needed to facilitate the development of the value chain and the linkages between stakeholders, i.e. encourage the development of private sector dealers, manufacturers and service providers and facilitate a competitive environment to support small-scale mechanization.

6.6 Efficient rate of utilization

Consistent findings from field studies on smallholder mechanization in SSA show that the costs of tractors complete with a full package of accessories, question the profitability of mechanization at the level of the individual farm. This has been one of the main arguments against investment in bulky and expensive tractor-based technologies. The cost of machinery and equipment, however, can be greatly reduced by extending its use over many hours or hectares of land annually. Since the size and fragmentation of holdings is a restriction for smallholder farmers, innovative use of capital equipment—hiring out machinery and asset-sharing—as well as careful planning of its use keeping in mind seasonality of demand is needed. Since small-scale farmers in SSA cannot, in most cases, afford to buy their own machinery and equipment, hire services offer a viable alternative.

The main arrangements for provision of machinery services can be divided into individual and group ownership (Landers, 2000). Individual ownership models can be sub-divided into mechanisms of informal sharing of machinery, farmers providing part-time hiring services, and more specialized service providers. Providers of hire services in SSA are most likely to be 'better off' farmers who have invested in equipment, both for their own use and because they have identified a demand to provide hiring services locally. Services tend to be provided to neighbouring small farmers who cannot afford to buy their own tractor, as an additional source of income. This practice is a logical continuation of draught livestock borrowing from neighbours in exchange for various forms of in-kind compensation. Alternatively, machinery may be shared between farmers informally with or without monetary payment. In more sophisticated settings with more rigorous demands and better rewards, specialized service providers have emerged. Alternatively, group ownership schemes can also be found. These can take the form of formal organizations such as cooperatives and farmer associations, and informal self-help groups. The type of ownership/ management model selected will depend on a host of factors—profitability of owning and operating farm machinery, initial capital investment, availability of finance, and management system.

6.7 Human resources development

Another key driving factor responsible for uptake of mechanization among smallholder farmers is the presence of local entrepreneurs involved in importing machinery, local manufacturing of accessories, local dealerships and repair workshops, and provision of specialized

mechanization services. Of significance, is the need to develop the capacity and skills of these supply chain actors by developing innovative human resource development programmes that support mechanization (Mrema and Woodend, 1994). In the 2WT sector, entirely new skill sets are required for both machinery and equipment users and support service enterprises. Critical to this process is developing farmers' operational and management capacity to effectively use and maintain the engine source and accessories for both on-farm and non-farm activities. Additionally, farmers may also require broader business management skills to commercialize their farming operations and adapt to changing markets, technologies and policies.

While capacity development activities in support of mechanization often occur through donor funding at field level to ensure sustainability and impact at scale, a more strategic approach is needed that involves policy makers at national level. Priority subject areas for human resources development that need to be addressed by the public sector to accelerate smallholder mechanization in SSA include:

- Establishing or upgrading training and extension facilities for users of mechanical equipment including progressive farmers, machinery operators, maintenance technicians and artisans; and creating skills that could lead to small enterprise development and employment opportunities in support of the sector.
- Strengthening the management and entrepreneurial skills of 2WT value chain stakeholders for better decision-making and response to market changes. Training may be required in topics such as contract negotiation, conflict resolution, price setting, business and financial management, and marketing. Farmers, entrepreneurs and local custom hiring service providers are also likely to require training in the benefits of CA to make the integrated use of farm machinery with improved husbandry methods and inputs more effective.
- Providing technical training for researchers, engineers, technicians and mechanics who design mechanical equipment, conduct mechanization research, and supervise mechanization programmes. Skills should be leveraged so that current expertise can be extended to support a broader range of farm and non-farm enterprises and entrepreneurs.
- Providing training in financial management and, in particular, term financing to accelerate the spread of mechanization among service providers and farmers. New financial products, such as leasing, need to be developed and information and skills provided on their application. Governments could play a role in increasing the supply of term financing for machinery investments by training financial service providers in new strategies and products.

For mechanization among smallholders to 'take off', it is not sufficient to focus solely on building capacity of the supply chain stakeholders. Changes are need at the organizational and enabling environment levels of the innovation system. While capacity development involves upgrading skills and knowledge of individuals, the output of individuals greatly relies on the quality of the organizations in which they work, the capacity of the networks and the attitude of policy makers. Ultimately, a capacity development approach should be followed that creates a knowledge learning environment allied with supportive policies that provide incentives and governance structures that are conducive for small-scale mechanization (World Bank, 2006).

7 Conclusion

The question of agricultural sector growth in sub-Saharan Africa is important for two reasons. First, it is a key conduit for resource distribution and inclusiveness for an otherwise-neglected rural population; a greater proportion of the rural population constitutes most of the poor in SSA countries. Second, with relatively higher comparative advantage with regards to crop production in relation to other countries globally, its success or failure has direct implications for food security in the region.

To ensure that the agricultural sector grows and plays its role as an attractive employment creating mechanism and food security strategy, effective production technologies are needed. The shift of innovations that are more appropriate for use by smallholder farmers may hold the key to unlocking the provision of appropriate techniques. The search for such technologies should engage policy makers and academics in the future. To push agriculture beyond subsistence and make it an engine of growth, there should be a gradual shift towards mechanizing aspects of production and non-farm activities.

This paper suggests that the introduction, successful adoption, adaptation and use of mechanical power on farms transiting from subsistence to small and medium scale commercial farming can be very challenging. This is very much so especially in a developing country context where capital is scarce and unskilled or semi-skilled labour is relatively abundant and there is paucity of basic infrastructure. There are contestations about the rationality of introducing machines when there is unemployed labour to carry out farm activities. Technologies that tend to absorb surplus labour are key. While some technologies may sacrifice some jobs at the initial stage, they may open up more jobs in other stages of the production and post-production process. Mechanization needs to be understood as a complex and dynamic process that cannot be appraised only from the standpoint of factor substitution or net contribution to production. Where mechanization has taken place worldwide, there have been fundamental and interlinked changes in the structure of agricultural sectors, in the nature and performance of agricultural support services, and in the livelihood strategies of farmers and rural entrepreneurs. And these changes do not necessarily take place simultaneously nor impact on all people in the same way.

Moving forward, other important barriers to successful mechanization by smallholders in particular relate to their ability to afford to buy machinery and equipment and this relates to the availability of finance, the structure and profitability of the farming system, access to markets and development of the entire value chain. For mechanization to be successful, essential mechanization supply systems and support services need to be established but this will only come about as a response to economic demand. In conclusion, a new perspective is required that views mechanization as part of a broader system that includes both public and private sector actors with the understanding that ‘transformative’ change is required over a longer term horizon.

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