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Assessment of Factors Limiting Agricultural Mechanization in Rwanda

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Abstract

Agricultural mechanization is an important symbol of agricultural modernization, and agricultural equipment is the carrier of agricultural modernization and thus an important tool used to promote agricultural mechanization. This study evaluated limiting factors to agricultural mechanization in Rwanda and carried out on key informants from the state, Machinery Assembly Workshops and garages, private companies delivering Agri-mechanization services and pilot farmers.The results showed that agricultural mechanization has a great positive effect on agriculture and socioeconomic development. The results showed that 100% of AM operators, and technicians received general training on site, they did not attend any training centre or specialized training and 57% of farmers reported that AM equipment is not easily accessible because all equipment is located far away from their farms and have to pay for fuel to transport the tractor to their farms, which increases the production cost Moreso, even if there is a significant role of government in agricultural mechanization, there are several factors that limit the adoption of agricultural mechanization in Rwanda like high cost of agricultural machinery, lack of spare parts, inadequate low skills and knowledge of technicians, operators and some agricultural mechanization stakeholders. The government should facilitate the availability of spare parts locally and make them easily accessible to the tractor owners, capacity building of technicians as well as garages reserved for only agricultural machines. The Agricultural Mechanization Centers should be strategically located in mechanization potential areas to support the beneficiaries. Rwanda should establish standards and certification schemes and schemes regulations for Agricultural mechanization equipment for both imported agricultural machines and locally manufactured.

Keywords: Agricultural Mechanization, Agricultural Modernization, Agricultural Machines, farm implement

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1. INTRODUCTION

The agricultural tractor is a self-propelled power unit having wheels or tracks for operating agricultural implements and machines including trailers. Agricultural mechanization is key to agricultural modernization and agricultural equipment is the carrier of agricultural modernization, thus an important tool to promote agricultural mechanization(Sebai, 2021). The choice of tractors as the preferred form of mechanization was not without controversy in the early days of a post-colonial history and gave rise to heated debates on the suitability of tractor technology for agriculture in developing countries(Cabral, 2019). Various tractor-based mechanization initiatives exit in many developing countries including Rwanda-Village Mechanization Service Centers Program which started in 2011 (ROR, 2014). The program in Rwanda is most like that in Ghana in it aiming to establish at least one mechanization service center in each of Rwanda's 31 districts to provide tractor rent and related services. Sixteen of these centers were established been set up by early 2013 (Samuel Benin, 2014). Specifically, Fonteh (2010) argues that mechanization strives to reduce drudgery in agriculture and increase land the productivity of land and labor productivity through timely operations and efficient use of inputs. The goal is to increase farmers' income, safety, and comfort, create jobs, and improve farmers' living standards.

Agricultural tractors require fewer of workers in the field to complete a given farm operation and at the same time, crop yields increased machineries. FAO, 2018 defines mechanization as "the use of tools, implements, and machinery in order to achieve agricultural production"(Li et al., 2019). These can be operated by manual, animal, or engine (fossil or electric) power. In Essence, agricultural mechanization involves technological change using tractors; and non-human sources perform agricultural operations. In Rwanda, the case study of the research, agriculture is sustained by poor, less educated smallholder farmers who account for 70% of the export revenues and 90% of the national needs, with less than a half hectare each (Murindangabo et al., 2021). Governmental efforts in the past did import tractors and other implements to encourage mechanization, these interventions in most countries experienced failure across the board for reasons which include; lack of knowledgeable personnel to manage the equipment, cost of the equipment, underutilization, lack of spare parts and largely, the running of the program by the government civil service system (Oluwole & Odogola, 2018). There is no doubt that the use machineries have been neglected for too long by smallholder farmers in sub-Saharan Africa (SSA). The Rwandan government is prioritizing agricultural mechanization to improve farmers 'access to farm machinery for various farming operations such as ploughing, crop treatment, agro-processing, post-harvest processing, and product transportation. The adoption of modern agricultural technologies an indispensable strategy for Rwanda to achieve a sustainable economy by increasing agricultural productivity and addressing food shortages (Sylvère & Jean D'amour, 2020).

Tractors for agricultural purposes are divided into three types based on their design: wheel tractors, crawler tractors (track type or chain type), and walking tractors. Wheel and walking tractors are the most used agricultural tractors in Rwanda. Wheel tractors are used for most farming operations such as ploughing, harrowing, sowing, harvesting, and all transportation work. They can also be used to cultivate crops in-furrow. Walking tractors are motorized

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machines typically used for soil preparation, seeding, spraying, and other tasks. Based on current data, this paper discusses the factors influencing agricultural mechanization in Rwanda, particularly the performance of tractor. It is important to recall discussions on appropriate technological solutions and the role of agricultural tractors in suitable mechanization. In the eastern province of Rwanda, most slopes are between 0 and 16%. This terrain is suitable for tractors and power tillers. The southern province has most of its lands in the 6-40% category which makes the use of risky but allows the use of two-wheel tractors and animal traction operation, although the topography is highly variable. In the northern and western provinces, most lands are in the 16-40% zone and are not very suitable for the use of tractors (World Bank, 2019). In fact, there is the need to adapt and choose a special mechanization for these specific areas. It should be noted that in all four provinces there are lands with slopes of 0-16% that are suitable for the use of tractors. The wide variation in topography of the terrain highlights the need for site-specific mechanization options in Rwanda (Ministry of Agriculture and Animal Resources, 2010).

There is inadequate repair and maintenance facilities for the farm machinery as well as inadequate quality control. Manufacturers must open shops for repair and maintenance. This is only possible if many farm machines are sold in the country. There is a lack of trained manpower and coordination between research institutions and manufacturers. This is due to the scarcity of suitable training institutions. It is also important to note that the availability of small farm equipment is insufficient to meet the needs of farmers (World Bank, 2019). Rwanda adopting mechanization properly and efficiently will bring out benefits, such as cutting off the emigration of young Rwandans from leaving rural areas because they are disenchanted with the arduous work of farming. However, mechanization is used disproportionately in Rwanda, meaning that priorities are set where the land is very apartment, which facilitates the use of machinery, and the use of machinery, mechanized land, and animal traction is relatively low (Sylvère & Jean D'amour, 2020).

In many developing countries, the adoption and increased use of tractors in agriculture remain difficult due to the high number of aging farmers, land constraints caused due to population pressure, and slope lands which make tractors difficult to use as well as a lack of knowledgeable and skilled individuals in agricultural technology. Agriculture in Rwanda, is still practiced as subsistence, accounting for over 90% of food production (RAB, 2025). The Rwandan agricultural sector still faces many challenges, such as low input utilization, lack of irrigation systems, and weak meteorological capacity (IPAR, 2009). In Rwanda, the performance audit conducted by the office of the General Auditor on the use and maintenance of irrigation and mechanization equipment shows that in January 2015, of the93 tractors owned by the Task Force on Irrigation and Mechanization, 46 tractors were defective, while 3 tractors had minor problems, meaning that only 44 tractors were in good condition. A large, big number of the tractors were not in use, which may lead to low outcomes. This study could enable to find out the factors affecting agricultural mechanization for beneficiaries and service providers in Rwanda. This study explores the current directions in research on performance, safety, and comfort of agricultural tractors. Therefore, suggestions were made to modify or improve the present testing standards considering the review.

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2. Materials and Methods

The land surface of Rwanda is 26,388 Km^2 and the country has a population of about 11.78 million (NISR, 2013). Rwanda is a landlocked country in East Africa whose green, mountainous landscape has earned it the nickname "Land of a Thousand Hills" (Bimenyimana, et al, 202). Rwanda is in the African Great Lakes region and is highly elevated; its geography is dominated by mountains in the west and savannah to the east, with numerous lakes throughout the country.

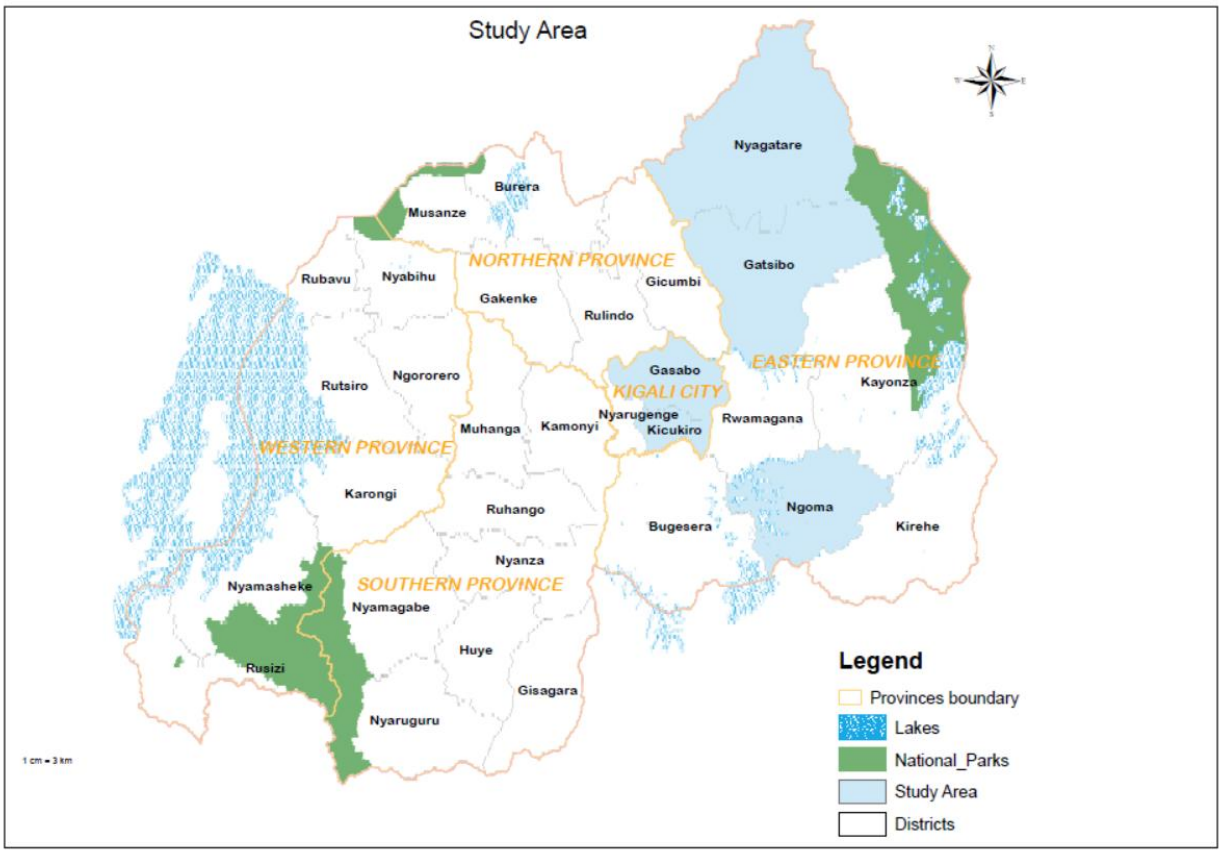

Figure1: Study area

1.2. Sampling and Data Collection Techniques

The Agricultural Mechanization chain consists of the entire farm machinery subsector, which includes manufacturers, importers, distributors, retailers, rent enterprises and end-users. Primary data were collected from stakeholders in the agricultural mechanization subsector. These stakeholders included relevant government staff involved in AM, AM company managers provided the information on how their companies import, sell and hire AM equipment, operators, technicians and drivers and pilot farmers.

Many factors such as farm size, labor availability, topography, agroecological condition and type

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of mechanized operation influence differences in mechanization services across regions. Timely and quality repair services, along with a reliable supply of spare parts, are imperative to keep machinery functioning during the peak plowing season. in a rainfed agricultural system, which is common in Africa, even a short delay in waiting for a relatively insignificant part can result in missing the crucial period plowing, ultimately affecting yields when farmers are forced to plant their crops without adequate soil preparation.

The following are research interviewees companies, organizations and workshops: Rwanda Agriculture and Animal Resources Development Board (RAB) Kabuye Mechanization Workshop for MINAGRI/RAB, MAHINDRA, JCB machines &tractor Rwanda, LONAGRO ltd, VOLUNTERS AGRICON LTD, Agro Processing Industry ltd (API), AGRESOL LTD, QUALIFIED &COMFORTABLE garage, E.T.C. AGRO TRACTOR&IMPLEMENT LTD, JOHN DEERE, and pilots farmers. The respondents in total were 7 Operators, 8 Technicians, 6 companies' Managers, and 2 key informants or mechanization specialists from RAB and 20 pilot farmers. To analyze the data for a better understanding of the study, we used the descriptive statistical techniques of the Statistical Package for Social Sciences (SPSS) version 21.0.

3. RESULTS AND DISCUSSION

3.1. The killed level of tractor technicians and operators compared to AM performance

Table 3.1, illustrates skilled level and knowledge of tractor drivers, technicians and operators, working in garages and machinery assembly plant in Rwanda.

Table 3.1: Skills level of tractor operators

ITEM	OPTION	FREQUENCY	VALID %
Education level	P_3	2	28.6
	P_6	3	42.9
	S_6	1	14.3
	A_0	1	14.3
Option section of education done	Vehicle mechanics	4	50
	General mechanics	2	25
	Other	2	25
Training	On farm	8	100
	Training center	0	0
	Specific training	2	25
	General training	6	75
Driving permit Category	Forklift permit	3	42.9
	Tractor permit	4	57.1
Job Test	Tested	6	75
	No test	2	25

Source: Author 2023

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P: Primary school, S: Secondary school, A_0: University degree(Bachelor)

The results showed that 71.5% of operators and technicians working for AM companies have only a primary level education. The use machinery and other agricultural equipment requires ability to read and understand the instruction Manual (IM). Most of IM used in Rwanda are written in English or other foreign languages, and we know that the first and most source of information for owning, using, and maintaining any machine is the Instruction Manual that comes with each machine. Joshua (1985) confirmed that many machine owners and operators in developing countries have no technical knowledge about the many machines they operate. Many of these people are illiterate unable to read or write. Even those who are fairly literate do not know how to read the owner's manuals of their machines. In order to fulfill the maintenance objectives already mentioned, it is important that each operator learns how to properly operate and maintain his or her equipment.. A certain level of technical knowledge is essential for effective machine operation and experiences with working in machines.

Any operator, technician or tractor 's operators should be able to carefully read and interpret the IM to become familiar with it, as it contains a lot of information and detailed instructions that are extremely helpful in the correct and safe use of the tractor. When using an attachment with the tractor you should , also refer to the tractor operator's manuals to understand and use the attachment correctly and efficiently (https://www.teamtractor.com/blog/tractor-owners-manual-part-i-tractor-safety). Failure to comply with IMnot only leads to inefficiency and poor performance on AM of AM machines, but also, to accidents and deaths of operators and famers. An example is figure 3.1 taken by the researcher in Mburabuturo-Nyagatovu marshland located in Kayonza where, a tractor operator and two people, including technicians are hanging from the tractor. This is one of the major causes of fatal accidents and shows that operator, drivers and technicians have poor knowledge of the work environment safety. The 2010 U.S. Census of Fatal Occupational Injuries found that 44% of tractor accidents resulted from tractor rollovers. The National Agricultural Tractor Safety Initiative reports that tractors cause about 130 deaths annually. When properly operated and maintained tractors can be very safe proper tractor handling and safety must be taken very seriously (Clarke, 2000).

Photo 3.1: Two people hanging from a tractor (photo taken in Kayonza)
Source: Author 2023

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Carefully study the Operator's Manual and learn the instructions in the Manual before operating or servicing any tractor. Operators and technicians should have at least secondary education and be adequately trained in the maintenance and operation of AM machines. Lack of these skills reduces the profitability and efficiency of mechanization. In additional to reducing profitability, lack of knowledge and skills can also lead to operators' errors, that can result in accidents and injuries, as shown in photo above. Moreover, lack of knowledge and skills can also affect soil fertility, such as when they lead to soil compaction or erosion (Senayah et al, 2012). The tractors are not common transport because the passengers fall from a tractor or injured during a rollover, passengers must not be carried on tractors but by vans or buses. If there is a second seat on the tractor, it must provide the same level of protection as the tractor's Rollover Protection Structures (ROPS) for the operator and be equipped with a seatbelt.

In terms of training, the results showed that 100% of AM operators, and technicians received general training on site, they did not attend any training center or speciaized training. Service providers, tractor operators, technicians, and farmers need knowledge and skills on how to operate, maintain, and repair tractors. Developing countries lack trained mechanics and technicians to maintain the agricultural machinery. In developing countries, automotive mechanics and technicians often work as trained agricultural machinery personnel. This practice should be stopped. It is not ideal because automotive personnel are not trained in matching equipment to the task at hand. They are not trained in selecting and calibrating machinery (JOSHUA, 1985).

Setting up organizations and institutions that provide information and support for skill developments is essential for successful mechanization, but such institutional developments as like technical schools, integrated Polytechnic Region Centers (IPRCs) should be used by Government for capacity building especially for special trainings. Ghana is an example. Although the country has a more effective government than many other countries in Sub-Saharan Africa, according to the World Bank's aggregate governance indicators. Ghana has used technical schools to develop AM in the country and now is a model country in Sub-Saharan-Africa in AM (World Bank, 2017).

3.2. Constraints to the Adoption of Mechanization in Rwanda

The following findings are the details of barriers to mechanization adoption cited by Agricultural mechanization stakeholders: farmers, mechanization company managers, operators and technicians

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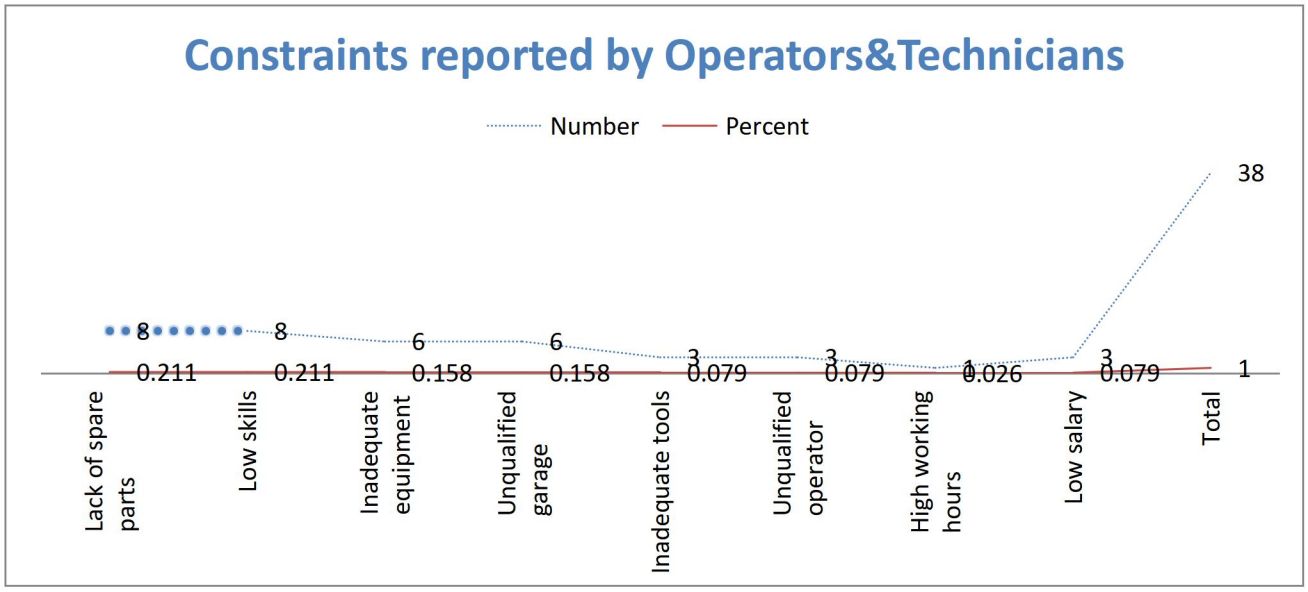

Figure 3.1: Constraints of mechanization

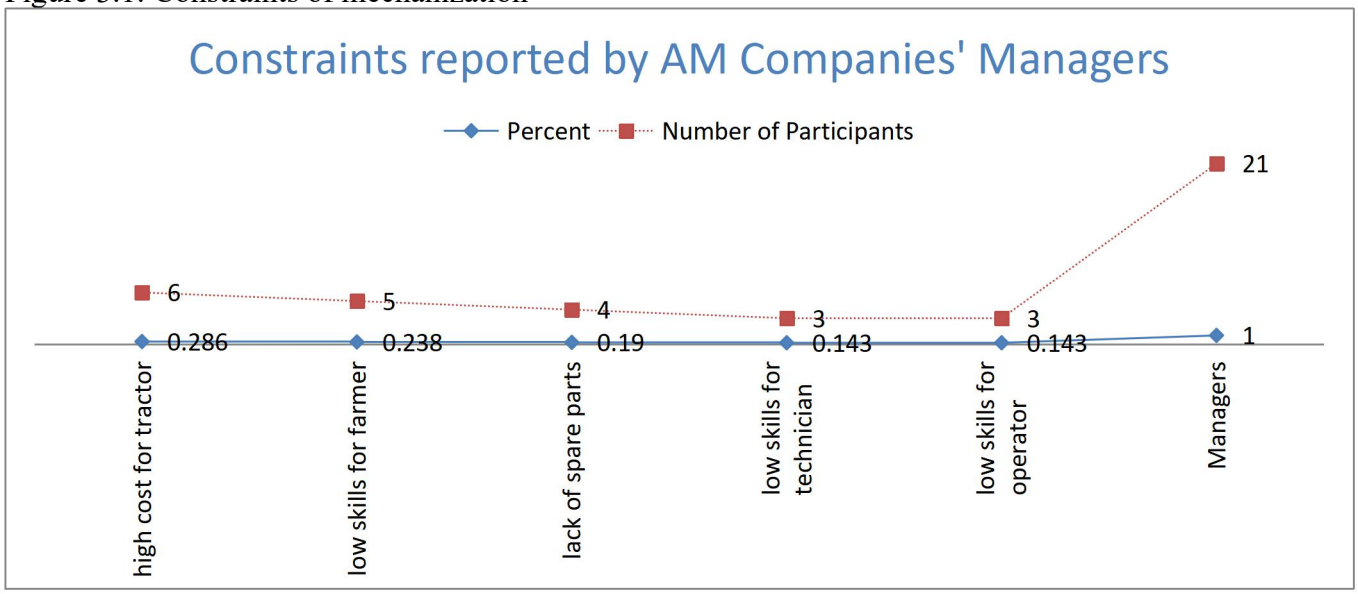

Figure 3.2: Constraints of AM

The results from farmers showed that 100% of farmers know the importance of using AM, they indicated the use of agricultural mechanization in their farms provides many benefits, such as time management, productivity and reduction of drudgery. Fifty-seven percent (57%) of farmers reported AM equipment is not easily accessible because all equipment is located from their farms and have to pay for fuel to transport the tractor to their farms which increase. Therefore, the location of the agricultural machinery center machinery parking site is an important aspect that needs to be thoroughly considered in order to achieve the lowest possible transportation cost for all the machinery that needs to be served and for spare parts from this warehouse. The company

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should conder whether it wants to have one or more machine parking sites center at the site to reduce transportation time. In Rwanda maintenance and repair of agricultural machinery tools, and traction implement is usually done at at local level especially in the city of Kigali rather than in rural areas near the farms.

According to FAO (2016), in many countries, suppliers of agricultural machinery exist only in large cities, as the perceived low demand for equipment in rural areas does not always justify the development of distribution networks. Smallholder farmers are often isolated by distance and poor infrastructure (especially feeder roads). Company managers indicated that the problem of affordability and availability is due to low demand and small land size. They said that famers should be organized in cooperatives or have a big land area and suggested that the government should provide subsidies for gas-oil for agricultural mechanization purpose. The company managers indicated that availability of spare parts is a manager problem in Rwanda. In general tractors and agricultural machinery can either be imported or manufactured locally. In the case of Rwanda there is no local manufacturing industry for these machine which is related to farmers and companies' claims about the accessibility, high cost and lack of spare parts for the machines and confirmed by the by researcher's observation in many workshops/garages and farms. Photos 3.2 and 3.3 show how technicians and operators address the problems of lack of spare parts.
Experience from other parts of the world shows that providing credit to farmers to invest in agricultural machinery not only allows them to increase their productivity and participate more in the market economy, but also creates incentives for the local machinery industry to meet their needs (Casão-Junior *et al*., 2012). In Ghana, the Agricultural Mechanization Centers (AMCs) are strategically located in areas where there is a need for mechanization. In the past, government centres failed in part because of low tractor utilization. Under the current programme the government has partnered with the private sector to operate these AMCs. Each center has eight tractors, a range of implements, a trailer, a pump powered by the tractor's power take off shaft, a tractor-operated mill, etc. The idea is that the centers should have year-round work or activities (i.e., from ploughing, planting, harvesting, transporting and milling) to maximize the use of the tractors and its profitability. Other equipment is expected to complete the equipment as it become available, such as seed drills and fertilizer applicators (FAO, 2010).

Photo 3.3: Lack of tractor spare parts
Source: Author 2023

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Above photos 3.2 and 3.3, show the tractor "type case international 4042" photos which were taken by the researchers on the field and confirmed the lack of spare parts. The tractor owners reported that they could not find spare parts and decided to use the small jerry can (blue in color) as fuel tank and unsafe wires for the start tractor. Poor maintenance facilities and lack of spare parts lead to long downtime and the use of inappropriate spare parts can affect the quality of work and the longevity of the machine and also cause serious accidents.

Coetzee (2004) states that spare parts are considered the lifeblood of the maintenance department. They must be handled carefully and efficiently by purchasing the right quantity of the right quality at the right time, keeping in mind the cost limit. Information from the technicians and operators working in workshops confirmed that three out of five tractors did not survive four years due to lack of maintenance, being completely unusable. Generally, the life of a well-maintained tractor is 10 to 15 years. Wilson (1999) explained that from the manufacturer's perspective, maintenance is done to meet standards for safety and to maximize the availability of all equipment and tools. The author estimated that maintenance aims to maintain production efficiency, safety at economic cost and profitability of quality products, maximize equipment utilization and capability, maintain high asset value, reduce costs and increase production of operations. Houssou et al. (2013) analyzed the operations of 136 Ghanaian tractor-service providers. They found that 86% of them could not use their tractors throughout the cropping period due to frequent and prolonged breakdowns. These were due to lack of maintenance and a shortage of qualified operators and skilled mechanics (Daum and Birner, 2017; Diao et al., 2016).

Therefore, AM companies should consider the quantity, quality, and period of replacement part imports. Because most sellers and users of AM machines said that spare parts are expensive in Rwanda. Duffuaa et al. (1999) noted that maintenance and procurement departments depend on well-organized spare parts inventories. Quantity and timing of ordering should be considered as one of the most important tasks in management. The importance comes from the change in price with quantity, where buying a small quantity results in a high unit cost and buying a large quantity results in a low unit cost, while inventory costs increase when there are many spare parts. It is best to balance the unit cost with the inventory cost. From another point of view, inventory levels depend on the investment the company is willing to make to achieve the desired availability, with more types of spare parts leading to more security and stability of maintenance time (Abbas, 2015).

3.3. Role Government in Agricultural Mechanization

As has been shown, demand for mechanization has increases in a number of sector within African countries, and private sector channels for purchasing machinery and providing mechanized services have grown in recent years. Nevertheless, there are many opportunities for governments to play a supporting role in the mechanization process, through investing in public goods, creating and enabling a policy environment, and building capacity and providing assistance technical needed. The role of government needs to be clearly defined, Clarke, (2000), stated that the government is responsible for policy, research and development, introduction of

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laws and regulations to protect consumers, testing of farm machinery, development of an integrated and network education, training and extension program. The formulation of national strategic and implementation plans for agricultural mechanization is now seen as a solution, using a holistic approach that includes, in particular private sector participation, economic viability the creation of an enabling environment with clear roles for public and private actors (FAO and UNIDO, 2008).

According to Clarke, (2000), once an overall strategy defined, governments can easily identify the components for which resources are needed and for which adequate external support may be required. Moreover, in 2012 the Rwanda government established five-year strategic Plan for the transformation of agriculture in Rwanda phase III from 2012 to 2017, which focused more on agricultural mechanization. Therefore, the total land suitable for mechanization was estimated at 1 million ha which is about 60% of the total cultivated area in 2011. The remaining area can be managed by specific mechanization and animal traction. Annual needs and anticipated machinery in the medium and long term through to 2020 were projected as follows: tractors 2,500; power tillers 17,000, planting machine 15,200; harvesting 7,600; post harvesting 17950 and agro-processing 45. The target was to mechanize 25% of farms 2017. The means that total of about 100,000 farmers should be able to own and/or hire mechanization services on their farms (MINAGRI, 2012). Unfortunately, the target was not achieved. The results showed that by the end July 2017, 76 % (19%) of mechanization target had been achieved (MINAGRI, 2017).

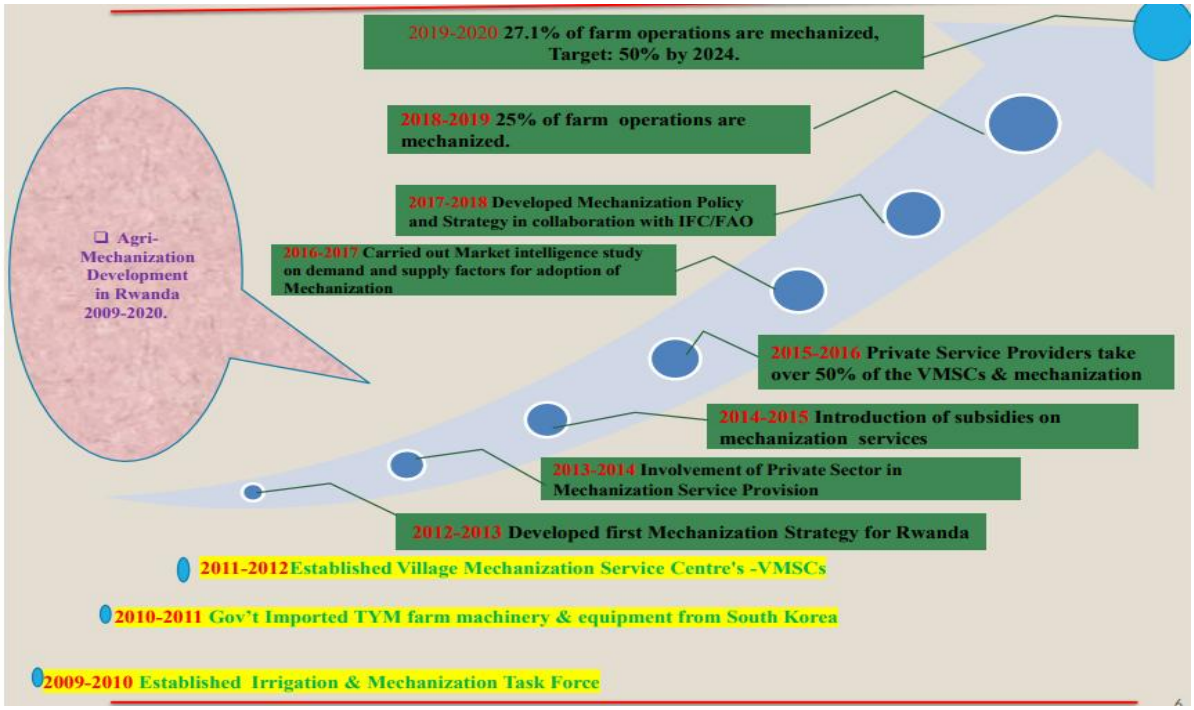

Fig 3.4: Agricultural Mechanization Development in Rwanda (2009-2020).

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Even though, Rwanda government has made more efforts to promote AM by establishing by adopting strong policies related to AM, such as zero tax exemption for importing agricultural macginery, linking the private investors and cooperative farmers to banks (Development Bank of Rwanda, Business Development Funds), providing subsidies for agricultural inputs and other measures. Interviewees uncovered some keys factors that have not been addressed in the implementation of the above AM strategies, such as standardizing farm machinery that is suitable or appropriate for Rwandan's pedology and relief. The Department for Agricultural Infrastructure and Mechanization (DIAM) and other institutions dealing with agricultural mechanization should recommend and make the necessary changes to equipment standards to adapt them to suit local conditions (MINAGRI, 2012).

Moreover, the Rwanda government should have made sufficient efforts to provide local agricultural equipment manufacturers with raw materials at stable prices, establish contacts with potential overseas partners/licensors, access to market information, provide support for product research and development and also with production technology , and strengthen local technical schools and training centers for agricultural mechanization development , provide qualified engineers and experienced technicians, enforce appropriation and standardization of locally manufactured machinery, and increase human resource capacity for research, design, testing, and promotion of locally manufactured products (Made in Rwanda). The 2012 Rwanda Strategic Plan called on MINAGRI and its agencies to work with the Rwanda Bureau of Standards (RBS) to establish standards and safety regulations for spare parts, implements, and machinery; certify agricultural equipment; field testing; and demonstration facilities for agricultural machinery; and implements for quality control for the benefit of farmers and manufacturers (MINAGRI, 2012). The lack of above measures could be the cause of the durability, quality and credibility of imported equipment. Therefore, the cornerstone of an AM strategy should be that agriculture is an economic enterprise and not just for poverty alleviation. The private sector will only provide services if the farm is profitable, which means that end users and suppliers will only play their role if everyone can make a living from their business (Clarke, 1997). It was found that farmers would only invest in farm mechanization if it would increase the profitability of their farms and if they are aware of the importance of farm mechanization.

4. Conclusion and Recommendations

This study examined the factors affecting the adoption of agricultural mechanization in Rwanda. Research has shown that agricultural mechanization has a great positive effect on agriculture and socioeconomics by increasing the productivity of labor, reducing drudgery, increasing farmers' income and raising the standard of living of rural communities. The Rwanda Government has made greater efforts in Agricultural Mechanization, achieving 76% of the five-year plan. However, as the researchers noted, major improvement is still needed: some factors negatively affect agricultural mechanization in Rwanda, such as the high cost of agricultural machinery, lack of spare parts, low skills of those involved in agricultural mechanization, and lack of standards and safety regulations. In addition, research and development are needed to ensure

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good quality of the machinery to be supplied and used. MINAGRI, in collaboration with the Rwanda Bureau of Standards, should establish standards and safety regulations for agricultural mechanization equipment. It was noted that farmers would only invest in agricultural mechanization if it would increase the profitability of their farms and if they are aware of the importance of agricultural mechanization.

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