Volume 5 No: 18 (2020)

Mechanization and Skills Development for Productivity Growth, Employment and Value Addition: Insights from KENYA

Felister Makini, Lawrence Mose, Geoffrey Kamau, Noah Wawire, Beatrice Salasya, Wellington Mulinge, Margaret Makelo, Stella Makokha, and Elias Thuranira

April 2020

KALRO
Kenya Agricultural & Livestock Research Organization

FARA
Forum for Agricultural Research in Africa

ISSN 2550-3359

Citation

Makini F, Mose L, Kamau G, Wawire N, Salasya B, Mulinge W, Makelo M, Makokha S, and Thuranira E, (2020). Mechanization and Skill Development for Productivity Growth, Employment and Value Addition. Insights from Kenya. FARA Research Report 5(18): PP38

Corresponding Author

Lawrence O. Mose (Lawrence.Mose@kalro.org)

Forum for Agricultural Research in Africa (FARA)
12 Anmeda Street, Roman Ridge PMB CT 173, Accra, Ghana Tel: +233 302 772823 / 302 779421
Fax: +233 302 773676 Email: info@faraafrica.org Website: www.faraafrica.org

Editorials

Dr. Fatunbi A.O (ofatunbi@faraafrica.org) and Mr. Benjamin Abugri(babugri@faraafrica.org)

ISSN: 2550-3359

About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.

FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).

FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its mission is the "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its Value Proposition is the "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision.

About FARA Research Result (FRR)

FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access to information generated from research activities, commissioned studies or other intellectual inquiry that are not structured to yield journal articles. The outputs could be preliminary in most cases and in other instances final. The papers are only published after FARA secretariat internal review and adjudgment as suitable for the intellectual community consumption.

Disclaimer

Acknowledgement
The authors thank all stakeholders who provided data and information contained in this report. Specifically, they are grateful to respondents from the following public and private institutions:
Nakuru County - Egerton University, Manera farm, Sensei Institute, Rift Valley Institute of Science and Technology; Kisii County - Kenya Institute of Highway & Building Technology, Kisii National polytechnic; Migori County - Miyare Agricultural Training Centre (ATC), Mawego Institute, South Nyanza Sugar Company, Miyare ATC; Kisumu County - Ramogi Institute of Advanced Technology (RIAT; Kisumu Polytechnic, Maseno University; Kakamega County - Masinde Muliro University of Science and Technology (MMUST), Sigalagala National Polytechnic; Bungoma County - Sang'alo Institute of Science and Technology, Nzoia Sugar Company in Bungoma County; Uasin Gishu County- Eldoret National Institute, University of Eldoret; Narok County - Masai Mara University, Kabete Technical and Kirinyaga County - Kirinyaga University, Dedan Kimathi University, Wambugu Agricultural Training Centre, Mwea Irrigation Agricultural Development Centre (MIAD)
The development and publication of this paper was made possible with support from the Forum for Agricultural Research in Africa (FARA) through the Programme for Accompanying Research in Innovations (PARI).

The authors acknowledge the facilitative support of the Director General, Dr. Eliud Kireger, the project accountants, Mr. James Karanja and Ms. Rose Wafula and the project secretary Ms. Irene Mogaka for their logistical support that led to the successful preparation and production of the Report. Materials in the Report have been sourced and referenced, to the best of our knowledge. Every effort has been made to ensure that the originality of sources of the copyrighted materials is provided. The authors also acknowledge all those who, in one way or the other, provided other support during the preparation of publication.

Executive Summary

In Africa, the importance of mechanization in agricultural transformation was recognized in the Comprehensive Africa Agriculture Development Programme (CAADP) and the Malabo Declaration. In Kenya, agricultural mechanization is low and limited for smallholder farmers with labour intensive farming. This study was conducted to identify opportunities of mechanization policies and investments to increase productivity, incomes, employment opportunities and add value to African produce. In particular, the four research objectives were to: compare different institutional options for mechanization, including state-led procurement and distribution of machinery and private sector activities; assess opinions and policy beliefs with regard to policy instruments and effects on mechanization, youth and digitalization; assess the state of skills development for mechanization and; assess the effects of agricultural mechanization on rural communities.

The study was conducted in seven out of 47 counties, and a total of 187 privately owned tractor owners and 19 government (public) owned tractor respondents were interviewed. On policy representatives from the national government, research and nongovernment organizations, farmer organizations, youth associations, women organizations, county governments, and private companies were interviewed using a structured questionnaire. Fourteen institutions offering mechanization courses provided the required information on skills development. Participatory impact diagrams were used to gather information from farmers on the impact of agricultural mechanization.

There were more private procured tractors than public procured ones and sources of information on choosing a tractor differed significantly, as private operators sourced information from other farmers and new tractor dealers, while public operators relied more on government agencies and new tractor dealers. New Holland was the popular tractor brand, while the popular tractor size was 70Hp for both privately and publicly-owned tractors; but publicly-owned tractors also had 40-50Hp. Private owners had varied sizes of tractors; this could be because private operators used the tractors for various functions, including land preparations and transportation.

The government was the main source of finance for publicly-owned tractors, while owners of privately-owned tractors used personal savings and bank loans. The major considerations before purchase of a tractor were quality, brand, capacity or size, and price.

Ninety percent of respondents for public-owned tractors had after sales services, compared to 63 percent of the respondents for privately-owned tractors. Maintenance level was the same for both categories of tractors. Both categories of tractors were used for ploughing, harrowing and planting, but privately-owned tractors were also used for transportation to ensure that the tractors were not idle during off-season. Seventy-seven percent of the respondents for privately-owned tractors said they met customer needs, while only 43 percent of the respondents for publicly-owned tractors said the same.

Skills development was mainly done in universities and technical and vocational training colleges, giving long-term as well as short-term courses. Public sector institutions had longer experience and better physical infrastructure with more flexibility in their courses than those of the private sector. The relevant degree course in the universities was agricultural engineering, while those in the technical and vocational education and training colleges were certificates and diplomas in automotives, and mechanical engineering. More men than women were enrolled in all the institutions surveyed. All respondents recommended that more time should be allocated to college programs and there should be more internships and linkages with industry. The universities and technical and vocational education and training colleges had more permanent than temporary staff, thus ensuring stability and continuity in learning.

A higher proportion of state-imported machinery operators were trained, compared to those of privately-purchased machinery. More state-imported machinery operators had prior tractor driving experience than those for privately-purchased machinery. Owners of privately-purchased machinery used all the indicators measured for monitoring their operators, but operators of state-imported machinery used mileage recording, monitoring fuel level and field checks only. Universities' linkages with other institutions were about student attachment and internship, while technical and vocational education and training colleges had linkages with private stakeholders on financial assistance and student attachment.

From the participatory impact diagrams, positive impacts of the tractors included ploughing a larger area, deep ploughing to improve fertility, reduced costs, timeliness of operations, optimal plant population, and improvement of soil aeration and water retention. The negative impacts were: reduced soil fertility due to deep ploughing, thus exposing subsoil; increased soil erosion and compaction, and increased cost of operations. From the results, agricultural mechanization in Kenya was found to be dominated by the private sector, with the national and county governments complementing in some areas.

This study showed differences in terms of tractor ownership, financing, servicing/maintenance and utilization by the privately and publicly-owned tractors. However, the differences did not offer either model undue advantage in terms of performance over the other; hence, a mix of the two would still be recommended.

There is need for the government to ensure proper implementation of the National Agricultural Mechanization Policy so as to ensure efficiency in service delivery by both privately and publicly-procured tractors.

The Participatory Impact Diagram approach is a cost-effective way to elicit information from stakeholders, as illustrated by the vibrant discussions among farmers.

Introduction

African (Kenya inclusive) farm systems are the least mechanized of all continents (Sheahan & Barrett, 2018). This is a concern, since low levels of mechanization are associated with low levels of labor productivity, a key determinant of farmers' incomes (Fuglie & Rada, 2013). However, there is renewed interest in agricultural mechanization (FAO,2016; Kirui and von Braun (2018); Malabo Montpellier, 2019), fueled by increasing evidence that poor access to labor limits development for many smallholder farmers (Baudron et al., 2019; Diao et al. 2014; Nin-Pratt & McBride, 2014).
Indeed, Adu-Baffour *et al.* (2019) and Kirui (2019) suggest that farmers benefit immensely from agricultural mechanization, for example, by being able to increase their farm incomes. Further, research and experience have shown that successful agricultural development and mechanization require knowledge and skills development (Daum et al., 2018; Daum and Birner, 2017; Kirui and Kozicka, 2018). However, it is not clear, for instance, "what are the best options for the mechanization of smallholder production and processing systems from an economic and institutional perspective? What roles should the private sector and the state play? What knowledge and skills are needed to promote mechanization? And what are the effects of mechanization on rural employment?"

To answer these questions and, thereby, scientifically accompany the recent mechanization efforts, the Program of Accompanying Research for Agricultural Innovation (PARI) identified "mechanization and skills development for productivity growth, employment and value addition" as one cluster of its top priorities. PARI is led by the Center of Development Research (ZEF) and funded by the German Federal Ministry for Economic Cooperation and Development as part of *One world, No Hunger Initiative* (SEWOH). PARI's research cluster on mechanization is led by University of Hohenheim, the Forum for Agricultural Research in Africa (FARA) and ZEF, and jointly implemented with the Institut National des Recherches Agricoles du Bénin (INRAB), Kenya Agricultural and Livestock Research Organization (KALRO), Agricultural Research Council of Nigeria (ARCN), and Institut d'Economie Rurale (IER) Mali
.
The overall objective of the research cluster is to identify opportunities of mechanization policy and investments to increase productivity, incomes and employment opportunities and add value to African produce. In particular, the research cluster addresses four research objectives:

i) **To compare different institutional options for mechanization, including state-led procurement and distribution of machinery and private sector activities**. The objective was formulated in responsive to the renewed efforts of many African governments to import and distribute machinery to farmers, despite that tractors are private goods and despite the unpleasant track record of such state-led approaches (Daum and Birner, 2017; Pingali, 2007).
ii) **To assess opinions and beliefs with regard to policy instruments and effects related to mechanization, youth and digitalization.** The objective was formulated as agricultural development trajectories, including those related to mechanization, youth and digitalization are contested. For example, domestic policymakers and donors often have different opinions and beliefs with regard to the best policies; understanding these differences is key to enabling more fruitful policy dialogues (Mockshell and Birner, 2015).
iii) **To assess the state of skills development for mechanization.** The objective was formulated because research and experience have shown that successful agricultural

development and mechanization requires knowledge and skills development (Daum *et al*., 2018; Daum and Birner, 2017; Kirui and Kozicka, 2018). The research component analyzes the extent in which existing formal and informal training programs provide the knowledge and skills needed for successful mechanization; this helps guide future knowledge and skills development efforts.

iv) **To assess the effects of agricultural mechanization on rural communities.** This objective was as a result of the fact that effects of agricultural mechanization have been subject to a controversial discussion. As Juma (2016) shows in his book on "Innovation and Its Enemies", farm mechanization has been one of the most controversial of all agricultural innovations – not only in contemporary times, but also historically. While proponents see mechanization as largely beneficial, opponents emphasize the effects on employment as downsides of mechanization. However, little actual research has been conducted on the effects of mechanization. The research component uses Participatory Impact Diagrams to assess the positive and negative impacts of mechanization at the household and/or community level. KALRO addressed the four objectives in the context of agricultural mechanization in Kenya being generally low and limited for smallholder farmers who have high levels of manual labour, accounted for by women and youth (60%), draught power (25%) and machinery and equipment (15%) (Wawire *et al.* 2017); agricultural mechanization was mainly in land preparation, harvesting, milling and transportation, as well as in value addition in banana (Makini *et al.,* 2017) which is consistent with findings of ASDSP (2014) for Kiambu and Busia counties. Wheat had the highest response on machinery use for all farm operations (65%), followed by maize (48%) and irrigated rice (47%); while coffee and mango were the least mechanized value chains (Wawire *et. al.* 2016). There were over 12,000 tractors (2-wheel and 4-wheel units) operating in Kenya.

Methodology

This section highlights the diverse methodology employed in each of the components of the mechanization study.

Institutional options for procurement and use of tractors

The study was conducted in seven counties, selected out of 47 counties. The selection criteria included the proportion of mechanized crops, scale of operation, and estimated number of tractors within the county. The higher the levels of the three criteria, the higher the probability of a county being selected. The counties selected were Kirinyaga, Nakuru, Narok, Migori, Bungoma, Kisumu and Uasin Gishu (Table 1; Figure 1).

Table 1: Counties sampled, mechanized crops

County	Crop mainly mechanized
Kirinyaga	Rice
Nakuru	Maize/wheat
Narok	Wheat/maize
Migori	Sugarcane/maize
Kisumu	Sugarcane/maize/rice
Bungoma	Maize
Uasin Gishu	Maize

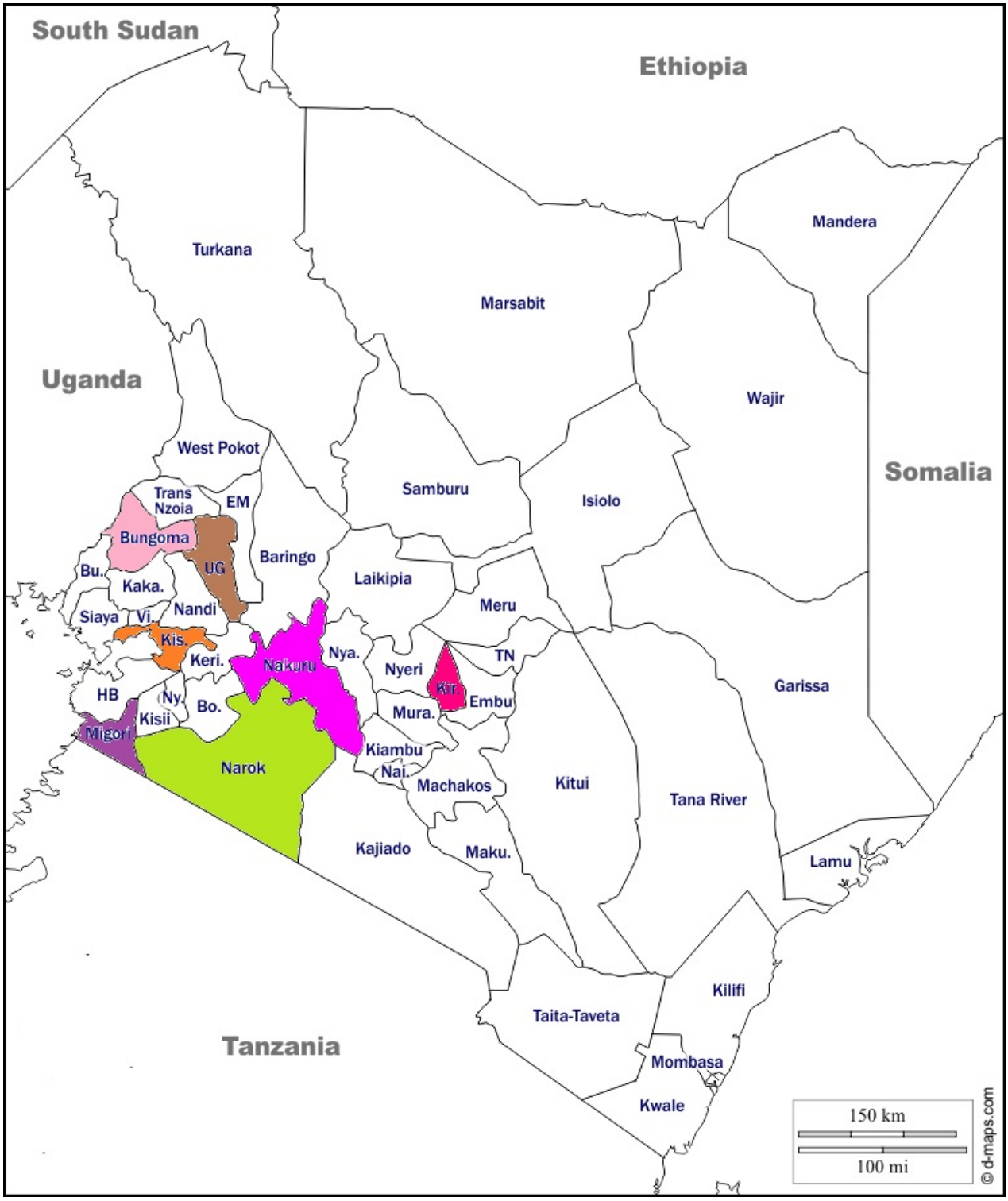

Figure 1: Map of Kenya showing the study counties

The intention of sampling was to randomly select 150 respondents from operators of privately-procured tractors and a similar number from those of publicly-procured tractors. For a person or entity to qualify as a respondent, they were expected to have a relatively new tractor (≤ 5 years old). Subsequently, the sampling frame obtained showed that the number of tractors that were privately and publicly-procured and which were less than five years were fewer than the required sample in all the selected counties. It was, therefore, decided to interview every tractor owner who met the set criteria, while the age of tractor was adjusted from five to eight years. The

publicly-procured tractors were much fewer than the privately–procured ones. Notably, none of the privately-owned tractors was procured under government assistance.
Using structured questionnaire data covering: demographics, employment and farm characteristics of respondents; ownership, motivation and financing of machinery and attachments; maintenance and repairs; service provision and related challenges; preference and knowledge of machinery; training institutions, programs offered and resource capabilities; and respondent opinions and policy beliefs on mechanization. A Focus Group Discussion (FGD) was thereafter held with a selected group of tractor beneficiaries, during which participatory impact diagrams (PIDs) were drawn depicting the positive and negative effects and the resultant impacts. Copies of the questionnaire were administered to households and representatives of government institutions by twelve trained enumerators under supervision of KALRO scientists using the Open Data Kit (ODK). A total of 187 privately-owned tractor owners and 19 government (public) owned tractors were interviewed. The completed questionnaire copies were uploaded to the server at the KALRO headquarters. The data were cleaned and analyzed using descriptive statistics.

Policy Beliefs, Opinions and Perceptions
Based on logistical constraints, data and information on this component of the mechanization study were collected from representatives of different stakeholders selected from some of the counties where the institutional options study was conducted (e.g. Nakuru) and from Nairobi County (Policy Dialogue headquarters). The final sample of 19 respondents were interviewed; this sample comprised 8 representatives from the National Government, two each from research and non-government agencies and one each from farmer organization, youth association, women organization, local/county government, private company, and CGIAR centre. Data were collected using a structured questionnaire and analyzed descriptively.

Skills Development
A sampling frame of respondents (institutions) in the seven study counties was developed. Based on expert knowledge, logistics and institutions actively involved in offering mechanization courses, 14 respondents (evenly distributed across the counties) were selected and provided the required information. A paper-based survey using a questionnaire was used to collect the data. The collected data collected were analyzed descriptively.

Impacts on beneficiaries
A total of 9 participatory impact diagrams (PID) (5 for men, 3 for women and 1 for both men and women) were used during the institutional options survey in six counties, one each in Narok, Kisumu and Nakuru and, two each in Bungoma, Uasin Gishu and Kirinyaga counties. The participants were a total of 47 men, 37 women and 10 men and women. Participants involved in the PIDs ranged from 7 to 15 members.
County extension officers assisted in mobilizing the PID participants, who were beneficiaries of tractor services (to the exclusion of tractor owners). Tractor owners were excluded because they could easily curtail free discussions on issues of service delivery. The individual participants were randomly selected, while others were chosen from farmers' group organizations, especially for women.
After explaining the purpose of the PID to the participants, the research team sought information on the positive and negative impacts that participants experienced in the use of tractor services in their farms. Participants consensually agreed on the information to be recorded after discussions. Table 2 shows the distribution of PIDs by location and gender.

Table 2: Number of Participants for each PID by County/Location and Gender in Kenya 2019

County	Location	Men	Women	Men and Women
Bungoma	Tongaren	-	-	10
	Kabuchai	-	10	-
Kisumu	Kobura	9	-	-
Uasin Gishu	Tapsagoi	-	15	-
	Moiben	7	-	-
Nakuru	Gitare	9	-	-
Kirinyaga	Wamumu	-	12	-
	Ngurubani	8	-	-
Narok	Ntulale	14	-	-
Total-Participation	**9**	**47**	**37**	**10**

Results and Discussion

In this section, highlights of the key findings by components of the study are presented and discussed.

State versus Private-led Procurement and Distribution of Tractors in Kenya

Tractor Ownership and Brands

The survey results showed that agricultural mechanization was dominated by the private sector in Kenya. Various companies dealing in agricultural machinery and equipment imported tractors and manufacture auxiliary equipment, such as ploughs, harrows, planters, sprayers, mills and silage processors. Publicly-procured tractors were mainly used in public institutions. However, county governments were responsible for Agricultural Mechanization Service (AMS) units, although none of the surveyed counties had a functional AMS unit. State-owned universities with agricultural engineering departments were involved in research as well as testing and fabrication of agricultural machinery.

The results also indicated that there were significant differences in the responses between publicly and privately-procured tractors on the source of information on tractor, and size of tractors, as opposed to the number of tractors functioning last season (Table 3).The reasons given for buying the tractors were generally similar, including the need to scale up and timely farming. However, there were differences regarding provision of hiring services (private) and replacing old ones (public). Indeed, the purchase of new tractors for both private and public institutions is often driven by business/ demand.

There were significant differences in the sources of information on tractors. Private operators sourced information from other farmers and new tractor dealers, while public operators relied more on government agencies as well as new tractor dealers. There was not much difference in the information on the number of tractors functioning the previous season: the commonest brand was New Holland— by publicly-operated tractors (40%) and privately-operated tractors (37.7%). There was a wide range of tractor models (>10) of different sizes (2WT, 4WT) with several attachment functionalities available both in public and private-led acquisitions. In the seven surveyed counties, it was observed that there were more than 10 types of tractors of sizes ranging from the two wheeler push models to the four-wheel drive tractors.

The commonest size of tractor was 70Hp for both privately and publicly- owned tractors. Private tractor owners had varied sizes, perhaps due to the fact that they used them for various farm operations, including land preparations and transportation.

Table 3: Tractor ownership characteristics in the study area

Variable	Publicly procured	Privately-procured	Statistical difference
	%	%	
Reasons to buy tractors	(n=52)	(n=472)	p-value=0.000***; $\mathbf{X^2}$=56.227
Scale up	65.4	65.3	
To farm timely	57.7	59.5	
Provide hiring services	28.8	69.9	

Replace old one	23.1	7.0	
Source of information for choosing	(n=52)	(n=472)	p-value<0.001***; **X^2**=214.108
Government	57.7	2.5	
Local Manufacturers	1.9	9.5	
New tractor dealer	32.7	20.6	
Used tractor dealer	7.7	10.0	
Other farmers	0.0	53.6	
Other	0.0	3.8	
Number of tractors functioning last season			
Brands	(n=15)	(n=151)	P-value=0.392
Ford	6.7	5.3	**X^2**=8.441. =
Mahindra	6.7	0.7	
Massey Ferguson	20	17.9	
New Holland	40	37.7	
Same	13.3	14.6	
John Deere	-	9.3	
Case	-	6.6	
Farmtrac	-	2.6	
Other	13.3	5.3	
Size of tractor (Horse power)	**(n=15)**	**(n=148)**	p-value<0.001***;
Below 40hp	-	0.7	**X^2**=36.452
40-60hp	33.3	1.4	
60-70hp	-	11.5	
>70hp	66.7	72.3	
Not known	-	14.2	

Financing of tractor Purchase

On the average, purchase payment for a tractor was Ksh3.7 million for the publicly-owned tractor and Ksh2.9 million for the privately-owned tractor (Table 4). There was, however, no statistical difference between the two responses. There was subsidy of 1.48% on the privately-owned tractors. The financing sources varied widely; the largest financial source for the publicly-owned tractors was government grant (73.7%), while for the privately-owned tractors, the main source was personal savings (54.3%), followed by bank loans (27.1%). Commercial banks thus played a significant role in financing tractor procurement in Kenya.

Table 4: Financing of tractor purchase

Variable			**Publicly procured**	**Privately-procured**	**Statistical difference**
Average amount paid for tractors at time of purchase, excluding			3,710,557.58 (1,250,816.667); (n= 19)	2,956,182.85 (277,417.988); (n=193)	t =0.589; p-value=0.563

insurance, registration, and transport					
% of the purchase price subsidized			0.000 (0.000); (n=7)	1.48 (0.315); (n=163)	t = -4.687; p-value=0.000***
Financed by inheritance/ family/ friends (%)			0.000 (0.000); (n=19)	2.04 (0.699); (n= 190)	t = -2.913
Payment through personal savings (%)			-	54.32 (2.803); (n=190)	-14.893 (106.508); p-value =0.000***
Payment from remittances (%)			0.000 (0.000); (n=19)	1.71 (0.658); (n= 190)	t = -2.598
Payment through bank loans (%)			0	27.12 (2.580); (n=190)	t = -2.869; p-value=0.008***
Payment through NGO loan (%)			0.00 (0.00); (n=19)	1.05 (0.742);(n=190)	t = -1.418
Payment through NGO grant (%)			5.26 (5.263); (n=19)	0.000 (0.000); (n=190)	1.00 (18.000); p-value= 0.331
Payment through micro finance loan (%)			0.00 (0.00); (n=19)	0.95 (0.672);(n=190)	t = -1.409
Payment through government loan (%)			0.00 (0.00); (n=19)	011 (0.105);(n=190)	t = -1.000;
Payment through government grant (%)			73.68 (10.379); (n=19)	1.63 (0.739); (n=190)	t = -6.925
Payment through Sacco loan (%)			0.00 (0.00); (n=19)	0.68 (0.448); (n=190)	t = -1.527

The critical factors considered before purchase of a tractor were not significantly different for both the privately and publicly-procured tractors. The major considerations, however, were quality, brand, capacity or size, and price.

Table 5: Criteria for choosing tractor type

Variable	%	%	P-Value
Sample size	**(n=52)**	**(n=472)**	p-value=0.213; $\mathbf{X^2}$=16.715
Price	40.4	48.3	
Strength / hp	42.3	40.5	
2/4 wheel drive	5.8	7.6	
Brand	44.2	40.3	
Age	5.8	5.9	
Capacity or size	44.2	36.2	
No Choice	7.7	1.7	
After sales service (spare parts)	17.3	15.0	
Fuel consumption	1.9	7.8	
Quality	55.8	57.6	
After sales service (cost)	0.0	2.3	
Mechanic knows how to fix it	5.8	3.6	
Other	0.0	3.0	

Maintenance of selected machinery

There were significant differences in the after sales services; the results indicated that 90% of publicly-procured tractors and 63% of the private ones had after sales services (Table 6). For most of the government procured tractors, there was the need for assurance of after sales service. The data also showed no significant differences in the frequency of oil change, greasing, change of filters and other expenditures on tractor maintenance for both the publicly and privately-procured tractors. Servicing was done by tractor owners, dealers and mechanics for 78.9% of state imported and 68.8% of privately- purchased tractors.

Table 6: Maintenance of Tractors

Variable	State-imported	Privately-purchased	Statistical difference
	%	%	**P_value**
After sale service package	90 (n=18)	63 (n=86)	0.027**
Current maintenance service providers	**n=19** Own = 10.5 Dealer = 10.5 Mechanic = 78.9	**n=187** Own = 16.6 Dealer = 16.6 Mechanic = 66.8	0.010***

Machine utilization and service provision

There was variation in the use of tractors by private and public owners (Table 8). Publicly-owned tractors were mainly used for ploughing, harrowing and, to some extent, planting, while privately-owned ones were used additionally for transportation. For the private operators, this ensured that the machines were not idle during the off-season. About 16% of publicly-owned tractors did not

provide services during the previous season, while 68% of privately owned tractors provided services. The privately-owned tractors met customer requests (77%), as compared to publicly-owned ones (43%). There were no significant differences with regard to the number of customers served, the liters of fuel used, and time taken to plough one acre, for the publicly and privately-owned tractors.

Table 7: Responses on the utilization and service provision for the last main season

Type of	**State-imported**	**Privately-purchased**	**Statistical difference**	
Type of operation	**n=18**	**n=181**	**Chi Test** χ^2	**P Value**
Land clearing	5.6	7.5	28.202	0.02**
Ploughing	88.9	84.5		
Ripping	0.0	2.5		
Harrowing	61.1	30.4		
Planting	33.3	24.2		
Fertilizing	5.6	8.1		
Weeding	11.1	3.1		
Irrigation	5.6	0.6		
Harvesting	5.6	13.7		
Shelling	5.6	5.6		
Threshing	0.0	0.6		
Milling	0.0	1.2		
Transport	5.6	39.8		
Baling	11.1	8.1		
Other	11.1	2.5		
Utilization of machines	**n=19**	**n=181**	**Chi Test** χ^2	**P Value**
% who provided services last main season	15.79	67.96	20.074	<0.001***
			T-test	P-Value
Number of days machine used in last main season	15.68 (2.19)	12.23 (1.79)	0.638	0.524
The area (acre) needed for own operations on own farm last main season	343.5 (149.4)	57.0 (8.7)	1.914	0.080*
The total area (acre) that was serviced for other farmers for this operation last main season	611.6 (264.5)	187.7 (32.9)	1.59	0.162
Customer Service	**n=14**	**n=244**	**Chi Test** χ^2	**P Value**
If customer needs were met last season	42.857	76.639	8.02	.005**
More services provided last compared to previous season	42.86	51.03	7.05	0.029**.
Number of customers provided services compared to last main season?	308 (209)	58.98 (13.73)	1.18	0.257

State of Skills Development for Mechanisation

Infrastructure in the colleges

Skills development in agricultural mechanization was mainly through long-term and short-term courses in public universities and TVET. There was one private institution which also offer short-term courses. The public institutions were, however, more established (over 40 years old) with 11 branches; the private institution was merely 4 years old. Respondents in the public institutions had an average of 12.8 years work experience in the institutions, compared to those of private institutions, who had 4 years' experience. This finding highlights the longer experience and better physical infrastructure with more flexibility of public than private institutions with regard to skills development.

Type of courses

The public sector had done their last needs assessment 1 year before the survey, while the private sector did their 4 years before. The relevant course in the universities was agricultural engineering, while TVETs had certificate and diploma courses in automotive and a diploma in mechanical engineering. The short-term courses in colleges were in farm mechanics and tractor operations. Male enrolment in public institutions was 4 times more than that in private institutions. This implies the need for strategies to encourage women in farm machinery operations. Since most of the farm work is done by women, training and use of machinery by women will reduce drudgery and increase overall farm productivity. According to Nozomi (2018), adjusting machinery to women's needs is often undervalued in the process of development and introduction; yet it is important in the adoption of machinery for increased farm productivity.

Respondents from the training institutions expected that those trained should be employed in the private sector or become self-employed; they suggested that more time should be allocated to formal skills development with more internships and stronger linkages with the industry. Although the government of Kenya provided and supported internship opportunities, its focus is mainly on degree graduates from recognized universities.

Teaching staff in colleges

A comparison of employment status of teaching staff in the universities and TVET is shown in Figure 2. Permanent staff in the institutions were more highly than temporary staff, perhaps to minimize brain drain.

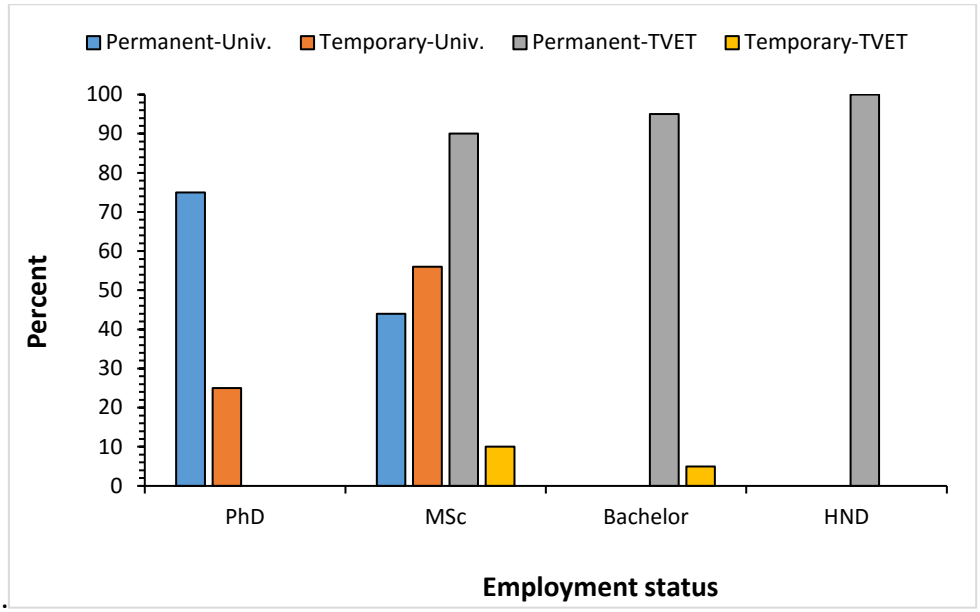

Figure 2: Proportion (%) of teaching staff under temporary and permanent positions

The data in Figure 3 show that in the universities, permanent staff were older and had more teaching experience than temporary staff. For the TVET, however, temporary staff had more teaching experience than the permanent staff. This may
mean that TVET was slower at regularizing (or making permanent) their temporary staff, which could be a disincentive for staff.

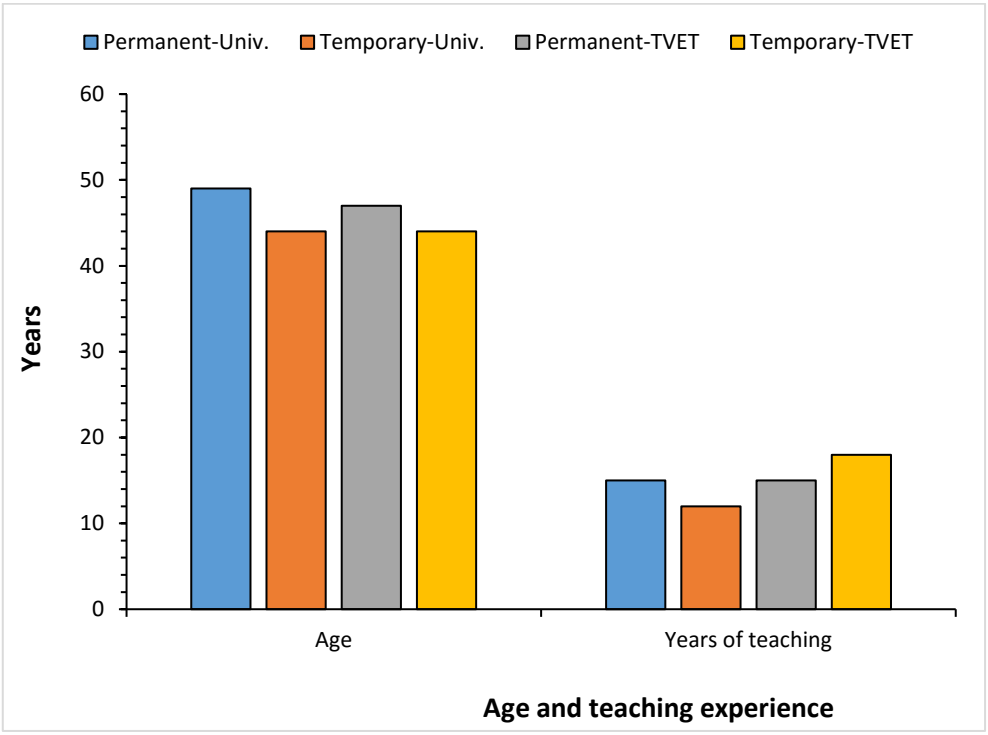

Figure 3: Age of teaching staff in teaching institutions

For universities and TVETs, over 80% of the respondents suggested further training of staff in core courses, hands-on and IT communications skills.
In the short-term training institutes, average age of the permanent staff was 52 years, while the average number of years teaching in current institute was 5 years. There were no temporary staff in the short-term training institutes. Further training was in core courses and IT communication skills was specifically suggested.

Level of training for machinery operators
A high proportion (82%, n=11) of the operators of state-imported machinery was trained, compared to those of privately-purchased machinery (30%, n=180), although the length of the latter's training was significantly longer (112.43 (31.63), n=52) than for the state-imported machinery (19.50 (11.41), n=8), p=0.06*).
It is important to note that both categories used hired labor with a certificate in tractor driving, while the training was mainly on tractor driving, maintenance and repairs; and least on machinery economics. The privately-purchased machinery seemed to be more concerned with the state of the machinery; hence, the training was of longer duration. State-imported machinery comprised solely tractors, while 8% of the privately-purchased machinery were combined harvesters. The operators' tractor driving experience was 87.5% (n=16) for operators of state-imported machinery and 57.6% (n=158) for privately-purchased machinery. About 23% of operators of privately-purchased machinery had no prior experience.

Training on maintenance was mainly formal in both categories of machinery ownership. The wage paid per month for hired operators was much higher for state-imported machinery (KES22,616.15 ($2907.6) than for those operating privately-purchased ones (KES16,192.3 ($1412.37), t=1.754, p=0.083. This could be due to the fact that state-owned operators were government employees on a regular salary. In most cases, the operators of privately-owned tractors were employed on a part-time basis. On the other hand, the wage paid per month was higher for privately-purchased than for state-imported machinery, although this was not significant. The level of satisfaction with the knowledge and skills received was high among over 90% of both categories of machinery ownership. The owners of privately-purchased machinery used all the methods for monitoring the operators, but the owners of state-imported machinery used mileage recording, monitoring fuel levels and field checks.

Linkages of training institutions with other stakeholders
The universities had linkages mainly with public and private institutions. The linkage concerned providing students to be trained, as well as providing work attachment and internship opportunities for university students. Public sector machinery operators suggested improvement of the curriculum content, while their private sector counterparts suggested improvement in content delivery rather than on the course content. In all cases, the suggestions made by partners were considered.

For the TVET institutions, linkages with private stakeholders concerned financial assistance, providing students for training, offering attachment, internship and employment opportunities for students. The public stakeholders for TVETs mainly provided student training, internship, attachment and employment opportunities for the students. The TVETs also had linkages with NGOs mainly for financial assistance and student training. All the three stakeholders (private, public and

NGO) made suggestions to TVETs on the study curriculum in terms of content and delivery. Most of the suggestions were considered by the TVET institutions.
Institutions providing short-term courses also had linkages with stakeholders from the private and public sectors, but not with NGOs. The linkages were on provision of students for training at the institution. The partners's suggestions on curriculum content and course delivery were also considered.

Policy Beliefs: What do Policy Stakeholders think about Different Impacts and Policies?

Perceptions on Budgetary Allocation to Agricultural Mechanization

The results reveal that most organizations had existed for the average of 18 years, with a 31 billion KES budget and attracted 55% funding from external donors. The mean age of respondents was 50 years; the majority (42%) of them were from the national government and devoted 72.5% of their efforts towards agricultural policies.

Figure 4 illustrates the respondents' hypothetical allocation of agriculture budget to agricultural policy compromises for different government programs. The results indicate that preferences on expenditure towards agricultural extension services, youth associations proposed 40%, NGOs, 35%, private sector and CGIAR, 40%, while women indicated 45% towards input subsidies and research organizations prioritized agricultural mechanization (30%).

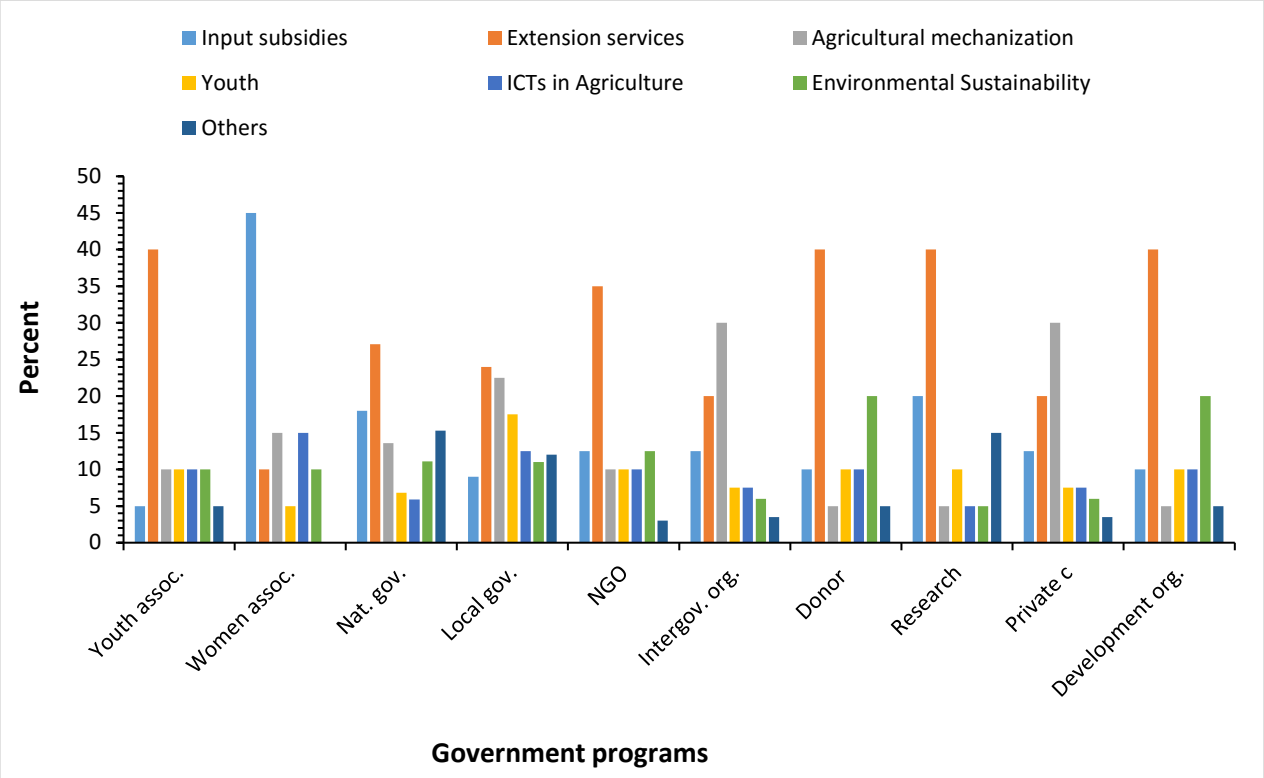

Figure 4: Hypothetical Allocation of Agriculture Budget to Various Government Programmes

Agricultural mechanization

Figure 5 presents the results of respondents' preferences on budgetary allocation to agricultural mechanization development through either animal draught or mechanical traction. All categories of respondents had a higher preference for animal traction and to allow importation, distribution and subsidies on machinery, except private companies who preferred knowledge and skills development (60%) and to take the lead in importation of farm machinery.

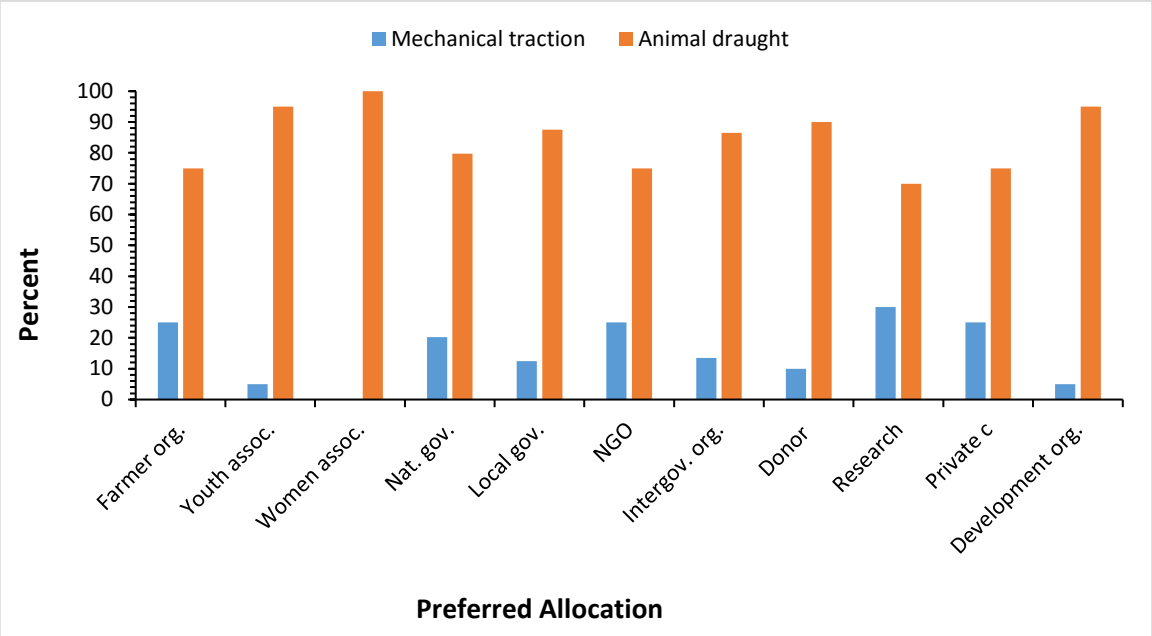

Figure 5: Preferred Budgetary Allocation between Support for Animal Draught or Mechanical Traction Programmes

On the distribution of agricultural mechanization budget between machinery imports, distribution and subsidies, on the one hand, and the provision of support infrastructure (e.g. knowledge and skills development), on the other, the result is shown in Figure 6.

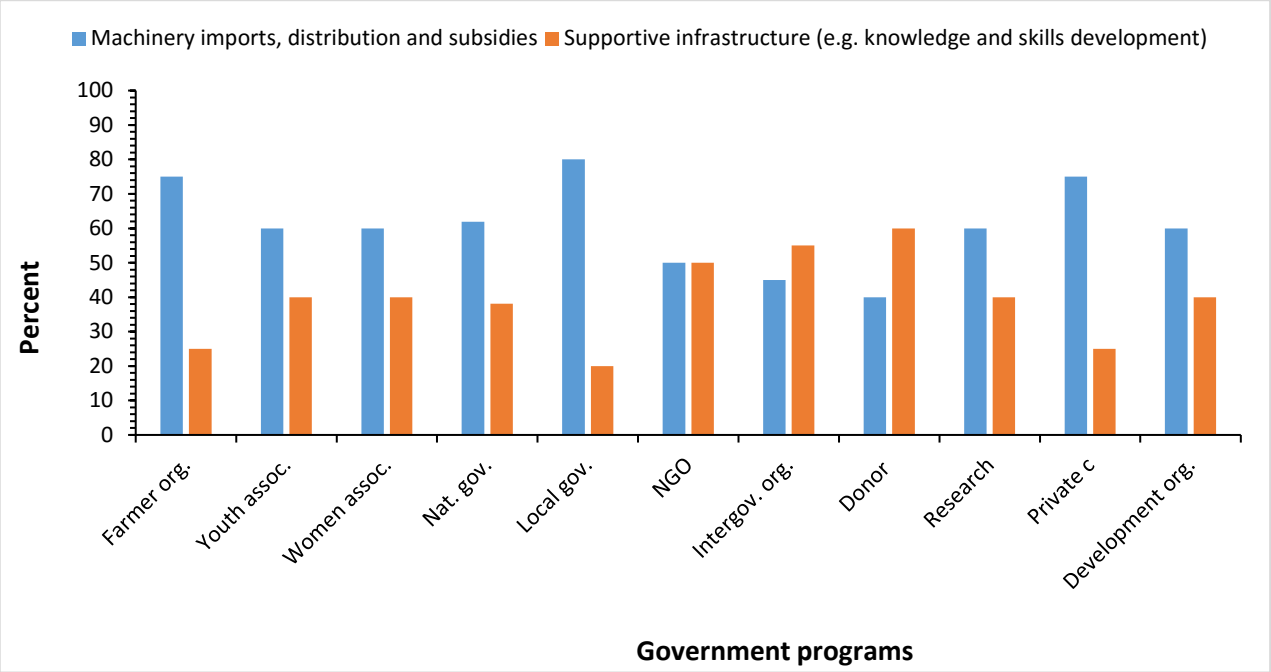

Figure 6: Preference on Budgetary Allocation between Agricultural Mechanization and Provision of Support Infrastructure

The development of business models that would benefit small-scale farmers was preferred across board (5.8); the respondents also preferred that tractor purchase should be subsidized for farmers, since banks do not sufficiently finance agricultural mechanization. Figure 7 presents the result on perceptions of respondents on the potential of institutional arrangements and reforms to promote smallholder mechanization. On the average, farmers cooperatives was ranked the most important (6.6) in promoting smallholder mechanization. This was followed by machinery hire markets (5.2), ICT-based solutions (5.1), land consolidation (5.0) and machinery associations (3.8).

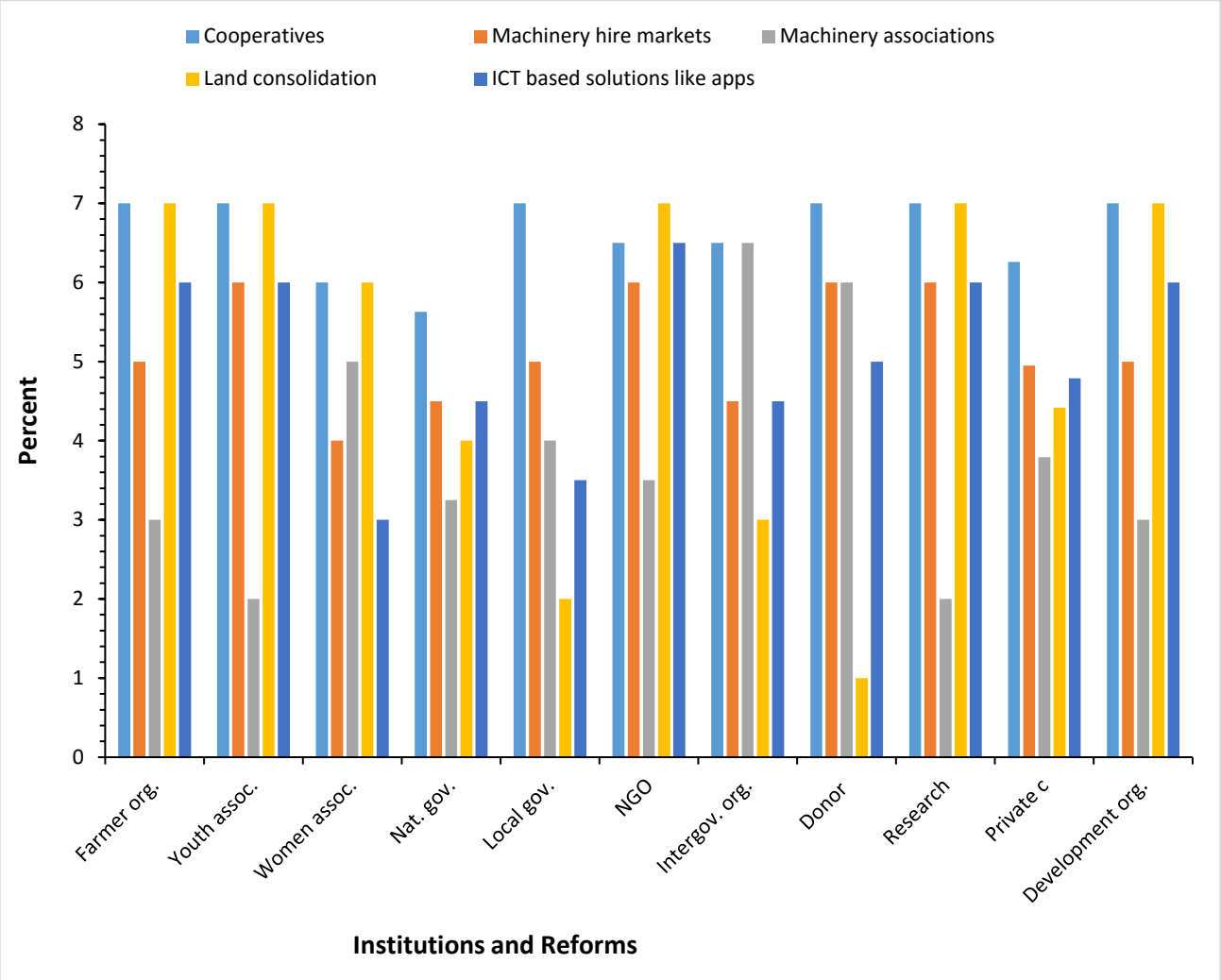

Figure 7: Ranked potential of institutional and reforms to promote smallholder mechanization

Status of Rural Youth in Agriculture

Farming remains unattractive to youths, but designing the right policies would reverse the situation, especially if they are involved in the policy formulation processes. The results of ranked perceptions on youth participation in agriculture are presented in Figure 8. The statement, "The youth finds farming unattractive under current conditions" was ranked highest with an index of 6.4, followed by "Designing the right policies, farming can become attractive to the youth" (6.1); other are: "Youth are not involved enough in agricultural policy processes" (5.7), Youth lack role models in agriculture (4.1), Providing 'too much education' unnecessarily raises the aspirations of the youth, which can become dangerous when not enough jobs are created for them (3.5); We should not be concerned if the youth leave farming to find work in urban areas (2.3) and Today's education system prepares the youth well for the job market (2.6).

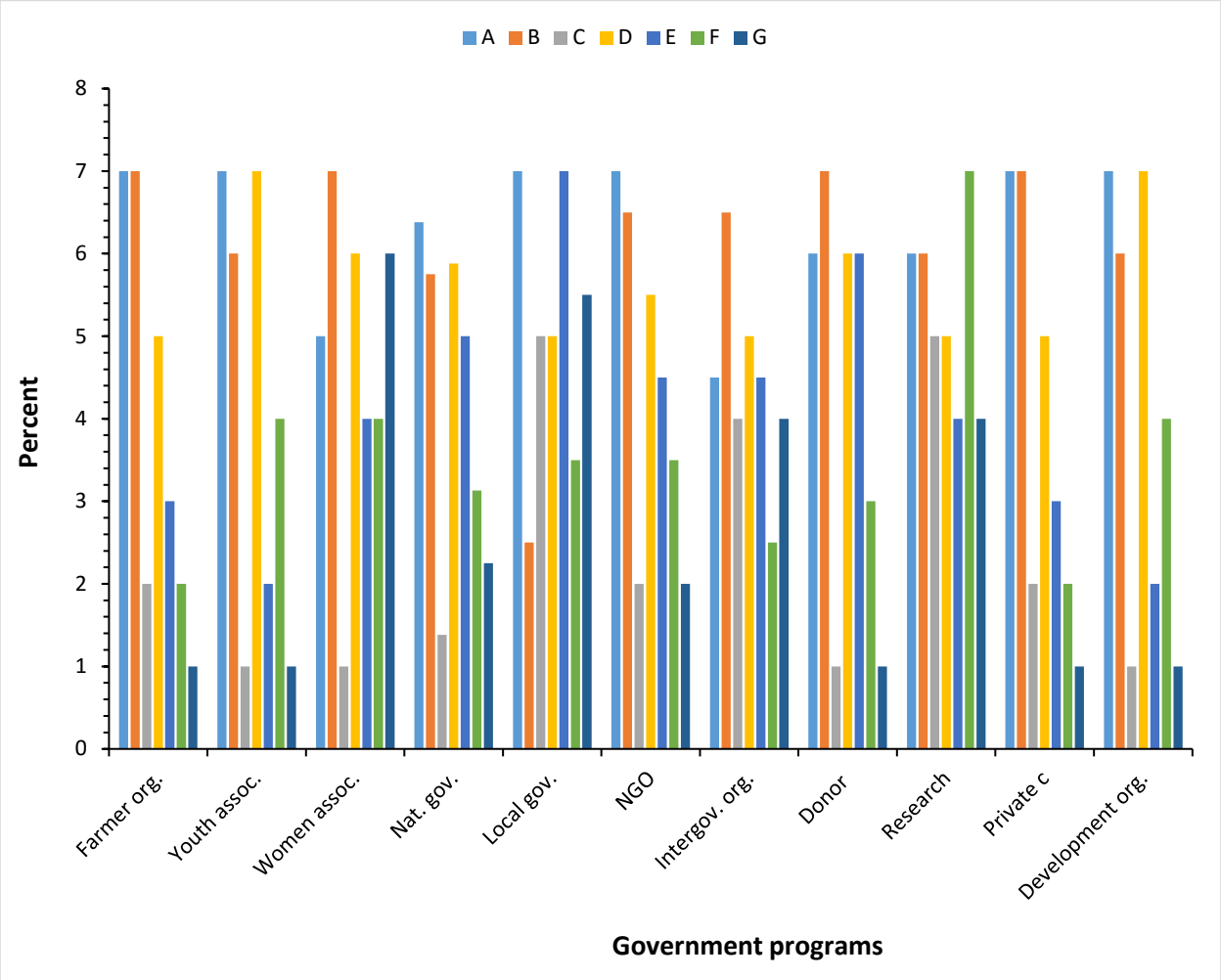

Figure 8: Ranked statements on youth participation in agriculture

Legend to Figure 8

Description	Codes
The youth find farming unattractive under current conditions	A
Designing the right policies, farming can become attractive for the youth	B
We should not be concerned if the youth leave farming to find work in urban areas	C
Youth are not sufficiently involved in agricultural policy processes	D
The youth lack role models in agriculture	E
Providing 'too much education' unnecessarily raises the aspirations of the youth, which can become dangerous when not enough jobs are created for them	F
Today's education system prepares the youth well for the job market	G

The most attractive policies for the youth were ICTs (6.5), agricultural mechanization (6.2), and access to credit (6.0), as indicated in Figure 9. The results also show that ICT applications and mobile services provide opportunities for agricultural development (6.5); although ICT applications are already helping farmers (5.6), they are limited by low connectivity (6.0), hence favoring mainly the wealthy households (6.5). There is, however, need to control the quality of mobile applications.

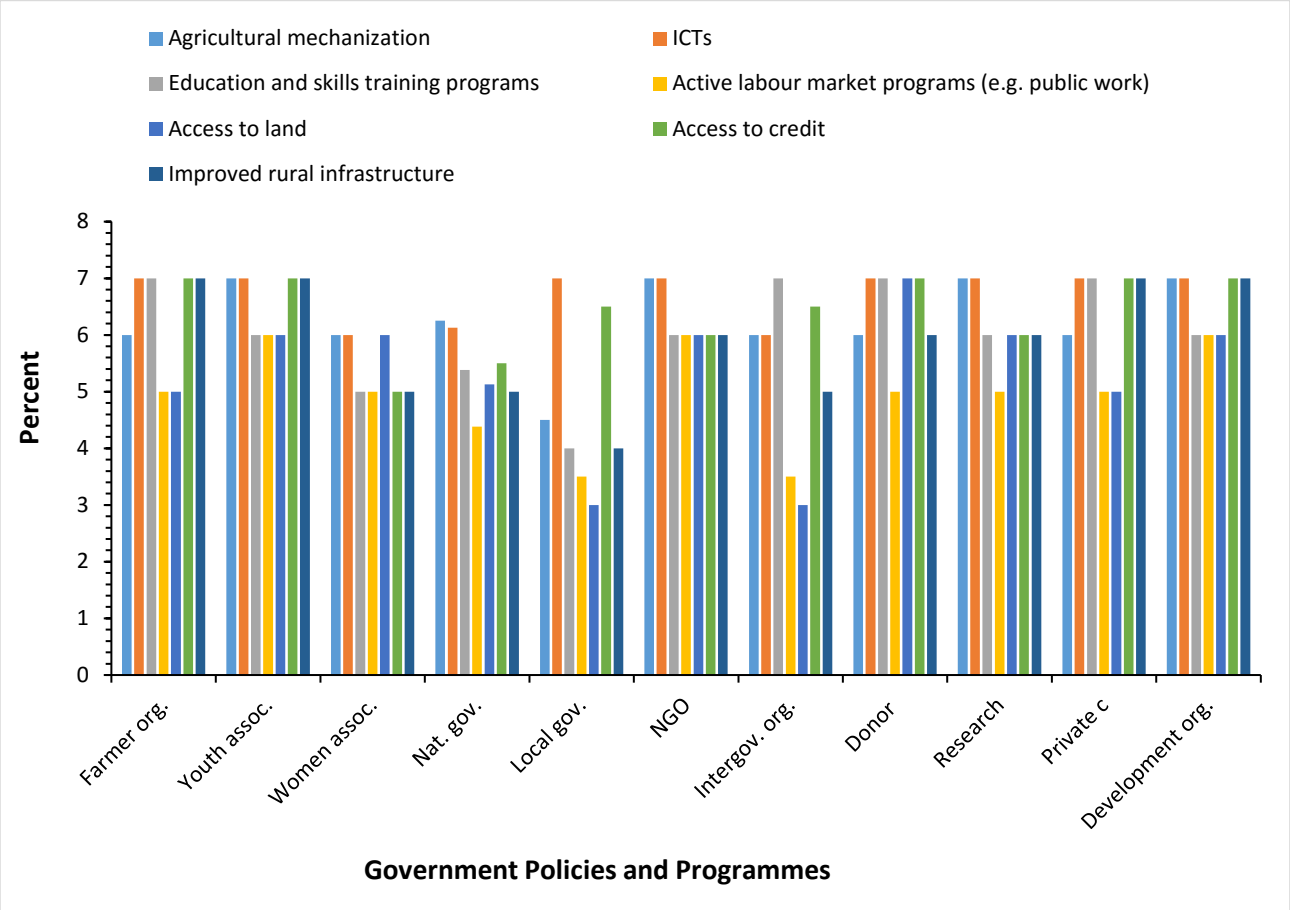

Figure 9: Rated Potential of Government Policies and Program to make Agriculture Attractive to the Youth

ICT in Agriculture

The results indicated that ICT applications and mobile services provided tremendous opportunities for agricultural development and were already helping farmers. ICTs also helped increase good governance by improving the management of agricultural agencies and empowering farmers to demand better services.

The results on ranked statements on ICT in agriculture are presented in Figure 10. The statement, "ICT applications and mobile services provide tremendous opportunities for agricultural development" was ranked highest at 6.4. This was followed by "ICT applications and mobile services are already helping farmers" (6.2), "ICT applications may help increase good governance by improving the management of agricultural agencies and empowering farmers to demand better services" (6.2); "Wealthy and educated households benefit more from ICT applications and mobile services" (5.9); "Low connectivity still limits the possibilities of many households to use ICT applications and mobile services" (5.4), "We need more quality control of ICT applications and mobile services" (5.0) and "ICT applications use personal and sensitive data and we should care more about data privacy and sovereignty" (4.9).

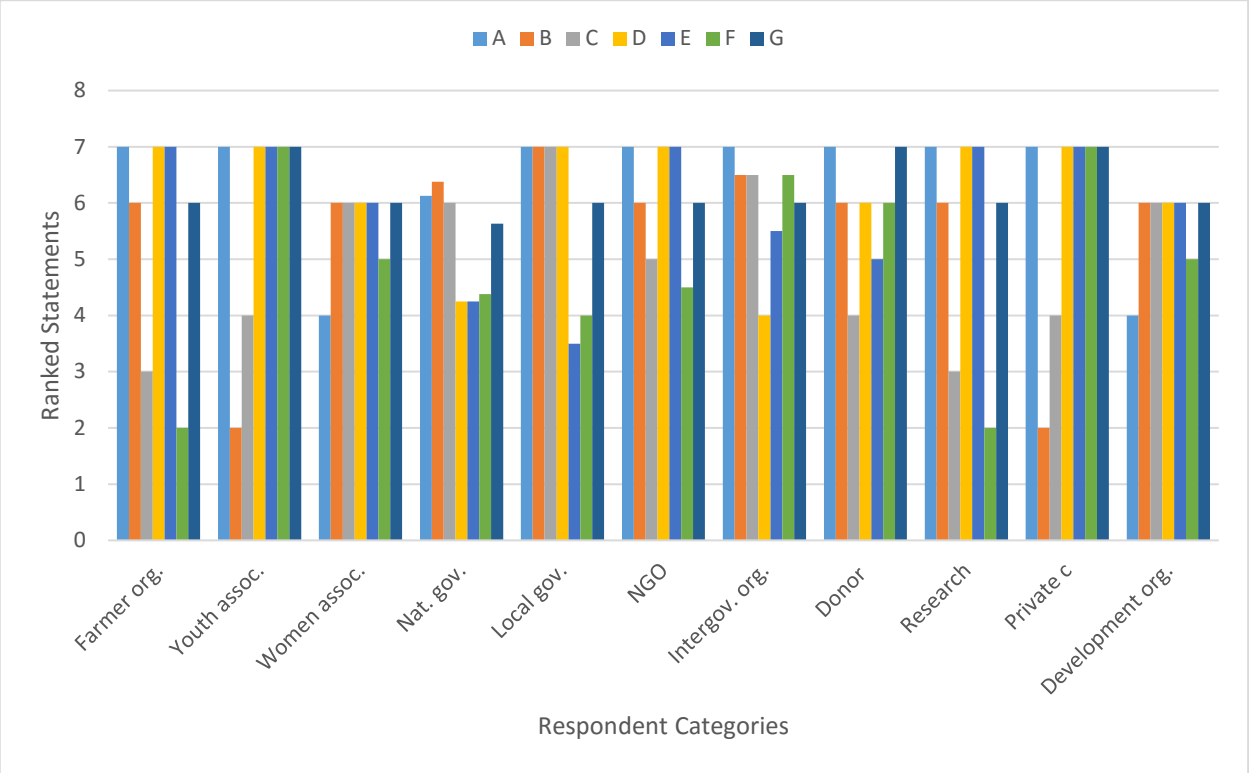

Figure 10: Ranked Statements on ICT in Agriculture

Legend to Figure 10

Statement	**Code**
ICT applications and mobile services provide tremendous opportunities for agricultural development	A
Low connectivity still limits the possibilities of many households to use ICT applications and mobile services	B
We need more quality control of ICT applications and mobile services	C
ICT applications and mobile services are already helping farmers	D
Wealthy and educated households benefit more from ICT applications and mobile services	E
ICT applications use personal and sensitive data and we should care more about data privacy and sovereignty	F
ICT applications may help to increase good governance by improving the management of agricultural agencies and empowering farmers to demand better services	G

The results also showed that ICT applications with the highest potential were marketing (6.7), mobile payment and savings (6.6), weather and price data (6.3), credit provision (5.9), machinery rental markets (5.7), insurance (5.5), and agricultural extension service (5.4) (Figure 11)

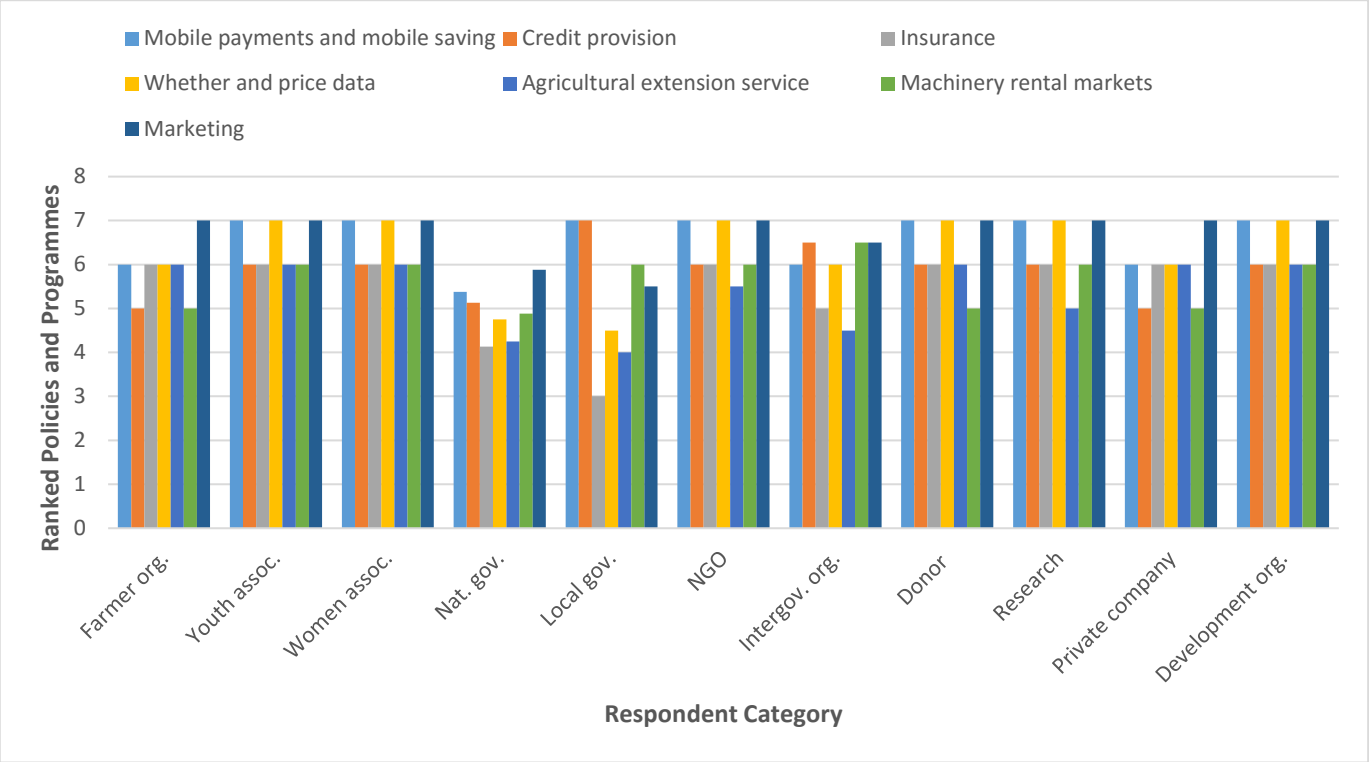

Figure 11: The Potential of Policies to make Agriculture Attractive to the Youth

Effects of Agricultural Mechanization on Rural Communities

Distribution of PIDs across the counties

The distribution of the study participants in groups across the counties is shown in Figure 12.

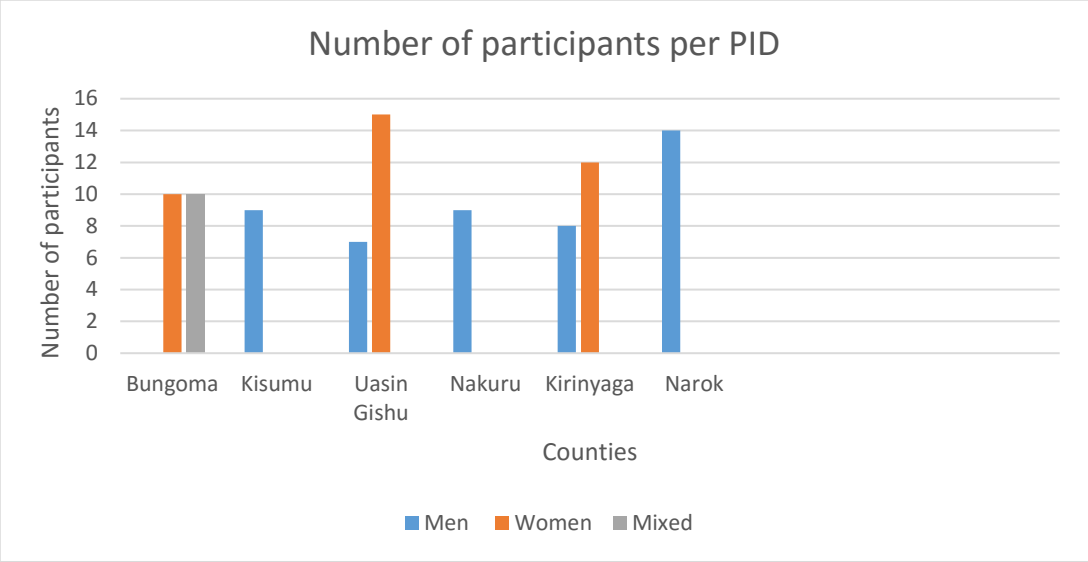

Figure 12: Number of PID participants in various counties

Effect of Tractor across Gender

A total of 12 positive and 12 negative effects were raised for gender considerations at the nine (9) meetings in six (6) counties (Tables 8 and 9). It was a bit difficult to discern the differences between positive and negative effects from the PID results, as the effects of the factors considered were not weighted. On the positive effects, the men groups raised 10 effects, while women groups raised 7 and the mixed groups raised 6 effects. On the negative side, the men raised 8 effects, compared to the women (7) and the mixed groups (4). This result implies that there is often more freedom when PIDs are organized by gender rather than as mixed groups.

Table 8: Positive effects of tractor use in selected counties of Kenya

No	Effect	Men	Women	Men and Women	Remarks
1	Larger areas planted	√	√	√	All
2	Deep ploughing to improve fertility	√	√	-	Men/WOmen
3	Reduces cost of operations	√	√	√	All
4	Faster/Timely operations	√	√	√	All
5	Improves soil aeration and water retention	√	√	-	Men and Women
6	Optimal Plant Population	√	-	-	Men
7	Improved quality of work	√	-	-	Men
8	Employment creation	√	-	-	Men
9	Reducing postharvest operations	√	-	-	Men
10	Improves quantity and quality	√	√	-	Men/ Women
11	Reduces drudgery	-	√	√	Women/mixed
12	Removal of hard pan	-	-	√	Mixed
	Frequency	10	7	6	

Table 9: Negative effects of tractor use in selected counties of Kenya

No	Effect	Men	Women	Men and Women	Remarks
1	Increased leisure	√	-	-	men
2	Deep ploughing –reduced fertility	√	√	-	Men and Women
3	Increased soil erosion	√	√	√	All
4	Reduced unemployment	√	-	-	Men
5	Spreading of weeds	√	-	-	Men

No	Effect	Men	Women	Men and Women	Remarks
6	Increased cost of operations	√	√	-	Men and Women
7	Reduced quality of work	√	√	-	Men and Women
8	Loss of gleaning opportunity	√	-	-	Men
9	Unsuitable for small plots-soil compaction	-	√	√	Women and mixed
10	Require skilled labour	-	√	√	Women and Mixed
11	Unsuitable for hilly and stony areas	-	√		WOmen
12	Not appropriate during rainy season	-	-	√	Mixed
	Frequency	8	7	4	

It was also likely that men had more to say about the effects because they usually supervise farm tractor operations. In addition, men did not raise issues of reduced drudgery and removal of hardpan, which were felt more by women who provide more labour services on the farm than men. The women groups did not also raise concerns on optimal plant population, improved quality of work, employment creation, reducing postharvest operations and removal of hardpan. The mixed groups listed 6 out of 10 effects and were the only groups which raised the issue of removal of hardpan.

On the negative side, the men highlighted various effects, such as unsuitable for small plots, requirement of skilled labor and unsuitability for hilly and stony areas. The mixed groups raised the issue of not being appropriate during the rainy season. The women were conscious of the limited land and its quality, as they relied more on land for subsistence than the men who mostly got involved in off-farm activities.

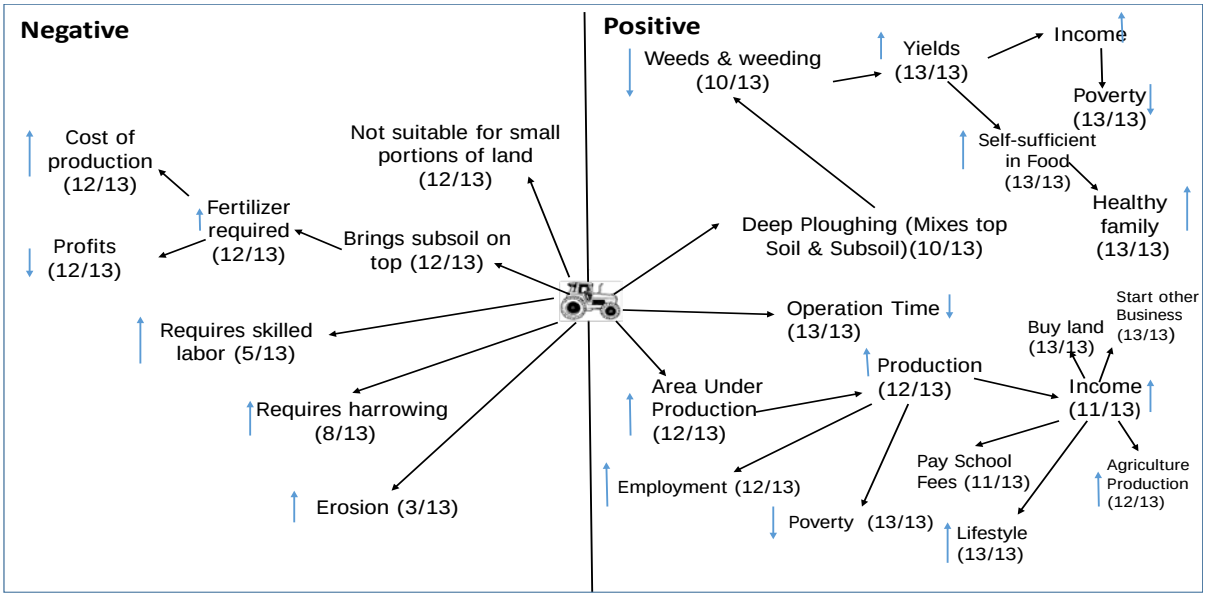

Figure 13: A sample of Participatory Impact Diagram

Positive impacts of tractor use on the community

a) Larger areas planted

A majority of farmers indicated that the use of tractor enabled them to plough a larger area. This was reported by 55.32% men, 29.73% women and 100% of the mixed group across the sampled counties. Ploughing larger farm areas led to increased production, employment opportunities, and income, and therefore, reduced poverty. The additional income from tractor use was used, for example, to pay school fees and meet other household needs. Also, this additional income was used to further improve agricultural production and enlarge other businesses.

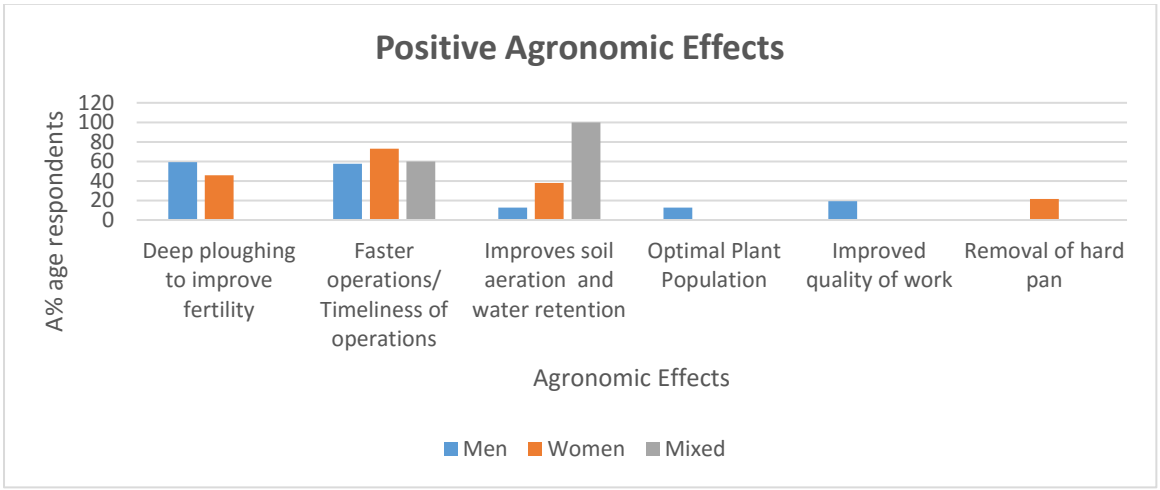

Figure 14: Positive agronomic efffects of mechanization

b) Deep ploughing to improve fertility

Majority of the men (59.32%) and women farmers (45.95%) indicated that deep ploughing positively impacted on soil fertility and moisture conservation, which in turn led to higher yields and incomes. Increased income was used to meet critical family needs, such as meeting nutrional needs, diversifying and modernizing agriculture enterprises.

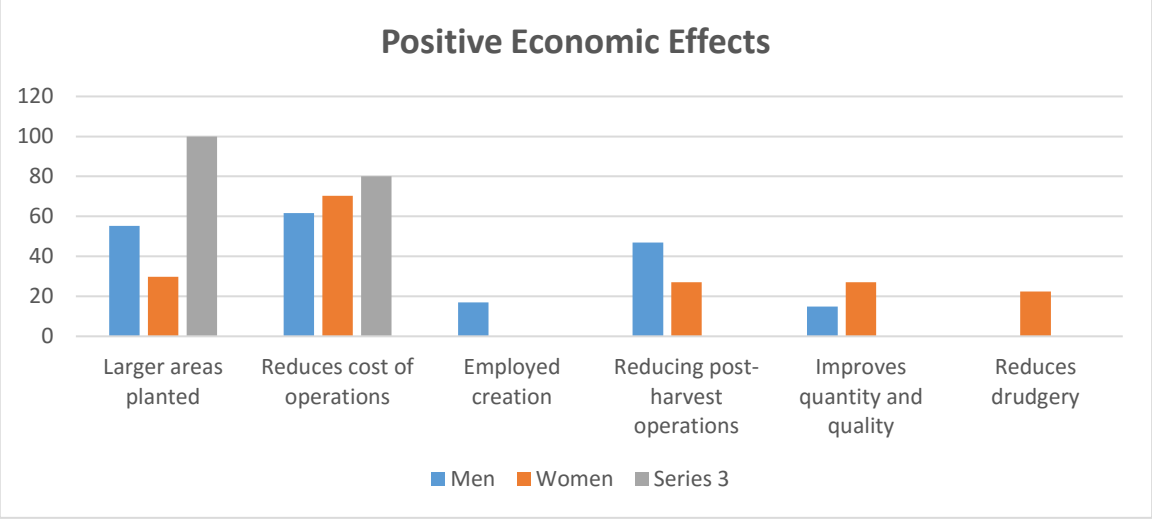

Figure 15: Positive economic effects of mechanization

c)Reduced cost of operations

About 62%, 70% and 80% of the men, women and mixed groups respectively indicated that it was cheaper to use a tractor than other means for land preparation. Reduced costs implies higher incomes.

d) Faster operations/timeliness of operations

The use of a tractor enabled faster operations (timeliness of farm activities), as was reported by 57.45% men, 72.97% women and 60% mixed group. This freed up time for other on-farm and off-farm activities and translated to improved household income and standard of living.

e) Improved soil aeration and water retention

The results also showed that tractor use improved soil aeration and water retention for the farmers.

f) Optimal plant population

The results also showed that the use of planters facilitated the achievement of optimum plant population and, therefore, increased yields and income.

g) Improved quality of work

The majority of participating farmers indicated that there was improved quality of work (ploughing, weed and pest control, etc) when tractors were used. This contributed to improved production and incomes, which enabled the farmers to meet their household needs.

h) Employment creation

The results also indicated that the use of tractors, for example, in hay baling, created employment opportunities for youths and provided them with means of livelihood. The hay, which was hitherto wasted before tractors were introduced, also provided extra income for the farmers.

i) Reduced postharvest operations

The results showed that farmers felt that mechanized harvesting was faster than manual harvesting and reduced the labor for threshing and winnowing. This availed the farmer time to engage in other on-farm and off-farm activities for increased income.

j) Improving quantity and quality in agricultural work

Participating farmers identified improved quantity and quality of work when tractors were used.

k) Reduced drudgery

The results indicated that tractor use reduced the unnecessarily long period of farming operations, such as ploughing, levelling and harvesting. The time saved was used for other on and off-farm activities, such as taking care of livestock, repair of farm structure, running other businesses, attending group meetings and resting. Some of these activities earned the farmers additional income and strengthened the family welfare.

l) Removal of hard pan

Majority of the farmers indicated that tractor use helped remove hard pans, which arose from shallow land preparation using oxen or manual labor. The removal of hard pan improves soil aeration, moisture retention and, ultimately, income and standard of living.

Negative impacts of tractor use

a) Deep ploughing

The results showed that deep ploughing had negative impact on the operations of men (29.79%) and women (89.19%) farmers. Deep ploughing was said to bring up subsoil, which has less nutrients, leading to low soil fertility and, hence, poor yields and low income.

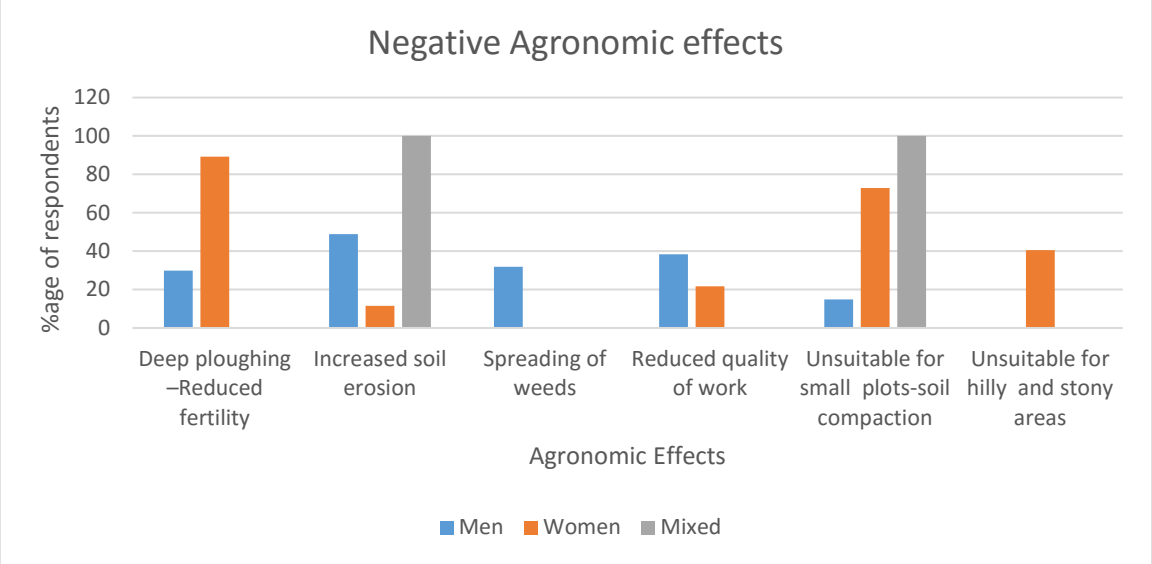

Figure 16: Negative agronomic effects

b) Increased leisure

The results showed that a few farmers identified bad leisure (wasting spending) as a negative impact of agricultural mechanization. The stated that higher incomes from mechanization encouraged promiscuity / infidelity in marriage through wasteful spending, thereby reducing money available for farming and other investments.

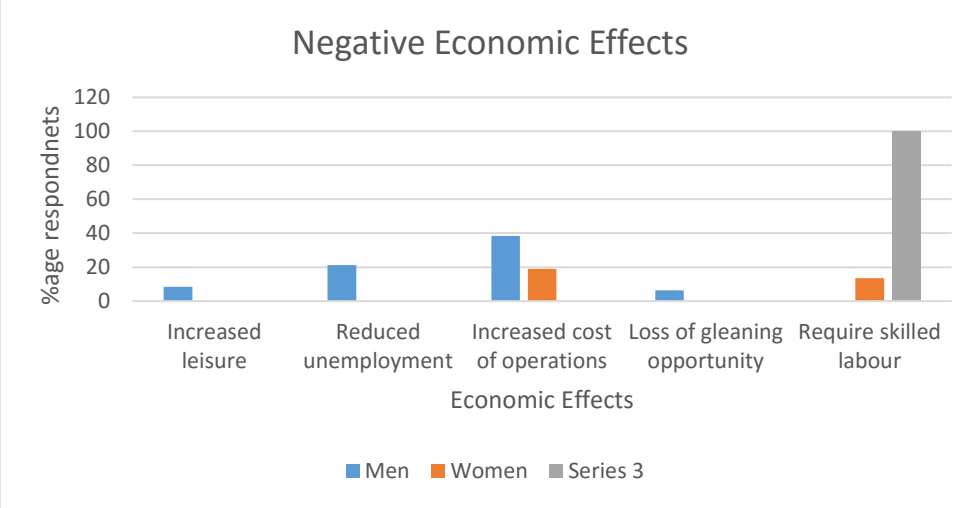

Figure 17: Negative economic effects

c) Increased soil erosion

About 49%, 12% and 100% of the men, women and mixed groups, respectively, indicated that the use of tractor loosened the soils and increased soil erosion. This implies nutrient loss and low productivity, income and food availability.

d) Reduced employment

Tractor use led to reduced employment for hitherto manual laborers; reduced income and increased incidences of poverty.

e) Spreading of weeds

The use of tractor increased the spread of pests and diseases through noxious weeds, such as Niger seed, and resulted in low yields and increased cost of pest and disease control. The overall result was reduced income and food security.

f) Increased cost of operations

Participants also indicated that the use of tractor led to an increase in the cost of farm operations, such as ploughing, harrowing and planting and harvesting. This led to a reduction in farmers' incomes.

g) Reduced quality of work

The results also showed that the inefficient use of tractors, such as using obsolete tractors and inexperienced operators, led to poor quality of work (eg, land preparation) and eventually to low yields, reduced food security and low incomes.

h) Loss of gleaning opportunity

The participants stated that the use of tractors led to a loss of gleaning (collecting leftover grains after threshing) opportunity, thus denying some community members extra sources of food and income.

i) Unsuitable for small plots

When tractors are used on small plots, they negatively impact on soil, as participants' responses showed (14.89% men, 72.97% women and 100.00% mixed groups). Tractor use can lead to soil being compacted, hence**,** resulting in hardpan and poor germination of crops, and ultimately to low plant population, low production, reduced food security and low income.

j) Require skilled labour

Tractor operation requires skilled persons. Therefore, if persons without adequate skills are engaged, there poor land preparation may ensue.

k) Unsuitable for hilly and stony areas

Famers identified the inability of tractors to operate in hilly and stony areas; this implies extra labor costs for land preparation.

l) Not appropriate during rainy season

Farmers also affirmed that tractors find it difficult to operate during rainy season, leading to delayed planting and farm operations, and consequently poor harvest.

Conclusions and Recommendations

This study showed some differences in terms of tractor ownership, financing, servicing/ maintenance and utilization by privately and publicly-owned tractors. However, the differences did offer either model undue advantage in terms of performance over the other; therefore, a mix of the two is ideal for Kenya.

The common size of tractor was 70Hp for both publicly and privately-owned tractors. Whereas private owners had varied sizes, public owners only had 40-50Hp tractors in addition to 70Hp ones. This was mainly because private operators used tractors for additional farm operations, such as transportation.

Issues on financing of tractor purchase are critical in Kenya for both priviate and public operators. The main source of funding for privately acquired tractors was personal savings, followed by commercial bankings; while publicly owned tractors were financed through government grants. There was insignificant contribution of subsidy in finacing the purchases. This, therefore, left commercial banks as the major players in agricultural mechanization.

The maintenance regime is improtant in the lifespan of a tractor. The study found that after sale service was relatively higher for publicly-owned tractors than privately-owned ones. Therefore, there is the need to develop a policy that will ensure that after sale service is guaranted by all tractor dealers. The study salso found that, for both categories of tractors, servicing was done by tractor owners, dealers and mostly mechanics. There is the need build capacity of service providers, such as, mechanics (including *jua kali*). In terms of tractor utilization, the commonest use of tractors was for ploughing, harrowing and, to some extent, planting.

Although the level of skills for machinery operators was low, as operators hardly had any formal training, there was low enrolment rate in skills development courses at various institutions. This was likely due to low government funding of the institutions. However, the situation is changing, with more government support to these institutions.

There is thus the need to invest in skills development and related policies to improve activities of agricultural organizations. There should be a wide range of courses in training institutions and these should be made more flexible.

Moreover, promotion of ICT in agricultural mechanization would significantly attract the youth into agriculture. The low enrolment of women in colleges could be due to the low support for women in the operation of farm machinery. Machinery training and operation should be gender-sensitive to encourage more women to operate farm machinery. More training institutions should be strengthened, especially with regard to internship for graduates.

The study provided various perspectives on and beliefs with regard to policy instruments and their effects on mechanization, youth and digitalization in Kenya. There was consensus that agriculture was not attractive to youths, hence the need to design clear policy frameworks that encourage youth inclusion in agriculture. The youths also lacked role models in agriculture; for even policymakers used photographs of people in torn clothes and with no shoes (that is, “poverty on display”) to depict farmers. Consequently, the potential of ICT and access to credit in increasing youth engagement in agriculture was discussed. The national government strongly believed that with mechanization, more youths will be involved in agribusiness. The study also found that ICT and mobile phone applications have tremendous opportunities for agricultural development if connectivity is improved and quality control measures are put in place.

The PID approach was used to elicit information on the positive and negative impacts of using tractor services from agronomic and economic points of view. From an agronomic point of view, the

positive impact included deep ploughing to improve fertility, timeliness of operations and improvement of soil aeration and water retention. In addition, tractor use allowed for planting of large areas and overall reduction in the cost of farm operations. There were also negative impacts, which included reduced soil fertility due to deep ploughing, and increased soil erosion and compaction due to reduction in land size. Based on these conclusions, the following are recommended:

1. There is a need to develop standards and recommendations for the most appropriate size and model of tractors, based on performance, as well as the appropriate model for financing tractor purchase.
2. Given that Kenya has a National Agricultural Mechanization Policy, which has addressed the issues raised in this study, the government should ensure proper implementation of this policy to achieve efficiency in service delivery by both privately and publicly-procured tractors.
3. The government should focus on funding of agricultural mechanization development and research programmes in order to develop productive innovations especially for small-scale farmers. The fund will also be used for research and building the required facilities.
4. The Participatory Impact Diagram approach is a cost-effective way to elicit information from stakeholders through vibrant discussions between farmers groups. At times, discussions take long and often bring on issues outside the impact areas. There is therefore, the need for effective moderation and the provision of adequate time for the survey.

References

Adu-Baffour, F., Daum, T., and Birner, R. (2019). Can small farms benefit from big companies' initiatives to promote mechanization in Africa? A case study from Zambia. Food Policy, 84, 133-145.

Agricultural Sector Development Support Programme (ASDSP). (2014). Household baseline survey Report, Embu County, Volume 1. Ministry of Agriculture, Livestock and Fisheries. Baseline survey Report, Busia County, Volume 1. Ministry of Agriculture, Livestock and Fisheries.

Baudron, F., Misiko, M., Getnet, B., Nazare, R., Sariah, J., & Kaumbutho, P. (2019). A farm-level assessment of labor and mechanization in Eastern and Southern Africa. Agronomy for Sustainable Development, 39(2), 17.

Brian Sims and Josef Kienzle, 2017. Sustainable Agricultural Mechanization for Smallholders: What Is It and How Can We Implement It? *Agriculture* 2017, *7* (6), 50; https://doi.org/10.3390/agriculture7060050

Daum, T., and Birner, R. (2017). The neglected governance challenges of agricultural mechanisation in Africa—Insights from Ghana. Food Security 9:959–79.

Daum, T., Huffman, W., Birner, R. (2018). How to create conducive institutions to enable agricultural mechanization: A comparative historical study from the United States and Germany. Economics Working Papers: Department of Economics, Iowa State University. 18009.

De Groote, H., Marangu, C., Gitonga, Z. (2018). Trends in Agricultural Mechanization in Kenya's Maize Production Areas from 1992-2012. Agricultural Mechanization in Asia, Africa and Latin America. 49:20-32.

Diao, X., Cossar, F., Houssou, N., & Kolavalli, S. (2014). Mechanization in Ghana: Emerging demand, and the search for alternative supply models. Food Policy, 48, 168-181.

Diao, X., Silver, J. and Takeshima, H. (2016). Agricultural Mechanization and Agricultural Transformation. IFPRI Discussion Paper 01527. Washington DC.

FAO (2016). Agricultural mechanization: a key input for sub-Saharan Africa smallholders. Integrated Crop Management 23. Food and Agriculture Organization (FAO). Rome.

FAO and African Union Commission (AUC). (2018). Sustainable Agricultural Mechanization: A Framework for Africa. Addis Ababa. 127pp. License: CC BY-NC-SA 3.0 IGO

FAO and UNIDO (2009). Investment in agricultural mechanization in Africa: Conclusions and recommendations of a Round Table Meeting of Experts. Hosted by Centre for Agricultural Mechanization and Rural Technologies (CAMARTEC) 3–5 June 2009. Arusha, Tanzania. Edited by John E. Ashburner FAO Consultant and Josef Kienzle FAO Rural Infrastructure and Agro-Industries Division

FAOSTAT (2016). Consultative Meeting on a Mechanization Strategy New models for sustainable agricultural mechanization in sub-Saharan Africa 30th November – 3rd December 2016, Venue: Safari Park Hotel, Nairobi, Kenya.

Fuglie, K., and Rada, N. (2013). Resources, Policies, and Agricultural Productivity in Sub-Saharan Africa. USDA-ERS Economic Research Report, (145).

GoK (2017). National Agricultural Mechanization Policy-Kenya.

Houmy, K., Clarke, L.J., Ashburner, J.E. and Kienzle, J. (2016). Agricultural Mechanization in Sub-Saharan Africa: Guidelines for preparing a strategy. FAO, Integrated Crop Management, Vol. 22.

IFPRI (2016). Diao, X., Silver, J., Takeshima., K. (Eds). Agricultural Mechanization and Transformation. IFPRI Discussion Paper 01527. Development Strategy and Governance Division.

Japan International Cooperation Agency (JICA) (2014) *Japan's Vice-Minister Visits Mwea* in JICA Newsletter Issue 2014 (https://www.jica.go.jp/kenya.pdf)

JICA, 2014. Japan's Vice-Minister Visits Mwea in JICA Newsletter Issue 2014. Japan International Cooperation Agency. (https://www.jica.go.jp/kenya/.pdf)

Juma, C. (2016). Innovation and its enemies: Why people resist new technologies. Oxford University Press.

Kavoi., Omari, J., Wanyonyi, N.W., and Ketiem, P. (2016). The Status of Agricultural Mechanization in Kenya. KALRO.

Kawarazuka Nozami, 2018. Agricultural Mechanisation. How far do women farmers benefit? Research Program on roots, tubers and bananas. CGIAR http://www.rtb.cgiar.org/blog/2018 *Accessed on 7th November 2019*

Kenya International Industrial Expo, (2019). Market status and demand of agricultural machinery products in Kenya. October 15, 2018 Economic and trade

Kirui, O. K. (2019). The Agricultural mechanization in Africa: micro-level analysis of state drivers and effects. ZEF-Discussion Papers on Development Policy No. 272.

Kirui, O. K. (2019). The Agricultural mechanization in Africa: micro-level analysis of state drivers and effects. ZEF-Discussion Papers on Development Policy No. 272.

Kirui, O. K., & Kozicka, M. (2018). Vocational Education and Training for Farmers and Other Actors in the Agri-Food Value Chain in Africa. ZEF Working Paper No. 164.

Kirui, O., & von Braun, J. (2018). Mechanization in African Agriculture: A Continental Overview on Patterns and Dynamics. ZEF Working Paper 169.

Lagat, C.K., P. Okemwa, H. Dimo, L. Kipkurui and J.K. Korir. (2007). "The State of Agricultural Mechanisation in Uasin Gishu District, Kenya, and its Impact on Agricultural Output." Agricultural Engineering International: the CIGR Ejournal. Invited Overview No. 8. Vol IX.

Lagat, C.K., P. Okemwa, H. Dimo, L. Kipkurui and J.K. Korir. (2007). "The State of Agricultural Mechanisation in Uasin Gishu District, Kenya, and its Impact on Agricultural Output." Agricultural Engineering International: the CIGR Ejournal. Invited Overview No. 8. Vol IX.

Makini, F.W; Kamau, G.M; Mose, L.O.; Ongala, J; Salasya, B; Mulinge, W.W and Makelo, M, (2017). Status, Challenges, and Prospects of Agricultural Mechanisation in Kenya: The case of Rice and Banana value chains. FARA Research Results Vol 1(2) PP 24.

Malabo Montpellier Panel Report (2018). Mechanized: Transforming Africa's agriculture value chains. International Food Policy Research Institute (IFPRI) and Malabo Montpellier Panel. Dakar.

Mbaka, M., Ngeli, P. & Apina, T. (2006). Business management skills of agricultural farm related entrepreneurs. A case study of Laikipia and Nakuru districts, (unpublished). FAO. Rome.

MoALF&I (2016). National policy workshop on smallholder agriculture mechanization in Kenya. Proceedings. Nairobi, Kenya.

Mockshell, J., & Birner, R. (2015). Donors and domestic policy makers: Two worlds in agricultural policy-making? Food Policy, 55, 1-14.

Nin-Pratt, A., & McBride, L. (2014). Agricultural intensification in Ghana: Evaluating the optimist's case for a Green Revolution. Food Policy, 48, 153-167.

Oluwole, F. and Odogola, R. (2018). Status of Smallholders Agricultural Mechanization in Sub-Saharan Africa. FARA Research Results Vol2 (10).

Pingali, P. (2007). Agricultural mechanization: adoption patterns and economic impact. Handbook of agricultural economics, 3, 2779-2805.

SAM (nd). Report on Consultative Meeting on a Mechanization Strategy New Models for Sustainable Agricultural Mechanization in sub-Saharan Africa, held in Nairobi-Kenya.

Sims B. G. and J. Kienzle (2009). Farm equipment supply chains: Guidelines for policy-makers and service providers: experiences from Kenya, Pakistan and Brazil. Food and Agriculture Organization of the United Nations Rome, 2009

Sustainable Agricultural Mechanization for Smallholders: What Is It and How Can We Implement It? by Brian Sims and Josef Kienzle Agriculture 2017, 7 (6), 50; https://doi.org/10.3390.

Wawire, N.W., Bett, C., Ruttoh, R.C., Wambua, J., Omari, F.G., Kisilu, R., Justus Kavoi., Omari, J., Wanyonyi, N.W., and Ketiem, P. (2016). The Status of Agricultural Mechanization in Kenya. KALRO - Katumani. Unpublished Report.

ANNEXES

Annex 1: Photo Gallery

Different tractor types

Rice combine Harvester and transport

Disk plow, PID session and hand threshing