Abstract: Tanzania has seen a slow but steady growth in agricultural mechanization over the past few decades. The country’s mechanization growth trend is fairly consistent with patterns elsewhere, with both agroecological and socioeconomic conditions as key determinants of increased mechanization. The private sector has often led the development of machinery markets and service providers to meet mechanization demand, including emerging medium- to large-scale farmers serving as self-financed owners of tractors providing custom hiring services. Despite such progress, several knowledge gaps exist regarding the roles of various factors in mechanization, including land tenure policy, and regarding identification of the roles of governments in effectively supporting the private sector toward further mechanization growth.

Evolution of Agricultural Mechanization in Tanzania

This chapter documents emerging mechanization patterns among smallholder farmers in Tanzania, including the changing trends in demand conditions, service provision, and related policies. It also uses case studies to provide narratives and insights into mechanization’s effect on agricultural transformation and key socioeconomic and environmental outcomes.

Evolution of Agricultural Mechanization in Tanzania from 1945 to 2015

Emphasis and priorities within the interventions in agricultural mechanization in Tanzania have alternated from 1945 to 2015 between motorized power and draft animal power (DAP), depending on the thrust of the major agricultural development strategies and programs being implemented at any one time. As in many other African countries, the history of the evolution of agricultural mechanization in Tanzania can be roughly categorized into three periods.
UP TO THE MID-1980S (PRIOR TO THE STRUCTURAL ADJUSTMENT PROGRAM)

The period preceding the mid-1980s was characterized by substantial public-sector promotion of agricultural mechanization, particularly through increased tractor supply and mechanization services. From 1945 to 1961, British colonial authorities sponsored various programs, such as the Great Groundnut Scheme (GGS) and subsidies for mechanization inputs provided to white settler farmers and a few African yeoman farmers. On the advice of the World Bank, between 1961 and 1970 the Tanzanian government implemented an agricultural transformation program anchored in highly mechanized village settlement schemes, modeled on the kibbutzim of Israel (World Bank 1961; De Wilde 1967; Ingle 1972; Maeda 1976; Hyden 1980). Between 1965 and 1985, the government and various cooperatives operated and managed tractor hiring services (THSs), providing land preparation services to small farms. Despite this public provision, more than 80 percent of the tractor fleet in Tanzania during this period was operated by the private sector (Collinson 1963; De Wilde 1967; Clayton 1972; Beeney 1975; TSAE 1974; Kinsey 1976).

From 1970 to 1990, socialist programs such as *ujamaa* (communal, or extended family) villages were implemented by the government. During the period, focus gradually shifted toward more appropriate technologies for small-scale and peasant subsistence farmers, though support remained for four-wheel tractors (4WTs) used by large-scale farms that were managed by the state, communal entities such as village leadership, and the private sector (Nyerere 1967; Hall 1968; Clayton 1972; Raikes 1975; Mrema 1981; Kjærby 1983).

During this period, available government records suggest that the number of 4WTs in use in Tanzania increased from about 2,000 in 1950 to 2,580 in 1960, 6,500 in 1970, and 18,500 in 1985 (Figure 14.1). However, this growth was not sustainable. For example, the GGS largely failed due to factors such as the introduction of inappropriate mechanization practices, and it was abandoned by 1954. Furthermore, after Tanzania gained independence in 1961, many of the white settler farmers moved on to what they perceived as more politically safe territories, such as Kenya and then Northern and Southern Rhodesia, and many of the prior settlement programs were abandoned for being too costly (Mayne 1954, 1955, 1956; Lord 1963; Austen 1968). Therefore, whereas 4WT use spread quickly during this period, the growth in mechanization was due to substantial economic distortions and did not necessarily reflect an optimal allocation of resources.
BETWEEN THE 1980S AND MID-2000S

During this period, the number of 4WTs in use fell from 18,500 in 1985 to 7,200 in 2005 (Figure 14.1). Loss of donor interest in mechanization and the government-implemented economic structural adjustment program (ESAP) from 1985 to 2005 created a period during which agricultural mechanization evolved without a clear strategy or vision. Although the political leadership remained highly supportive of agricultural mechanization, government ability to finance investments in the sector was constrained by the implementation of the ESAP (CCM 1988). Meanwhile, at the behest of Bretton Woods institutions, the economy was gradually opened to private-sector investment. Many of the public-sector THSs were privatized and the tractors sold to private operators. Due to financial austerity measures, the focus also shifted back to appropriate technologies such as DAP, which were disseminated through nongovernmental organizations funded by donor agencies and philanthropic organizations (Tanzania, MAFC 2006).

At the same time, overall demand for more intensive farming had risen in some parts of Tanzania. In eastern central Tanzania, between the mid-1990s and 2014, examinations through socioeconomic and remote-sensing data suggested that population growth drove a gradual transition from shifting cultivation to more intensive land preparation methods such as deep tillage (Kilawe et al. 2018), consistent with the evolution of the farming system and the role of that evolution in mechanization growth.
PERIOD SINCE THE MID-2000S

The period since 2005 has seen a general reversal of the prior decline in mechanization. During this period, the number of operational 4WTs has increased to reach 13,146 units in 2015. There has also been importation of secondhand tractors—mostly 4WTs from Europe and Japan (Agyei-Holmes 2014; Mmari and Mpanduji 2014; Tanzania, MAFC 2015; Mrema 2016; Shetto 2016). In addition, the number of two-wheel tractors (2WTs) started growing during this period, from fewer than 300 units in use in 2005 to more than 9,000 units in 2015. Part of the growth in 2WTs was induced by the severe drought in 2009 and 2010 that killed 50 percent of the cattle and oxen in the country (Kahan, Bymolt, and Zaal 2018). Tanzania, together with Madagascar and South Africa, had 70 percent of the 2WTs in Africa in 2018 (Mrema, Kienzle, and Mpagalile 2018). As of 2015, national data from the Ministry of Agriculture show that tractors and DAP were used for 14 percent and 24 percent of land preparation on cultivated land, respectively. The remaining 62 percent of land still relies entirely on manual labor with hand-tool technology (HTT). In some regions, however, land preparation with tractors is well above the national average and reaches up to 48 percent of cultivated land—for example, in the Arusha, Manyara, Mbeya, and Kilimanjaro regions (Tanzania, MALF 2016).

Several factors may have raised the demand for mechanization, albeit somewhat slowly, during this period. Over the past few decades, socioeconomic developments such as availability of social services (for example, universal primary education), migration to urban areas, aging rural populations, and new economic opportunities in rural areas have reduced the availability of labor for arduous field tasks, even at the very basic subsistence levels. For example, the urban population is growing at 4–5 percent per year, and its population share is expected to grow from 30 percent today to 50 percent by 2030. Although Tanzania is still a relatively agricultural economy when compared with countries in West Africa, the share of the workforce employed in the nonfarm sector has been rising steadily, and recently exceeded 30 percent.

There has also been a shift in the government’s mechanization policies. From 2005 to 2015, Tanzania implemented the first Agricultural Sector Development Program (ASDP1), and ASDP2 is expected to be implemented from 2016 to 2022. The Tanzania Agricultural Mechanization Strategy (TAMS) was developed and approved in 2006 as part of ASDP1 and was supposed to provide the framework for guiding interventions in the subsector,
such as increased emphasis on private-sector provision of THS (Tanzania, MAFC 2015; Mrema 2016). Under the TAMS framework, incentive structures have been established to expand the provision of mechanization services (mainly farm equipment hiring services) to smallholder farmers in the rural community. This includes financial incentives to local institutes of technology to encourage design and development of appropriate farm tools and machinery suited for different categories of farmers and farming systems, and to build capacity for mechanization support services, especially for small-scale farms. Since 2009, subsequent investment initiatives have focused on the acquisition of mechanical power, especially 2WTs, 4WTs, and harvesting and postharvest processing equipment.

**Demand-Side Analysis**

Ergonomically, land preparation tasks are the most difficult and demand excessive power input from human muscles. These include basic tillage using the hand hoe, planting, and weeding. Land tillage by hand hoeing is ergonomically the most difficult task and requires 8–10 kcal per minute in tropical environments such as Tanzania (Passmore and Durnin 1955; Stout 1979; Fluck and Baird 1979). Planting and weeding demand about 25–40 percent of the power required for hand hoeing. The significant effort required for these processes informs the Tanzanian ruling party’s strategy to significantly reduce the area tilled by the hand hoe, currently at 60 percent, by 2035 (CCM 2015).

**The Agricultural Sector and the Demand for Farm Power**

Tanzania has a total area of 960,000 km², about 886,040 km² of which is land. Of that, there were approximately 45 million ha of arable land and 10 million ha under cultivation as of 2015. In the country, demand for farm power is informed by the dualistic nature of the large-scale farms (LSFs) and small-scale farms (SSFs) making up its agricultural sector. Medium-scale farms (MSFs) also operate in the country.

LSFs occupy 12–15 percent of the land currently under cultivation. In Tanzania, these farms are defined as those with area greater than 50 ha (Mrema 1991; TSAE 1974; Shetto 2016). Most range between 50 and 2,000 ha, with a few as large as 10,000 ha. The LSF subsector produces cash and food crops often linked to downstream agroprocessing value chains, including coffee, sisal, tobacco, pyrethrum, flowers and horticultural products,
tea, maize, rice, wheat, dairy, beef, and sugarcane (Mayne 1955; World Bank 1961; Tanzania, MFEP 1988; BoT 2015). Around the time of Tanzania’s independence, the LSF subsector was dominated by settler farmers and transnational corporations. During the 1970s and 1980s there was an increase in state-owned and -operated farms, though the private sector continued to dominate. After the ESAPs of the 1990s, most of the state farms were privatized.

Although MSFs and LSFs own most of the mechanically powered agricultural machinery in use in Tanzania, LSFs are particularly mechanized and have consistently owned more than 50 percent of the 4WTs in the country at any given time (Hall 1968; TSAE 1974; Fear 1976; Mrema 1981, 1991). Most LSFs have a fleet of 4WTs complete with different accessories and may also hire out specialized machinery such as combine harvesters. Some LSFs offer machinery hiring services to MSFs on a contract farming basis.

MSFs are defined as those with 10–50 ha of land. They typically own new 2WTs and sometimes new or used 4WTs, along with different accessories. For MSFs that do own 4WTs, it is unlikely that they are fully used on the farm because they are often hired out to SSFs or used in nonfarm activities such as transportation. In instances where there are nearby THSs, MSFs may opt not to purchase such equipment and instead to rely on hiring services.

The SSF subsector is estimated to occupy up to 70 percent of the cultivated arable land in Tanzania and is split into two subgroups—peasant subsistence farms (PSFs) and small-scale commercial farms (SSCFs). PSFs produce largely for subsistence, whereas SSCFs produce for both subsistence and the market. It varies somewhat by region and population density, but generally PSFs are defined as cultivating 1–2 ha of land, whereas SSCFs operate on 4–10 ha. Improvements in infrastructure and market linkages are normally what help a PSF to grow into an SSCF.

When available, SSCFs typically use DAP or tractors for land preparation. However, some other tasks, such as planting maize, harvesting paddy, and shelling and threshing may also be mechanized. SSCFs either own or hire draft animals and 2WTs, and hire 4WTs. A few SSCFs may own 4WTs bought secondhand, in which case they likely offer THS to other SSCFs and to PSFs.

PSFs typically rely on family labor and HTT for all land preparation and crop husbandry tasks. This includes primary tillage and hoeing, planting, weeding, harvesting, and postharvest processing such as shelling or threshing. PSFs may hire DAP or tractors for land preparation to break the hardpan if they have nonfarm income and the hiring cost is affordable.
Regional Variations in Mechanization Patterns

DRAFT ANIMAL POWER AND TECHNOLOGIES

DAP has been promoted in Tanzania for more than a century; however, its adoption has largely been confined to six drier regions in the northwest of the country: Shinyanga, Mara, Singida, Manyara, Tabora, and Mwanza. In 2005, these regions had about 83 percent of the 1.4 million draft animals in use, and the situation was largely unchanged as of 2015 (Figure 14.2) (Tanzania, MAFC 2006, 2015). These are also the regions where farmers have a tradition of both livestock and crop husbandry. Thus, the use of draft animals for tillage and transport services is especially important to those farmers who engage in both types of activities. Cultivation of cotton and tobacco, which as cash crops have greater market and institutional support, has also played a key role in advancing DAP in these regions.

The remaining 17 percent of DAP use is spread over the other 19 regions of mainland Tanzania. There are several factors limiting DAP use across the country. Unlike in the six drier regions mentioned above, tsetse flies are present throughout most of the country and as a result, a livestock husbandry tradition is relatively absent. Furthermore, the heavy soils found in many parts of the country make it necessary to use two or three pairs of oxen for tillage, increasing the investment and training costs of the process. Finally, where the window is short for using animal traction, feeding costs for draft animals (either purchased feed or biomass, which is equivalent to up to a few metric tons per year per farm) outweigh the benefits of owning them (Baudron et al. 2015). These factors may also explain why 2WTs may be more widely used than DAP for tillage and puddling, even though these operations alone can be done more cheaply by DAP than 2WTs, as was witnessed in Mbarali district in Mbeya (Babu 2017).

In addition to these issues, there are factors that suggest DAP use will not gain prevalence even in the long term. Increasing demand for livestock products and the high costs of keeping livestock for draft purposes reduce its appeal (Tanzania, MAFC 2015; Mrema 2016). Also, because DAP is almost always employed at full capacity, families owning draft animals do not hire them out to others. Thus, DAP’s role in the machinery hiring market is limited and likely to remain so. Finally, young Tanzanians tend to view DAP as an outdated technology that should not be used in the 21st century. This idea is reinforced by the rapid pace of technological transformation that has been seen in other sectors, such as information and communication technology, and transportation.
MECHANICAL POWER

Various types of mechanical technologies have been adopted in Tanzania, albeit with regional heterogeneity. These include tractors, motorized pumps and other water lifting devices, motorized harvesting and postharvest processing equipment such as combine harvesters and thresher, and grain milling equipment. The following section will discuss some of these technologies in more detail.

Tractors

The types of tractors in use in the country include traditional two-axle 4WTs in either the two-wheel drive or four-wheel drive version; low-horsepower 4WTs developed specifically for developing countries; and the power tiller, or 2WT.
In the 1970s and 1980s, tractors designed specifically for agriculture in developing countries were brought into Tanzania. Most notable of these was the Swaziland-designed and -manufactured Tinkabi tractor, more than 500 of which were imported to Tanzania during the mid-1980s. However, these types of tractors were largely failures, and experimentation with them was stopped by the mid-1990s (Holtkamp 1989, 1991; Dihenga and Simalenga 1989).

The use of 4WTs and 2WTs has been growing through THSs, though adoption levels are still low. About 65 percent of 4WT ownership is concentrated in six regions—Morogoro, Arusha, Kilimanjaro, Manyara, Dodoma, and Shinyanga—and the remaining 35 percent is spread over the other 19 regions of the country (Figures 14.2 through 14.4). This regional distribution has not changed much from the years 2005–2015, though the actual number of 4WTs has increased significantly through imports from Asia. In 2005, there were an estimated 7,200 serviceable and operational 4WTs; this had grown to 13,000 by 2014 (Tanzania, MAFC 2016). The quality of the fleet is unclear, however, with a 2005 national survey finding that 73 percent of units were more than 15 years old, which is well beyond the design life of a 4WT; 35 percent were more than 25 years old, and fewer than 10 percent were less than 10 years old.

Most 4WT ownership is not concentrated in the main grain surplus—producing regions of Tanzania. These regions—Songea, Iringa, Mbeya, and Rukwa—are in the south, whereas the majority of 4WT ownership tends toward northern regions. Anecdotal evidence suggests there is considerable interregional mobility of 4WTs, which could lead to the development of a THS business model focused on specialized land preparation operations. Though detailed information on tractor use by non-owners is not available, THSs with 4WTs appear also to be concentrated in the regions that are well connected with roads, such as Arusha, Iringa, Manyara, Kilimanjaro, Dodoma, and Morogoro, and are linked to Dodoma’s Kibaigwa International Grain Market as well as to cross-border food exports to Kenya. Most 4WTs in Tanzania are old. In 2005, 4WTs more than 15 years old accounted for 73 percent of all 4WTs in the country (Figure 14.5).

The use of 2WTs has also grown in recent years. Importation of 2WTs peaked in 2009, when the government supported the import of more than 2,000 units (Figure 14.6). These were distributed to district authorities throughout the country. The number of imported 2WTs has since declined, though new units continue to come into the country.

In 2015, 51 percent of 2WT ownership was concentrated in six regions: 27 percent of all 2WTs were in Mbeya, 7 percent in Morogoro, 7 percent
in Iringa, 6 percent in Ruvuma, 6 percent in Shinyanga, and 5 percent in Lindi. These regions are generally southern and at relatively high latitudes (Figure 14.7). The remaining 49 percent of 2W Ts were spread over the rest of the country. Three of the six regions where most of the 2W Ts were found (Mbeya, Iringa, Ruvuma) are also among the main regions of southern Tanzania that produce grain surpluses. Surveys undertaken in Mbeya showed that more than 80 percent of the 2W Ts in the region were in a single district—Mbarali—where they were used in rice and maize production as well as in many nonfarm activities such as transportation (Lwesha 2015). The use of 2W Ts for transportation has also been rising in other parts of the country as
the demand for transport has grown, and as the capacity for repair of motorized vehicles and the availability of fuel and lubricants that can benefit 2WTs have increased (Baudron et al. 2015).

The data from Lwesha (2015) also suggest important cross-brand variations in power tiller utilization rates given machine prices (Table 14.1). Although Amec and Siam Kubota brand tractors were obtained at around the same time on average (2009), Amec brands were typically half the price of Siam Kubotas; nonetheless, their average utilization rates did not vary significantly in 2012/2013, indicating that Amec brand power tillers tended to be used more efficiently in economic terms.
**FIGURE 14.5** Age of four-wheel tractors in Tanzania, 2005

![Bar chart showing the age distribution of four-wheel tractors in Tanzania, 2005.](image)

<table>
<thead>
<tr>
<th>Period (years)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(5 yrs or below)</td>
<td>4.9%</td>
</tr>
<tr>
<td>(5–10 yrs)</td>
<td>10.2%</td>
</tr>
<tr>
<td>(10–15 yrs)</td>
<td>11.7%</td>
</tr>
<tr>
<td>(15–25 yrs)</td>
<td>38.1%</td>
</tr>
<tr>
<td>(25–35 yrs)</td>
<td>20.1%</td>
</tr>
<tr>
<td>(More than 35 yrs old)</td>
<td>15%</td>
</tr>
</tbody>
</table>

**Source:** Tanzania, MAFC (2006).

**FIGURE 14.6** Number of two-wheel tractors imported by Tanzania, 2005–2014

![Bar chart showing the number of two-wheel tractors imported by Tanzania, 2005–2014.](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>2WT Imported</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>500</td>
</tr>
<tr>
<td>2006</td>
<td>500</td>
</tr>
<tr>
<td>2007</td>
<td>500</td>
</tr>
<tr>
<td>2008</td>
<td>500</td>
</tr>
<tr>
<td>2009</td>
<td>2,500</td>
</tr>
<tr>
<td>2010</td>
<td>1,000</td>
</tr>
<tr>
<td>2011</td>
<td>500</td>
</tr>
<tr>
<td>2012</td>
<td>1,000</td>
</tr>
<tr>
<td>2013</td>
<td>500</td>
</tr>
<tr>
<td>2014</td>
<td>500</td>
</tr>
</tbody>
</table>

**Source:** Tanzania, MAFC (2016).

**Note:** 2WT = two-wheel tractor.
FIGURE 14.7 Distribution of two-wheel tractors in different regions, 2014

Source: Tanzania, MAFC (2016).
Note: 2WT = two-wheel tractor.

TABLE 14.1 Significant difference in utilization rates per price of machines between Siam Kubota and Amec power tillers in Mbarali district, Tanzania, 2012/2013

<table>
<thead>
<tr>
<th>Category</th>
<th>Siam Kubota</th>
<th>Amec</th>
<th>p-value (null hypothesis of no differences between brands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average utilization rate (hours per year)</td>
<td>633</td>
<td>636</td>
<td>.959</td>
</tr>
<tr>
<td>Average year of purchase</td>
<td>2009</td>
<td>2009</td>
<td>.894</td>
</tr>
<tr>
<td>Average price (1,000 Tanzania shillings)</td>
<td>8,365</td>
<td>3,705</td>
<td>.000</td>
</tr>
</tbody>
</table>

Source: Authors’ analysis based on data in lwesha (2015, appendix).
Combine harvesters

Combine harvesters and other postharvest processing equipment (for example, threshers and shellers) are restricted to the large-scale commercial farms. There is, however, anecdotal evidence of increasing smallholder use of small combines and other equipment from Japan, China, and India. This has helped increase efficiency of harvesting and postharvest operations, and reduce postharvest losses. Unfortunately, there is a lack of information on the extent of use of these technologies in Tanzania, especially with regard to SSFs and farmers cultivating rice (Mrema 2016). Given the fact that the harvesting seasons change from the south to the north sequentially through the year, there is potential that entrepreneurs could invest in and offer commercially sustainable machinery hiring services to farmers, especially those cultivating rice.

Supply-Side Analysis: Sourcing Machinery

Evolution of the Supply Chains for Agricultural Machinery and Implements

Following the end of the Second World War, supply chains for agricultural machinery and implements were established through franchises of major global tractor manufacturers such as Ford, John Deere, Massey Ferguson, and Fiat. Although initially intended to supply agricultural machinery, implements, and equipment to the 1 million-acre GGS in southern and central Tanzania, they also supplied the emerging LSFs in the north of the country as well as the eastern and southern highlands regions (Mayne 1954, 1955, 1956; Lord 1963; Mrema 1981, 1991; Burch 1987). The farmers purchasing the equipment were largely European settlers and sisal plantation owners, as well as a few African and Asian yeoman farmers.

The franchises were all managed by private firms, some of which were Tanzanian-owned (such as KJ Motors, which sold John Deere tractors) and some of which were part of multinational corporations (MNCs). For example, Farm Machinery Distributors sold Massey Ferguson tractors and Riddoch Motors sold Ford tractors—both were owned by Lonrho. Other companies in the market included Incar, which managed Fiat tractors, and Gailey & Roberts, which sold Caterpillar crawler tractors.

These companies dealt with agricultural machinery in addition to other equipment and vehicles, and were generally regarded as being quite efficient. Even as Tanzania gained independence and adopted socialist policies,
these companies were not nationalized. However, in 1978 the two companies owned by Lonrho were nationalized, allegedly due to the MNC’s actions against liberation efforts in southern Africa. The only state-owned company in the sector prior to this was Agricultural and Industrial Supplies Company, which sold International Harvester tractors (TSAE 1974). The supply chains that these companies created served individual farmers (MSFs and LSFs), state-owned farms, and other THS providers such as cooperatives and ujamaa villages.

In 1982, TRAMA (Tanzania Tractor Manufacturing Company) was established as a joint company that assembled Finnish-made Valmet tractors. By the mid-1980s, the Tanzanian economy was in a recession, and with the implementation of the ESAPs there was a decline in interest in mechanically powered mechanization and an increase in prioritization of appropriate technologies. The number of tractors being imported declined appreciably throughout the late 1980s and the 1990s, and this led to the collapse of the franchises that had been established in the 1960s (Tanzania, MAFC 2006; Mrema 2016). In 2005, when the government reactivated its programs in agricultural mechanization following the TAMS, new companies and players emerged that are now managing the supply chains for agricultural machinery and implements (Tanzania, MAFC 2006; Agyei-Holmes 2014; Mrema 2016).

Import and Domestic Policies

The TAMS, developed through Food and Agriculture Organization and United Nations Industrial Development Organization assistance, rekindled the government’s interest in agricultural mechanization (Tanzania, MAFC 2005, 2006; Mrema 2016). Following the TAMS, major mechanization policies have included trade and import policies (tariffs, direct restriction), promotion policies (subsidies), concessional loans, licensing, subsidies on parts, and policies affecting financial support for machinery purchases and inputs. Manufacturing of agricultural machinery and implements in Tanzania is limited, and supply is largely sourced through imports. Import tariffs have therefore been waived by the government to reduce importer costs and increase affordability for farmers. Consequently, agricultural machinery and implements are exempt from import duties as well as value-added tax (VAT). Additionally, for imported farm machinery and implements, dealers are at liberty to import spare parts equivalent to 10 percent of the value of the good with no import duties or VAT imposed—duties and taxes apply only beyond this 10 percent.
Recent Government Support Initiatives

Concessional loans and grants secured by the government have played a significant role in increasing imports of agricultural machinery and implements. Other initiatives have included the establishment of an agricultural window at the Tanzania Investment Bank to help farmers access loans for agricultural investments and subsidies for 2WTs under the Agricultural Sector Development Strategy, or ASDS (Tanzania, MAFC 2001), which make machinery affordable to both owners and those who hire the equipment. The subsidy initiatives are aimed at creating profitable markets for machinery dealers and distributors of farm machinery, especially within the 2WT subsector. The subsidies have also encouraged the establishment of farm machinery hiring services at the regional, district, and local levels. Similarly, the Japanesefunded 2KR program and the UK’s Research Into Use program supported the development of 2WT mechanization through the provision of grant subsidies of up to 50 percent.

Between 2010 and 2011, a $40 million concessionary credit obtained from the Indian government was used to import and distribute 1,800 units of 4WTs to farmers. This was supervised by the state-operated National Service Corporation Sole Agri-Machinery Project (SUMA-JKT). Homegrown policies such as Kilimo Kwanza (Agriculture First), targeting agricultural growth and transformation, have also been critical for mechanization (Mgeni and Yustin 2014). One of the five initiatives under Kilimo Kwanza was the promotion of agricultural mechanization through the Ministry of Agriculture, Food Security, and Cooperatives, with public–private partnerships also expected to play a role. It covered activities that accommodated small-scale mechanization using 2WTs and 4WTs to facilitate commercial production. In response to the Kilimo Kwanza policy, the Agriculture Inputs Trust Fund (AGITF) redirected its efforts toward supporting the purchase of farm implements and tractors. Financed by the central government, the AGITF provides credit to farmers on concessionary terms to procure farm machinery (Agyei-Holmes 2014).

The creation of the Private Agricultural Sector Support Trust and the revamping of the AGITF, plus the establishment of the Tanzania Agricultural Development Bank in 2015, have also facilitated farmers’ ability to acquire loans for machinery purchases by easing some bottlenecks of credit access,

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1 Dollar figures are US dollars throughout the chapter.
such as the inability of farmers to develop business plans and the unavailability of collateral.

**Public–Private Sector Collaboration**

Government and private-sector dealers are actively engaged in importing a wide range of farm machinery. The volume of imports by the government has at times been large, but supply has been erratic. On the other hand, imports through the private sector have been relatively small but constant over time (Agyei-Holmes 2014). Pre-2008, the number of units of 4WT imports through the private sector hovered at around 500 units per year. Total imports increased markedly, to 1,960 and 3,183 in 2010 and 2011, respectively, as a result of central government involvement. Although government participation can help to bridge supply gaps, it sometimes outcompetes the private sector; for example, the lower prices caused by subsidies can crowd out private firms (Lyimo 2011).

Trade liberalization policies have removed restrictions on the types of machines private businesses can import, provided they meet quality standards (Kazungu 2009). This has encouraged numerous private-sector actors to participate in the supply chain and led to a proliferation of the types and brands of tractors imported. As of 2012, there were 10–12 major and 30 minor companies engaged in the farm machinery import market. However, on an individual basis, each of these major companies imported fewer than 50 units per year (Mundial 2012). Limited volumes of imports result in high unit costs that tend to be passed on to the farmer. These cost challenges are exacerbated as import markets widen with new suppliers such as China and India entering the market (Agyei-Holmes 2016).

In the past, a greater proportion of farm machinery imports came from Europe, where quality standards were usually guaranteed. However, the cheaper imported tractors from China and India have captured a larger share of the market (Agyei-Holmes 2016). Also, private-sector dealers often fail to ensure that imports are accompanied by the necessary spare parts, which has dire consequences for the end user. This suggests the need for a stronger role of government in regulation in order to avoid negative externalities for the rest of the private sector (Mkubwa, Mtengwa, and Babiker 2014).

**Domestic Machinery Manufacturing, Standards, and Regulations**

Tractors are usually imported together with their accessories. Despite the dominance of imports in supplying these parts, the government continues to support domestic development of prototypes of machines and equipment
through the Centre for Agricultural Mechanisation and Rural Technology (CAMARTEC). CAMARTEC has the responsibility to develop, redesign, and modify imported machinery to match local needs. Additionally, CAMARTEC has a regulatory function that makes it responsible for testing imported tractors and farm machinery implements to determine their suitability for local use.

In addition to CAMARTEC, there are also private local manufacturers that produce some of the less complex farm implements, such as rippers and subsoilers. Examples of these include Nandra Engineering Company Ltd., Seaz Agricultural Equipment Ltd., and InterMech Ltd. (Mkoga 2010). A recent phenomenon has been the expansion of private companies that are involved in the testing of prototypes and assembly of 2WTs and 4WTs. An example, albeit on a small scale, is a private firm in Mwanza region that assembles Victoria power tillers.

Collaboration with foreign firms through licensing agreements for the local assembling of tractors has also occurred in the past. In the 1980s a licensing agreement was reached between the government and the Finnish company Valmet Tractors, which resulted in the assembly of 2,300 tractor units (Simalenga 1989). However, by the end of the 1980s the assembly plant had difficulties competing with imports and eventually closed. More recently, negotiations have taken place with Iran Tractors and M&M Tractors regarding the possibility of manufacturing tractors locally. In 2016, a contract was concluded between Ursus and SUMA-JKT, with the former company expected to supply 2,400 units of “semi-knocked-down” (that is, partially assembled) tractors to SUMA-JKT. This contract will involve some level of local assembling, though on a limited scale (Ursus 2016).

Ownership and Mechanization Hiring Services
Although the government intervened heavily in tractorization through THSs during the 1960s to the mid-1970s, its role has gradually diminished since then. Since the early 2000s, THSs in Tanzania have been predominantly operated by the private sector, with the public sector–owned and –operated THSs controlling less than 20 percent of the tractor fleet. More than 90 percent of tractor-owning farmers now provide THSs.

LSFs normally procure new 4WTs and use them for 5–10 years before depreciating them for tax purposes and selling them to either MSFs or SSCFs, or to other freelance THS operators. In surveys of operators who offer THSs using 4WTs, a significant proportion indicate that they procured their tractors secondhand either from public-sector THSs or from LSFs and MSFs that
have sold them off. Furthermore, many of these operators have previously worked for the public-sector THS or the MSFs and LSFs. This suggests that the role of the public sector and the LSF and MSF sectors in building capacity and facilitating the procurement of secondhand machinery and implements to freelance operators, who then go on to offer machinery hiring services to smallholder farmers, has been underestimated (Lwesha 2015; Mrrema 1991, 2016).

TRACTOR HIRING SERVICES IN FOUR CASE STUDY DISTRICTS
This section briefly describes key characteristics of agricultural machinery hiring services in Tanzania, based on case studies in four districts (Shetto 2016; Mrrema 2016). Selected districts are Mbarali district in Mbeya region, Kiteto district in Manyara region, Kongwa district in Dodoma region, and Mvomero district in Morogoro region, which all represent different parts of the country. In Mbarali, irrigated paddy production is relatively common and 2WTs and 4WTs are commonly used. LSFs coexist with MSFs and SSCFs, and several cooperative and private-sector organizations have set up marketing and agroprocessing industries—for example, the Raphael Group, which won the 2015 European Marketing Research Center Africa Enterprise Award (EMRC 2016). Kiteto has a long tradition of mechanized agriculture due to the settlement schemes of the 1960s that led to several private and state-owned LSFs. It is anchored on a maize value chain linked to the Kibaigwa International Grain Market, Arusha City, and Kenya. Kongwa is also anchored on a maize value chain, linked through good roads and railways to the Kibaigwa International Grain Market, Dodoma Municipal Council, Dar es Salaam, and other major areas such as Mwanza and Morogoro. Finally, the sector in Mvomero is built around a combination of rice, fruit, and vegetable value chains and is linked to the large Dar es Salaam and Morogoro markets.

Table 14.2 shows the number of tractors and implements in 2015 in these four districts. There were a total of 1,630 4WTs in these four districts, which accounted for about 12 percent of all functioning 4WTs in the country at the time.

Three of these four districts were considerably more mechanized relative to the rest of Tanzania (Figure 14.8). The shares of the cultivated arable area in the districts prepared by tractors in 2015 were 78 percent in Kiteto, 65 percent in Mbarali, and 58 percent in Kongwa. Only in Mvomero was the share closer to national levels, at 16 percent (Tanzania, MAFC 2016; Shetto 2016).

Most tractor-owning farms surveyed in these four districts were MSFs or LSFs (Figure 14.9). Figure 14.10 shows the farm sizes of 2WT and 4WT
owners in Mbarali district, which had the most 2WTs in Tanzania. Typically, 2WT owners have farm sizes of 4–8 ha and rarely own more than 20 ha of land. Though 4WT owners in Mbarali district had relatively more variable farm sizes, most owned less than 40 ha and therefore fell under the MSF category.

Other key characteristics of the owners of 2WTs and 4WTs in Mbarali district suggest that 2WT owners were slightly younger than 4WT owners. A considerable share—about 40 percent—of 4WT owners had a university or vocational college education. Finally, most 2WT and 4WT owners were engaged in other income-earning activities, including artisanal and nonfarm business activities.

HIRING SERVICE BUSINESS MODELS

Three hiring service business models were identified through the survey: individual ownership, cooperative and joint ownership, and enterprise ownership.

### TABLE 14.2 Number of tractors and implements in surveyed districts, Tanzania, 2015

<table>
<thead>
<tr>
<th>District</th>
<th>Tractors</th>
<th>Plows</th>
<th>Harrows</th>
<th>Trailers</th>
<th>Planters</th>
<th>Combine harvesters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kongwa</td>
<td>735</td>
<td>650</td>
<td>32</td>
<td>490</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Kiteto</td>
<td>357</td>
<td>342</td>
<td>20</td>
<td>252</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Mbarali</td>
<td>310</td>
<td>300</td>
<td>130</td>
<td>278</td>
<td>—</td>
<td>57</td>
</tr>
<tr>
<td>Mvomero</td>
<td>228</td>
<td>115</td>
<td>92</td>
<td>105</td>
<td>26</td>
<td>13</td>
</tr>
</tbody>
</table>

**Source:** Shetto (2016); Mrema (2016).

**Note:** — = data not available.

### FIGURE 14.8 Level of mechanization in the four case study districts, Tanzania, 2015

- **% area cultivated tractor**
- **% area cultivated animal traction**
- **% area cultivated hand hoe**

**Source:** Shetto (2016); Mrema (2016).
FIGURE 14.9 Size of farms operated by four-wheel tractor owners in the case study districts, Tanzania, 2015

Source: Shetto (2016); Mrema (2016).

FIGURE 14.10 Size of farms in Mbarali district, Tanzania, farmed by tractor owners in 2013

Source: Shetto (2016); Mrema (2016).
Note: 2WT = two-wheel tractors; 4WT = four-wheel tractors.
Individual ownership—Farmer-tractor-owner hiring service providers (4WT and 2WT)

The most commonly found business model is the farmer-tractor-owner custom hiring service. MSFs and LSFs that own 4WTs provide custom hiring services to other farmers in their locality and sometimes outside their districts. Data obtained from district offices show that about 92 percent of tractor owners provide THSs, ranging from 75 percent in Kongwa to 100 percent in Kiteto. Kongwa district has one of the largest concentrations of 4WTs in the country and a similarly high concentration of THS providers. However, some LSFs that own tractors in Kongwa use tractors more for the farm and less for THSs. Shares of tractor owners providing THSs are also high in districts without data from district offices, such as Mvomero, at 97 percent, and Mbarali, at 88 percent (Shetto 2016).

Shetto (2016) described the nature of farmers who were also THS providers, based on a survey of selected service providers. About half of 4WTs were secondhand, and most had been bought outright; furthermore, about half of interviewed 4WT owners also owned trailers. Many tractor owners interviewed were involved in both farming and the provision of THSs to neighboring farmers (Shetto 2016). Typically, 4WTs were used for plowing and transportation, and about 62 percent of the owners hired out their tractors, mainly for transportation,2 and 38 percent used their trailers exclusively for their own farm activities. The size of the 4WTs generally varied from 20 hp to 80 hp, with 61–80 hp being the most common sizes (Bymolt and Zaal 2015). Lower-horsepower 4WTs were preferred in areas where the soils are light, whereas larger 4WTs were preferred where heavy clay soils are dominant and where tractors are used for plowing paddy and sugarcane fields.

Almost 40 percent of the interviewed hiring service providers were found to serve clients more than 100 km away, and movement of combine harvesters was particularly extensive, with some owners traveling up to 600 km. However, about 60 percent of respondents provided hiring services only to nearby villages and did not travel to other districts (Shetto 2016). There is an advantage to providing hiring services to multiple areas, because the variation in preparation and planting seasons that exists across the country helps

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2 Some respondents indicated that there is high competition with other modes of transport such as ox carts, power tillers, and small trucks (of 3–5 tons). Ox carts and power tillers are preferred by some farmers with small farm sizes because the small harvested crop volume makes them more cost-effective and they can easily move around in areas with poor infrastructure, as compared with 4WTs. Small trucks constitute increased competition in areas with improved infrastructure, especially for ferrying produce to markets over longer distances.
overcome the fact that most seasons last only 30 days or less (Simalenga 1989; Simalenga and Have 1992).

The land preparation and planting seasons range from October/November in the most southern areas of the country (Mbeya and Songea regions) to March in the most northern districts (Arusha and Kilimanjaro). This creates a six-month period during which tractors can be fully engaged if they are moved around, and offers benefits to those farmers who provide services outside of their own district. From October through March, there are two distinct periods of 4WT movements. The most movement occurs from October through December, during which time 4WTs are moved to Kiteto, Kongwa, Kilosa, Kilindi, Morogoro, Kilombero, Iringa, and Mbarali. From January through March, some 4WTs travel to Morogoro, Mvomero, Kilindi, and Handeni.

Ownership of a 4WT has benefits through both personal crop production and profits from providing THSs. For most tractor owners, revenues from crop sales are much greater than revenues from THSs (Shetto 2016). Therefore, in order to encourage continued private provision of THSs it is important that this service be profitable. The average cost of a 4WT plowing operation is $15 per hour, with fixed costs accounting for 29 percent of the total operational costs. Variable costs comprise fuel (58 percent), labor (21 percent), and repairs and maintenance (20 percent). Farmers report that they rarely consider fixed costs when examining their operational costs, because fixed costs do not involve direct cash transactions. Shetto (2016) conducted a profitability analysis and a gross margin analysis that showed that 86 percent of surveyed THS providers were profitable, but the remaining 14 percent were not. About 30 percent had gross margins ranging from $238 to $950 per year, 36 percent had gross margins between $950 to $2,300, and 20 percent had gross margins greater than $2,300 (Shetto 2016).

Anecdotal evidence and data from several studies has indicated that the profitability and sustainability of THSs are dependent on the farmer’s ability to generate nonfarm work, especially during the off-season. Reports indicate that just 400 of the 1,000 recommended annual utilization hours for 4WTs can be obtained from land preparation, crop, and husbandry activities during the main cropping season. The remaining 600 hours come from nonfarm work, work in other parts of the crop production value chain (such as postharvest work in shelling, threshing, and transportation), or providing THSs in other parts of the country, where the cropping season is different (Simalenga and Hatibu 1994; Mpanduji 2000; Federico 1999; Lwesha 2015; Mrema 2016).
Many farmers also provide THSs for 2WTs, which have been studied through the Farm Mechanization and Conservation Agriculture for Sustainable Intensification (FACASI) project. This project focused on 2WT hiring services in Arumeru, Mbulu, and Babati, all districts where farm households owning between 0.2 and 0.8 ha are engaged in maize- or legume-based farming systems. The FACASI survey identified around 117 2WT THS providers operating in these districts, typically using Chinese-brand 2WTs with 16–18 hp (Kahan and Titus, forthcoming). Around half of the 2WTs were bought by farmers through direct payment, and the other half relied on government loans provided on concessionary terms. The 2WTs in these districts were found to offer services for plowing on small, fragmented plots, as well as for shelling and transportation (Kahan and Titus, forthcoming).

Although 2WTs are used for plowing, their limited power means that this can be quite difficult, especially if soils are hard and dry. For this reason, government-promoted 2WT service centers have had relatively little success. Some 2WTs were originally introduced for minimum tillage operations with the combined ripper-seeder technology. However, most smallholders—even when exposed to conservation farming—prefer to plow their soils, which is often difficult with the limited power of 2WTs (Bymolt and Zaal 2015).

However, there may be more potential for increases in 2WT THSs for transport purposes. In Mvomero district, for example, both 4WTs and 2WTs are gradually replacing ox carts for transporting building brick and for gathering firewood. Cost–benefit analyses have been conducted that support this view. Agyei-Holmes (2014) found that among 225 sampled owners of power tillers and tractors across five regions, more than half used their machines to provide transportation services in order to bring in extra income.

The typical customers of 2WT hiring services are small farmers on landholdings of between 0.1 and 2.0 ha. Providers of 2WT services obtain the highest profits from shelling, followed by transportation, and then plowing operations. The typical annual number of customers for shelling is 200, but it is just 30 for plowing operations. These data are consistent with the hypothesis that the viability of the 2WTs is enhanced by expanding 2WT use beyond time-bound and potentially difficult land preparation activities to include activities such as shelling and milling operations, and transport. There is also evidence to show that 2WT service providers earn higher levels of profit in maize-based systems.
It is noteworthy that among some of the 2WT service providers there is a move to expand their fleet and purchase 4WTs. The provision of 2WT hiring services often represents an initial stage in motorized mechanization, giving service providers experience in machinery use and the hiring service business. The smaller 2WTs are more affordable than 4WTs, but most 2WT THS providers aspire eventually to buy the larger machines (Shetto 2016; Kahan and Titus, forthcoming). Another study, in Babati district in Manyara region, also suggested the higher efficiency of individual-owner THSs for 2WTs, compared with group-owner THSs (Mbesa 2017).

Cooperative/group farmer model
Another THS business model is the cooperative/group farmer model. Many of the THSs provided by cooperatives that were promoted in the 1960s and 1970s were not successful, including the World Bank–supported cooperative-owned THSs (Collinson 1963; De Wilde 1967; Adhola-Migot 1969; TSAE 1974; Alcober et al. 1983; Mrema 1991). However, there has recently been some recurrence of this type of provider, with two main types of cooperative and joint ownership models emerging. First, there are farmer groups that have been encouraged by the government to apply for tractor loans to ease the individual burden and encourage higher capacity utilization of tractors. Second, there are cases of two or three individuals coming together to procure a tractor for their own use and to hire it out to other farmers.

In the Dakawa Irrigation Scheme, a 2WT is owned by a group of about 20 farmers who share a communal plot of 8 ha in addition to their own individual farms. Land preparation with the 2WT is prioritized for the communal plot, after which farmers hire the mechanization services for their individual landholdings. Group members contribute to the running and maintenance costs of the tractor as well as fees for servicing the loan used to procure the machine. In another example, from Mbarali district, a group of farmers came together to create a partnership and raise funds to buy a tractor. They cultivate an area of 16 ha divided into four plots, with each plot owned by a different farmer. During the land preparation season, the tractor works on each of the four plots in turn. After work is completed on the group members’ farms, they then hire the machine out to other farmers who want the service.

Despite positive anecdotal evidence, the management of shared property is sometimes difficult, especially when the size of the group increases and group members have significantly different farm sizes, and this may discourage cooperative ownership.
Enterprise ownership of the hiring service

Finally, some THSs are provided through enterprise ownership business models. These include contract farming, commercial farming, and machinery dealer hiring services; however, compared with the other THS types, these enterprise models are generally less common.

Under the contract farming arrangement, private companies, commercial farms, and agroprocessors enter into contracts to provide guaranteed markets to producers and increase the accessibility of inputs and mechanization services on credit terms, in exchange for committing the harvested crops. For example, Arusha-based Quality Food Products Ltd. (QFP) operates contract farming on about 20,000 ha of maize, safflower, sunflower, and beans in several districts of Manyara and Singida regions. QFP provides machinery hiring services for planting with direct seeders, spraying, and harvesting, along with financing for inputs.

In areas where the land is very heavy and difficult to till with small tractors, some LSFs either have outgrower relations with smallholder farmers (especially in the sugar-growing areas) and provide mechanization services for their land preparation and harvesting, or they hire out portions of their land to small farmers and charge a fee for plowing, leveling, and the supply of irrigation water (Agie-Holmes 2014).

A few agricultural machinery dealers have started providing machinery hiring services to targeted customers. The Tanzania Farmers Service Centre provides hiring services for combine harvesters to a few LSFs in Arusha and Kilimanjaro, and Tractors Ltd. and Agricom Ltd. provide services to specific customers. In another example, a company known as Unitrans has been contracted by Kilombero Sugar Company to provide machinery services at its sugar estate farms (Shettoo 2016).

Financing of tractors and the growth of spare parts and repair markets

The majority (62 percent) of respondents to the survey acquired their tractors through cash financing from their own equity; 23 percent acquired them through machinery dealer agreements, about 13 percent obtained loans from the AGITF, and only 4 percent got loans from commercial banks. This is despite the government-led facilitation of low-interest loans for agricultural machinery through the AGITF, the Tanzania Investment Bank, and the Tanzania Agricultural Development Bank. As in other African countries, loans from commercial banks are rarely used for the purchase of agricultural machinery. The TAMS survey and other studies have shown that a significant
The proportion of the 4WTs owned by farmers and private operators were obtained from the public sector as secondhand units bought for cash, whereas only 3 percent of respondents purchased them through credit.

The accessibility of fuel, lubricants, and repair services was deemed satisfactory, with more than 85 percent of tractor owners reporting that they could source those inputs and services within 5 km of their location. Repair and maintenance services are mainly provided by mechanics in small garages found in various townships and village centers. Mobile mechanic services are also available when tractors are operating in places far from their homes. Spare parts are mainly sourced from machinery dealers (sometimes 50–300 km away), because spare parts traders usually have limited stocks. In districts where 2WTs are relatively common (such as Mbarali), 75 percent of 2WT owners travel less than 30 km to get spare parts because they can be obtained from dealers serving the large motorcycle transportation sector (Figure 14.11). In contrast, 85 percent of 4WT owners in Mbarali district travel more than 100 km to get spare parts, suggesting heterogeneity in the spare parts market for 2WTs and 4WTs.

FIGURE 14.11 Distances from home to shops selling spare parts, Mbarali district, Tanzania, 2013

<table>
<thead>
<tr>
<th>Distance in kilometers</th>
<th>2WTs (%)</th>
<th>4WTs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 30</td>
<td>75.4</td>
<td>4.8</td>
</tr>
<tr>
<td>30–100</td>
<td>15.8</td>
<td>9.6</td>
</tr>
<tr>
<td>Over 100</td>
<td>8.8</td>
<td>85.6</td>
</tr>
</tbody>
</table>

Source: Shetto (2016); Mrema (2016).
Note: 2WTs = two-wheel tractors (power tillers); 4WTs = conventional four-wheel tractors.
Effects of Mechanization on Agricultural Transformation

This section offers some insights into the effects of mechanization. A few of the key issues are its effects on agricultural transformation (farm size dynamics, productivity effects, and use of other modern inputs), labor markets, and to a lesser extent gender roles in farming and the environment.

In Tanzania, the ASDS has provided a long-term strategic framework for the development of the agricultural sector. The ASDS specifically stipulates that agricultural mechanization services will be provided largely by the private sector and should be one of the engines driving agricultural transformation. The evidence suggests that many farmers in rural areas, including the most vulnerable, have benefited substantially from THSs (Agyei-Holmes 2014).

Effects on Farm Size

In the four districts described in the previous section, accessibility of farm power was associated with a greater area cultivated by non-owners of tractors (1.6–2.0 ha, compared with 0.4–0.8 ha) (Shetto 2016). Those farmers who relied on draft oxen hiring only managed an area of between 0.4 and 0.8 ha. In Mbeya region, farmers who cultivated 2 ha of paddy rice before the introduction of 2WTs were found to cultivate around 8 ha after 2WTs became available (Agyei-Holmes 2014).

Similarly, a study in two districts (Kilombero district in Morogoro region and Mbarali district in Mbeya region) suggested that for a significant share of interviewed farmers, use of 2WTs was associated with greater area cultivated (Mmari and Mpanduji 2014). In particular, within the public irrigation schemes, some rice farmers increased their area from 1–2 ha to 2–5 ha. Farmers attributed this to the possession of power tillers and tillage implements such as plows and rotavators.

Generally, farmers expand their farm size once they acquire a tractor, but cannot fully utilize the capacity of the tractor on their own farms (Bymolt and Zaal 2015). For instance, in the Mbarali district 2WT owners use less than 30 percent of the capacity of their machines per year (Agyei-Holmes 2014). Thus, tractor owners have to extend their services to other farmers to enable the machines to work enough hectares to justify their cost. Tractor owners who work smaller areas on their own farms provide more THSs to other farmers, whereas those who work larger areas provide fewer THSs. Those farmers who invest in buying tractors and those who hire out their services have both been seen to benefit from increased incomes. Tractor owners realize benefits from increased crop production as a result of cultivated land area expansion,
and they also benefit through direct income from the payments for services rendered.

Other case study evidence for the adoption of 2WTs in Babati district has suggested that land size influences the ownership decision. Farmers who own tracts of land greater than 6 ha are more likely to be willing to purchase a 2WT than those farmers who own less than 4 ha, because land can be used as collateral for credit accessibility (Mbesa 2017). This suggests that farm size and tractor ownership are bi-causal. In other words, owning a tractor might encourage the farmer to cultivate larger tracts of land, and at the same time, cultivating large tracts of land might also encourage the farmer to procure or hire a tractor for use.

**Effects on Productivity and on the Adoption of Other Modern Technologies**

Agriculture in Tanzania is primarily rainfed, with less than 4 percent of the cultivated land under irrigation (Kalinga 2001). However, rainfall seasons in many places are characterized as short. This means that the completion of key farming tasks such as plowing, planting, and weeding must be carried out in a short period of time. When using HTT to accomplish these tasks, only a small area of less than 1 ha can be cultivated. Therefore, increased mechanization can help to realize benefits from Tanzania’s available arable land.

Studies based on the 2002/2003 and 2007/2008 Household Budget Surveys suggest that tractor use on farms has been found to correlate with higher yields of maize, beans, and paddy rice in Tanzania (Lokina, Nerman, and Sandefur 2011). Similarly, the use of 2.5-meter-wide combine harvesters by smallholders on rice fields not only reduces harvest losses, but also reduces the harvesting time from three days to three hours for 1 ha of paddy field (Wilson and Lewis 2015). This finding has been corroborated by the Lower Moshi Irrigation Scheme.

With respect to 2WTs, the Mmari and Mpanduji (2014) study showed variable results dependent on agroecological conditions and farming systems. Data provided by district authorities in Mbarali corroborate farmers’ claims regarding increased productivity, especially of paddy. However, in areas with harder soils (particularly in Kilombero district, which accounts for 19 percent of the 237 2WTs found in Morogoro region), 2WTs are rarely used for plowing, and their effect on productivity is found to be limited. Furthermore, in the areas that have found a correlation between 2WTs and productivity growth, it is possible that the productivity improvements are a result of other factors. For example, in Mbarali they may be due to improved ability to
prepare better seedbeds faster. In some cases, extra income obtained from hiring out 2WTs is used to purchase fertilizer, thus considerably increasing the amount of paddy produced per unit area.

Effects of mechanization on overall labor use are mixed. Among Mbarali farmers using 2WTs, greater area cultivated leads to higher demand for hired labor for transplanting. However, though farmers are working with the Mbarali District Council to explore ways of acquiring tiller-powered rice transplanters, for the time being, transplanting remains a manual activity.

The use of 2WTs seems to reduce transportation costs by substituting tractor transport for manual transportation and other, costlier transportation services. Among the respondents in the Mmari and Mpanduji (2014) study, 91 percent of the Kilombero farmers and 80 percent of the Mbarali respondents using 2WTs reduced their transport costs as a result of tractor transport accessibility.

In terms of mechanization’s impact on adoption of other technologies, such as improved seeds, planting in lines, improved seed rate, and chemical fertilizer use, there is limited empirical evidence in the Tanzanian context. A few exceptions include one by Nkonya and colleagues (1998), who studied the adoption of maize production technologies in northern Tanzania over a 20-year period (1974 to 1994). They showed that using tractors instead of ox plows was positively associated with greater use of chemical fertilizer, although differences were insignificant between tractor and hand hoe users.

**Effects on Gender, Feminization of Farming, Labor Markets, and Youth**

The evidence on other socioeconomic effects of mechanization is scarce in Tanzania. However, some insights can be obtained from various case studies.

**Effects on Gender**

The farming activities that Tanzanian women commonly participate in include weeding, tillage and land preparation, postharvest management, and transportation of agricultural produce. A research study conducted by the Royal Tropical Institute explored issues relating to gender and mechanization in East Africa, including Tanzania (van Eerdewijk and Danielsen 2015). The research recognized the dominant position of men within the farming community and identified male-dominated plowing as the most common application of on-farm mechanization. In this respect, increased mechanization for land preparation and plowing was seen to have relatively little direct impact on women’s labor burden.
The major impact on women depends on resource ownership and intra-household dynamics. Due to a complex interplay of values and assumptions, access to and control over resources, and intrahousehold decision-making, women’s high labor burden does not translate into articulated demand for and adoption of mechanization. Intrahousehold power relations and decision-making determine how resources are accessed and allocated across household needs. The research findings showed that women in male-headed households are not given an opportunity to articulate their demand for mechanization in order to reduce labor intensity, because they are excluded from most household decisions (van Eerdewijk and Danielsen 2015). Consequently, access to machinery may not contribute to women’s well-being, unless intrahousehold effects are addressed.

Discussions around 2WTs have also shown that women were willing to adopt this technology as long as they could access financial and information resources. Male household heads were more likely than women to own a 2WT, due to better access to technical information from extension agents (Mbesa 2017). A major shift in the reduction of labor and in access to and control over benefits from mechanization occurs for women who own their own resources, either through formal employment or through owning land (van Eerdewijk and Danielsen 2015). Women’s low level of articulated demand for small-scale mechanization also must be understood within the broader context of low levels of adoption of mechanization in general. This is especially true considering that 2WT adoption is particularly low, and women’s tasks are most likely to require 2WTs (Bymolt and Zaal 2015).

In some cases, however, mechanization may affect women indirectly. Increased production of maize as a result of mechanization is likely to create indirect benefits for women, because they can access more produce that can ultimately be sold in markets. Another indirect benefit is that mechanization of male labor tasks in farming (land preparation and tillage) reduces women’s labor burden because men can help with other, non–land preparation activities (van Eerdewijk and Danielsen 2015). It has also been shown through causal empiricism and key informant interviews that 2WTs have reduced the time spent by families on their paddy fields during the cropping season, meaning that women can return from the farm early and work on household chores or go to the market (Agyei-Holmes 2014). This finding is also confirmed by Shetto (2016). In addition, the multifunctionality of tractors described in the previous section may be an important entry point to mechanization of non-farm women’s tasks (Misiko et al. 2013), though the costs of buying or hiring additional equipment must be taken into account.
EFFECT ON YOUTH ASPIRATIONS

Educated and young people make up the bulk of the rural-to-urban migrants and are motivated by a desire to liberate themselves from the drudgery associated with traditional hand tool–based farming. Data collected in 1990 in Tanzania shows that more than 50 percent of heads of rural households were 45 or older (Tanzania, BoS 1992). In communities in Tanzania where successful mechanized farms have developed over time, youths are more likely to think that the sector presents economic opportunities through commercialization and “farming as a business.” If mechanization is to be further expanded, the users of mechanization technologies cannot be small-scale peasant farmers who are aging. They must instead be young and educated people who can engage in agricultural activities as commercial farmers. This argument is in agreement with the Tanzania Development Vision 2025 (Tanzania, Planning Commission 1999), which states that if agriculture in Tanzania is to be expanded, the current farming community (80 percent of the population) needs to change from peasant-dominated to primarily commercial MSFs (Mpanduji and Salim 2008).

There is some anecdotal evidence of young people making a viable career in farming (Agyei-Holmes 2016). Examples of farmers who have succeeded in commercial agriculture could potentially serve to promote agricultural mechanization through youth engagement. Moreover, mechanization provides many other employment opportunities for youth—as mechanics, machine operators, processors, and transporters—where skilled labor demands can be met.

Key Environmental Effects

Although agricultural mechanization is indispensable for production, it can have detrimental effects on the environmental sustainability of farming through soil compaction and erosion, tillage, and chemical pollution. Soil compaction amplifies harmful physical, chemical, and biological processes, which, when combined with inappropriate soil management, lead to soil degradation. Soil degradation, in turn, can affect the amount of fertilizer and energy used in crop production, and may have additional adverse environmental consequences (Soane and van Ouwerkerk 1994). Though soil compaction is a challenge, it can be mitigated by ensuring that the power source matches the local soil and climatic conditions.

There is currently considerable awareness among policymakers that mechanization must be accompanied by adoption of environmentally friendly techniques in tillage, such as minimum tillage and conservation agriculture. To
this end, mechanization in Tanzania is currently being promoted as part of a sustainable agricultural mechanization strategy (Mrema 2016). If the correct technologies are applied—such as climate-smart agriculture, efficient application of pesticides, precision application of fertilizers, soil compaction management, efficient harvesting, and natural resource conservation—then sustainable intensification can ensue. This has been the experience of the FACASI project, which introduced 2WTs as part of a conservation agriculture–based approach. Combined with adoption of conservation agriculture, 2WTs have a broader impact on soil and water conservation, particularly in areas characterized by steep slopes (Baudron 2014). Furthermore, equipment for seeding and minimum tillage is vital to reduce energy demands and enhance smallholder profitability.

**Conclusions**

Tanzania has seen a slow but steady growth in agricultural mechanization over the past few decades. The country’s mechanization growth trend is fairly consistent with patterns elsewhere, with both agroecological and socio-economic conditions as key determinants of increased mechanization.

The speed of mechanization growth varies across regions. Whereas the share of cultivated area plowed by tractors is still around 14 percent for the whole country, it has reached almost 50 percent in regions such as Arusha, Manyara, Mbeya, and Kilimanjaro. In addition, different types of mechanization are emerging in different regions, indicating the varying needs for each type of mechanization based on heterogeneous production environments. For example, 4WT use is mostly emerging in rainfed maize-legume systems in lower-latitude zones, whereas 2WTs are emerging in higher-latitude zones, where more temperate production technologies such as irrigated rice production are commonly used. DAP is emerging primarily in highland zones.

Within each of these mega-regions, demand for mechanization is linked to the availability of markets for the output of the farming enterprise. Areas that are near major population centers or at least linked to them through improved infrastructure see higher growth in demand. Mechanization demand is also raised by reduced availability of labor in rural areas due to universal primary education, availability of other employment opportunities in industry and services, migration to urban areas, and remittances from relatives in urban areas and outside the country. Although Tanzania is still an agrarian society, the share of the workforce employed in the nonfarm sector has been rising.
steadily, and it recently exceeded 30 percent. At the same time, the urban population is growing at 4–5 percent per year and its population share is expected to rise from 30 percent today to 50 percent by 2030.

The private sector has often led the development of machinery markets and service providers to meet mechanization demand, despite the government’s interventions through THSs, which is consistent with the patterns described in the Asian chapters. Similar to what happened in a country like Ghana, both MSFs and LSFs have emerged as the self-financed owners of 4W Ts, and MSFs have become the major providers of hiring services to other smallholders. Ownership of 2WTs appears to be largely motivated by their multifunctionality, because they can be used not only for land preparation but also for shelling and transportation. Again, this pattern is consistent with the spread of 2WTs in some Asian countries. Though still small in number, combine harvester hiring service providers are emerging following the advent of small Chinese and Indian shellers as well as paddy harvesters. Similar to those in other countries, such as China, some of these service providers are specialized nonfarmers and often travel more than 600 km away from their home to deliver harvesting services.

The lack of available information on mechanization’s impact on agricultural development is a major challenge in Tanzania. In the past, there have been many failures (especially of the public sector–operated machinery hiring services) and some successes, but records of both have been poorly maintained. This makes it difficult to draw lessons from them. Moreover, much of the information available on the supply side and on mechanization’s relationship with agricultural transformation is largely anecdotal and based on case studies. Reference has been made to the TAMS study (Tanzania, MAFC 2006), and this should be taken as the baseline upon which a detailed impact assessment of agricultural mechanization interventions can be built. In addition to the general lack of information, failed agricultural mechanization projects (for example, government-operated THSs) appear to have received more research attention than the successes.

There are several knowledge gaps that need to be addressed in future studies. Despite Tanzania’s transition from a socialist to a capitalist economy, there is a lack of data regarding corresponding changes in issues such as land tenure policy, which may be critical in understanding the relation between mechanization and farm size growth. The role of land tenure policy is also important in view of experiences in Asian countries like Myanmar, where land reform partly led to significant growth in the uptake of bank loans for machine purchase, for which land-use rights could be used as collateral. There is also a
need to identify whether and how government can effectively support the private sector through agricultural finance, training of tractor operators, business management, entrepreneurship and record keeping, demonstrations and exhibitions to reduce information costs, quality control and testing of equipment, and marketing of spare parts in the country. Institutional support can also underpin the formation of tractor owners’ associations that would bring farmers together to discuss issues of common interest and push their development agenda. Importantly, the government does not always have a comparative advantage in providing these supports. Experiences detailed in the Asian chapters also suggest certain dynamics and sequences that make the combination of policies effective. For example, it may be critical to reduce import restrictions in the current system whereby a government agency must inspect all imported tractors, to allow for the importation of a more diverse set of tractors that are “good enough” and affordable. Regulatory measures could be enhanced once the number of tractors in the domestic market is sufficiently high, as was experienced in several Asian countries. Future research should therefore also investigate what role the private sector has played and can play in providing such services.

References


