THE STATUS OF AGRICULTURAL MECHANIZATION IN KENYA

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ABBREVIATIONS AND ACRONYMS

AMRI	Agricultural Mechanization Research Institute
AMS	Agricultural Machinery Services
DDG	Deputy Director General
FAO	Food and Agriculture Organization of the United Nations
KAFACI	Kenya-Africa Food and Agriculture Initiative
KALRO	Kenya Agricultural and Livestock Research Organization
KENDAT	Kenya Network for Dissemination of Agricultural Technologies
KIRDI	Kenya Industrial Research and Development Research Institute
KRA	Kenya Revenue Authority
MoAL&F	Ministry of Agriculture, Livestock and Fisheries
NGO	Non-Governmental Organization
RDA	Rural Development Administration
SSA	Sub Saharan Africa

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1.0 BACKGROUND

Agricultural mechanization is low in Kenya and yet there have been several efforts by the government, voluntary and non-organizations (NGOs) to promote it since independence. The low agricultural productivity has been associated with numerous factors, one of them being low levels of mechanization. The goal of this study was to contribute to the understanding of the agricultural mechanization systems among selected value chains for purposes of recommending research and policy interventions in Kenya and beyond. The study was undertaken on major agricultural value chains in Kenya, between March and June 2016. It focused on value chains of highest economic importance in Kenya, viz, food crops; (maize, rice and wheat) industrial crops; (tea, sugarcane and coffee), horticultural crops;(tomatoes and mangoes) and livestock (cattle, dairy, sheep/goats, and poultry).

2.0 OBJECTIVES

The study had five main objectives including appraising the status of information on agricultural mechanization in Kenya, establishing the levels of agricultural mechanization among selected agricultural value chains, identifying constraints and proposing interventions for the adoption of the improved agricultural mechanization technologies and innovations, recommend strategy and research agenda and make technical and policy recommendations to enhance agricultural mechanization in the respective value chains in Kenya.

3.0 METHODOLOGY

Data collection was done at different levels that included secondary sources, Key informant interviews and use of the semi-structured questionnaires for the selected agricultural value chain. This was undertaken in three phases, with the first phase involved in collecting secondary information and desktop reviews through key informants' interviews via taking notes, use of checklists and discussions. The focus was on development partners, relevant research institutions, universities, agro-dealers, headquarters and county ministry of agriculture. The second phase involved developing and finalizing the interview tools that included questionnaire development and pretesting as well as recruitment and training of enumerators A total of eight value chain teams were formed to coordinate the survey. The third and final phase was the actual implementation of the questionnaire in the selected counties. The questionnaires were

administered to the respondents by trained enumerators particularly on their farms where coordinates and elevations were determined using global positioning system (GPS) equipment. The completed questionnaires were inspected and corrected by the respective value chain coordinators. Data entry was done by data entry clerks while the cleaning, data analysis and report writing was done by the value chain coordinators.

The survey was undertaken using a multistage sampling design which included, selecting the nine value chains, the counties, sub counties and wards or production zones and finally random sample of respondentsusing transects depending on the nature of the value chain. The study considered the value chains in terms of the enterprise sizes, viz small, medium and large scale. A total of 555 respondents were interviewed for various value chains in the following counties; Trans Nzoia (Maize), Bungoma (Rainfed rice) and Kirinyaga (Irrigated rice), Nakuru (Wheat), Kericho (Tea),Kisumu (Sugarcane), Muranga (Coffee), Kirinyaga (Tomatoes), Makueni (Mangoes) and all the crop value chain counties selected for livestock.

4.0STUDY FINDINGS

4.1.1. An overview of Agricultural Mechanization in Kenya

Agricultural mechanization came into being in Africa during the early civilization around 6-5000bc in Egypt where the first draught animals were used for land preparation and transport. The draught animals used then; were the oxen, donkey, mules and horses. The camel was also used to a limited level as pack? animal in the Horn (of Africa) and North Africa. It is believed that animal drawn technology spread to the Sudan, Mediterranean and North Africa from Egypt (Starkey, 1994).

Donkeys were used as pack animals, while horses and oxen were used in transportation and pulled ox-wagons and/ or carts. Land preparation was mainly done by oxen and donkeys (Starkey, 1994). Besides transport and land preparation, these animals were used in threshing and milling in the early days. Animals were let to continuously tremble over cereals, pulses and oil crops leading to separation of grains from the husks. Milling was done in a similar way, although the oil crops (sesame and groundnuts) were placed in a long wooden mortar and the animals (camels and oxen) dragged a long pestle over the produce until the oil was excelled and butter formed (Starkey, 1994).

Draught animals and technology were introduced in 1910 by European settlers in Kenya. By 1920 the technology was adopted by small holder farmers in Ukambani and in the 1930s the technology was wide spread in the region. Sub Saharan Africa (SSA) has the lowest uptake of agricultural mechanization in the world and largely depends on manual labour (Bymolt and Zaal, 2015). For example in Kenya the use of motorized power stands at 30%, hand and animal draught is 50% and 20% respectively (FAO, 2006; MoAL&F, 2015). In the 1960s many countries in SSA, Kenya included established public sector operated machinery hire services with the objective of enabling small holder farmers accessing these services to produce high value crops (Ahmed, 2015), though they faced various challenges.

According to Mutua *et al*., 2014, records from the Kenya revenue authority (KRA), revealed that four wheel tractor (4WTs) sales in Kenya have risen slowly since 1961 when only 6,422 units were operational. This rose to 12,844 units in 2002 which translates to one tractor to 195 hectare. Most 4WTs operating in the country are in the large commercial farms, both in the public and private sectors, including sugarcane, wheat/barley, tea and maize. Tractor ownership among small scale Kenyan farmers stands at 5% and use of this machine is declining because of continuous land fragmentation (Bymolt and Zaal, 2015).

Agricultural mechanization is dominated by the private sector, there are well established private companies in the country dealing in agricultural machinery and equipment including, Farm Engineering Industries Ltd, Massey Fergusson, Hughes Ltd (Ford), John Deere and Car&General among others (Mutua*et al*., 2014). The medium scale firms like Ndume also deal in farm machinery; these firms import and manufacture axillary equipment such as ploughs, harrows, planters, sprayers, mills and silage processors (Mutua*et al*., 2014).

There are several institutions involved in testing, fabricating and evaluating of agricultural mechanization technologies including; universities, non-governmental organizations (NGOs), public institutions and private companies (Mellis *et al*., 1999). There are many agricultural machines that have been developed and modifications/improvements made. These technologies include tillage implements, irrigation equipment and agro-processing equipment. The agricultural mechanization testing ensures quality assurance. The main government players in agricultural mechanization services include;

- **Agricultural Engineering Services** – This is a division within the Ministry of Agricultural, Livestock and Fisheries providing mechanization and land and environmental services. Under this division Kenya has ten Agricultural Technology Development Centreswhose mandate include developing and testing agro-processing, renewable energy and storage technologies. In addition the government has donor funded projects for providing agricultural machinery targeting agronomic and irrigation operations, for example National Irrigation Board Schemes including Mwea, Bunyala, etc., for Rice production. Japan and Korea are some of the major donors
- **Research Institutions** -The Kenya agricultural and livestock research organization (KALRO) established the Agricultural Mechanization Research Institute (AMRI), in 2015 with the mandate of generating and disseminating agricultural mechanization technologies and innovations that are geared towards enhancing productivity and value addition in Kenya. KALRO has 10 agricultural engineering units spread within the 16 institutes. These are involved undertaking research in irrigation, soil and water management, crop and livestock value addition amongst others. In addition the Kenya Industrial and Research Development Institute has participated in generating and promoting innovations for agro-processing and farm machinery.
- **Agricultural Mechanization Services-**In Kenya there are twenty three agricultural machinery services (AMS) across the country, which have been devolved to the County governments. The AMS provide hire tractor machinery services for the farmers. These centres generate revenue for the ministry of agriculture (county governments), regulate cost of hiring tractor and provide service to farmers (Mutua *et al*., 2014).
- **Universities with Agricultural Engineering departments**. Kenya state owned Universities (University of Nairobi, Jomo Kenyatta University College of Agriculture and Technology, Egerton University etc.) with agricultural engineering departments are involved in research in agricultural machinery including testing and fabrication of agricultural machinery
- **International organizations and Non-governmental organizations** – These include FAO, World Vision, KENDAT are involved in the dissemination of agricultural mechanization technologies through donor funded projects.

4.1.2. Mechanization Status for Selected Value Chains

4.1.2.1. Crop Value Chains

4.1.2.1.1. Land preparation

Land preparation is one of the key operation required for a proper seed bed establishment for all the crops. In the food crops system mechanization for land preparation was relatively high with the lowest being 67% and the highest being 100% (Table 1.1 and Table 1.2). This may be due to the high drudgery in carrying out land preparation and the high cost of labour. For the industrial crops the percent use of machines ranged from 0 to 100%. The level of mechanization was nil in coffee because of low or nil replanting since coffee is a perennial crop therefore land preparation isundertaken after a long time.The horticultural crops mechanization use ranged from 81 to 96% of the sample farmers.

Ploughing is mostly done by oxen and four wheeled tractors using, implementssuch as ox plough, disc plough and mouldboard depending on the soil type. Where harrowing is done disc harrow is used, while for rotavation motorized rotavator is used.In terms of ownership the machinery used is either owned on hired.

4.1.2.1.2. Planting

In Kenya, most of the planting operations are done using human labour as the source of power. Mechanization for planting is practiced only for the food crops, maize (56%) and wheat (95%). However, for rice, industrial crops and horticultural crops considered mechanization was absent. The machinery used in planting is the tractor drawn planters. The machinery in planting are either owned or hired. The lack of mechanized planting for mechanization was associated with lack of the appropriate machinery or lack of in information on the existence in the local or external market.

4.1.2.1.3. Weeding

Weed control is labor intensive and has relatively very low levels of mechanization.This is one operation that is poorly done and contribute to reduced crop yields. Maize value chain has the highest level of mechanized weeding (46%) followed by tea (14.1%). The rest of the value chainshave less than 5% use machinery in weed control. The machineries used include knapsack, boom sprayer and motor blower which are owned or hired. Manual weeding is more expensive

thanmechanized weed control and experiences heavy drudgery which should be reduced through mechanization.

4.1.2.1.4. Harvesting

Harvesting was done mostly using manual labour and because of its high cost makes it an expensive undertaking. There were no significant mechanization in harvesting for both industrial and horticultural crops. This may be explained by lack of appropriate technology within the Kenyan market. However, harvesting for rice and wheat value chains have significant mechanized harvesting, with wheat value chain exhibiting the highest level of 98%, followed by irrigated rice (55%) and upland rice (11%). The high level for wheat is due to the high cost of labour and its shortage. There was no mechanized harvesting reported for maize, tea, sugarcane and tomatoes. There was very little (less than 5%) for coffeeand mangoes. The machinery used include combine harvesters. The machines are either hired or owned.

4.1.2.1.5. Transportation

Transportation is key in Kenya and highly mechanized. All the food crops considered were mechanized (100%), except for rice. The upland rice had the lowest level of mechanization 4.5%, which associated with the relatively small land crop units which are operated by family and hired labour.

The machinery used in transportation for food crops included Ox/donkey carts, tractor trailers and three wheeler vehicle, while for industrial crops and horticultural crops use wheel barrow and motor vehicle. The machinery were often owned and or hired.

4.1.2.1.6. Value Addition

Value addition is an activity which has been given prominence in Kenya. This operation uses simple to complex machines. In the value chains studied value addition was limited to sorting, grading and use of stovers in the preparation of silage for the food crops with limited preparation different food products at the farm. There was immense mechanization in the food value chains using hammer mill, shredders, tractor drawn chaff cutter, baler and wet mill. On the other hand there was virtually no value addition except for grading and sorting for the tea and coffee which are done manually. Similarly for the horticultural crops there was no significant value addition for the farmers interviewed.

Value addition, although given prominence in Kenya there is little effort in its promotion as is evident on the value chains studied. There is great opportunity in this activity which requires availing and promotion of the relevant machinery, especially for industrial and horticultural crops.

Table 1.1: Summary of level of mechanization in the value chains

Value chain	Activity	Farm scale and % level			Average
		Small-scale	Medium scale	Large scale	
Maize	Ploughing	100.0	100.0	100.0	100.0
	Planting	32.0	77.0	58.0	56.0
	Weeding	27.0	40.0	71.4	46.0
	Harvesting	0	0	0	0
	Threshing	76.7	100.0	87.5	88.0
	Transport	100.0	100.0	100.0	100.0
	Average	**39.0**	**53.0**	**53.0**	**48.0**
Irrigated rice	Ploughing	66.7	66.7	-	67.0
	Rotavation/ harrowing	70.3	91.7	-	81.0
	Levelling	70.3	83.3	-	77.0
	Planting	0.0	0.0	-	0.0
	Weeding	0.0	0.0	-	0.0
	Harvesting	48.6	60.9	-	55.0
	Threshing	58.3	83.3	-	71.0
	Transport	91.9	95.8	-	94.0
	Average	**42.0**	**52.0**	-	**47.0**
Upland rice	Ploughing	80.3	-	-	80.3
	Harrowing	51.9	-	-	51.9
	Planting	4.9	-	-	4.9
	Weeding	1.6	-	-	1.6
	Harvesting	10.6	-	-	10.6
	Threshing	15.5	-	-	15.5
	Transport	4.5	-	-	4.5
	Average	**13**	-	-	**13**
Wheat	Ploughing	94.0	100.0	100.0	98.0
	Harrowing	98.0	100.0	100.0	99.0
	Furrowing	-	-	-	-
	Planting	85.0	100.0	100.0	95.0
	Weeding	0.0	0.0	0.0	0.0
	Harvesting	94.0	100.0	100.0	98.0
	Transport	100.0	100.0	100.0	100.0

	Average	**63.0**	**67.0**	**67.0**	**65.0**
Tea	Ploughing	76.9	50.0	66.7	64.5
	Harrowing	0.0	50.0	50.0	33.3
	Planting	0.0	0.0	0.0	0.0
	Weeding	3.8	10.0	28.6	14.1
	Harvesting	0.0	0.0	0.0	0.0
	Transport	20.0	80.0	100.0	66.7
	Average	**3.4**	**20.0**	**25.5**	**16.3**
Sugarcane	Ploughing	100.0	100.0	100.0	100.0
	Harrowing	96.0	100.0	100.0	99.0
	Furrowing	48.0	86.0	100.0	78.0
	Planting	0.0	0.0	0.0	0.0
	Weeding	0.0	0.0	13.0	4.0
	Harvesting	0.0	0.0	0.0	0.0
	Loading	77.0	76.0	88.0	80.0
	Transport	100.0	100.0	100.0	100.0
	Average	**40.0**	**45.0**	**50.0**	**45.0**
Coffee	Ploughing	0.0	-	-	0.0
	Planting	0.0	-	-	0.0
	weeding	4.3	-	-	4.3
	pruning	0.0	-	-	0.0
	Harvesting	5.0	-	-	5.0
	Transport	37.0	-	-	37.0
	Average	**8.0**	-	-	**8.0**
Tomato	Ploughing	87.7	100.0	100.0	96.0
	Harrowing	83.3	75.0	100.0	86.0
	Transplant	0.0	0.0	0.0	0.0
	Weed control	0.0	0.0	0.0	0.0
	Staking	0.0	0.0	0.0	0.0
	Irrigation	50.0	57.7	70.0	59.0
	Harvesting	0.0	0.0	0.0	0.0
	Transport	100.0	100.0	100.0	100.0
	Average	**29.0**	**29.0**	**34.0**	**31.0**
Mango	Ploughing	83.9	91.3	66.7	81.0
	Planting	0.0	0.0	0.0	0.0
	Weeding	0.0	4.3	0.0	1.0
	Pruning	3.3	0.0	0.0	1.0
	Harvesting	3.2	0.0	0.0	1.0
	Transport	69.2	75.0	25.0	56.0
	Average	**13.0**	**13.0**	**4.0**	**10.0**

Source: Survey Data

Table 1.2: Operations, Machines and Implements used

Crop category/ Operation	Land preparation	Planting	Weeding	Topdressing, manure and pesticide application	Pruning, harvesting and post-harvest handling	Transport	Value addition – processing and utilization
Industrial crops	Tractor and oxen ploughs	Manually using hoe, fork Jembe, mattock,	Knapsack sprayer for herbicides,	Knapsack	Pruning saw, panga, harvesting is manual	Wheel barrow and motor vehicle	Rotarvin, CTC machine
Horticultural crops	Tractors	Mostly manual using fork jembe mattock, hoe, shovel,	Knapsack sprayer, hoe and machete,	Knapsack sprayers, motor blower,	Machetes and secateurs, pruning saw, panga	Wheel barrow, motor vehicle	-
Food crops	Tractor-Mouldboard plough, and ox drawn plough	Tractor drawn planters	Knapsack and boom sprayer, motor blower,	Knapsack and boom sprayer	Combine harvesters, maize shellers, rice harvesters	Ox/donkey carts, tractor trailers, three wheeler vehicle	Hammer mill, shredders, tractor drawn chaff cutter, baler, machete, wet mill
Livestock type/operation	**Feeding and watering**	**Animal protection**	**Milking and transportation**	**Slaughtering**	**Manure handling**		
Cattle	Chaff cutters, hay balers,	-	Milking parlor,	-	-		

Source: Survey Data

4.1.2.2. Livestock Value Chain

This study considered mechanization in livestock which included cattle, poultry, sheep and goats. In this category mechanization was relatively low. The food crops/livestocksystem had the highest mechanizationlevel at 40.9% for chaff cutting. Other activities with notable levels of mechanization were in hay production and milk production. Milking operation was done manually by all the respondents within this system. There is immense opportunity in mechanizing in these activities. There was no mechanization in poultry management operations.

In the industrial crops/livestock system the high mechanization level was registered in chaff cutting (37.5%). Other activities which reported notable mechanization are hay production, milking and hay transportation. The horticultural crop/livestock system's highest mechanization level was reported in manure handling (33.3%). Similarly, modest mechanization was reported

in chaff cutting and milk transportation. There was no mechanization reported for poultry management, milking, and forage production in this system.

In conclusion it was noted that the livestock mechanization was required in feeding, deworming, animal protection, milking and slaughtering. As well, there was no value addition reported and hence providing an opportunity for increased productivity, value addition and income through mechanization.

4.1.3. Mechanization constraints and proposed interventions

In a free market economy like Kenya, the amount and choice of mechanization inputs is demand driven, whereas in a planned economy it is supply driven. Mechanization should not be an end in itself and therefore, in a free choice situation, like Kenya, the government has not refrained from making policies which will stipulate by which means or by how much, agriculture will be mechanized. The type and degree of mechanization should be decided by the producer to best suit his/her business and his/her own particular circumstances, and the choice of suitable methods will therefore be just one of a number of choices that the farmer has to make.

The study identified major constraints impacting on agricultural mechanization as follows;

- Inadequate and uncoordinated research and development of agricultural mechanization
- Limited research funding in agricultural mechanization
- Unavailability of machinery services
- Lack of finance to acquire machinery
- High cost of machinery and equipment for crops and livestock management
- Small farm holdings are fragmented, and therefore machinery cannot be used.
- Inadequate information on agricultural mechanization
- Lack of skills on agricultural machinery
- No commercialization strategy for agricultural mechanization innovations
- No agricultural mechanization testing/inspection unit for machinery
- Uncoordinated research on agricultural mechanization
- Poor access roads in the rural areas

The analysis of the existing situation, provided suggestions for an (ideal) future situation. The actions required to move from the existing situation to the future situation were defined as interventions. The proposed interventions could be undertaken by researchers, private andpublic sector. These include:

- Provision of subsidy
- Avail low cost county tractor hire services
- Develop and introduce appropriate machines for small farmers
- Increase extension services and farming training
- Enhance access to affordable loans
- Encourage private investment in machinery
- Formation of farmer groups to access credit and agricultural technology
- Provide market incentives to enable farmers make profit to purchase agricultural mechanization inputs
- The Government to finalize the draft agricultural mechanization policy to address issues of commercialization, testing, capacity building and research

4.1.4. Research Strategy and Agenda

The Kenya Agricultural and Livestock Research Organization (KALRO) established the Agricultural Mechanization Research Institute (AMRI), with the mandate of generating and disseminating agricultural mechanization technologies and innovations geared to enhancing productivity and value addition in Kenya (MoAL&F, 2013). AMRI was established in December 2015 with its headquarters at Katumani in Machakos County and therefore required a clear understanding of the current agricultural mechanization systems, mechanization policies and constraints to enable it develop its research strategy and research themes.

According to the study the proposed research strategies were:

i. Undertake collaborative applied and adaptive researchin agricultural mechanization with universities and other research institutions
ii. Coordinate research and technology dissemination in agricultural mechanization in Kenya
iii. Provide incentives for product development and commercialization to enhance adoption

iv. Enhance appropriate linkages with various stakeholders in order to enhance agricultural mechanization use

v. Develop short and long term research strategies for enhancing agricultural mechanization in Kenya

vi. Embrace demand driven research on agricultural mechanization

The proposed agricultural mechanization research themes were:

i. Agricultural mechanization technology development for all categories of farmers (small, medium and large scale) along the crops and livestock value chains

ii. Agro-processing, value addition and farm structures technologies

iii. Renewable energy

iv. Adaptive research of agricultural mechanization technologies and innovations to local conditions to meet farmers needs

v. Research in soil management and water use efficiency for improved performance

vi. Technology testing and dissemination for agricultural mechanization in Kenya

vii. Socio-economic and research of agricultural mechanization technologies (economics and social acceptability)

4.1.5. Technical and policy recommendations

This study identified various key technical and policy recommendations aimed at enhancing agricultural mechanization in Kenya, which include;

- Finalization and implementation of the national policy on agricultural mechanization. This policy will be pertinent in guiding the agricultural mechanization in terms of acquisition, evaluation/ testing and certification of the appropriate machinery, pricing of the machinery, and production of the spares, local fabrication of machinery and spares. Other fields where the policy has to provide guidance are research and dissemination of the agricultural mechanization
- There is need for the government to focus on how to fund agricultural mechanization research in order to develop innovations especially for small scale farmers due to declining land sizes. The funds will also enable research and set up the required facilities including the headquarters with modern workshops and equipment/implements.

- There is need for harmonization of agricultural mechanization research and promotion activities with universities and international institutions, NGOs, Community Based Organization, national government e.g. ATDCs, county governments and machinery dealers.
- Development of a technology commercialization strategy in collaboration with the public, private sector and research institutions aimed at improving the adoption of agricultural mechanization innovations
- There is need for enhancement of credit access and subsidy for the purchase of the appropriate farm machinery to enhance productivity at the farm level as well as value addition or post-harvest activities.
- There is need for providing guidelines on agricultural mechanization standards for different operations and value chains

5.0 CONCLUSION AND RECOMMENDATIONS

The findings of this study will be crucial in generating information that will help in understanding of the existing agricultural mechanization practices, constraints and opportunities. This will also help in guiding the research agenda for agricultural mechanization, promotion of existing technologies and make technical and policy recommendations not only in Kenya but the rest of Africa. The implementation of recommended technical and policy interventions will lead to the realization of measurable qualitative and quantitative outcomes through the improvement of productivity amongst the selected value chains ensuring improved farm production, incomes, and food and nutrition security.

6.0 REFERENCES

Ahmed, A. and Ariyo, O. 2015. Agricultural mechanization. Background paper. Proceedings ofWorkshop held in Dakar, Senegal, 21-23 October, 2015.

Bymolt, R. and Zaal, F., 2015. Moving to Mechanization: Mechanization in Maize Farming Systems in Kenya, Tanzania and Ethiopia

FAO (2006). Farm power and mechanization in sub-Saharan Africa. Sims, BG and Kienzle, J. Food and Agriculture Organization of the United Nations. Rome, Italy. Agricultural and Food Engineering Technical Report 3. 65 pp.

Mellis, D., Matsaert, H. and Mwaniki, B. 1999. Participatory technology development for animal traction; Experiences from a Semi-arid areas of Kenya. In Starkey and Kaumbutho (Eds). Improving animal Traction Technology. Proceedings of the first workshop for East and Southern Africa, held 18-23 January, 1992, Lusaka, Zambia. Technical Centre for Agriculture and rural cooperation (CTA), Wigeningen, The Netherlands, 490p. ISBN 92-9081-127-1.

Ministry of Agriculture, Livestock and Fisheries (2013). Kenya Agricultural and Livestock Research Act 2013, No 17. Government Printer, Nairobi, Kenya.

MoAL&F (2015). Achievements under the Jubilee Government's One Year in, 1–18.

Mutua et. al. 2014. Farm Mechanization and Conservation Agriculture for Sustainable Intensification (Facasi Project- Kenya), 1–88.

Starkey, P.H. 1994. A worldwide view of animal traction, highlighting some key issues in eastern and southern Africa. Pp 66-81. In: Starkey P, Mwenya E and Stares J (eds). Technical Centre for Agriculture and rural cooperation (CTA), Wigeningen, The Netherlands, 490p.929081-127-7.