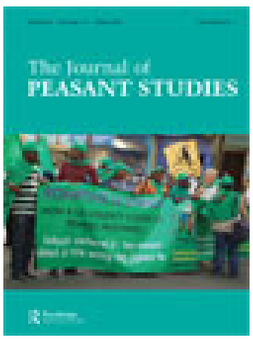

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The resurgence of agricultural mechanisation in Ethiopia: rhetoric or real commitment?

Seife Ayele

Institute of Development Studies, University of Sussex, Falmer, Brighton

ABSTRACT

Ethiopia's agricultural development strategies bypassed smallholder mechanisation for decades. Mechanisation returned to the policy agenda in 2013 but recent pro-mechanisation rhetoric lacks operational commitments. Based on primary and secondary data, this paper traces the policies and policy narratives that have led to low mechanisation, and finds that mechanisation was deprioritised on the grounds that Ethiopia is labour- and land-abundant, but short of capital. With policy encouraging multiple cropping, but farming vulnerable to climate change, the paper argues for the development of a market for mechanisation, including mechanisation service provision through private and cooperative agents, to enhance smallholder access to mechanisation and unleash human energy.

KEYWORDS

Smallholder agriculture; mechanisation; farm power; policy; Ethiopia

Introduction

Smallholder farms predominate in the Ethiopian economy and society and account for over 90 per cent of Ethiopia's agricultural production (NPC 2016). For over a decade, Ethiopia's agriculture has grown by an average 6.5 per cent a year, contributing to reducing poverty and undernutrition (NPC 2016; Ayele et al. 2020). Nonetheless, agricultural production has not reached its full potential (NPC 2016), and millions of Ethiopians remain dependent on either food assistance or social safety net programmes (WFP 2019). Agricultural mechanisation is argued to be a key instrument to reduce harvest and post-harvest losses (some studies, such as Hengsdijk and Boer [2017] put the figure as high as 24 per cent for cereals) and contribute to food security. Mechanisation also reduces drudgery and improves the timeliness and efficiency of farm operations (Kelemu 2015; Mrema, Mpagalile, and Kienzle 2018; Sims, Hilmi, and Kienzle 2016). Mechanical tools themselves, particularly those originating from the global south, have become increasingly suited to Africa both in specification and price (Hanlin and Kaplinsky 2016). Despite this, from the time Ethiopia started implementing development plans and strategies in the 1950s, mechanisation by smallholder farmers in Ethiopia has been sidelined and, over 1991–2013, deprioritised. Consequently, there is a severe shortage of farm power[1] on

CONTACT Seife Ayele s.ayele@ids.ac.uk Institute of Development Studies, University of Sussex, BN1 9RE Falmer, Brighton

[1]'Farm power' refers to the product of one or more of human muscle, animal traction or mechanical device/engine used in agriculture (MoA/ATA 2017).

smallholder farms. In 2014, at the national level, available farm power stood at only 0.5 hp/ha – 50 per cent of the minimum recommended level for optimum operation (MoA/ATA 2014, 2017), causing production constraints such as delays in operations and production losses, leaving Ethiopia far behind other countries, including its close neighbours (MoA/ATA 2014; Berhane et al. 2017).

Why discuss smallholder mechanisation now? There are at least three interrelated motivations. First, as I will show, triggered by smallholder farmers' increased demand for mechanisation[2], it re-emerged as a policy imperative in 2013, and a national mechanisation strategy was launched in 2014 (MoA/ATA 2014). Increased attention has also been given to agricultural mechanisation since Prime Minister Abiy Ahmed came to power in 2018[3], and the African Union recently pledged to 'banish the hand hoe' by 2025 (FAO & AUC 2018). However, Ethiopian smallholder mechanisation has still not received the requisite resources, or institutional and operational commitments. This paper therefore aims to bring this timely challenge to light.

Second, the recent history of mechanisation in Ethiopia – particularly the effect of government policy – has not been coherently documented. Moreover, while some of the literature on farming systems and technical change (e.g. Binswanger and Pingali 1989) has influenced policy making in different moments in Ethiopia's mechanisation history (Zenawi 2017), it has insufficiently accounted for policy's influence on mechanisation policy and strategy in Ethiopia. To address these gaps, the paper aims to provide a fresh synthesis of, and insight into, Ethiopian mechanisation policy and strategy. It discusses narratives and policies that sidelined and deprioritised mechanisation and then brought it back to Ethiopia's agenda and, along with the roles that state, non-state and the private sector play in smallholder mechanisation, considers the benefits to smallholders.

Third, many labour abundant countries like Bangladesh are far more mechanised than Ethiopia (Biggs and Justice 2015; Mottaleb et al. 2017). The paper, therefore, aims to revisit and contribute to the long standing debate on the 'conditions for mechanisation' (Pingali, Bigot, and Binswanger 1987; Binswanger-Mkhize and Savastano 2017).

The core question addressed is, therefore: why have successive Ethiopian government policies and strategies downplayed smallholder mechanisation? What are the consequences for smallholder farms and what lessons can be learnt? The paper draws on theories of induced technical change (e.g. Ruttan and Thirtle 1989) and the literature on farming systems and implications for technical change (e.g. Pingali, Bigot, and Binswanger 1987; Binswanger and Pingali 1989). It also builds on Cabral (2019) and Amanor (2019) and offers a historical perspective on the politics of mechanisation policy in Ethiopia.

The paper is organised as follows. Section two briefly sets out the theoretical reasons for agricultural mechanisation and sketches the history of mechanisation in Africa. Sections three and four outline the methodology and focus of the study, while section five provides a review and synthesis of the literature on Ethiopia's mechanisation history, policy and practice, and the current status of mechanisation. Section six discusses mechanisation development post 2013, the resurgence of mechanisation, and assesses the commitment to it. Finally, section seven offers discussion and the conclusion of the paper.

[2]The trigger was increased demand for *teff*. A combination of seeds and fertilizer inputs, along with row planting, created jumps in yield notably on demonstration plots (Vandercasteelen et al. 2014). However, for millions of farmers, planting *teff* manually in rows became an arduous and time consuming task, leading to a strategy, not just for *teff*, but for broader smallholder mechanisation.

[3]See various reporting, including Bekele (2020), Regasa (2018) and Ethiopian Press Agency (2018).

Theoretical foundations and brief history of mechanisation in Africa

Agricultural mechanisation has been evolving and developing throughout human history (Binswanger 1986; Pingali, Bigot, and Binswanger 1987), and farm tools including the plough and animal power have been in Ethiopia for millennia (see McCann 1995). For many, mechanisation means tractors and combine harvesters, but this is only part of the story. FAO/UNIDO (2008, 1) defines mechanisation as '… the application of mechanical technology and increased power to agriculture, largely as a means to enhance the productivity of human labour and often to achieve results well beyond the capacity of human labour'. In this sense, mechanisation refers to any mechanical aid in agricultural production (FAO/UNIDO 2008), ranging from the application of simple tools (such as animal drawn ploughs) to tractors, and from hand-operated sickles to combine harvesters. Mechanisation also includes irrigation systems, tools and machines in agricultural production – for land preparation, crop and livestock production, harvesting and storage, and non-farm activities such as processing and transport (FAO & AUC 2018). It also covers manufacturing, distribution, and repair and maintenance of farm tools and implements (FAO & AUC 2018). Also key to the understanding of mechanisation is the source of power to operate the variety of machines – humans, draught animals, engines or electric power (Pingali, Bigot, and Binswanger 1987; Kelemu 2015). This paper adopts this broad definition of mechanisation and discusses policies and strategies aimed at smallholders.[4]

In his seminal work, Lewis (1955) was critical of the adverse effect of mechanisation on employment in labour abundant countries. As a labour saving device, he noted, mechanisation reduces the demand for labour in agriculture, and its introduction leads to unemployment (Lewis 1955, 129), although it increases output per worker through extensive and/or intensive cultivation. He thus concluded that '[Mechanisation] is a necessary part of condition of economic growth where labour is scarce, but is only marginally relevant where labour is abundant' (Lewis, 1955: 130). Likewise, work initially theorised by Boserup (1965) and Ruthenberg (1971), and advanced by subsequent research (see, for example, Pingali, Bigot, and Binswanger 1987; Binswanger and Pingali 1989), firmly put the choices of farm tools and implements within the context of the 'evolution of farming systems': forest fallow, bush fallow, short fallow, annual cultivation and multiple cropping systems. Each farming system has different farm operation conditions such as land preparation and planting, fertilisation, weeding and harvesting. During the forest fallow stage, for example, fire is used to clear land, and land preparation and planting uses simple digging sticks. But as a farming system evolves, for example reaching annual and multiple cropping systems, land preparation uses draught animals and/or tractors. According to this theory, a multiple cropping system, in particular, faces high labour demand during peak periods of land preparation, planting, and harvesting (Binswanger and Pingali 1989). The forces that facilitate transition from one farming system to another are population growth and market access (the latter expressed in terms of opportunities such as growing domestic and export markets), growth in incomes and access to infrastructure (Binswanger-Mkhize and Savastano 2017; Binswanger and Pingali 1989). As market access and population grow, farming systems become more labour intensive and a

[4]Mechanisation is understood in the same way in Ethiopia's recent mechanisation strategy (MoA/ATA 2014).

shift to labour-saving devices such as pumps and tractors becomes necessary, but the transition very much depends on the relative cost of labour, machines and other inputs such as fertilisers (Binswanger and Pingali 1989; Binswanger-Mkhize and Savastano 2017). Just like Lewis, the conclusion that emerged from farming systems studies was that where labour and land are abundant relative to capital, mechanisation is the 'wrong' technological priority (Binswanger and Pingali 1989; Pingali, Bigot, and Binswanger 1987).

While these theories broadly hold, specific contexts and conditions – agro-climatic conditions, socio-economic conditions or availability of markets for mechanisation services – facilitate (or prevent) the introduction and growth of mechanisation. A theory that comes under the rubric of induced technical change (see, for example, Ruttan and Thirtle 1989; Ruttan 2002) shows such a condition for mechanisation where, even in the presence of scarcity of one or another input, increased demand for a product could lead to technical change, and also institutional change facilitating the adoption of such technical change. It is also worth noting that, despite its broad definition (above), both in academic circles and practice, mechanisation has been frequently equated with 'tractorisation' which has been unhelpful in terms of promoting tools and equipment that are more suited to smallholders.

As a development agenda, mechanisation has a contested history, particularly in post-independent Africa (Mrema, Mpagalile, and Kienzle 2018; Amanor 2019). It made a positive start in the early 1960s, but between 1975–2010 concerns over mechanisation's adverse effect on employment and the failure of many poorly managed state-run tractor schemes led to either a halt or decline in agricultural mechanisation in Africa (Gass and Biggs 1993; Mrema, Mpagalile, and Kienzle 2018; FAO & AUC 2018).

However, a number of factors brought mechanisation back to the policy agenda in Africa over the past decade. First, global food price rises in 2007/8 brought attention to investments in agricultural production, including the application of mechanisation (FAO & AUC 2018; Mrema, Mpagalile, and Kienzle 2018). Second, new suppliers of agricultural machinery and implements emerged, notably from Asia and Latin America. Hanlin and Kaplinsky (2016) argue that machines became more suited to Africa both in specification and price; Cabral (2016) notes however that not all equipment of southern-origin necessarily fits the African context. Her study showed that the application of supposedly 'appropriate' Brazilian tractors in Mozambique, apart from primarily promoting the interest of Brazilian industry and Mozambican government elites, little served the interest of African smallholders. Third, demographic trends in Africa such as urban growth and an ageing farming population started to reinforce the need for mechanisation (Baudron 2015; Baudron et al. 2019). Finally, the recent rhetoric about mechanisation at the continental level has arguably also been a driving factor (FAO & AUC 2018).

In recent years, service models (such as fee for service) to access mechanisation particularly by smallholders have started to grow (Khan, Bymolt, and Zaal 2018; Houssou et al. 2017; Daum and Birner 2017). For example, in their paper 'Thinking Outside of the Plot', Khan and colleagues (2018) discuss service provider models for two wheel tractors (2WTs). Their empirical analysis showed 2WT service providers break even financially when serving 20–40 customers, i.e. smallholder farmers. Likewise, Houssou et al. (2017) documented the development of custom hiring in Ghana. They found that medium and large-scale farmers either owned tractors or rented them, increasing the use of the tractors and creating better conditions for the growth of mechanisation.

Yet, despite the long history and recent re-emergence of mechanisation, its status in Africa remains weak. Recent reports (Malabo Montpellier Panel [MMP], 2018; Sims, Hilmi, and Kienzle 2016; Mrema, Mpagalile, and Kienzle 2018) show that African farmers have 10 times fewer mechanised tools per farm hectare than farmers in other developing regions, and access has not grown as quickly as elsewhere. Only 10 per cent of the power sources for African farmers comes from engines; 65% still comes from human muscles and 25% from draught animal power (Sims, Hilmi, and Kienzle 2016).

Methodology

Situating itself within the theoretical framework of induced technical change and evolving farming systems (e.g. Ruttan and Thirtle 1989; Pingali, Bigot, and Binswanger 1987), this paper takes a historical perspective and explores policy narratives and political drivers to consider successive Ethiopian governments' stance towards mechanisation. The methods used included:

First, a thorough review and synthesis of the academic and grey literature on mechanisation in Ethiopia was conducted, covering past and current policy documents pertaining to agricultural development and mechanisation. Second, two recent mechanisation survey reports were studied: the Baseline Study Report on Agricultural Mechanisation (MoA & ATA 2017) which covers a sample of 1270 representative farmers, drawn from Oromia, Amhara, Southern Nations, Nationalities and Peoples (SNNP) and Tigray regional states. This survey covered smallholders producing five major crops: wheat, *teff*, maize, sesame, and sorghum. The second survey is the Agricultural Mechanization Value Chain Actors Profile Development Technical Report (ATA 2016) – which was a count of 'agricultural mechanisation value chain actors' in the same four major regions as well as Addis Ababa as a major business centre for commercial activities. The survey identified 505 machinery importers, producers, dealers and training providers.

Third, over a dozen key informant interviews were undertaken. Informants were drawn from different segments of mechanisation activities – policy and promotion (the federal Ministry of Agriculture (MOA), the Ethiopian Transformation Agency (ATA) and three regional bureaus of agriculture); federal agricultural mechanisation research, non-governmental organisations, and private and cooperative sector mechanisation service providers. Finally, I drew on my personal[5] experience of mechanisation in Ethiopia over 2013–2015 when I extensively travelled there, staying with farmers during peak planting and harvesting seasons to understand their needs and capacities, and studied the challenges of mechanisation. I draw insights from these farmers, as well as from further meetings with policymakers, extension workers, agricultural economists, engineers, researchers, leaders of donor-funded mechanisation programmes and private sector operators.

The focus of the study

For several decades, Ethiopia used a dual approach to mechanisation, one applying to smallholders and the other to large (private and/or state) farms. The focus of this study

[5]The author was responsible for setting up and leading the Mechanisation Department at the Ethiopian Agricultural Transformation Agency – ATA over the period 2013–2015.

is mechanisation on smallholder farms owning and operating less than 10 hectares (MoA/ATA 2017). These smallholders often depend on family labour and production is mainly for subsistence, although some is also for market. These are at least 16 million family farms (providing livelihoods for around 78.4 million people or 71 per cent of the total population[6]) producing the bulk of Ethiopia's agricultural outputs (MoA/ATA 2017). The majority of these farmers occupy the most populous temperate savannah and highlands of Ethiopia and operate in crops and/or crop-livestock farming systems (Amede et al. 2017). Three of the dominant farming systems (in terms of their farming population and volume of production) are: (i) *teff* mixed farming system – considered 'the breadbasket of highland systems'; (ii) wheat mixed farming system – characterised as 'increased market-oriented farming' and (iii) perennial farming system – farming based on dominant tree crops including coffee and *enset* but also cereals like maize, vegetables and root and tuber species such as cassava, yam and potato (Amede et al. 2017).

A commercial farm operates on more than 10 ha of land, and produces for market, often employing improved inputs, machinery such as tractors and combine harvesters, and skilled labour (MoA/ATA 2017). In post 2000, in particular, the government promoted limited commercial farming in the highlands such as in cut flowers, and more aggressively large scale commercial farms in 'sparsely' populated or 'unused' lowlands in the west and the south – Gambella; Benishagul-Gumz and SNNPR regional states (Rahmeto 2011; 2014; Lavers 2012a, 2012b; Ayele et al. 2020). Tracks of publicly owned land (estimates range from 3.0-3.5 million ha between mid 1990s and 2011) were transferred to private investors at low or subsidised prices (Rahmato 2014; Ayele et al. 2020). A number of farms ranging over 5000 ha (some as high as 100,000 ha) were set up and investors were also incentivised to import machinery free of import duties (Ayele et al. 2020). Critical studies (e.g. Rahmato 2014; Lavers 2012a) analysed state's motivation behind promoting large scale farmers and attributed it to the failure of the government agriculture development-led industrialisation (ADLI) strategy, which failed to generate sufficient surplus for the state to invest in public programmes such as roads, railways and dams. Export-oriented large scale commercial farming, it was thought, would generate such surplus for investment. The strategy also aimed to facilitate technology transfer and create linkages with the smallholders. On the contrary, compelling studies (such as Rahmato 2014) show that local communities were evicted from their ancestral lands, and some successfully set up farmers were vertically integrated islands with no or little linkages with smallholders to benefit them in technology and skills transfers (Ayele et al. 2020). The drive towards large scale commercial farms also put Ethiopia in the spotlight for activists and academics who perceived it as 'land grabbing', as large tracts of state-owned land were transferred to investors (see, for example, Rahmato 2014; Lavers 2012a, 2012b). So while government policy, past and present, consistently supported mechanisation of large commercial farms, these are not the focus of this study. I now turn to the policy and practice of smallholder mechanisation in Ethiopia.

[6]Based on the average rural family size which in 2016 was 4.9 (CSA 2017) and 110 million total population of Ethiopia in 2019 (Table 1).

Smallholder mechanisation in Ethiopia

A profile of Ethiopian agriculture and the economy

With 110 million people in 2019, Ethiopia is the second most populous country in Africa after Nigeria. Its government is a federal parliamentary republic, with ten self-governing regions.[7] Between 1991 and end of 2019, the country was ruled by the Ethiopian People's Revolutionary Democratic Front (EPRDF).[8] Agriculture continues to play a dominant role in the economy and contributes 35% of GDP (Table 1). About 80% of Ethiopians live in rural areas.

Owing to agriculture's importance, and the potential it offers for growth, successive governments in Ethiopia have prioritised agriculture to ensure food and nutrition security, and economic growth (Alemu and Berhanu 2018; Ayele et al. 2020). From 1993, the EPRDF implemented ADLI strategy (Zenawi 2017; Berhanu 2016; Lavers 2012a, 2012b). As the name suggests, ADLI was conceived as a precondition for industrialisation as well as growth in the rest of the economy.[9] Focussing on smallholder agriculture, it ensured usufruct rights for smallholders of state owned land (Zenawi 2017; Lavers 2012a), and provided access to inputs such as seeds and fertiliser, and extension services (Zenawi 2017; Rahmato 2014; Berhanu 2016). ADLI was welcomed by a wide range of development actors (Rahmato 2014), and was believed to have contributed to growth in agriculture (Table 1). However, it has had fundamental limitations, including the inability to increase labour productivity (Berhanu 2016). It was also a statist, top-down strategy (Rahmato 2014; Berhanu 2016) in that, at least as far as mechanisation is concerned, it involved little or no consultation with smallholders on their choice and use of mechanical technologies (MoA/ATA 2014). From early 2000, the EPRDF also embraced the 'developmental state' approach and played an active role in the economy, implementing two successive Growth and Transformation Plans (GTP-I and GTP-II) (NPC 2016; Alemu and

Table 1. Selected indicators of the Ethiopian agriculture and economy.

Major indicators	Value of indicator
Population (est. 2019)	110 million
Of which of urban pop (est. 2019)	22 million
Total number of smallholders	15 million (MoA/ATA 2017)
GDP growth (2007/8–2017/18)	9.9%
Agri. growth (2007/8–2017/18)	6.5%
Agri. share in GDP (2019)	35
Agri. contribution to employment (2019)	70
Population head poverty count (2015)	23.5

Source: Author's, based on World Bank (2019b, 2019c) and MoA/ATA 2017.

[7]Following a referendum, Sidama Regional State become the 10th member of the Ethiopian Federation on June 18 2020 (see Abdu 2020).

[8]Since taking power in 2018, Prime Minister Abiy Ahmed embarked on radical political and economic reforms, including dissolving the EPRDF and forming a new Prosperity Party in November 2019 (BBC 2019).

[9]ADLI have been discussed since the 1970s (see review in Vogel 1994) and, as a strategy, it recognises that increasing agricultural productivity is key to a successful industrialisation, and growth in agriculture stimulates industrialisation, through backward and forward linkages between the two sectors – agriculture using industrial products and inputs but also supplying industry with raw materials (Vogel 1994). Later studies showed that increasing agricultural productivity, and incomes, particularly in countries with a large rural population, is a potent poverty reduction strategy (Irz et al. 2001). While the classic roles of agriculture (such as source of labour, food, raw materials and export) continue to be important, the ability of smallholders to meet these increasing demands has been questioned (see, for example, Collier and Dercon 2014).

Berhanu 2018; Ayele et al. 2020). Recent plans and strategies increasingly focused on commercialisation of smallholder agriculture, irrigation and multiple cropping (e.g. NPC 2016).

In many respects, the economy responded to the various measures. It registered double digit growth for years, averaging 9.9% a year from 2007/8–2017/18. Over the same period, agriculture grew by around 6.5 per cent per year, and this growth was a major factor in reducing the number of people living below the poverty line from 44.2% in 2000 to 23.5% in 2015 (Ayele et al. 2020). Likewise, between 1990 and 2016, stunting rates declined from 57 to 38 percent (WFP 2019). However, Ethiopia remains food and nutrition insecure. In 2017, around 8.5 million Ethiopians required food assistance, while another 8 million depended on the National Productive Safety Net Programme (WFP 2019).

There are deep-rooted social, economic and political challenges to the development of Ethiopian agriculture which are beyond the scope of this paper. But low use of improved inputs has contributed to Ethiopia's food and nutrition insecurity. Although gradually increasing, fertiliser use has been as low as 20 kg/ha (MoA/ATA 2014). Compared with research sites, on smallholder farms the yields for major crops like maize, wheat, barley and *teff* are 67, 61, 52 and 41 per cent lower respectively (Amakelew 2019; NPC 2016). As will be shown below, shortages of farm power have also become a constraint to farming.

Status of mechanisation

Statistics on farm power are difficult to come by, however, recent surveys produced some data, summarised in Table 2. It is important to interpret the data in relation to the minimum recommended amount of farm power (1 hp/hectare) (MoA/ATA 2014).

The following observations can be made: the shortage of farm power on smallholder farms is severe and stands at only 0.5 hp/ha – 50 per cent of the recommended level. Moreover, almost 95 per cent of available farm power comes from human and animal power, a clear indicator of drudgery and an inability to perform operations in a timely manner. Engine-driven production was the highest for wheat (around 16%) but for *teff*, it was the lowest (0.02 percent) which in part indicates the lack of availability of mechanical technologies for native crops. Regarding specific farm operations, those requiring the most power were ploughing, weeding and harvesting, taking 64%, 11%, and 6% of power respectively (MoA/ATA 2017). Berhane et al. (2017) noted that 25% of wheat fields were harvested with combine harvesters. They also commented that the uptake of agricultural

Table 2. Status of mechanisation in Ethiopia – selected statistics.

Indicator	Status and source
National est. of smallholder farm power/ha	0.5 hp (MoA/ATA 2014)
Source of farm power	5.4% engine-driven; 94.6% human and animal sources (MoA/ATA 2017)
Engine-driven source of power for major crops:	
wheat	15.7 % (MoA/ATA 2017)
teff	0.02 % (MoA/ATA 2017)
Engine-driven source of power: commercial farmers	60% (MoA/ATA 2017)
Land prepared with tractors (all crops)	
Wheat harvesting	< 1 % of land in the country (Berhane et al. 2017) 25 % with combine harvesters (Berhane et al. 2017)

Source: Collated by author.

mechanisation in Ethiopia is low with less than one percent of agricultural plots ploughed with a tractor.

Finally, relative to demand, little progress has been made in mechanisation over the past years. In 2013 Ethiopia had about 12,500 tractors, a very low number compared to Kenya and Tanzania with 14,000 and 21,500 tractors respectively (MoA/ATA 2014). Ethiopia had 2.1 tractors per 100 km^2 of arable land compared to 26.9 and 23.9 tractors for Kenya and Tanzania, respectively (MoA/ATA 2014).

Understanding the political economy of agricultural mechanisation in Ethiopia

Four eras of agricultural mechanisation. This section focuses on the past seven decades, when mechanisation has become a development agenda in Ethiopia. Four phases are identified:

Phase 1: promotion of engine-driven mechanisation (1957–1974): precipitated by three successive five-year plans of the Imperial time, the period saw government encouragement of engine-driven mechanisation (Adams 1970; Zewde 1991). The first five-year plan (1957–1961) gave barely any attention to agriculture, let alone mechanisation. However, the first university programme in agricultural engineering started in 1959 at the then Alemaya (now Haramaya) University and the Jimma Agricultural Technical School followed suit, opening at about the same time to train agricultural engineers and extension workers. The second five-year plan (1962–1966) gave particular focus to large scale private commercial farms where over 50% of the budget allocated to the sector went to supporting them (Adams 1970). Consequently, although geographically uneven, some high-profile large scale private farms run by Ethiopians and expatriates emerged, including some in Setit Humara, and the Tendaho cotton plantation run by the British Mitchell Cotts Company in the Rift Valley (Zewde 1991; Kelemu 2015). The government was also an agent of mechanisation running large farms such as the Awash Valley Authority (Zewde 1991).

Like its predecessor, the second five-year plan effectively bypassed smallholder farmers and it was not until the third five-year plan (1969–1973) that work started on an area-based smallholder development strategy. A prototype of such area development was the Chilalo Agricultural Development Unit (CADU) which was set up in 1967 to provide 73,000 families with access to a package programme consisting of fertiliser, improved seeds and feeds, improved farm implements and access to credit and markets (Adams 1970). Following CADU, the Wolaita Agricultural Development Unit (WADU) was set up to deliver a similar package. Eight dedicated mechanisation centres were set up in Assela (in CADU area) and in Sodo (in WADU area) but also in Kombolcha, Mekele, Bako, Jimma, Bahir Dar and Harar. These centres aimed at promoting rural mechanisation and many have argued that the diffusion of implements (such as improved ploughs and carts) still used today on farms across Ethiopia have their origins in these mechanisation centres (MoA/ATA 2017; Kelemu 2015). Studies also note some adverse effects of mechanisation promoted during this era, for example, private farms operating within CADU evicted some tenants (Zewde 1991, 195). However, many of the initiatives did not materialise because of challenges, including the oppressive landlord-tenant agrarian system (see, for example, Berhanu 2016).

Phase 2: state-led mechanisation (1974–1991): the military-cum-socialist government (aka Derg, 1974–1991) overthrew the Imperial Government in 1974 and fundamentally reversed the direction of farming in favour of cooperative and state farms. Some 448

state farms were set up, many of which were nationalised private farms (Kelemu 2015). Large-scale state and cooperative farms would, it was thought, improve productivity and bring about broader economic growth (Berhanu 2016). The Derg's drive towards large scale mechanised farming was epitomised by its setting up of the Adam Tractor Factory in 1984. Likewise, the Agricultural Equipment and Technical Service enterprise was set up for the purchase and distribution of agricultural and construction equipment (Kelemu 2015). However, because of poor farm management and poor choice of machinery, the tractors and combine harvesters faced frequent breakages and oil leaks, and consequently the Derg's experience was largely a failure (Kelemu 2015). In addition, the bulk of smallholder farms that were not drawn into cooperatives experienced decline due to neglect and adverse policies such as low farm gate prices (Berhanu 2016). However, CADU was expanded to province level – the Arsi Rural Development Unit (ARDU) – and one of its purposes was to meet the increasing demand for farm machinery in Arsi and neighbouring province Bale. In 1976, the Agricultural Mechanization Research Unit was placed at Melkassa Agricultural Research Centre and it still serves as an apex agency in the country researching agricultural mechanisation. Despite the increased cooperative movement, smallholders were hardly land secure and some became victims of mechanised state farms. Abegaz (1994) reported at least 90 683 farmers being displaced by state farms.

Phase 3: mechanisation stalled (1991-2013): following the EPRDF coming to power in 1991, agricultural mechanisation was deprioritised. This followed an analysis by the then influential leader of the EPRDF, Ethiopian President (1991-1995), and Prime Minister (1995-2012), Meles Zenawi[10]:

> Under [Ethiopia's] condition, there is a shortage of capital which cannot be addressed in a short time. On the contrary, we have a large number of industrious people and abundant land. We can ensure fast and sustained development if we follow a strategy that economises scarce capital, but extensively and exhaustively uses abundant labour and land. (Zenawi 2017, 4 - translation from Amharic by the author)

The EPRDF focused on an optimum combination (or allocation) of capital, labour and land as a critical condition for economic development. Moreover, it stressed that apart from large-scale commercial farms in less populated lowland areas, smallholder agriculture should remain dependent on labour and animal traction (Zenawi 2017).

Two important, arguably detrimental, developments to smallholder agriculture ensued from the analysis and policy perspective. First, EPRDF's proposition on mechanisation became part and parcel of ADLI strategy (Zenawi 2017; Berhanu 2016; Lavers 2012a, 2012b). Subsequent to ADLI becoming the government's official development strategy in 1993, apart from a few donor-led efforts and limited private operations, mechanisation-related institutions and practices either stalled or were shelved. The department coordinating mechanisation at the Federal Ministry of Agriculture (MoA) was disbanded and degree courses in agricultural engineering at higher education institutions were either closed or reduced (MoA/ATA 2014). But the Agricultural Mechanization Research Directorate was restructured into the Ethiopian Institute of Agricultural Research in 2000 and, in parallel, restructuring took place at the regional level (MoA/ATA 2014).

[10]Meles Zenawi's 734 page-long Essays (Zenawi 2017) – believed to have been written since he ascended to power in 1991 – were posthumously published in 2017.

Clearly, the government's policy appears to be informed by studies, for example, that warned against using mechanisation in a labour and land abundant county (Binswanger 1986; Binswanger and Pingali 1989). However, as I will show below, it consistently failed to draw on nuanced lessons and successful experiences of smallholder mechanisation in labour abundant countries.

Another effect of the government's proposition was that, similar to the 'developmental state' approach and many other strategies initiated and constituted as national policies by the EPRDF (see, for example, Lefort 2013), the position on smallholder mechanisation became a conviction where any counterargument (or dissent) was systematically discouraged by hard-line party members and officials who remained loyal to the party and the government's vision.[11]

It is notable that, even when mechanisation was low on the policy agenda, a few donor programmes and private sector activities promoted smallholder mechanisation. These include the Sasakawa Global-2000 which successfully promoted different post-harvest technologies, notably stationary multi-crop threshers and maize shellers; and the Ethio-German Agricultural Training Centre at Kulumsa which trains technicians and farmers on the use of modern agricultural machines (MoA/ATA 2017).

Phase 4: resurgence of mechanisation (2013 – present): since 2013, the EPRDF brought smallholder mechanisation back to its agricultural development agenda, and set up mechanisation departments in the Ethiopian Agricultural Transformation Agency (ATA) and the Ministry of Agriculture (MoA). As noted before, the resurgence of mechanisation was triggered by demand for *teff* row planters (see Fig. 1b). *Teff* is Ethiopia's major cereal crop grown by over 6 million smallholders and consumed by many more millions in rural and urban Ethiopia, and close to 30 percent of the produce feeds cities (Lavers 2012a). *Teff* has benefited less from technological advancements than other crops (Vandercasteelen et al. 2014; MoA/ATA 2017). However, the introduction of a package programme that consisted of improved seeds, row planting and reduced seeding rates in 2012 helped farmers (a) to reduce the seeding rate from around 30 kg/ha in the conventional broadcasting method of sowing teff to 5 kg/ha in row planting; and (b) row planting facilitated an increase in yield by 12 per cent (Vandercasteelen et al. 2014), due to reduced competition between seedlings for sunlight, water and nutrients, and also facilitating better weeding (interviewees[12]). As interviews with MoA and ATA staff revealed, while broadcasting is a matter of a few hours of work, row planting tiny seeds of teff by hand means hours and days of work, on average 72 h/ha with several kilometres of walking. No reliable device existed to plant *teff* in rows.

While the demand for teff row planters was the trigger, demand for mechanical tools such multi-crop threshers and maize shellers was already high, and it led to the mechanisation strategy launched in 2014 (MoA/ATA 2014). By 2025, the Government aims to raise the level of agricultural mechanisation from 0.5 hp/ha to 1 hp/ha, with at least 50% derived from mechanical/electrical power; reduce the use of animal power for agricultural operations by 50% and mitigate environmental degradation; increase the usage of

[11]An example was, echoing the vision set out in ADLI, in 2013 a senior government official commented: 'I don't think mechanisation is a timely issue. We have not exhaustively used improved seeds and fertilizer as yet'.

[12]Many agronomists, agricultural economists, etc., I talked to (over 2014–2015) also noted that on demonstration and model farmers' plots, yield increased from an average 1.3t/ha to 2.2t/ha but this was not corroborated by a survey-based study.

Figure 1. (a) A farmer behind two oxen: a symbol of resilience, fossil fuel free farming or farm power poverty? Oromia Region, 2013 (Source: author's own). (b) *Teff* planter testing, West Gojam, Amhara Region, June 2015 (Source: author's own).

agricultural mechanisation technologies by female farmers to at least 30% and address at least 50% of the needs of pastoralists and agro-pastoralists for mechanisation inputs (MoA/ATA 2014). The strategy also outlined specific targets for access and use of a wide range of mechanisation tools to fulfil the aims and vision of GTPII, to 'Increase national food production and security through enhanced and sustainable use of agricultural mechanization technologies in order to support Ethiopia's middle-income status by 2025' (MoA/ATA 2014, 36). In May 2019, Ethiopia allowed the import of agricultural mechanisation, irrigation and animal feed technologies, and equipment tax-free in support of sustainability and structural transformation (MoF 2019).

In summary, over the past seven decades, the policy and policy narratives about agricultural development have focused on modernising and/or transforming agriculture, economic growth and food security, but the means by which successive governments went about achieving their goals varied. While large scale mechanisation was promoted, mechanisation bypassed smallholders. Over 1991–2013, smallholder mechanisation was deprioritised, leaving an average Ethiopian farmer walking behind a pair of oxen as the postcard image of Ethiopian agriculture (see Fig. 1a). Understandably, policies were taken in good faith, and stemmed from concerns of potential adverse effects on employment, and for smallholder livelihoods, but none consulted with nor received the consent of farmers. The blind spot was the failure to understand that demand for mechanisation actually came from farmers across the country (MoA/ATA 2014).

Analysis of post resurgence of mechanisation

Institutional and operational commitment for mechanisation. The mechanisation strategy was launched in 2014, but strategies do not implement themselves. Even five years after the launch of the strategy, the status of institutions and resources committed to promoting smallholder mechanisation at the federal and regional levels is far from satisfactory.

At federal level, the Agricultural Mechanisation Directorate (AMD) at the MoA is tasked, among other things, with developing a framework for facilitating access and use of mechanisation tools and with supporting the establishment of Ethiopian standards for agricultural machinery. However, the Directorate suffers from a shortage of personnel and budget. In 2013, it started with three staff (one of whom was seconded). It took two

more years to increase its staff to six, but in 2019 it was still operating with under 50% of the required staff simply because of insufficient budget to attract and hire competent people. Consequently, the Directorate struggles to deliver on targets. For example, in 2016, one of its activities was to procure and demonstrate 7168 threshers and shellers in pilot areas (*woredas* or counties) but it achieved only 465 units (6.5%). In an interview, a senior member of the AMD noted:

> … [in 2014] we had high expectations and targets for smallholder mechanisation but we have not matched the promise. We are still battling to get resources allocated to the sector both at the federal and regional levels. Many regions have no mechanisation experts and a few have only assigned 2–3 staff … in all the regions, the extension system has an inadequate number of personnel to work on farm mechanisation. (Senior AMD staff, MoA, April 2018)

Resonating with the interviewee at MoA, other federal and regional level interviewees also noted 'a lack of ownership of mechanisation' at the regional level. One manifestation of this was that in 2018 almost no regions set up mechanisation teams. Similarly, the extension system lacks qualified/trained staff to promote mechanisation on the ground. The training programmes that the Directorate at MoA managed to organise were few and far between.

Realising the challenges of organising mechanisation, over the past year the Government has embarked on a new pilot project: Mechanisation Service Centres (MSC). ATA's (ATA 2019) report shows that the initiative acknowledges (a) increasing demand for mechanisation services by smallholders, (b) the high cost of owning and operating machinery by the majority of smallholders, and (c) the challenges of organising and providing mechanisation services to smallholders. Hence, the MSC's initial aim is to set up 10 centres in four major regions with requisite machinery and maintenance, spare parts and training services. The impact of the centres is yet to be seen, but the plan is they will be owned and run by cooperative unions and private sector actors who directly provide mechanisation services to smallholders and also machinery rental, maintenance, spare parts and training services to others. If successful in three years, the scheme will then be scaled up.

Private sector-led delivery of mechanisation service

While government-led promotion of mechanisation services has faced many challenges, since the launch of the mechanisation strategy in 2014 private sector-led mechanisation has been growing (Table 3). In 2016 ATA conducted a count of mechanisation value chain actors in five major regions (Oromia, Amhara, Tigray, SNNR, Addis Ababa). The survey identified 505 machinery importers, distributors, repair and maintenance service providers (ATA 2016). Some striking observations can be made. First, many of the businesses entered the sector over the past five years (71% of importers and 76% of service providers) indicating a strong business response to policy change and growing demand for mechanisation. Second, most mechanisation operations have been taking place in Oromia, including the two training and repair and maintenance service providers. This is unsurprising, given the region's suitable landscape, proximity to infrastructure and major markets like Addis Ababa (see below).

Third, regarding source and type of machinery, 42% of the machinery was locally sourced, while 58% was imported from different countries. By far the largest number of

Table 3. Main mechanisation supply chain actors by categories: 2016.

Actor Category	Numbers	Location/region
Machinery importers	77	93% in Addis Ababa (AA)
Domestic manufactures and assemblers	24	Mainly in AA and Oromia
Distributors and dealers	29	Mainly in AA and Oromia
Repair & maintenance	37	Mainly in AA and Oromia
Custom hire/service providers	336	66% in Oromia; 26% in Amhara
Mechanisation training service providers	2	Oromia (Adama and Shashemene)
Total	505	

Source: Author's based on ATA (2016).

imports (68%) were from China. The survey gives neither quantity nor value of machines imported but many businesses imported a variety of machinery – land preparation and planting equipment, harvesters and threshers, pumps for irrigation. Fourth, despite the huge demand for training across operations like harvesting, there were only two training service providers – the government-run Adama Agricultural Mechanisation Industry, and a private company, Kaleb FSH PLC. The survey and our interviews showed that the country does not have an agricultural machinery driving school nor an agency that issues licenses for such operations – all training is done on-the-job by farm operators.

Who owns and accesses mechanisation, and who benefits from it?

The MoA/ATA (2017) showed several challenges for smallholders, including high cost of machinery, lack of supply and spare parts, poor quality machinery and lack of credit. Thus, the best that many smallholders own are tools like *maresha* (oxen-pulled plough), sickles, and a pair of oxen (MoA/ATA 2017).[13] Only a small number of smallholders (less than 1% of the total surveyed) own one or more of a motorised water pump, a small tractor, and a hand-held motorised tiller (MoA/ATA 2017). These albeit limited data suggest that smallholders are better served if they access (particularly engine-driven) mechanisation through service providers rather than owning and operating it themselves. Interviews and literature (for example, Khan, Bymolt, and Zaal 2018) suggest at least three emerging business models for mechanisation[14]:

- Farmer owned and operated mechanisation: where farmers use engine-driven machinery (relatively smaller machines like 2WTs and multi-crop threshers) primarily for own use but also, on a part-time basis, used to provide services to neighbourhood farms.
- Farmer cooperative-run mechanisation service provision, and
- Private sector-operated mechanisation service provision.

There are two sub-groups of private sector operators. First, those who operate large scale engine-driven machinery such as tractors and combine harvesters and provide ploughing, harvesting and threshing services. Owners are often city-based, and own other businesses such as cereal trade, consumer shops and flour mills (Berhane et al.

[13]The broad range mechanisation technologies include traditional tools like the hoe, plough and sickle; and improved and/or modern mechanisation technologies, including animal drawn carts, broad bed makers, stationary threshers and maize shellers, 2WTs, 4WTs, combine harvesters (see reviews in MoA/ATA 2014, 2017).

[14]Several studies including Biggs and Justice (2015), Mottaleb et al. (2017), Amanor (2019) and Daum and Birner (2017) offer lessons on how labour abundant countries support mechanisation.

2017). Spatially, many of them operate in Arsi and Bale zones (of around 300 operators in these zones, at least 200 are run by private operators and the remainder by cooperatives). Second, there are growing numbers of small scale machines such as multi-crop stationary threshers and sheller service providers. Geographically, these are dispersed, but still with a high concentration in Arsi (MOA/ATA 2017).

It is no mystery why Arsi-Bale zones have become the hot spot of mechanisation in Ethiopia. Smallholders in these zones have had decades of exposure to mechanisation, since the days of CADU in the late 1960s. They have relatively flat and large plots of land and predominantly grow wheat, supplying to processors and consumers downstream in the value chain. In some parts, smallholders also enjoy two cropping seasons. Moreover, smallholders in these regions co-exist with large commercial farms and previous state farms (Berhane et al. 2017) and benefit from, for example, maintenance services. Many in other parts of the country are hampered by such constraints as fragmented plots, rugged topography, and the widespread presence of stones in fields, which hamper mechanised ploughing (Berhane et al. 2017).

Service charges vary. Flat land, plots free of stones and stumps or close to roads, the type of crop, farmers' gender, age and education status are key factors (MOA/ATA 2017; Berhane et al. 2017). Data on actual services charges are less reliable. For example, for 2016, Berhane et al. (2017) reported first round tractor ploughing in Arsi at *birr* 1200 (or US$60) and in Ginir the price of a similar operation was birr 1800–2000 (or 90–100 US$). Interviewees' view of fees is broadly 'affordable' but they note that the main challenge is making the service available. They noted that providers themselves are still learning the trade, or are under pressure from local authorities and charge 'below cost' (not even covering fuel and labour costs). Some other interviewees noted while private providers 'rip off' farmers, cooperatives charge a 'fair' amount as they look after their members. However, when it comes to decision-making on operational matters, cooperative service providers were said to be 'hierarchical' and caused delays. According to the interviewees, there was a clear gap in public guidance regarding charges for mechanisation services, for example, whether charging should be based on area harvested, yield thereof or number of hours of operation. Many of the interviewees also noted issues related to the environmental sustainability of mechanisation – many private sector operators are new to and/or not trained in agriculture and often they do not seem to give much attention to maintaining and improving soil health or the farm ecosystem. Finally, for many of the interviewees there do not seem to be 'adverse effects', but a few noted a decline in migrant labour in mechanisation hot spot areas such as Arsi and Bale zones.

The preceding section clearly indicated that despite growing demand for smallholder mechanisation, the market for the provision of smallholder mechanisation services is insufficiently developed. Below I argue that the development of a thriving market for mechanisation services should be the next agenda for policy and action.

Discussion and conclusion

For decades, Ethiopia pursued a dual, sometimes contradictory, policy of agricultural mechanisation: one aimed at large farms and another at smallholders. While large scale mechanisation (state and/or private) has been promoted, smallholder mechanisation strategy and

practice in Ethiopia exhibited a saw-tooth trajectory. For the most part, and resonating with Bernstein's (1990) description of 'modernisation', mechanisation *bypassed* Ethiopian smallholders, and over 1991–2013, it was deprioritised as a matter of policy. After decades of hiatus, and induced by increased demand for *teff* and *teff* row planters, smallholder mechanisation returned to the policy agenda in 2013 but recent pro-mechanisation rhetoric lacks operational commitments. The cumulative effect of neglect has left a legacy of low level of smallholder mechanisation (Berhane et al. 2017; MoA/ATA 2017).

The EPRDF government in particular appeared to believe that in a country where labour and land are abundant but capital scarce, mechanisation was the 'wrong' technological choice (Binswanger 1986; Pingali, Bigot, and Binswanger 1987; Binswanger and Pingali 1989). It pursued ADLI, believed to be suited to Ethiopia, abundant with land and labour but short in capital (Zenawi 2017). However, ADLI was a top-down strategy (Berhanu 2016; Lavers 2012a), which hardly considered smallholder demand for mechanisation. Some aspects of the policy and policy narratives towards smallholder mechanisation were flawed on many counts, either misunderstanding or wrongly applying the notion of mechanisation – implicitly equating mechanisation with tractorisation (which arguably does raise concerns about adverse effects on jobs and use of scarce foreign exchange to pay for the machinery, spare parts and fuel). By focusing disproportionately on tractors, policy has overlooked a range of mechanical technologies more suited to the socio-economic and agro-ecological conditions of smallholder agriculture.

Second, lessons from countries that *are* labour abundant and successful in smallholder mechanisation were not drawn – for example, Bangladesh successfully used inputs like seeds as well as 2WTs, pumps and rural transport vehicles (Biggs and Justice 2015). Third, there have been glaring contradictions in the government's policies on mechanisation. On the one hand irrigation and multiple cropping have been promoted (it aimed, for example, to nearly double irrigation farming from 2.3 million ha in 2014/15–4.1 million ha in 2019/20 [NPC 2016]). On the other hand, such departures from annual rain-fed agriculture to multiple cropping clearly requires mechanical inputs like pumps – yet the policy deprioritised mechanisation or barely implemented it.

Moreover, ADLI made barely any effort to nurture the private sector and to serve smallholder mechanisation (MoA/ATA 2014). This neglect has left a diminutive mechanisation industry, with limited capacity to design, manufacture, and run a variety of operations (MoA/ATA 2014). Private sector and cooperative-led mechanisation services in Arsi-Bale have been an exception, a success story built on the historical exposure of farmers to mechanisation. Amanor's (2019) study on Ghana corroborates this conclusion that present mechanisation hotspots are products of historical developments, with past mechanisation efforts leading to land being cleared of stones, and training and maintenance services becoming available, thus making mechanisation technically and economically feasible.

As with all theory, the theory underlying 'conditions for mechanisation' is not immutable but evolves according to context. One fast moving condition is climate change (Kelemu 2015). Ethiopian agriculture heavily depends on the weather (Kelemu 2015; Amede et al. 2017), and in some parts of the lowlands where the level of moisture is low, the window of opportunity to prepare and plant crops is as little as 11 days (Kelemu 2015). Farmers require more power at that time, and immediately. In some highland areas too, where excessive rain leads to waterlogging, farmers are forced to wait until

the water subsides and planting becomes easier. Small mechanical devices such as simple broad bed makers can help to drain water, plant and harvest early, as well as replant the same land with other crops (Kelemu 2015).

Emerging supply and demand side forces also favour smallholder mechanisation. Ethiopian agriculture is – slowly – becoming more commercialised (NPC 2016), which requires smallholders to supply farm produce for the growing urban population, agro-processors and the competitive export market. Moreover, as elsewhere in Africa (e.g. Jayne 2016), small entrepreneurial farms and small and medium-size farms are growing; over the past ten years, at least 2000 agribusinesses (many of which are farms) have been set up (Ayele et al. 2020). With the growth of commercial farms and farm sizes, the need for mechanisation increases (Binswanger 1986). Also, emerging studies such as Baudron and colleagues (2019), reported shortages of farm power among smallholders around Assela and Hawassa – family labour is insufficient so more than 85 per cent hired human labour, draught and/or engine power (Baudron et al. 2019). Likewise, a study conducted in three *kebeles* (villages) in West Gojam (Takele and Selassie 2018) revealed farmers reporting up to 70 per cent labour shortages and 52 per cent shortages of animal traction during peak operation time. Finally, on the supply side, farm machinery is becoming more flexible, affordable, and appropriate to the conditions of smallholders (Hanlin and Kaplinsky 2016).

The evidence (including MoA/ATA 2017; Berhane et al. 2017), analysis and discussion presented here suggest that, supported by non-governmental actors, the government's primary role should be creating an enabling environment for mechanisation. Well staffed and resourced institutions need to be developed and strengthened, which can regulate and promote mechanisation at federal and regional levels, supporting extension systems, providing incentives and credit to make mechanisation attractive to suppliers and farmers, and facilitating smallholders – who otherwise cannot access mechanisation technologies – to be served by cooperative and private sector service providers. Although not as widespread as elsewhere (see, for example, Khan, Bymolt, and Zaal 2018; Biggs and Justice 2015), fee-for-service provision has made a start in Ethiopia, but private and cooperative sectors service provision is not a magic bullet, as there are many policy issues to address.

First, policy needs to ensure that there is competition between mechanisation service providers, and that smallholders who have little bargaining power are not exploited (MoA/ATA 2017). Second, guidelines are needed so that mechanisation operations do not harm the environment nor evict farmers off their plots. Third, while an increasing number and type of machines are entering the country, and this diversity helps to address the different needs of farmers, many of the interviewees were concerned about quality and lack of spare parts. Developing machinery standards and testing centres, and ensuring availability of spare parts, should be another priority area. Fourth, the public sector needs to address the acute shortage of trained personnel in the sector (MoA/ATA 2017). Fifth, because Ethiopia is home to native crops with few or no research centres outside of Ethiopia, it needs to pay attention to developing machinery for such crops (MoA/ATA 2017). Finally, many Ethiopian farmers still lack awareness of agricultural machinery (MoA/ATA 2017). Hence, through the extension system, demonstrating newer and more effective tools to farmers should be pursued vigorously, to overcome farm power production constraints and contribute to production and productivity growth and food security.

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Seife Ayele is a Research Fellow at the Institute of Development Studies, United Kingdom. He is a development economist by training and his work focuses on agriculture and agribusiness, renewable energy, enterprise development and employment. He leads the Matasa Fellows Network supporting young African researchers to develop policy-relevant research in youth employment. He has extensively published, including *Enhancing innovation in livestock value chains* (*Science and Public Policy*, 39 [2012]).