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Mechanization and Skill Development for Productivity Growth, Employment and Value Addition: Insights from Benin

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Introduction

African 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, with the re-emergence of agriculture on Africa's development agenda, there is now renewed interest in agricultural mechanization (FAO, 2016; Kirui and von Braun, 2018; Malabo Montpellier Panel, 2018). Governments aim overcoming "hoe and cutlass" types of farming to make agriculture attractive to the youth (Birner and Mockshell, 2015); donors are increasingly funding mechanization-related projects and machinery companies have discovered Africa as an emerging market (Daum & Birner, 2017; FAO 2016; Oluwole and Odogola, 2018).

The renewed interest in agricultural mechanization has been fueled by increasing evidence that access to labor limits development for many smallholder farmers (Baudron *et al*., 2019; Diao *et al*. 2014; Nin-Pratt & McBride, 2014). Indeed, studies suggest that farmers benefit from agricultural mechanization, for example, by being able to increase their farm incomes (Adu-Baffour *et al*., 2019; Kirui, 2019). However, there are still ample open questions, since African agricultural mechanization has long been neglected by scholars. This leaves policymakers and practitioners ill-equipped to design good policies and programs. These open questions include: What are the best options for the mechanization of smallholder production and processing systems from economic and institutional perspectives? What is the role of the private sector and which role should the state play? What knowledge and skills are needed to promote mechanization? 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 skill development for productivity growth, employment and value addition" as one 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 the 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) in 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 objectives:

1) **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).
2) **To assess opinions and beliefs about 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).

3) **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.
4) **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.

Country Background on Mechanization

Mechanization covers the use of tools and machines for land reclamation, production and postharvest techniques, using human, animal or motor energy (Balse *et al*., 2015). Thus, the introduction of motorization has led to a huge increase in the area cultivated per farm. On the average, farmers who are members of Agricultural Equipment Utilization Cooperatives (CUMAs) have multiplied by 3.5 the areas they have been cultivating since they ploughed with tractor. This increase concerns both small and large farms, especially cotton and maize farms, which shows a certain specialization of farms and a direction of production for the market (Balse *et al*., 2015). In general, CUMAs ploughed about 4,000 hectares each year (Balse *et al*., 2015). On the average, the area planted by farmers was 1.7 hectares before joining CUMAs, while it was 4.2 hectares after joining them (Balse *et al*., 2015).

Also, based on the diagnostic results of Agbangba *et al*. (2017), the hypothesis of a gradual intensification of crops to the detriment of extensive farming currently practiced has been put forward. They found that 23% of the areas were cultivated using animal traction and 1% was motorized. Thus, the number of hectares cultivated each year using animal traction, tillers and tractors respectively, increased from 6, 30 and 100 ha / year to 7, 20 and 60 ha /year in the medium term, and to 7, 15 and 40 ha/year. This increase in annual area for animal traction cultivation from 6 to 7ha/year could be explained by the passage of plowing (a currently painful and demanding operation) to lighter farming operations (weeding, transport, etc.). According to Adegbola *et al.* (2019), producers tend to use animal traction for crops larger than 1ha. On the other hand, animal tractor and tillers were used for cultural operations when the area to be sown was respectively greater than 2ha and 1ha. The area planted also depended on the tools used. Thus, 0.25ha was plowed per day for animal-drawn plow; 0.08 ha per hour for a plow driven by a tiller (more than 3 days per ha) and 0.2ha per hour for a towed disc plow which amounted to more than 4 hours per ha (Agbangba *et al*. 2017). The tools that are sparcely used, they have 6.5 to 10 ha per year with a single animal traction tool, 18 to 20 ha of plowing per year (a tiller can plow theoretically 22 ha to 45 ha per year respectively in the zone to a campaign and in that to two campaigns). For tractors, even if the number of hectares plowed was relatively high in some

cases (about 116.00 to 160.00 ha per year), in general these expensive machines were underutilized. They were only required for two months a year. Currently, tractors operate on the average of 100ha to 530ha per year; while under the agro-ecological conditions of the areas concerned, they can plow 450ha to 900ha per year. If other operations are taken into account, the annual use will increase to 1000 or 1500 ha per year (Agbangba *et al*., 2017).

Activities mechanized

In West Africa, mechanization is used primarily for hard and demanding work in energy (soil works, transport and processing). It takes the place of labor to prepare the soil more quickly and to increase the area of production and facilitate the transport of large quantities of harvested products (Basle *et al*., 2015). Other operations (sowing, crop maintenance, harvesting, threshing) are mostly manual on family farms (Side, 2013). It is mainly tillage, pumping and processing of products that are mechanized.

For Side and Havard (2014), the use of engines on machines used at fixed positions, or worn on the backs, is relatively developed in sub-Saharan Africa for operations such as pumping water, phytosanitary treatments, harvesting, threshing and processing of agricultural products.

Agbangba *et al*. (2017), in their analysis of the needs in equipment and production equipment of agricultural development hubs of Benin, found that in plant production, plowing is a heavy consumer of energy and the most mechanized operation. They pointed out that whatever the speculation involved, plowing and weeding are the most cited operationsby producers. In addition, for maize, soybean, cowpea and groundnut farming, seeding is the most cited operation. The study also highlighted the main mechanized cultural operations according to crops. Generally, the most restrictive operations at the level of each crop were mechanized. For maize, the most cited operations were winnowing, milling, ginning, transportation and storage. For cassava, the most cited operations were: cooking, pressing, grating, and peeling. Threshing, transporting, cooking, dehulling and winnowing were the first five operations that constituted constraints in rice processing. The most cited operations for peanut were mixing, threshing and peeling. For soybeans, pressing, threshing, milling and cooking were the most cited operations (Agbangba *et al*., 2017). It should be emphasized that these operations were both for the production and processing of these crops.

While the most common agricultural machinery include combined harvesters, threshers, pasta rollers, fertilizer spreaders, plows, cultivators, seeders and weeders, the use of tractors remains low. At this level, towed tools are more devoted to soil preparation, with plowing being the most performed operation (Side, 2013, Balse *et al*., 2015, Houssou *et al*., 2017). According to Adegbola *et al*. (2018), plowing is the only farming operation performed using the tractor.

In postharvest operations, mechanization improves the quality of products and the socioeconomic performance of the actors. Nago (1995) saidthat the mechanization of grating and pressing has improved hourly yields of these operations and reduced the overall duration and hardness of the preparation work. IFAD (2005) mentioned that the mechanization of grating and pressing in processing cassava into gari undoubtedly increases the productivity of the work and reduces the difficulty of the stages of processing. Through mechanization, farmers save labor and improve the quality of work. In general, they increase their area under cultivation and yields and reduce postharvest losses, resulting in overall increase in production (Balse *et al.*, 2015).

Crops mechanized

The crops mechanized have been identified by agricultural development hub (ADH) and by gender. Indeed, the report of Adegbola *et al*. (2019) on producers' preferences and the impact of agricultural mechanization in Benin revealed that animal traction, tractors and tillers were heavily used by men for crops such as rice, cotton, soy, cowpea, and corn. Women used these mechanization options for maize, cotton, sorghum, peanuts, soybeans, rice and cowpeas. Animal traction was heavily used by men for rice (78%), cotton (76%), soybeans (76%), cowpea (76%), and maize (74%). A similar trend was observed for women who also used animal traction for maize (60.16%), cotton (60.16%), sorghum (58.3%), peanut (40.66%) and cowpea (40.33%). This high proportion of producers using animal draught cultivation was due to the prominence of large ruminant (cattle) rearing in ADH2, which allowed for easy access to cattle/ donkeys for traction. Tractors were used for maize (38% of men, 23.3% of women), cotton (38% of men, 26.6% of women), rice (32% of men, 16.6% of women), yam (26% of men, 20% of women) and soybean (16% of men, 18.3% of women).

The weak trend of motorized tiller was confirmed, as it was used for maize (42% of men, 31% of women), cotton (47% of men, 35% of women), rice (41% of men, 21.6% of women), yam (32% of men, 27% of women) and soybean (19% of men, 25% of women) (Adegbola *et al*., 2019).
For ADH3, animal traction was moderately used for crops, such as maize, soybean, cowpea, sorghum, groundnut and peanut. Differences were observed for maize (57.5% for men, 47.5% for women), soybeans (55.0% for men, 37.5% for women), sorghum and groundnut (50.0% for men, 30.0% for women). For the two types of motorization (tractors, tillers), the observation was the same: There was low level of use of the components of mechanization in ADH3. The crops for which tractor was used were: maize (37.5% for men, 32.5% for women), cotton (37.5% for men, 35% for women), and soybeans (37.5% for men, 7.5% for women). The trend was similar for the tiller, with maize (45.0% for men, 39.5% for women), cotton (45.0% for men, 39.5% for women), and soybeans (43.0% for men, 10.0% for women). It is important to note that ADH3 is an area of agricultural diversification (cotton and food). This explains the mechanization of the production of several crops. Moreover, the variability of mechanization modes was highly significant for men with regard to maize, cotton, soybean and cowpea; and for soybean and voandzou for women (Adegbola *et al*., 2019). Concerning ADH4, animal traction was used for crops, such as soybean, rice, sorghum, peanut and cotton. There were differences in the use of this mode of mechanization by sex for soybean (58.3% for men, 47.5% for women), rice (53.3% for men, 44.0% for women), sorghum (48.0% for men, 40.0% for women), groundnuts (48.0% for men) and cotton (45.7% for men, 48.0% for women). For the two types of mechanization encountered (tractors, tillers), the observations were the same on the low level of use of the components of modes of mechanization for ADH4. The crops for which tractor was used were: soybean (37.5% for men, 23.3 % for women), millet (36.6% for men), and cotton (33.3% for men, 46.6% for women). This trend was also similar for the tiller with regard to groundnut (38.6% for men, 0.0% for women), soybean (37.5% for men, 27.2% for women), and cotton (35.0% for men, 49.6% for women). The main reason for these proportions of data for animal traction was the high numbwe of cattle breeders in the area (Adegbola *et al*., 2019).

State of animal traction

In French-speaking Africa, animal traction was introduced at the end of the 19th century with transportation for the needs of soldiers and traders (Bigot 1985). In Benin, the first animal draft tests consisted of donkey-drawn materials on the Ina experimental farm in 1930. Thus animal traction farming became effective in the 1960s through the French Company for the Development

of Fibers and Textiles (CFDT), the International Company of Rural Development (CIDR), Society of Technical Assistance and Cooperation (SATEC) (Havard and Le Thiec, 1996). Animal traction was then limited to plowing and ridging with cattle teams in the cotton zones. Balse (2014) reveals that weeding and lopping of cotton and maize were carried out by animal traction, as tractors could not effectively handle these operations with the available equipment. The geographical distribution of plant production equipment in the various departments showed a higher concentration of animal traction cultivation in the former cotton areas of the North (Alibori: 61,710 teams, Borgou: 15,259 teams and Atacora: 9947 teams) (FAO, 2005). Even in areas where animal traction cultivation was well-established, the materials used wes not very diversified. Also, animal-drawn seed drill was rare, while cartage was 40% in some areas and non-existent in others. This implies that animal-drawn cropping is used mainly during rainy periods (6 to 12ha sown per year). The rest of the year, draft animals are fed and used a few times for maintenance work. Considering its annual charges, animal traction cutivation is expensive (Agbangba *et al*., 2018). The adoption rate of animal-drawn cultivation, even where higher than mechanization, remains low in the context of sustainable agriculture. This weakness may be due on the one hand to the agroecological and pedoclimatic conditions of the environment. The center of Benin comprises two zones: the hilly zone characterized by a Sudano-Guinean bimodal climate and gradually sliding towards a unidodal Sudano-Sahelian type; and the Zou zone, which is a Sudano-Guinean type climate with two rainy seasons—with a total rainy season of more than 6 months. Trypanosomiasis still hinders the spread of zebu rearing and disease-resistant bulls are not large enough to perform heavy work (Yebou *et al*., 2018). The annual net gross margin of a farmer who owns his own team and equipment varies between FCFA13,000 and 20,000/ha for a farm of 10 to 15ha (Agbangba *et al*., 2018).

Mechanization studies in Benin

The achievement of good agricultural performance depends on technical progress, including the introduction and use of high level of mechanization (Giffort, 1985). Aware of the imperative nature of this technical progress in most developing countries and particularly in Benin, several studies were carried out in the field. FAO (2005) studied the national agricultural mechanization strategy of Benin. Indeed, the development of mechanization in Benin requires a coherent national strategy in the short, medium and long–term, integrating the different aspects of mechanization processes (technical, economic, legal, institutional, social and cultural) and associating directly with all its development and operationalization partners. Such strategy is a dashboard that allows decision-makers to better optimize actions of the state, anticipate their impacts and monitor them on rural populations, economy and the natural environment. The strategy uses the approach developed over several years by FAO and applied in several developing countries. The steps are as follows: diagnosis of the current situation of mechanization, analysis of the various policies of development in relation to mechanization, prospects for changing the current situation and formulation of a strategy. The results of research on the economic valuation of rice farms carried out by Adegbola *et al*. (2011) showed that mechanization improves economic performance in agriculture.

Gibigaye (2013) analyzed the policy of mechanization and agricultural production in the town of Glazoué in central Benin, and reveals that the program designed by the government since 2006 has enabled the acquisition of 13 tractors, including three (3) privately–owned tractors. This mechanization favored the increase of planting areas of up to 63% between 2000 and 2011; it also has a spillover effect on the use of improved seeds, fertilizers and pesticides. This has led to

improvements in productivity and producers' incomes. However, the increase in planting areas due to mechanization involves deforestation, which exposes the soils by subjecting them to weather, leading to their degradation.
Balse *et al*. (2015) studied an original experience of shared mechanization among farmers cooperatives Benin. The project on experience of shared mechanization lasted 18 years in Benin with support of the National Union of Cuma of Benin (UNCuma) and the French Association, Cuma Benin. To evaluate the achievements of the project against its objectives, UNCuma and the French Association decided to take an external evaluation of the experience. The National Federation of French Cumas (FNCuma), the Foundation for Agriculture and Rurality in the World (FARM) and the United Nations Food and Agriculture Organization (FAO) contributed to the achievement of this capitalization.

Loko (2016) showed that mechanization reduces production costs, improves labor productivity, etc. To achieve this, he advocated shared mechanization (a method of collective acquisition and management of equipment) to facilitate the acquisition and maintenance of machinery by farmers. Houssou *et al*. (2017) made an inventory of the mechanization (preproduction and postharvest processing and storage) of rice, maize and vegetables in the departments of Alibori, Borgou and the hills. The results showed that cultural and postharvest operations of these three crops were little mechanized in the various areas of intervention. The majority of operations was performed using rudimentary tools. There is, however, a strong use of animal traction and affiliated equipment in Karimama community, Banikoara. Tractors were used by a minority of people who had the physical and financial strength. In the field of post-harvest operations, some equipment and materials, such as Engelberg gins, huskers, steaming kits for rice, and mini-rice mills were used. These equipment / materials were used by a small proportion of individual actors, in the form of group or individual services. The various players in the agricultural value chains of maize, rice and market gardening need to be reinforced in agricultural equipment and training to improve production and processing performance.

Agbangba *et al.* (2018) analyzed equipment uses and production needs of farmers in Benin's agricultural development hubs. The aim was to develop a participatory approach to identify agricultural materials and equipment that meet the needs of producers in the country. Villages were selected in six agricultural development hubs (PDAs) to identify the main crops contributing to income and food security. In addition, the equipment/ material requirements, as well as constraints were identified by sector. Further, the study considered how to improve the mechanization of agricultural operations in order to increase productivity, reduce crop shedding and postharvest losses, and create value addition for smallholder farmers.
The results revealed a significant variation ($p < 0.01$) in the ranks attributed to the crops of economic importance according to villages, speculations and PDAs; plowing and weeding were the most operations performed by producers. Production materials and equipment were presented in a participatory manner to identified major production constraints.The results also suggested that the agricultural equipment generally found in Benin and West Africa were characterized by a variety of technical and technological perspectives. The impact of mechanization on the soil, food security, youth employment and the general socioeconomic conditions of farmers was further discussed. It was recommended that to achieve robust and sustainable agricultural development in West Africa, stakeholders should always take into account the socioeconomic and demographic conditions of farmers when developing and implementing mechanization projects.

In another study, titled ‘Using a whole-farm modelling approach to assess changes in farming systems with the use of mechanization tools and the adoption of high yielding maize varieties under uncertainty in Northern Benin Adegbola *et al*. (2018) examined the effects of high-yielding maize varieties and use of machineries on the production, income, crop mixtures, and demand for production resources in two farms and farming household typologies in the northern cotton-growing belt of Benin. The results indicated that the introduction of new varieties and machineries enhanced farm household income in the two typologies and had varying effects on land allocation for the crops.

Study 1: Institutional options for mechanization, including state-led procurement and distribution of machinery and private sector activities

State and private-led efforts to promote mechanization

The period 1970-1980 was characterized by intensive agricultural mechanization activities in Benin, with the creation of farms and state companies like the Beninese Company of Palm Oil (SOBEPALH), the National Society of Irrigation and Development of Hydro Agricultural (SONIAH), the National Society for Forest Development (SNAFOR), the Provincial Society of Agricultural Extension (SOPROVA) etc. (Adegbola *et al*., 2018). These companies then had large parks of tractors, buldozers, rotary crushers, combine harvesters, and so on, for land preparation up to harvesting. Following the limited success of these initiatives, there were new attempts at agricultural mechanization. Thus, in 1988, state farms were created in partnership with Argentina through the Agro-Pastoral Farms Project of Kika (Tchaourou) and Sakabansi (Nikki) with a large delivery of agricultural equipment for the mechanization of cultural operations, from land preparation to storage. In 1990, the China-Africa Agricultural Machinery Center (CEMACA) was established to accelerate the mechanization popularized through the various Rural Promotion Centers (CPR), the irrigated areas of Deve, Koussin-Lele, Malanville, and the Regional Action Centers for Rural Development (CARDER). Other initiatives followed until 2003, but not much success was recorded (Adegbola *et al*., 2018).
In 2005, FAO supported Benin in the development of the National Agricultural Mechanization Strategy (SNMA) (Balse, 2015). After a thorough diagnosis of the situation of agricultural mechanization, SNMA selected a progressive mechanization, which was carried out in stages through the use of animal-drawn cultivation, and light mechanization. Diplomatic strategies with certain countries, such as India, China and Libya have produced large batches of agricultural equipment (tractors and accessories, tillers, etc.) for Benin.

Through the Strategic Plan for the Revival of the Agricultural Sector (PSRSA) adopted in June 2008, a fund of about CFAF10 billion was mobilized by the national budget to initiate the first actions (Saizonou, 2018, Inter- Réseaux, 2008). A light structure, the Program for the Promotion of Agricultural Mechanization (PPMA) was therefore set up in 2008 to drive this long-term strategy. The PPMA is to acquire tractors, put them in place according to the conditions defined by the government and monitor their operation. To guarantee the correct operation of the tractors, it was necessary to have equipment of the same type and origin.

Benin received a donation of about 100 tractors from China and India, which were sold in cash or on credit, donated or used to provide services (MAEP, 2010). To ensure the maintenance of this equipment given to the Regional Centers for Agricultural Promotion (CERPA), Beninese managers were sent for training in these countries. It was to take advantage of the experience tractor drivers in China and India that PPMA had to acquire the tractors from these countries. Thus, through limited consultations with suppliers accredited by Indian and Chinese manufacturers, PPMA acquired in several lots 300 tractors with various accessories for farm mechanization in Benin; this was also to complete the range of tractors in use. For the first season, PPMA also acquired 4 wringers from Canada.
In 2009, more than 600 tractors were acquired by the PPMA for the benefit of producers. After purchase, the agricultural machines were made available to farmers in all regions of the country. The PPMA set conditions to facilitate farmers' access. Tractors were awarded free of charge to groups, while individual farmers received a 50% subsidy on tractor cost; a 6hp tractor bought at

CFAF 12 million was sold to individual farmers at CFAF 6 million, with the possibility of payment over four years.
In 2004, the construction of agricultural machinery assembly plant in Ouidah was also part of the Program for the Promotion of Agricultural Mechanization (PPMA). The plant comprised five units, namely, water treatment unit, paint unit, electrical control building, the assembly unit, and maintenance unit. The site had a main block, which housed the administrative complex, a showroom and some of the aforementioned units. The plant was expected to manufacture 2000 agricultural machines every year, including 300 tractors, 300 trailers and 500 disc plows.
In March 2004, Program Team 10 (which means, in French: Technico-economic approach for cooperation between Africa and India) was set up between India and 8 African countries: Burkina Faso, Chad, Côte d'Ivoire, Equatorial Guinea, Ghana, Guinea-Bissau, Mali, and Senegal. Niger and Benin were later to make them ten (10). Through this program, India intensified its cooperation with West African countries. A preferential credit line of US$500 million was allocated by India to the 10 African countries for financial assistance on various priority programs, including the mechanization of agriculture through the purchase of Indian agricultural equipment. Among other things, Benin acquired 300 equipped tractors with this assistance. The various countries put there procured equipment up for sale, often with a subsidy (50% for tractors in several countries) and on credit (of 3 to 5 years). Where the beneficiaries were individual farmers, the initial outcomes (low patronage, difficulties in repayment) forced the countries to explore different options (large-scale farmers/ producers, politicians involved in farming, etc) or rental services (eg, Niger). The second component of the mechanization program concerns the construction of assembly plants for tractors.

The national agricultural mechanization strategy elaborated by the MAEP in 2011 aimed to achieve a mechanization rate of 20% of plowed land by 2015 (PRSA, 2011). Agricultural mechanization was to be introduced in stages, based on technologies adapted to the needs of the different agricultural subsectors through public-private partnership. Specifically, the PSRSA focused on:

(i) setting up the institutional framework implementation of the National Agricultural Mechanization Strategy;
(ii) availability of suitable agricultural equipment through local production, import and distribution; and
(iii) maintenance and repair of agricultural equipment.

In terms of institutional arrangements and support, these were to:

- Create the Agricultural Mechanization Development Agency (ADMA) to support the modernization of family farming and the promotion of large farms and agricultural entrepreneurship;
- Assess the need for production and processing equipment for agricultural products, and update the database on these materials annually;
- Strengthen agricultural research and advisory, respectively, for the development and dissemination of adapted technologies using new energies, biofuels, etc., for agricultural purposes;
- Develop an environmental support mechanism for agricultural mechanization;
- Carry out standardization of equipment;
- Take into account appropriate agricultural mechanization in the development and implementation of SNFAR;
- Develop local expertise in agricultural mechanization through support for existing local businesses (COBEMAG, SONGHAI, Atelier Steinmetz, CAMEMEC, EPAC-UAC, etc.);

- -Strengthen the technical and financial capacities of actors for optimal and sustainable use of agricultural equipment, particularly in terms of installation, after-sales support and maintenance services;
- Support private producers and companies to invest in agricultural and processing equipment;
- Promote CUMAs and reorient CEMAs on their training role.

With regard to the availability of agricultural equipment, the priority actions were to:
- Monitor, test, test and evaluate locally manufactured equipment for improvement, certification and extension;
- Collect the working standards for each category of equipment related to the different types of soils and carry out the subsequent technical-economic studies, including environmental impact studies;
- Organize, at least once a year, an exhibition of local materials;
- Identify local manufacturers of agricultural equipment and machinery;
- Support existing local businesses by developing local expertise in agricultural mechanization;
- Define and implement, in liaison with the services concerned, training programs for users of agricultural equipment and local craftsmen;
- Reduce or eliminate customs fees on imported raw materials and parts for the production of agricultural equipment at the local level;
- Facilitate the importation and distribution of agricultural and processing equipment through structures close to the field;
- Put in place participatory mechanisms to ensure equitable distribution and effective management of donations of agricultural equipment and materials;
- Introduce tax and customs exemption measures to promote imports of agricultural and post-harvest production equipment (hullers, ginners, raspers, oil presses, multi-purpose platforms, etc.).

When it comes to maintenance and repair, it is about ensuring:
- Specific training of artisans in the field of production and maintenance of agricultural equipment;
- The development of local services;
- Tax exemption measures for the import of spare parts.

Thus, in 2011, other batches of tractors were acquired. Through this mechanization program, 4 types of beneficiaries were distinguished: individual farmers, producer groups, youths in agriculture, and training centers. The training centers and various regional ramifications of the program for the integration of youth in agriculture were automatically given 5% and 10%, respectively, of the total number of tractors acquired by PPMA. On the other hand, individual farmers and groups had to make requests; allocations to them was based on availability. For the 225 tractors distributed in 2011, more than 1,500 applications were received. The Atlantic Regional Center for Agricultural Promotion (CERPA) received 24 tractors of 30hp and 10 tractors of 60hp; but not all the tractors were given with their accessories. Thus, increases in planting areas, on many occasions, were associated with mechanization (Saizonou, 2018).

The partnership developed by Benin and the Angelique International Limited of India facilitated the daily production of a dozen tractors of 60hp Mahindra brand in Ouidah (Boko, 2016), thus promoting increases in agricultural equipment in the country. This partnership also facilitated in August 2012 a loan of FCFA 7.5 billion (11.4 million euros) to install in Benin a factory for the manufacture and maintenance of tractors, trailers and disks on an area of about five hectares. The Ouidah plant, known as Benin Tracteurs, was managed through a public-private partnership

agreement, signed in March 2015 between the Benin and the Indian firm, Angelique International Limited (AIL). AIL has 51% ownership in the company while the Beninese government has 49%. AIL produces in India spare parts for agricultural tractors and equipment and then send this for assemblage in Benin. Since its establishment, Benin Tracteurs has received from the Beninese government, through the Agricultural Mechanization Development Agency (ADMA), an order for 500 tractor kits, including 60hp tractors, 5-tonne trailers and two disc devices: the plow discs and the "harrow" discs that serve to loosen the soil (Boko, 2016).

In an effort to strengthen agricultural policy in Benin, the government decided in 2018 to create an agency for agricultural mechanization. The agency was to improving work tools and farm yields through advanced agricultural equipment (Benin24, 2019). The same year, the government sold 480-tractor kits at a reduced price to the former Agricultural Mechanization Development Agency (Mehouenou, 2018). The tractors, whose units were initially purchased at 15.5 million francs, were sold at a price of 8.5 million francs. This amount covered all fees, and also offered the opportunity for purchasers to stagger the repayment over three years. The objective is to create favorable conditions for the acquisition of these machines to peasants who wished to improve their production capacity. Other options available included that purchasers would benefit from a free 15-day training on the use and maintenance of tractors; a one-year warranty for each tractor purchased and for 1000 hours of work; as well as after-sales service and access to appropriate spare parts (Mehouenou, 2018).

In 2019, the government approved the statutes of the National Agricultural Mechanization Agency (ANaMA) (Houngbo, 2019). The mandate of this agency is to develop and promote the technical agricultural policy as the core of the national economic development. The aim is to guarantee food and nutritional security and make agriculture the hub of job creation.
Despite the steady increase in production, the agricultural sector faced many difficulties related, among others, to low level of agricultural mechanization, a situation that justified the creation of National Agency for Agricultural Mechanization. ANaMa is to help meet the current and future challenges of the agricultural sector, so that it is profitable and competitive (Houngbo, 2019).

With the goal of achieving 2 to 3 tons/ ha of maize, 3 to 5 tons/ha for rice, and 15 to 20 tons/ha for cassava (PAG, 2016-2021), the challenge of mechanization (a cross-cutting issue of the Government Action Program) and the use of high-performance equipment are a necessity in the seven Agricultural Development Hubs (ADH) (Gibigaye, 2013). In addition, the government, through the Program for the Improvement of Smallholders' Agricultural Productivity (PAPAPE), initiated a study to identify the real needs in terms of materials and equipment of the different intervention villages of the program (Agbangba, 2019).). It appears that whatever the speculation concerned, the machines sought are to facilitate the operations of plowing, weeding, and transportation.

Overview of private tractor market (types of brands and amount of tractors sold) in Benin
Balse (2015) showed that in Benin, multiple organizations of producers (OP) integrate the issue of agricultural mechanization of agriculture. These organizations are:

- Federation of Producers' Unions of Benin (FUPRO), created in 1994, is the largest producer group in the country.
- Union Synergies Paysannes.

- The National Platform of Peasant Organizations and Agricultural Producers of Benin (PNOPPA), member of the Network of Farmers Organizations and Agricultural Producers of West Africa (ROPPA).

At the local level, many mechanization initiatives are carried out by POs, with the support of NGOs, mainly on the processing of agricultural products (motorized or manually fixed). For example, Zogbodomey, the Union Communale des producteurs (UCP), supported by the NGO GERES (Renewable Energies, Environment and Solidarities Group) developed soybean processing machines for women producers. Also, the NGO CIDR (International Center for Development and Research) supports the creation of service companies and producer organizations (ESOP) in Togo and Benin. These companies develop shelling and rice marketing equipment.

Agricultural mechanization initiatives, using animal traction, are initiated in the north by the former cotton companies; and they are operated in certain areas where there are networks of blacksmiths and veterinary services. Some regional agricultural equipment manufacturing cooperatives, such as the Benin Agricultural Equipment Cooperative (COBEMAG) in Borgou, are suppliers of animal traction (seeder, plow) and processing equipment. In addition, the Regional Union of Producers of Borgou-Alibori (URP-B/A) establishedthe program of mechanization of agricultural production operations, with the support of the Swiss Cooperation.

The Agricultural Equipment Utilization Cooperatives (CUMAs or simply Cuma) program of POs begun in 1997 and inspired by the French Cuma, mobilized the know-how of farmers in Benin. In 20 years, the Cuma of Benin gradually developed and networked in a constant dialogue between Beninese farmers and their French partners. The program provides farm improvement opportunities and development of mechanized plowing equipment.

The Cuma of Benin was established following the initiative of a group of producers (the Sub-Prefectural Union of Producers (USPP)) of the commune of Bembéréké, in the department of Borgou. The farmers, who had wanted to buy tractors, learnt about the Cuma of France through *Caisse Française de Développement,* which financed Benin's Professionalization Program for Agriculture (PPAB). Through PAIMAF (Institutional Support Project for the Modernization of Family Farming), these producers received support from AFDI, which, in collaboration with the Cuma Departmental Federation (FDCuma) of Dordogne, started a project of shared mechanization in Benin in 1995. Of the 18 files created of Cuma, one came to fruition in 1997: the farmers of Ina, a village in central Benin. Then in 1998, with the support of FDCuma, three Cuma Beninese got financial support from a Swiss financial institution, which was deposited with a local branch of Bank of Agricultural and Mutual Credit (CLCAM).

Until 2006, there was marginal increase in the number of Cuma, often created with the support of the department of Borgou. During this period, farmers and employees of Dordogne FDCuma provided technical support and sensitization on mechanization to Beninese farmers. They also facilitated the importation of used tractors.

PPAB also supported Cuma development activities through awareness campaigns and facilitating access to certain imported equipment. In 2003, a partnership was set up between the Regional Solidarity Bank (BRS) and the Benin Cuma to finance the purchase of tractors. Unfortunately, a very few Cuma were able to repay the loan given. The loan was largely unaccessible to many Cuma, and the interest rates and bank charges were considered by some as very high and unaffordable. There were also problems of misunderstanding and mistrust between the farmers and financial institution.

In 2003, the Cuma Regional Union of Borgou-Alibori (UR Cuma) was created. This union of cooperatives made it possible to pool the services provided to producers, particularly with regard to the maintenance of equipment (Chignac, 2012). In 2006, the Beninese government received a

gift of sixty Indian tractors, four of which were assigned to Cuma in four communes (Sinende and Bembéréké in Borgou, Gogounou and Kandi in Alibori). The gift encouraged other farmers to regroup, so that over fifteen Cuma were created that year in the communes of Kandi and Gogounou; but no tractor was allocated to them.
At the end of 2007, the Union Communale des Producers of Grand-Popo, in the department of Mono, began a partnership with AFDI and FDCuma Pyrénées Atlantiques to experiment with shared mechanization. The year 2008 marked first exhibition of Cuma of Benin in the departments of Borgou-Alibori; the aim, among other things, wsa to make the Cuma known to other actors of mechanization in Benin.

In 2009, the National Union of Cuma of Benin (UNCuma) and the Regional Union of Cuma of Mono-Couffo were established. The same year, the PPMA supply of tractors accelerated the creation twenty more Cuma, including twelve in Mono-Couffo. On their part, the French partners structured their network to attract more financial partners. In 2007, AFDI withdrew from the scheme, so that "mechanization of Beninese agriculture through cooperatives and use of agricultural equipment" had to rely mainly on the financial support of Regional Council of Aquitaine, the General Council of Dordogne and French ministerial funds (MAEDI10), which had contribute immensely to the development of the Beninese federative network. In 2014, the program ended and was not renewed by MAEDI.
In February 2010, FRCuma Aquitaine and the FDCuma of Dordogne, Gironde, Pyrénées Atlantiques and Landes founded the Association of Cuma Benin (France), specifically dedicated to their cooperation activities in Benin. Actions of the Association of Cuma Benin were based on the transfer of knowledge through exchanges between the North and South (from peasants to peasants, or technicians to peasants, or technicians to technicians) between France and Benin. The association mobilized a range of skills complementary to those of the Cuma network and facilitated the coordination and visibility of this Franco-Beninese cooperation. Today, the association brings together about thirty volunteers with profiles that represent all Cuma-related professinals: farmers, mechanics, farmers and employees of the Cuma France network, retirees responsible for the agricultural market at the Banque Populaire du South West, computer scientists at Banque Populaire du Sud Ouest, and people in charge of economic and political issues of the General Association of Corn Producers (AGPM), etc.
In 2012, the Cuma Benin Association established Tracto Agro-Africa (T2A), with a subsidiary in France (SARL) and another in Benin (commercial company). The initiative was a response to the challenge of insufficient tractors in Benin, and the desire to create more Cuma groups (some prospective groups had for a tractor for years). Funding of the two companies was entirely by the Association of Cuma Benin, while the management was by French Cuma. The objective was for UNCuma to eventually buy up the shares of the Beninese company and operate it. The companies purchased agricultural equipment from France12 and exported them to Benin. These commercial structures were imposed by certain tax obligations (VAT recovery, export rules, etc.) to which an affiliate could not respond. In eighteen months of activity, T2A sold 24 tractors to Cuma of Benin.

These companies effectively supplied agricultural equipment to individual farmers to optimize production.
The Cuma network in Benin was structured around a federation, UNCuma, which relied on regional and departmental organizations. All Cuma unions were affiliates of the federation. Theseunions were– established in 2013 in UD Alibori, UD of Borgou and Couffo. But they experienced some investment difficulties with their officials, particularly due to the distances to travel to participate in management activities. URCuma is, however, still operational in northern

Benin. Today, 102 Cuma, including 850 producers, are listed in the network. These Cuma are, however, not equipped with motorized equipment: only 57 Cuma (or 56% of them) are equipped to plow about 4000 hectares per year. Each Cuma comprises about ten farmers on the average and has the main objective of mechanizing plowing, in addition to transport activities during harvest.
The basic equipment of a Cuma in Benin corresponds with a tractor of 30 to 70hp, a plow with 3 disks and trailer of three tons. On the average, a Cuma plows about 100 hectares using a tractor. Some groups particularly in Mono-Couffo use cassava rippers or palm-nut spreaders, powered by dermal engine (but not connected to a tractor). Group members contribute to the operating expenses of the equipment, in proportion to its use. The amount contributed by each member to the Cuma is a function of their area worked.

After a failed credit financing experiment, farmers have to raise the capital needed to buy the equipment themselves. The purchase and import of agricultural equipment is done either through the French partner of Aquitaine (T2A company), or PPMA, or other specific state programs or NGOs. Farmers obtained very little from the few private distributors.
Farmers have generally been aware of the "Cuma" approach via their professional networks, relatives, friends or family (in the surrounding villages), or through the mass media (radio or television). The visit of Cuma network coordinators to these villages often arouse curiosity. Following the sensitization activities of the coordinators, interested producers get together to form a group, ready to invest jointly in the purchase of a tractor. A group is made up exclusively of farmers from the same village who know each other and, for some, who have already carried out activities together (groups of farmers or young people performing work or jointly purchasing equipment). Some groups are exclusive members of the same family, or religious affiliation (Moumouni *et al*., 2013).

Groups are supported by the local Cuma coordinator and Ministry of Agriculture, with regard to registration as cooperative entities. In the majority of cases, the registration procedure demands the use Cuma's registration number, so that they are treated as cooperatives in accordance with the legal requirements (Law No. 61-27 on the Statute of Agricultural Cooperation of August 10, 1961). Recently, some new Cuma had challenges with the registration procedure, as the cooperative registration body in Benin were yet to be fully functional, despite the passage into law the Uniform Act on the Law of Cooperative Societies OHADA since May 2011.

The Cuma network in Benin operates in close relation with professionals in agricultural vocational education. This orientation is characteristic of the desire to link continuing education, professional training and farmers' organizations.
The Association of Cuma Benin has the capacity to develop partnership with high school professionals in France through active membership in French agricultural schools. There have been several exchanges between French and Beninese high schools, the establishment of machinery centers in such high schools and the development of training contents. This way, high schools in Ina (Borgou-Alibori) and Akodeha (Mono-Couffo) have machinery training centers installed by the Cuma network; these are maintenance and repair workshops, the first of which was installed in September 2009 in Ina.
They are used for the repairs and rehabilitation of tractors, the assembly of T2A tractors and training avenues for mechanics and students in machinery. In practice, while these centers are not accorded sufficient value by agricultural teachers, they are highly valued by the Ministry of Secondary Education for technical and vocational training and retraining. The integration of young

Beninese, especially from the University of Kétou, which provides vocational training in agriculture has good prospect for national economic development. There are several benefits of these exchanges between high schools (and universities) and the professional world; such as being an avenue for knowledge sharing in agricultural operations and research.

As part of the Agricultural Sector Recovery Strategy, the Benin Ministry of Agriculture developed a national agricultural mechanization policy, which recognised Cuma as "the reference structure in the use of agricultural equipment" (MAEP, 2011). However, the Cuma network is still not large enough to fully participate in the mechanization policy. This situation also explains the lack of regular contact between the Cuma network and national policymakers, which limits farmers' participation in the implementation of the policy.

In some villages, however, Cuma has favored the development of other mechanization initiatives. In Ina village (ofBorgou), for example, where the first Cuma was established in 1997, mechanized tillage services are a thriving business. It is very easy to find private providers because they are numerous, available and accessible to farmers. In fact, when due to the large increase in maize production in Borgou, the Cuma community created the Borgou Maize Cooperative (CMB) in 2010. The objectives were to: guarantee the supply of inputs to members; set up stores at the collection points; market quality corn; and adapt their business strategy to market structures. Its launch was sponsored by EURALIS23 Cooperative (which took care of the feasibility study, training of managers in France, and a few other activities) and Crédit Agricole National Banks and Regional Banks (Pyrenees Gascogne) (which catered for the purchase of equipment); there was also financial support from USADF for the construction of warehouses. Today CMB has about 160 maize producers who collect and market more than 900 tonnes of maize.
The Ninth Uniform Act of the Organization for the Harmonization of African Business Law24 (OHADA), Uniform Act on Cooperative Company Law, became applicable in the seventeen state parties to the OHADA Treaty from 15 May 2011, with the objective of standardizing cooperative law and improving the legal environment and economic development. This Act works for an autonomous private sector in the establishment and management of cooperatives, for more democratic functioning, greater financial transparency and reinforcement of the economic fabric, as well as promotion of inter-cooperation of cooperatives (Gning and Larue, 2014).

The OHADA Uniform Act applies as much to local cooperatives as to unions and federations of cooperatives in the Cuma network. Strengthening its links with policymakers is thus a priority for the network. The role of the state is central in the establishment of a national agricultural mechanization system. The state can direct mechanization, for example, by building an institutional and economic incentive environment through robust support mechanisms, such as tax incentives, subsidies, training and financing. It is therefore essential to work in close collaboration with the various agencies responsible for mechanization; Synergy with policymakers would enable Cuma to play its key role in agricultural development; to be both actors and beneficiaries of Benin's agricultural policies.
Unlike the Agricultural Equipment Utilization Cooperatives (CUMA) in northern Benin which acquired the tractors by groups and rented them at a flat rate to members (Gibigaye, 2008), the tractor rental services in Glazoué were provided by private individuals with varying rental prices, between 37000F CFA and 40000F CFA, depending on the distance, relationship, and/or bargaining power of the hiring farmer.
To be effective in its area of intervention, the Food Production Support and Resilience Support Project of the departments of Alibori, Borgou and Collines (PAPVIRE-ABC) carried out a state–of-

the-art pre-production and post-harvest mechanization of rice, maize and vegetable crops. One of PAPVIRE-ABC's intervention goals was the provision of post-harvest equipment (tarpaulins, threshing machines, maize gins, tomato processing complex, rice parboiling equipment, onion and chilli drying equipment, and mini-rizeries).

Furthermore, the Village Cooperative of Rice Farmers and Gardeners of Boutena has been supported since January 2012 by the Millennium Villages Project (PVM) (PNUD, 2013). This project, funded by the Government of Benin, Banikoara Town Hall, Japan and the United Nations Development Program (UNDP), aims to eradicate extreme poverty in the municipality of Banikoara. The PVM also strengthens their technical capacities and provision of materials, as well as provides them with equipment (gins, tractors, etc.) and inputs (fertilizers and pesticides). For example, a high-capacity tractor was provided for the cooperatives for land preparation; members organized themselves to rent these equipment and inputs among themselves and to other groups. The revenues are used to finance the maintenance of machinery, acquisition of more equipment and inputs.

Sampling, data collection and study sites

The sample for the quantitative survey comprised tractor owners, selected through stratified sampling, using an exhaustive inventory of government and private purchasers of agricultural machinery in three ADHs (2, 3, 4) of the existing seven. These ADHs were selected because they represented Central and North Benin, known for high level of use of agricultural machinery and animal-drawn traction (Agbangba *et al*., 2018; Gibigaye, 2013; Balse *et al.*, 2015). For the quantitative survey, 150 beneficiaries of government tractors, and 150 beneficiaries of private sector tractors (being a total of 300 tractor owners) were selected. Thus, the total number of owners sampled at the level of each PDA was calculated in proportion to the weight of beneficiaries present in each ADH (2, 3, 4). Subsequently, 145 buyers of PDA2, 4 of ADH3, and 151 of AD4 were randomly selected from the Excel spreadsheet (table 1). The survey was conducted between February and March 2019 using 10 research assistants for data collection.

The study assumed Y_n as the number of tractor owners in ADH_n, with $n = \{2, 3, 4\}$.

$$number\ of\ sampled\ private\ tractor\ owners\ in\ the\ ADH_n = 150 \times \frac{Y_n}{\sum Y_n}$$

$$number\ of\ sampled\ government\ tractor\ owners\ in\ the\ ADH_n = 150 \times \frac{Y_n}{\sum Y_n}$$

Table 1. Distribution of tractor owners sampled by ADH

PDA	Number of tractor owner identified though qualitative survey			Number of owners sampled at the 3 ADH levels selected			Communes
	Government	Private	Total	Govt	Private	Total	
2	94	109	203	58	87	145	Banikoara; Bembèrèkè; Gogounou; Kalale; kandi; Pehunco; Sinende
3	5	1	6	3	1	4	Boukoumbe; Cobly; Materi
4	144	78	222	89	62	151	Dassa; Bante; Djougou; Glazoue; N'Dali; Nikki; Ouesse; Parakou; Perere; Savalou; Save; chaourou; Djidja
Total	**243**	**188**	**431**	**150**	**150**	**300**	

The quantitative data were collected at the ADH 2, 3 and 4 using electronic Tablets, preloaded withquestionnaire and using trained research assistants. A pretest had been conducted to refine the questionnaire.

ADH2

ADH2 was Alibori Borgou South-North 2KP, comprising the following communes: Kandi, Banikoara, Ségbana, Gogounou, Kouandé, Kèrou and Péhunco, Sinendé, Kalalé, and Bembéréké. This area had a large amount of arable land, with avegetation characterized by plateaux, soil degradation, fallow vegetation, and slopes. Access rate to credit was relatively average (MAEP, 2017, INRAB, 2017), while the main income generating activities were food production and processing, trade, craft activities, and forest resource activities. This area covers the main cotton basin of Benin; there are also maize, soybean and sorghum production activities, as well as intensive cattle, sheep, goat and poultry farming. (MAEP, 2017; INRAB, 2017).

ADH3

ADH 3 was Atacora West, and comprised the communes of Tanguiéta, Materi, Cobly, Boukoumbé, Toucountouna and Natitingou. The landscape was characterized by cultivated and fallow perennial vegetations; access rate to credit was also relatively average (MAEP, 2017; INRAB, 2017). Food and livestock production and trade, and craft activities were the main income-generating activities for households in this area. It was also a cotton-food diversification zone, with a system of agroforestry-pastoral integration with cotton and rice. The zone also produced maize, cowpea, peanut, and mango.

ADH4

The ADH4 was Borgou South-Donga- Collines, comprising the following communes: Tchaourou, Parakou, N'Dali, Nikki, Pèrèrè, Djidja, Savalou, Bantè, Dassa-Zoumè, Glazoué, Savè, Ouèssè, Djougou, Ouaké, Bassila and Copargo. The agrarian landscape was characterized by cultivated and fallow vegetation, as well as plantations. Many households had commercial plantations; the rate of access to credit was relatively average (MAEP, 2017; INRAB, 2017). Food and livestock production, trade, and craft activities were the main income generating activities for village households. ADH4 was cotton-food-cashew zone, with also activities in agro-sylvo-pastoralism and

production of maize, rice, roots, cassava, yams, cowpea, soybean, peanut, and mango, as well as intensive livestock farming (bovine, ovine, goat and poultry) (MAEP, 2017; INRAB, 2017).

Results

Demographic, Emplyoment and Farm Characteristics

Table 2 presents the demographic, employment, and farm characteristics data by the two types of tractor acquisition (government and private sector). The data show that the levels of education differ significantly according to type of tractor acquisition. Farmers who bought their tractor through the government were more educated than those who bought from the private sector. Average age was about 47 (± 9) years for government tractor owners, and about 45 (± 9) years for tractor owners through the private sector. The respondents were, therefore, relatively young. Moreover, most of the respondents, regardless of the type of acquisition, played no specific leadership role in their respective villages. A non-negligible proportion of the respondents were, however, chairmen of committees or pilot farmers in their villages. As regard the membership of farmers group, a majority of the farmers, at approximately equal proportions, belonged to cooperative /association or producers' organization. Significant difference was observed for the levels at which respondents belonged to religious organizations, that 2.0% for government tractor owners (GTOs) and 0.67% for private sector tractor owners (PTOs). Considering the main sources of income, most respondents got their income from agriculture. However, a significant difference was found for the share of agriculture in annual incomes of the two groups of tractor owners, with GTOs being 75.20% and PTOs 67.78%. As for the share of annual income allocated to tractor services, PTOs had 14.62%, while GTOs had10.54%. The same was true for the share of annual income from formal / informal activities. Moreover, the share of annual income from regular salary was 4% for GTOs and 1.23% for PTOs. In terms of area cultivated, the data show that GTOs farmed 50.58ha, while PTOs farmed 32.66ha ($p < 0.05$). The same observation is made on the amount of land cultivated during the last farming season, which averaged 30.26 (± 24.76) ha for GTOs and 26.50 (± 25.30) ha for PTOs.

Table 2. Demographic, emplyoment and farm characteristics

Characteristics	State-imported	Privately-purchased	Statistical difference
Education level			
*None	24.67	38.67	7.26*
*Primary	35.33	26.00	
*Secondary	35.33	30.67	
*Tertiary	4.67	4.67	
Age of head	47.38 (9.40)	44.97 (8.91)	2.28**
Percentage of Income from Farming	75.20 (21.21)	67.78 (25.39)	2.74***
What role do you play in community			
*None	76.67	86.00	4.30**

*Chief of the village	2.00	1.33	0.20
* Son of the chief	1.33	0.67	0.33
* Chairman of a committee	16.00	6.67	6.50**
*Religious leader	2.00	0.67	1.01
* Pilot farmer	6.67	6.67	0.00
* Health worker	00.00	00.00	-
Number of group memberships			
* Cooperative / Association	49.33	55.33	1.08
* Religious organization	6.00	0.67	6.62**
* Producer organization	47.33	48.00	0.01
* OERT	00.00	00.00	-
* Women's Association	1.33	0.67	0.33
* Group / Youth Association	4.00	2.67	0.41
* Political party	6.00	7.33	0.21
Percentage of income from tractor services	10.54 (13.20)	14.62 (16.41)	-2.37**
Percentage of income from formal/informal business	10.16 (14.54)	15.05 (20.41)	-2.38**
Percentage of income from regular wage/salary	4 (13.80)	1.23 (8.51)	2.08**
Land owned last season	50.58 (39.03)	32.66 (33.25)	4.27 ***
Land cultivated last season	30.26 (24.76)	26.50 (25.30)	1.29
Etc.			

2. Ownership, Motivation and Financing of Machinery and Accessories

Table 3 presents data on ownership and financing of machinery and equipment. The results show equal amount of tractors for GTOs and PTOs. The reasons for purchasing a tractor included, for GTOs (80%) and PTOs (84%), to develop their farms. The main source of information for both groups was the government; a significant proportion of the respondents also chose other producers/ tractor owners as sources of information. Most of the respondents stated that no criteria/ specifications influencing the choice of tractor; for others, the dominant choice criteria were the price and horsepower of tractor. With regard to the number of functional tractors during the previous farming season, 92.0% of PTOs and 61.3% of GTOs stated that their tractors were functional.

The farmers with dysfunctional tractors stated that the major reason for the non-repair was the lack of spare parts and skill in repair of tractor. There was a significant difference between the proportion of operators of the two types of tractor owners who could not access spare parts. The most popular brands among GTOs were Mahindra (30.00 %), Farmtrac (29.33%), Massey Ferguson (14.67 %), and Sonalika (9.33%); among PTOs, the most popular brands were Massey Ferguson (47.33%), Farmtrac (28.00%), and Mahindra (14.00%). Moreover, 68.67% of PTOs had mainly tractors of 60hp, while 20.67% of GTOs had 60hp tractors.

The average age of government tractors (7 years) was greater than that of private tractor (6 years). Also, the average price of tractor at the time of purchase, excluding insurance, registration and transportation costs, for GTOs was FCFA 6208839, which was higher than that of PTOs at FCFA 5779140. The proportion of the purchase price of tractor that was subsidized (25%) did not vary significantly between the two classes of tractor owners. The majority of tractor owners (more than 95%) did not use a particular credit service to purchase tractor.
The share of 'clean bottom' owners of government tractors was 57.80%, higher than that of private tractors (50.98%). The share of inheritance/ parents / friends was significantly different between GTOs (5.93%) and PTOs (1.6%) at $p < 0.05$.
Furthermore, it took both operators 4 years to save before buying their tractor. The average time taken to obtain credit by PTOs was 21 months, while that of GTOs was 13 months; the interest charged by the banks was on the average, 22%.
In addition, the average repayment period for credit was significantly higher for PTOs (around 3 years) than for GTOs (around 2 years). Moreover, no tractor purchased by farmers was manufactured locally.

Table 3. Ownership, motivation and financing of machinery and accessories

Characteristics	State-imported	Privately-purchased	Statistical difference
Number of tractors	1.36 (0.67)	1.44 (0.79)	-0.93
Main reasons to buy tractors			
* Develop your farm	80.00	84.00	0.93
* Produce on time	12.67	10.67	
* Provide services	6.67	4.67	
* Replacement of old machines	0.67	0.67	
Main source of information for choosing			
* Government	55.33	58.67	2.40
* Other producers / owners	28.67	31.33	
* Distributors of used tractors	12.67	8.00	
* Distributors of new tractors	3.33	2.00	
* Local industries	0.00	0.00	
Which criteria to choose			
* Price	18.67	24.67	13.91
* Power / Horses	21.33	18.00	
* 2/4 driving wheels	1.33	0.00	
* Manufacturer	9.33	6.00	
* Age	0.67	0.00	
* Capacity	2.67	5.33	
* No choice	35.33	39.33	
* After-sales services	0.00	0.00	
* Fuel consumption	0.00	0.00	
* Quality	2.00	3.33	
* After-sales service costs	0.00	0.00	
* Self control of the repair by the mechanics	4.00	2.00	
* Availability of spare parts	1.33	1.33	
* Handling mode	3.33	0.00	
Number of tractors functioning last season	61.33	92.00	39.42***
Why does your tractor no longer work?			
* Waiting for spare parts	12.07	41.67	6.13**
* No spare parts	86.21	75.00	0.94
* Expensive spare parts	41.38	33.33	0.26

* Lack of skill to repair	51.72	50.00	0.01
* Broken beyond repair	15.52	16.67	0.00
Brands			
*John Deere	0.67	0.00	17.18
*Massey Ferguson	14.67	47.33	
*Mahindra	30.00	14.00	
*Farmtrac	29.33	28.00	
*Ford	1.33	0.00	
*Same	0.00	0.67	
*New Holland	0.00	0.00	
*Landini	0.00	0.00	
*Case	0.00	0.00	
*TS	5.33	1.33	
*Solanika	9.33	3.33	
*Fonton	0.67	2.67	
*Eebro	0.00	0.00	
*Yto	1.33	2.00	
*Shakti	0.00	0.00	
*Kobouta	0.00	0.00	
*Soneca	0.00	0.00	
*Humt	0.00	0.00	
*Jinma	0.00	0.00	
*Renault	1.33	0.00	
*Sifang	0.00	0.67	
Horse power			
*30ch	14.00	6.67	83.38***
*45ch	65.33	20.67	
*60ch	20.67	68.67	
*80ch	0.00	0.67	
*90ch	0.67	3.33	
Age	7.06 (4.86)	6.44 (4.53)	1.14
Average amount paid for tractors at time of purchase, excluding insurance, registration, and transport.	6208839 (3592609)	5779140 (2614415)	1.18
% of the purchase price subsidized	24.04 (37.42)	25.11 (38.51)	-0.24
How much of the payment (%) came from Inheritance/family/friends?	5.93 (20.30)	1.6 (7.94)	2.43**
How much of the payment (%) came from personal savings?	57.80 (42.52)	50.98 (44.03)	1.36
How much of the payment (%) came from remittances?	1.53 (11.15)	1.33 (11.50)	0.15
How much of the payment (%) came from bank loans?	3.33 (13.98)	5.46 (17.52)	-1.16
How much of the payment (%) came from NGO loan?	0.00 (0.00)	0.56 (4.96)	-1.39
How much of the payment (%) came from NGO grant?	1.9 (9.68)	1.66 (12.17)	0.18
How much of the payment (%) came from microfinance loan?	3.68 (12.28)	4.28 (14.02)	-0.39
How much of the payment (%) came from government loan?	1.00 (7.11)	0.53 (6.53)	0.59
How much of the payment (%) came from government grant?	6.14 (19.34)	4.06 (15.24)	1.03
How much of the payment (%) came from circles loan?	0.00 (0.00)	0.16 (2.04)	-1.00
Years saved before purchase	3.59 (3.95)	3.4 (3.53)	0.45
How long did it take to get the loan in months?	13.25 (19.83)	20.55 (28.70)	-1.09
What is/was the loan term? (years)	1.77 (0.97)	2.41 (1.40)	-1.95*
What is/was the interest rate (%)?	21.81 (2.89)	21.79 (2.69)	0.02
Percentage of equipment locally manufactured	0.00	0.00	-

3. Background of Selected Machinery

A. State-imported

In order to purchase a tractor through the government, farmers went through a well-defined process. The majority of farmers had heard about such government program through agricultural extension (44%) and public authorities (town hall, etc.) (39%) (Table 4). It took about 20 days to finalize the formalities in demanding for a machine; if successful at this stage, it took about 45 days after to receive the machine. Only a few operators (18.00%) made a payment in the process of requesting for the machine; and the application process was largely free. A few, however, paid CFA 2,552,585 (1 dollar = 599.76 FCFA) as application fee. Most of the farmers who purchased their tractor through the government (63.33%) would have liked to buy their tractor outside the government program. But they got their preferred brands (Massey Ferguson and Mahindra) through government program; The most desired tractors were those of 60hp (54.55%), followed by 70hp (23.64%). A majority of the tractor operators (91.33%) had not previously received a machine from any government program.

Table 4. Information on selected machinery (state-imported)

How did you hear about government program?	**Count**
Agricultural extension	44.67
Public authorities (Other than agricultural extension, eg town hall, etc.)	39.33
Friend / family / neighbor / colleague	6.67
Media	4.00
Other applicant	5.33
NGO	0
How many days did it take to apply for the machinery?	19.76 (20.80)
How many days did it take to receive the machinery?	44.71 (73.79)
Did you have to pay anything in the process of applying for the machinery?	
Yes	18.00
No	82.00
How much did you need to pay?	2552585 (1625644)
Would you have bought machinery without government program?	
Yes	36.67
No	63.33
Which brand would you have chosen yourself?	
Mahindra	23.64
Massey Ferguson	74.55
Sonalika	1.82
Which HP would you have chosen yourself?	
45	21.82
60	54.55
70	23.64

Have you received machinery as part of a government program before?	
Yes	8.67
No	91.33

B. Privately-purchased

The data show that 72.00% of farmers who purchased tractors from the private sector never applied for a machine within government program (Table 5); the main reasons given were the fact that the process was tedious, that they were not influential enough in the community to have had such opportunity, or they were not sure the application would work. Many of the farmers (57.14%) who once sought a machine from government program did not get one; for the most part, they had no sufficient influence to secure any. About 31.0% of this group said they did not know why the process of getting a machine from government was unsuccessful.

Table 5. Information on selected machinery (privately-purchased)

Have you ever applied for a government program to obtain machinery?	Percentage
Yes	28.00
No	72.00
If no, why not? Reason	
Too tiresome	25.23
Not sure it would work	21.50
Does not appreciate this type of machine	9.35
I am not influential enough	22.43
Do not know	9.35
Cherry machinery of the state	7.48
Difficulty of access to spare parts of state machinery	4.67
If yes, were you successful?	
Yes	42.86
No	57.14
If not successful, why do you think you were not successful?	
Not enough land	0.93
Not enough own capital	12.04
Not enough influence	56.48
Do not know	30.56

Maintenance of Selected Machinery

When purchasing a tractor, only a few of the surveyed operators had after-sales service included. The proportion of operators who recognized the existence of after-sales service was significantly higher among government tractor owners (GTOs) (18.67%) than private sector tractor owners (PTOs) (5.33%). Tractor maintenance was done in mechanical workshops; but the number of operators who used mechanical workshops for repairs was significantly higher among GTOs (82.67%) than PTOs (75.33%). In terms of satisfaction with the maintenance service, most PTOs

(57.38%) were satisfied with the maintenance service, while GTOS (38.24%) were somewhat satisfied with the service. In general, PTOs were more satisfied with the maintenance service than GTOs. The maintenance services were related to change of engine oil, filter and tractor lubrication. Thus, the number of times that engine oil and oil filter were changed and lubrication done the previous year were collected from these operators. The average number of times that motor oil was changed the previous year was significantly higher among PTOs (about 6 times) than GTOs (about 3 times). For the oil filter change also, the number of times was significantly higher for PTOs (about 12 times) than for GTOs (about 5 times), as well as for lubrication, which was 5 times for PTOs and 2 times for GTOs. The differences in maintenance services resulted in additional costs for PTOs, so that the average maintenance cost was significantly higher for PTOs (CFA 121,438.5) than GTOs (CFA 81,919.12).

Table 6. Maintenance of Selected Machinery

Characteristics	State-imported	Privately-purchased	Statistical difference
When you acquired machinery, was a service package included?			
*Yes	18.67	5.33	12.62***
*No	81.33	94.67	
Who is doing maintenance/servicing currently? Percentage of own, mechanic, dealer…			
* Yourself on the farm	9.33	18.67	10.42**
* Mechanical workshop	82.67	75.33	
* Distributor of machines	0.00	0.00	
* Tractorist	4.67	6.00	
* Person (the machine is no longer functional)	3.33	0.00	
Satisfaction with maintenance and services			
* Really	9.56	21.31	43.697***
* Yes	30.88	57.38	
* Somehow	38.24	18.85	
* Not really	5.88	1.64	
* Not at all	15.44	0.82	
How many times did you change engine oil last year?	2.87 (3.41)	6.17 (5.47)	-6.26***
How many times did you grease last year?	5.34 (8.30)	12.24 (23.83)	-3.34***
How many times did you change filters last year?	2.28 (2.87)	3.55 (3.30)	-3.56***
How much did you pay last year for maintenance and services?	81919.12 (111595.9)	121438.5 (129120.8)	-2.63**

Repairs of Selected Machinery

Table 7 presents data on challenges faced by tractor operators. Both PTOs and GTOs had issues with engine lock, about twice the previous year. GTOs' machines were immobilized for an average of 71 days, while PTOs' machines was immobilized for an average of 40 days. Engine repair was higher among GTOs (CFA 244,777.8) than their PTO counterparts (CFA 172,211.1). The majority of

operators did engine repairs with independent technicians. Consequently, PTOs were relatively more satisfied than their GTO counterparts with regard to engine repairs. The repairs took an average of 7 days for GTOs and 5 days for PTOs.

Regarding problems relating to fuel supply and ignition, both categories of operators experienced them equal number of times. The average number of days in which their machines were locked due to these problems was 55 for GTOs and 47 for PTOs. The average total cost of repairing machine due to fuel and ignition problems was CFA 83,266.67 for PTOs and CFA 69,523.81 for GTOs. Independent technicians were also used for the repairs of these problems for most operators; PTOs were more satisfied with the repairs than their GTO counterparts. The repair took an average of 7 days for GTOs and 4 days for PTOs.

Moreover, the average number of days in which machine was locked due to transmission problem was 38 for GTOs and 4 for PTOs. The average cost of repairing the machine with this problem was CFA 172,763 for GTOs and CFA 138,550 for PTOs. Most of the operators also used independent technicians for repairs of this type of engine problem. In addition, some PTOs (10.00%) repaired engine transmission problems themselves; in spite of this, PTOs were more satisfied with the repair work than GTOs. There is only an average difference of one day between the two categories of operators in terms of duration of the repair.

Furthermore, the average number of days during which the machines were locked due to hydraulic problems was 113 for GTOs and 22 for PTOs. The average total cost of repairing the hydraulic problem was somewhat high for GTOs at CFA 202,113.4, compared to PTOs at CFA 183,924.2. Independent technicians were also used for the repair of hydraulic problems by both categories of operators. As for transmission problems, 19,7% of PTOs repaired them themselves. The majority of GTOs were not satisfied with the repairs, while PTOs were mostly satisfied. The repair lasted on the average of 10 days for GTOs and 4 days for PTOs. Moreover, PTOs had problem with tyres about three times on average the previous year, while GTO had it about twice. The average number of days in which machines were locked due to tyre problems was 41 for GTOs and 6 for PTOs. The average total cost of repairing the machine the previous year due to tire issues was CFA181,236.8 for GTOS and CFA 147,388.9 for PTOs. Independent technicians were also engaged in the repairs of tractors of about 95% of both tractor operators. However, GTOs were largely not satisfied with the repairs, unlike the PTOs, who were satisfied with the repair works. A difference of one day was found between the two categories of operators in terms of the duration of repair.

PTOs also experienced problem related to staff turnover about four times the previous year, while GTOs experienced it about twice. However, this immobilized machine operations for just one day among PTOs and about 6 days for GTOs. The machine repairs cost CFA 60,104.17 for GTOs and CFA 40,019.23 for PTOs. Independent technicians were mostly used to handle the repairs for GTOs; whereas these independent technicians were themselves owners of tractors (in the PTO category. GTOs experienced problems with engine shafts only once the previous year, whereas PTOs had it twice. The average number of days in which their machines were locked due to this problem was 66 for GTOs and 47 for PTOs. The average total cost of repairing the machines was CFA 120,157.9 for GTOs and CFA 124,000.0 for PTOs. All the operators (100%) of both categories used independent technicians to repair engine shaft problems. Moreover, PTOs were relatively more satisfied than their GTO counterparts with regard to the repairs. There was an average of one day difference between the two categories of operators in terms of duration of repair.

Further, GTOs had issues with cooling system of their tractors about once the previous year, while PTOs had this problem eleven times. Problem with the cooling system resulted in a one-day downtime for PTOs and nine days for GTOs. The cooling system repairs cost GTOs about CFA 35,000.00 and PTOs CFA 20,000.00. Unlike GTOs, all of whom used independent technicians to solve the cooling system problems, 33.33% of PTOs repaired their tractors themselves. Generaly, PTOs were more satisfied with the cooling system repairs than their GTO counterparts. The repairs lasted, on the average, 6 days for the latter and one day for the former.

Both tractor categories had problem with their PTO about twice the previous year. The average number of days in which their machines were locked due to PTO was 181 for the private sector tractor operators and 82 for government-assisted operators. The average total cost of repairing the PTO problem was CFA 111,358.3 for government-assisted tractor operators and CFA 65,000.00 for the private sector counterparts. All operators (100%) of both categories used independent technicians to fix their PTO problems. The repairs took an average of 13 days for government tractor owners and 8 days for their private sector counterparts.

Other problems relating to tooth, welding and rechecking, defective beats and bolts not earlier considered relevant were identified by some operators. GTOs had problems with machine toothabout four times the previous year, compared to five times for PTOs. This resulted in 131 days of machine downtime for GTOs and 124 days for PTOs. The cost of repairs was CFA 191,156.3 for GTOs and CFA 70,833.33 for PTOs. Those who repaired tooth problems for GTOs were mainly independent technicians and tractor drivers, while for PTOs these were independent technicians and tractor owners. PTOs expressed higher level of satisfaction on the repairs than GTOs; and the repair lasted 21 days for PTOs and 14 days for GTOs on the average.

Only PTO respondents made reference to welding and rechecking problems, which immobilized their tractors for about 21 days the previous year and cost CFA 164,000 in repair. Independent technicians were also used to undertake the repairs; and the operators were satisfied with the repair, which lasted on the average of one day.

More so, PTOs encountered problems with battery about four times the previous year; this was twice with GTOs. The average number of days in which their machines were locked due to this problem was 93 for GTOs and 55 for PTOs. The battery repair cost PTOs CFA 54,714.29 and GTOs CFA 21,750.00. All operators (100%) of both tractor categories used independent technicians to repair their battery problem; but almost half of the GTOs were not satisfied with the repairs, unlike their PTO counterparts, who were all satisfied. There was an average difference of one day between the two categories of operators in terms of the durationof repairs.

With regard to bolt-out problem, PTOs experienced it only once the previous year, while GTOs had it about eight times. The problem resulted in the immobilization of their machines for seventeen days (PTOs) and three hundred and sixty days (GTOs). The average total cost of repairing the machines for GTOs was CFA 25,000 and for PTOs CFA 20,000. Independent technicians were used solely for the repairs. GTOs were, however, not satisfied with the repairs, while their PTO counterparts were satisfied. The repair took an average of 35 days for GTOs and 4 days for PTOs. Overall, the average total cost of all repairs on the machine the previous year was CFA 471,415.3 for GTOs and CFA 295,931.5 for PTOs.

Table 7. Repairs of selected Machineries

	State-imported									Privately-purchased								
	Frequency	**Lengths**	**Total cost**	**Who did repair**		**Satisfaction**		**Days**	**Costs**	**Frequency**	**Lengths**	**Total cost**	**Who did repair**		**Satisfaction**		**Days**	**Costs**
Engine	1.48 (2.59)	71.355 (133.46)	244777.8 (233353.3)	Machine distributor	2.22	Really	11.11	6.51 (11.84)	471415.3 (520897.8)	1.51 (1.03)	40.22 (127.17)	172211.1 (164204.9)	Machine distributor	2.22	Really	22.22	4.75 (7.77)	295931.5 (381584.5)
				Independent technicians	97.78	Yes	22.22						Independent technicians	88.89	Yes	60.00		
				Owner himself	0.00	Somehow	35.56						Owner himself	8.89	Somehow	13.33		
				Tractor driver	0.00	Not really	13.33						Tractor driver	0.00	Not really	0.00		
						Not at all	17.78								Not at all	4.44		
Fuel supply/ignition	1.71 (2.39)	54.95 (127.63)	69523.81 (49607.08)	Machine distributor	0.00	Really	0.00	7.19 (16.13)		1.90 (1.37)	47.38 (145.58)	83266.67 (143111.4)	Machine distributor	0.00	Really	4.76	3.61 (4.67)	
				Independent technicians	95.24	Yes	42.86						Independent technicians	80.95	Yes	76.19		
				Owner himself	0.00	Somehow	38.10						Owner himself	14.29	Somehow	9.52		
				Tractor driver	4.76	Not really	14.29						Tractor driver	4.76	Not really	4.76		
						Not at all	4.76								Not at all	4.76		
Transmission	1.84 (3.62)	38.36 (100.21)	172763.2 (210664)	Machine distributor	0.00	Really	5.26	4.13 (3.48)		1.66 (1.06)	4.00 (6.23)	138550 (367811.8)	Machine distributor	0.00	Really	3.33	2.9 (4.41)	
				Independent technicians	97.37	Yes	26.32						Independent technicians	86.67	Yes	76.67		
				Owner himself	0.00	Somehow	42.11						Owner himself	10.00	Somehow	13.33		
				Tractor driver	2.63	Not really	13.16						Tractor driver	3.33	Not really	6.67		
						Not at all	13.16								Not at all	0.00		
Hydraulic	1.79 (2.37)	112.85 (152.40)	202113.4 (226013.9)	Machine distributor	0.00	Really	7.46	9.98 (19.04)		1.87 (1.07)	22.00 (84.91)	183924.2 (145514.6)	Distributeur de machine	0.00	Really	34.85	4.39 (9.24)	
				Independent technicians	95.52	Yes	17.91						Techniciens indépendants	78.79	Yes	45.45		
				Owner himself	1.49	Somehow	40.30						Propriétaire lui-même	19.70	Somehow	13.64		
				Tractor driver	2.99	Not really	20.90						Tractoriste	1.52	Not really	4.55		
						Not at all	13.43								Not at all	1.52		
Tires	1.60 (1.92)	41.39 (111.28)	181236.8 (229852.9)	Machine distributor	0.00	Really	21.05	4.02 (12.06)		2.25 (2.75)	5.51 (13.49)	147388.9 (227704.3)	Machine distributor	1.85	Really	33.33	2.83 (6.72)	
				Independent technicians	97.37	Yes	36.84						Independent technicians	98.15	Yes	62.96		
				Owner himself	2.63	Somehow	31.58						Owner himself	0.00	Somehow	3.70		
				Tractor driver	0.00	Not really	7.89						Tractor driver	0.00	Not really	0.00		
						Not at all	2.63								Not at all	0.00		

Bearing/beam	1.95 (1.85)	5.66 (16.02)	60104.17 (47249.1)	Machine distributor	0.00	Really	41.67	2.41 (2.14)		3.84 (2.47)	1.09 (1.48)	40019.23 (51719.36)	Machine distributor	0.00	Really	51.92	1.34 (0.81)		
				Independent technicians	95.83	Yes	25.00						Independent technicians	71.15	Yes	48.08			
				Owner himself	0.00	Somehow	20.83						Owner himself	23.08	Somehow	0.00			
				Tractor driver	4.17	Not really	12.50						Tractor driver	5.77	Not really	0.00			
						Not at all	0.00								Not at all	0.00			
Drive shaft	0.52 (0.77)	65.94 (132.57)	120157.9 (141096.6)	Machine distributor	0.00	Really	5.26	4.57 (3.59)		1.87 (1.12)	47.25 (126.37)	124000 (82302.58)	Machine distributor	0.00	Really	12.50	3.25 (4.80)		
				Independent technicians	100.00	Yes	26.32						Independent technicians	100.00	Yes	62.50			
				Owner himself	0.00	Somehow	47.37						Owner himself	0.00	Somehow	25.00			
				Tractor driver	0.00	Not really	5.26						Tractor driver	0.00	Not really	0.00			
						Not at all	15.79									0.00			
Cooler	0.66 (0.57)	9.00 (8.54)	35000 (36055.51)	Machine distributor	0.00	Really	0.00	6.00 (4.00)		10.66 (16.74)	0.66 (0.57)	20000 (17320.51)	Machine distributor	0.00	Really	33.33	1.00 (0.00)		
				Independent technicians	100.00	Yes	33.33						Independent technicians	66.67	Yes	66.67			
				Owner himself	0.00	Somehow	66.67						Owner himself	33.33	Somehow	0.00			
				Tractor driver	0.00	Not really	0.00						Tractor driver	0.00	Not really	0.00			
						Not at all	0.00								Not at all	0.00			
PTO	1.83 (1.97)	82.25 (145.93)	111358.3 (88542.71)	Machine distributor	0.00	Really	0.00	12.83 (21.84)		2.00 (0.00)	180.5 (253.85)	65000 (77781.75)	Machine distributor	0.00	Really	0.00	8.00 (9.89)		
				Independent technicians	100.00	Yes	12.50						Independent technicians	100.00	Yes	0.00			
				Owner himself	0.00	Somehow	66.67						Owner himself	0.00	Somehow	100.00			
				Tractor driver	0.00	Not really	16.67						Tractor driver	0.00	Not really	0.00			
						Not at all	4.17								Not at all	0.00			
Tine	3.75 (4.13)	130.75 (155.08)	191156.3 (410075)	Machine distributor	0.00	Really	0.00	14.12 (25.60)		4.33 (3.51)	123.66 (209.00)	70833.33 (112036.1)	Machine distributor	0.00	Really	33.33	21.33 (23.43)		
				Independent technicians	87.50	Yes	37.50						Independent technicians	66.67	Yes	33.33			
				Owner himself	0.00	Somehow	37.50						Owner himself	33.33	Somehow	0.00			
				Tractor driver	12.50	Not really	12.50						Tractor driver	0.00	Not really	33.33			
						Not at all	12.50								Not at all	0.00			
Welding	-	-	-	Machine distributor	-	Really	-	-		1.6 (0.54)	21.2 (44.05)	164000 (245825.1)	Machine distributor	0.00	Really	20.00	1.00 (0.00)		
				Independent technicians	-	Yes	-						Independent technicians	100.00	Yes	80.00			
				Owner himself	-	Somehow	-						Owner himself	0.00	Somehow	0.00			

				Tractor driver	-	Not really	-						Tractor driver	0.00	Not really	0.00		
						Not at all	-								Not at all	0.00		
Battery	1.5 (2.38)	93.25 (177.85)	21750 (21422.34)	Machine distributor	0.00	Really	0.00	2.00 (2.70)		4.14 (7.01)	54.57 (134.76)	54714.29 (56218.96)	Machine distributor	0.00	Really	28.57	2.57 (3.30)	
				Independent technicians	100.00	Yes	50.00						Independent technicians	100.00	Yes	57.14		
				Owner himself	0.00	Somehow	0.00						Owner himself	0.00	Somehow	0.00		
				Tractor driver	0.00	Not really	25.00						Tractor driver	0.00	Not really	14.29		
						Not at all	25.00								Not at all	0.00		
Defective bolts	8.00 (0.00)	360 (0.00)	25000 (0.00)	Machine distributor	0.00	Really	0.00	35.00 (0.00)		1.00 (0.00)	16.5 (19.09)	20000 (28284.27)	Machine distributor	0.00	Really	0.00	38.5 (47.37)	
				Independent technicians	100.00	Yes	0.00						Independent technicians	100.00	Yes	50.00		
				Owner himself	0.00	Somehow	0.00						Owner himself	0.00	Somehow	50.00		
				Tractor driver	0.00	Not really	100.00						Tractor driver	0.00	Not really	0.00		
						Not at all									Not at all	0.00		

Preferences for Machinery

Table 8 shows the main machines sought by producers. The data show that tractors, plows and trailers were the main machines sought by all producers. Apart from tractors, government tractor owners (GTOs) preferred trailers (36%) and plows (32%), while private tractor owners (PTOs) preferred plows (44%) and trailers (38%); although, some GTOs preferred seed planters (14%), sprayers (9.33%), combine harvesters (8.67%) and gins (8%).

Massey Ferguson was the most preferred tractor brand (70%) by GTOs and PTOs;, while 25.41% of GTOs and 21.7% of PTOs preferred Mahindra brand. Generally, respondents desiring combine harvesters and tillers had highest preference for Massey Ferguson and Mahindra brands. Power, quality or strength, availability of spare parts, mastery of repair by mechanics, hourly capacity of the tractor were the main criteria for preferring Massey Ferguson brand; and there was no statistical difference observed on data for GTOs and PTOs. Power (69.32%) and availability of spare parts (47.73%) were the highest criteria chosen by GTOs for selecting a tractor, quality (59.09%) was the highest criterium for PTOs.

In the case of combine harvesters, the main selection criteria were quality, availability of spare parts and hourly capacity. The data show that the majority of PTOs preferring Massey Ferguson was due to its quality (92.31%), while for GTOs, it was due to the availability of spare parts (75%). Moreover, quality and availability of spare parts were also the most criteria for GTOs' choice of Mahindra brand of combine harvesters.
Furthermore, tractors and combine harvesters with 60-70hp were the most desired criteria by producers: about 40% of PTOs preferred tractors and combine harvesters of 40hp to 60hp, compared to about 16% of GTOs.

Table 8. Data on Preferences for Machinery

Characteristics	State-imported	Privately-purchased	Statistical difference
If you were to own (additional) machineries/attachments, which one would you buy given the resources you have? (Repeat for all types)			
Tractor	81.33	90.67	5.42 **
Tiller / tractor with two wheels	2.67	4.00	0.41
Generator	2.00	0.00	3.03 *
Combine harvester	8.67	10.00	0.15
Shelling machine (autonomous)	8.00	4.00	2.12
Thresher (autonomous)	2.00	2.00	0.00
Water pump	0.00	1.33	2.01
Mill (autonomous)	0.67	1.33	0.33
Plow	32.67	44.00	4.07 **
Harrow	2.67	2.67	0.00
Subsoiler	3.33	0.00	5.08 **

Sprayer	9.33	3.33	4.55 **
Planter	14.00	5.33	6.45
Fertilizer spreader	3.33	2.00	0.51
Trailer	36.00	38.67	0.22
Hay harvester	2.00	0.67	1.01
Vertical axis	3.33	3.33	0.00
Rototillers	2.67	0.00	4.05 **
Sprayer	0.67	3.33	2.72 *
Which brand do you prefer?			
TRACTOR			
John Deere	1.64	0.74	0.45
Massey Ferguson	72.13	78.68	1.49
Mahindra	25.41	21.06	0.60
Farmtrac	0.82	1.47	0.23
Ford	0.00	0.74	0.90
Same			
New Holland			
Landini			
Case			
TS			
Solanika	0.82	0.00	1.11
Fonton			
Eebro	0.82	0.00	1.11
Yto			
Shakti			
Kobouta			
Soneca			
Humt			
Jinma			
Renault	0.82	0.00	1.11
Sifang			
TILLER / TRACTOR WITH TWO WHEELS			
John Deere			
Massey Ferguson	75.00	83.33	0.10
Mahindra	25.00	0.00	1.66
Farmtrac			
Ford			
Same			
New Holland			

Landini			
Case			
TS			
Solanika			
Fonton			
Eebro			
Yto			
Shakti			
Kobouta			
Soneca			
Humt			
Jinma			
Renault			
Sifang			
HAY HARVESTER			
John Deere			
Massey Ferguson	61.54	86.67	2.34
Mahindra	38.46	20.00	1.16
Farmtrac			
Ford			
Same			
New Holland			
Landini			
Case			
TS			
Solanika			
Fonton			
Eebro			
Yto			
Shakti			
Kobouta			
Soneca			
Humt			
Jinma			
Renault			
Sifang			
Why do you prefer this brand?			
Massey Ferguson-TRACTOR			
Price	28.41	31.78	0.25

Power / Horses	69.32	60.75	1.55
2/4 wheel drive	15.91	12.15	0.57
Maker	36.36	33.64	0.15
Age	3.41	3.74	0.01
Capacity	44.32	45.79	0.04
No choice	3.41	9.35	2.73 *
After sales services	1.14	3.74	1.31
Fuel consumption	13.64	10.28	0.52
Quality	59.09	59.81	0.01
Costs of after-sales services	4.55	7.48	0.71
mastery of the repair by the mechanics	47.73	43.93	0.28
Availability of spare parts	47.73	47.66	0.01
Handling mode	12.50	9.35	0.49
Mahindra-TRACTOR			
Price	12.90	43.33	7.02 ***
Power / Horses	67.74	66.67	0.01
2/4 wheel drive	22.58	13.33	0.88
Maker	29.03	16.67	1.31
Age	0.00	6.67	2.13
Capacity	45.16	40.00	0.16
No choice	22.58	13.33	0.88
After sales services	0.00	6.67	2.13
Fuel consumption	3.23	26.67	6.66 ***
Quality	48.39	43.33	0.15
Costs of after-sales services	0.00	3.33	1.05
mastery of the repair by the mechanics	12.90	10.00	0.12
Availability of spare parts	16.13	23.33	0.50
Handling mode	0.00	6.67	2.13
Massey Ferguson- TILLER / TRACTOR WITH TWO WHEELS			
Price	33.33	40.00	0.03
Power / Horses	100.00	60.00	1.60
2/4 wheel drive	0.00	20.00	0.68
Maker	33.33	20.00	0.17
Age	33.33	0.00	1.90
Capacity	33.33	20.00	0.17
No choice	33.33	20.00	0.17
After sales services			
Fuel consumption	66.67	20.00	1.74
Quality	33.33	60.00	0.53

Costs of after-sales services			
mastery of the repair by the mechanics	33.33	0.00	1.90
Availability of spare parts	33.33	40.00	0.03
Handling mode	33.33	20.00	0.17
Mahindra TILLER / TRACTOR WITH TWO WHEELS			
Price			
Power / Horses	100.00		
2/4 wheel drive			
Maker			
Age			
Capacity			
No choice	100.00		
After sales services			
Fuel consumption			
Quality			
Costs of after-sales services			
mastery of the repair by the mechanics			
Availability of spare parts			
Handling mode			
Massey Ferguson-HARVESTER			
Price	12.50	7.69	0.13
Power / Horses	37.50	30.77	0.10
2/4 wheel drive			
Maker	25.00	23.08	0.01
Age	25.00	0.00	3.59
Capacity	25.00	46.15	0.93
No choice	25.00	23.08	0.01
After sales services			
Fuel consumption	25.00	0.00	3.59 **
Quality	37.50	92.31	7.28 ***
Costs of after-sales services	12.50	7.69	0.13
mastery of the repair by the mechanics	50.00	23.08	1.61
Availability of spare parts	75.00	69.23	0.08
Handling mode	37.50	15.38	1.33
Mahindra- HARVESTER			
Price	20.00	0.00	0.68
Power / Horses			
2/4 wheel drive			

Maker	20.00	0.00	0.68
Age			
Capacity	0.00	33.33	1.90
No choice	80.00	33.33	1.74
After sales services			
Fuel consumption			
Quality	80.00	66.67	0.17
Costs of after-sales services			
mastery of the repair by the mechanics	20.00	0.00	0.68
Availability of spare parts	80.00	33.33	1.74
Handling mode			
Which horse power do you?			
TRACTOR			
Under 40 ch	1.64	0.00	2.24
40-60 ch	31.15	34.56	0.33
60-70 ch	60.66	50.00	2.95
70+ch	13.11	22.79	4.04
TILLER / TRACTOR WITH TWO WHEELS			
Under 40 ch	75.00	0.00	6.42
40-60 ch	25.00	16.67	0.10
60-70 ch	25.00	66.67	1.66
70+ch	0.00	16.67	0.74
HARVESTER			
Under 40 ch	15.38	0.00	2.48
40-60 ch	38.46	33.33	0.07
60-70 ch	69.23	80.00	0.43
70+ch	15.38	40.00	2.06

Machine Utilization and Service Provision

Table 9 presents information on mechanized agricultural operations. The data show that mechanized operations were mostly plowing (use of plow, tractor) and transport (use of trailer and tractor). The data show that 93.33% of PTOs were involved in mechanize plowing activities, compared to their GTO counterparts (76%). Generally, less than 5% of the mechanized operations related to seedbed preparation (use of harrows), clearing (using a rotary cutter), ginning (ginning), and harvesting (use of combine harvester).

The number of days that machines were used for plowing the previous season by GTOs 37, while that for PTOs was 35. Also, PTOs used machines for transportation for about 32.28 days, while GTOs used them for the same purpose for 29 days. The machines were generally used for land clearing, preparation of seedbeds, harvesting and ginning for a period less than 5 days.
Also, more than half of the sample provided services in plowing, transportation, clearing, harvesting, and ginning; about 84% of GTOs provided plowing services, compared to82.27% of PTOs. On the other hand, over 79% of PTOs provided transportation services to farmers, compared to their GTO counterparts (71.74%). The proportion of operators who used the machines for seedbed preparation and harvesting was low and comprised solely PTOs.
The average area planted PTOs (33.08ha) was higher than that of of GTOs (29.72ha). Regardless of service being delivered, however, GTOs carried greater amounts of sacks (31754.89kg) than PTOs (28970.3kg).

The average area planted by GTOs (484.62 ha) was higher than that of PTOs (147.5 ha); but the latter borne more load (82606.25 kg) than the former (74742.42 kg). Also, the total area cleared by PTOs was 147.5ha, while that of GTOs was 87.5ha. In terms of harvesting, more than 35ha was cleared for other producers in the form of service provision by PTOs. GTOs ginned about 18,500kg, which was lower than the 24,000kg of ginning services by PTOs.
All growers claimed to have met their customer's demands for clearing, harvesting and ginning operations. With regard to plowing, however, 28% of the demand was met by PTOs due to breakdown of machines, poorly prepared fields (having stumps and stones), and machine capacity. PTO was more responsive to transportation demand (86.25%), compared to GTOs' 81.82%.

Furthermore, over 80% of the producers provided plowing services, a situation that was higher than the record of previous season. More than 10% of GTOs tillage service the previous season. With regard to transportation, less than 8% of both operators provided services during the season under study.

Plowing, preparation of the seedbed, land clearing, and transportation were the main service provided for clients. Although there was no statistical difference between the two classes of tractor owners, the number of PTOs' customers was 30 for clearing, and 16 for transportation, compared to their GTO counterparts of 21 and 14 customers respectively. Nevertheless, GTOs provided tillage services for 58 customers and seedbed preparation for 25 customers during the last agricultural season, compared to PTOs' 54 and 20 customers, respectively. Operations related to harvesting and ginning were carried out for about 3 customers. With regard to customers with less than 2ha, PTOs had more than 12 and 9 customers respectively for clearing and transportation services, while these were 6 and 7 customers respectively for GTOs—but the latter had more 2ha customers for plowing operations (17) and seed bed preparation (14). For plowing services, all customers were located at a distance greater than 10 kilometers. Concerning transportation, clearing, and preparation of seedbed, the customers were located less than 7km to the service providers.

There were about 8 female clients for plowing services; and there was no significant difference observed at the level of the two classes, in terms of the number of female clients for other mechanized operations. However, PTOs got more female clients than their GTO counterparts for transportation and clearing operations.

There was also no significant difference recorded for the two classes of service providers on the cost of mechanized operations. The minimum cost for plowing was about CFA 26,000/ha, while the maximum was about CFA 28,000/ha.
With regard to clearing, the minimum cost was CFA 17,000/ha for PTOs, while the maximum was about CFA17,500 / ha, which was higher than the CFA 14,000 / ha of GTOs. A similar trend was observed for the cost of transportation operations, with a maximum cost of about CFA 650/km. The minimum cost of seedbed preparation for GTOs was CFA5000/ha, compared to PTOs' CFA 4000/ha.

The minimum duration of clearing per unit area was estimated at 1 hour, while that for plowing was at about one hour and a half and maximum of 3 hours. The maximum duration achieved by GTOs was greater than that by PTOs. For transportation, the maximum duration was about 13 minutes per kilometer. The fuel consumption of a machine for plowing was about 11 liters per hectare. Fuel consumption in relation to land clearing for PTOs was 12 liters/ha; for transportation, this was 0.48 liters/km.

Table 9. Machine utilization and service provision

Characteristics	State-imported	Privately-purchased	Statistical difference
Farming operation mechanized			
Clearing	4.00	3.00	1.03
Plowing	76.00	93.33	17.35 ***
Subsoiling			
Sowing bed preparation (Harrow)	1.33	1.33	0.00
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	0.67	0.67	0.00
Shelling	2.67	0.67	1.83
Threshing			
Milling			
Transport	61.33	66.67	0.92
Bunching (rice case)			
% who provided services last main season			
Clearing	66.67	66.67	0.00
Plowing	84.21	82.27	0.16
Subsoiling			
Sowing bed preparation (Harrow)	100.00	50.00	1.33
Sowing / planting			
Spreading			

Weeding			
Irrigation			
Harvest	0.00	100.00	2.00
Shelling	50.00	100.00	0.83
Threshing			
Milling			
Transport	71.74	79.21	1.45
Bunching (rice case)			
For how many days did you use your machine last main season?			
Clearing	1.00	1.00	0.00
Plowing	37.10 (22.29)	35.17 (20.48)	0.71
Subsoiling			
Sowing bed preparation (Harrow)		4.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	1.00 (0.00)		
Shelling	4.66 (2.08)		
Threshing			
Milling			
Transport	29.78 (14.38)	32.28 (15.64)	-1.15
Bunching (rice case)			
What is the area (bags) that you needed for your own operations on your own farm last main season?			
Clearing	3.00 (0.00)	3.00 (0.00)	
Plowing	29.72 (28.72)	33.08 (31.83)	-0.35
Subsoiling			
Sowing bed preparation (Harrow)		4.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	1.00 (0.00)		
Shelling	4.66 (2.08)		
Threshing			
Milling			
Transport	31754.89 (25350.31)	28970.3 (26554.17)	0.74

Bunching (rice case)			
What is the total area (bags) that you serviced for other farmers for this operation last main season?			
Clearing	87.5 (13.15)	147.5 (32.5)	
Plowing	484.62 (220.43)	468.72 (200.99)	
Subsoiling			
Sowing bed preparation (Harrow)			
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		35.00 (0.00)	
Shelling	18500 (24000)	24000 (0.00)	
Threshing			
Milling			
Transport	74742.42 (37714)	82606.25) (41448.74)	-1.78
Bunching (rice case)			
Did you meet all your customer requests last season?			
Clearing	100.00	100.00	
Plowing	78.13	71.55	1.19
Subsoiling			
Sowing bed preparation (Harrow)	100.00	100.00	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		100.00	
Shelling	100.00	100.00	
Threshing			
Milling			
Transport	81.82	86.25	0.46
Bunching (rice case)			
Did you provide more services last seaon compared to previous season?			
Clearing			
Yes	25.00	50.00	0.37
No			
No change	75.00	50.00	

Plowing			
Yes	82.29	81.90	2.46
No	10.42	6.03	
No change	7.29	12.07	
Subsoiling			
Yes			
No			
No change			
Sowing bed preparation (Harrow)			
Yes	50.00	100.00	0.75
No			
No change	50.00		
Sowing / planting			
Yes			
No			
No change			
Spreading			
Yes			
No			
No change			
Weeding			
Yes			
No			
No change			
Irrigation			
Yes			
No			
No change			
Harvest			
Yes			
No		100.00	
No change			
Shelling			
Yes			
No	100.00	0.00	3.00
No change	0.00	100.00	
Threshing			
Yes			
No			

No change			
Milling			
Yes			
No			
No change			
Transport (bag)			
Yes	81.82	75.00	1.01
No	6.06	7.50	
No change	12.12	17.50	
Bunching (rice case)			
Yes			
No			
No change			
How many customers did you provide services to last main season?			
Clearing	21 (3.91)	30 (14.14)	-1.32
Plowing	58.16 (2846)	54.36 (26.88)	0.99
Subsoiling			
Sowing bed preparation (Harrow)	25 (4.24)	20.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		3.00 (0.00)	
Shelling	2.5 (0.70)	1.00 (0.00)	
Threshing			
Milling			
Transport (bag)	14.66 (7.37)	16.11 (7.89)	-1.12
Bunching (rice case)			
How many customers did you provide services to last main season? (below 2ha)			
Clearing	6.25 (4.99)	12.5 (3.55)	-1.54
Plowing	17.27 (8.56)	15.68 (7.50°	1.43
Subsoiling			
Sowing bed preparation (Harrow)	13.5 5 (6.36)	3.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			

Irrigation			
Harvest	0.00	0.00	
Shelling	0.5 (0.5)	0.00 (0.00)	
Threshing			
Milling			
Transport (bag)	7.28 (6.46)	8.51 (7.15)	-1.07
Bunching (rice case)			
What is the average distance of the customers?			
Clearing	3.66 (3.05)	4.5 (0.70)	-0.3
Plowing	11.18 (8.36)	10.64 (10.57)	0.41
Subsoiling			
Sowing bed preparation (Harrow)	6.5 (2.12)	3.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		2.00 (0.00)	
Shelling	3.5 (2.12)	1.00 (0.00)	
Threshing			
Milling			
Transport (bag)	7.19 (4.97)	6.08 (4.36)	1.43
Bunching (rice case)			
How many of the customers were female?			
Clearing	1.25 (0.50)	4.00 (1.41)	-3.82
Plowing	8.17 (4.28)	8.12 (4.38)	0.07
Subsoiling			
Sowing bed preparation (Harrow)	1.5 (0.70)	0.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	0.00	0.00	
Shelling	2.00 (0.00)	1.00 (0.00)	
Threshing			
Milling			
Transport (bag)	5.13 (3.63)	6.00 (3.44)	-1.46
Bunching (rice case)			

What was the service charge/fee per unit? (minimum)			
Clearing	11750 (3500)	17000 (7071.068)	-1.30
Plowing	25854.71 (3132.106)	25413.79 (2138)	1.21
Subsoiling			
Sowing bed preparation (Harrow)	5000 (0.00)	4000 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	0.00	25000	
Shelling	450 (212.13)	400 (0.00)	
Threshing			
Milling			
Transport (bag)	520.45 (214.29)	603.16 (983.64	-0.66
Bunching (rice case)			
What was the service charge/fee per unit? (maximum)			
Clearing	14000 (3366.50)	17500 (3535.53)	-1.18
Plowing	28541.67 (3211.54)	28491.38 (3242.37)	0.11
Subsoiling			
Sowing bed preparation (Harrow)	8500 (2121.32)	5000 (0.00)	0.92
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		30000.00 (0.00)	
Shelling	750 (353)	700 (0.00)	
Threshing			
Milling			
Transport (bag)	662.12 (212.50)	627.84 (25.72°	0.92
Bunching (rice case)			
What is the time length you need per unit? (minimum)			
Clearing	0.75 (0.20)	1.00 (0.00)	-1.6
Plowing	1.39 (0.54)	1.62 (0.61)	
Subsoiling			
Sowing bed preparation (Harrow)	0.75 (0.35)	0.50 (0.00)	
Sowing / planting			

Spreading			
Weeding			
Irrigation			
Harvest	0.00	2.00 (0.00)	
Shelling	0.5 (0.00)	1.00 (0.00)	
Threshing			
Milling			
Transport (bag)	10.77 (2.38)	11.69 (0.27)	-2.30 *
Bunching (rice case)			
What is the time length you need per unit? (maximum)			
Clearing	1.12 (0.25)	1 (0.00)	0.66
Plowing	2.79 (2.33)	2.52 (0.64)	1.19
Subsoiling			
Sowing bed preparation (Harrow)	-	3.00 (0.00)	
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest		3.00 (0.00)	
Shelling	4.66 (3.21)	1.2 (0.00)	
Threshing			
Milling			
Transport (bag)	12.15 (2.58)	13.03 (2.71)	-1.97 *
Bunching (rice case)			
How many liters of fuel do you need per unit?			
Clearing	9.16 (0.98)	12 (0.57)	-4.05 ***
Plowing	10.97 (2.19)	10.76 (0.21)	0.69
Subsoiling			
Sowing bed preparation (Harrow)			
Sowing / planting			
Spreading			
Weeding			
Irrigation			
Harvest	-	9.00 (0.00)	
Shelling	0.75 (0.35)	0.5 (0.00)	
Threshing			
Milling			

Transport (bag)	0.48 (0.15)	0.48 (0.17)	-0.07
Bunching (rice case)			

Additonal Service Provision

Table 10 shows that producers provided services to other producers mainly to generate income to financial their farms and off-farm activities; about 72% of PTOs and 61% of GTOs reported this. With regard to the order in which customers were served, the producers considered them according to time of request. About 57% of tractor owners gave importance to this criterion. Location, loyalty and size of operation were also used as criteria for prioritizing customer service. More than half of GTOs (57.89%) refused to help some farmers the previous season because of their farm terrain, such as the presence of heavy stones on their lands. About 44% of the study sample did not provide credit services, but preferred full payment in advance; about 32% received total payment after harvest (that is, offering full credit facility); while about 25% of GTOs and 21.7% of PTOs received partial payment in advance. More than 67% of the sample stated that other competing service providers in their area; these competitors were about 6 on the average for PTOs, and about 8 for GTOs. There was a lack of government-led mechanization service provision in the study area.
The proportion of GTOs (66.67%) providing services in other areas / regions of the country (that is, outside the study area) was higher than that of PTOs (59%). The estimated number of days of migration for GTOs (30 days) was statistically higher than that of PTOs (25 days) at $p<0.05$. The daily additional costs for servicing these additional areas was CFA28,926.47 for PTOs and CFA27,765.63 for GTOs.

Table 10. Additonal service provision

Characeristics	State-imported	Privately-purchased	Statistical difference
Why do you provide hired services to others? (Repeat for all reasons)			
* To have financial resources for your own farm	61.33	76.00	7.49***
* To fund other activities	61.33	72.67	4.35**
* Help the neighbors	32.67	44.67	4.55**
How do you plan in which order customers are served? (Repeat for all options)			
* First come first serve	43.33	56.67	5.33**
* Depending on the location	29.33	36.67	1.82
* Priority to parents / friends	19.33	26.00	1.90
* Priority to loyal customers	26.67	30.67	0.58
* Use of ICT	0.00	0.00	-
* High demand in an area	22.00	21.33	0.01
* Priority to operators with the largest area	24.67	27.33	0.27
Have you refused farmers asking for your service last season?			
*Yes	49.47	42.11	1.13
*No	50.53	57.89	

What kind of credit scheme do you mostly provide to customers? (Repeat for all option)			
* Full credit (total payment after harvest)	30.21	31.30	0.31
* Partial credit (partial payment in advance)	25.00	21.74	
* Does not provide credit (full payment in advance)	44.79	46.96	
Do you have other competing mechanization service providers in your service area?			
*Yes	67.71	67.83	0.00
*No	32.29	32.17	
If yes, how many of your competitors are based in your service area?	6.00 (4.71)	5.83 (3.59)	0.23
If yes, how many of your competitors are coming from other areas outside your service area?	7.90 (8.14)	7.17 (7.97)	0.53
Are there any government led/supported mechanization service providers in your service area?			
*Yes	0.00	0.00	-
*No	100.00	100.00	
Are they a competition to you?			
*Yes	-	-	-
*No	-	-	
Did you migrate to provide services in other rainfall zones / countries / other areas last season?			
*Yes	66.67	59.13	1.26
*No	33.33	40.87	
If yes, for how many days did you migrate?	31.04 (18.43)	25.33 (15.98)	1.90*
If yes, what are the average daily extra costs by staying in other rainfall zones / countries / other areas? (e.g. for hotels)	27765.63 (8477.31)	28926.47 (9172.17)	-0.75

In Table 11, at least 27% of machine owners used their machines without calling on a particular operator / assistant. More than half of PTOs used a worker as an assistant, while the proportion at the tractor level was 46%; less than 20% of producers used their family members. The majority of assistants had no experience or certificate of conduct. This was common with PTOs (64.67%). Nevertheless, some PTOs had assistants with driver experience / certificate (32%); this was about 35.33% with GTOs.

Nearly 14% and 11% of PTOs and GTOs respectively received no informal training on the use or maintenance of machinery. Most of their assistants had informal training on the use / maintenance of machines, especially for 53.33% of PTOs. However, 24% of PTOs and 30% of GTOs had formal training, while less than 15% of farmers had assistants who were learning through them or through other operators. The number of training days for GTOs was 249.73, while for PTOs, it was 222.89.

The number of days spent finding an appropriate operator at the level of PTOs was 11, which was higher than that of GTOs (9).

Less than 5% of PTOs and about 10% of GTOs were dissatisfied with the knowledge and skills level of their operators. PTOs paid a monthly salary of CFA 40000) and premium of CFA 4306.66) to their operators, compared to their GTO counterparts, who paid CFA35000 and premium of

CFA2708.73. The salary paid to operators per unit area was estimated at CFA1850/ha for PTOs and CFA1425 / ha for GTOs.
More than 42.50% of government tractor owners and 29.27% of private tractor owners did not control their operators; 43.90% of the latter and 35.0% of the former were more willing to control themselves, or through relatives. A minority conducts field verification, assistant control, phone calls; for example about 15% of PTOs made telephone calls.

Table 11. Additonal service provision

Characteristics	State-imported	Privately-purchased	Statistical difference
Relationship with owner (Repeat for all options)			
* Owner	26.67	27.33	0.01
* Son / daughter	19.33	14.67	1.15
* Other family member	17.33	15.33	0.21
* Worker	46.00	50.67	0.65
What kind of prior driving experience/certificate does he/she has? (Repeat for all options)			
* None	54.67	64.67	3.11*
* Experience / driving certificate	15.33	7.33	4.77**
* Experience / driving certificate tractor	35.33	32.00	0.37
Has he/she received training on machine use/ maintenance? (Repeat for all options)			
* Formal	30.00	24.00	1.36
* Informal	49.33	53.33	0.48
***Learning by the owner himself or by other operators**	14.67	13.33	0.11
*No	11.33	14.00	0.48
How many days?	249.73 (682.62)	222.89 (848.79)	0.28
How long did you need to find a suitable operator?	8.49 (7.10)	10.86 (8.78)	-1.33
How satisfied are you with the knowledge and skills?			
* Really	37.50	29.27	0.61
* Yes	47.50	43.90	0.10
* Somehow	15.00	34.15	3.99*
* Not really	2.50	7.32	1.00
* Not at all	10.00	4.88	0.77
Is this person paid a wage (cash/kind)? If yes, how much on average per month?	35000	40000	-
Were there any other payments last season (daily expenses. bonus or incentive)? If yes, how much?	2708.73 (6345.99)	4306.66 (8265.35)	-0.65
If paid per unit, how much was the payment per unit?	1425 (589.84)	1850 (1231.53)	-0.98
How do you control the operator? (Repeat for all options)			

* No control	42.50	29.27	1.54
* Mileage record	0.00	0.00	-
* Timed field work	0.00	0.00	-
* Owner / parent follows the tractors	35.00	43.90	0.67
* Controlled by the assistant	5.00	4.88	0.00
* Field verification	7.50	2.44	1.10
* Operator working in a limited radius	0.00	0.00	-
* Monitor the fuel level	0.00	0.00	-
* GPS tracking	0.00	0.00	-
* Calling customers	5.00	14.63	2.11

Tractor Owners

The majority of farmers (87%) had household members who had not received any mechanization training (Table 12), but no significant difference was observed between the two classes of farmers. In the sample of farmers whose household members received training (around 13%), household members mainly received courses in driving, machine maintenance and repair; no statistical difference was also observed for the two classes of tractor owners. However, the proportion of PTOs whose household members were trained in machine repairs (42.11%) was significantly higher than their GTO counterparts (15%). The average length of training in tractors for GTOs was 2017.2 days, while that of of PTOs was 183.36 days.

Table 12. Tractor owners

CharacteristicsCharacteristics	State-imported	Privately-purchased	Statistical difference
Have you or any household member received any training on mechanization?			
*Yes	13.33	12.67	0.02
*No	86.67	87.33	
Which training? (Repeat for all options)			
*Driving lesson	75.5	63.16	0.64
* Machine maintenance	65.00	68.42	0.05
* Machine repair	15.00	42.11	3.53
* Economic and profitability aspects	10.00	5.26	0.30
* Securing the machines	10.00	10.53	0.01
Overall lengths for all options)	207.2 (268.73)	183.36 (160.39)	0.33

Knowledge In Machinery Mentainance

Table 13 shows that more than 36% of GTOs had limited knowledge of machinery hydraulic system. The statistical differences observed showed that 27% of PTOs with limited / average knowledge of the hydraulic system was lower than that of GTOs (36%) at $p < 0.05$. More than 15% of PTOs and 6% of GTOs had very good level of knowledge of machinery maintenance.
Fewer than 32% of farmers had limited knowledge of machine cooling systems. The proportion of GTOs (39.33%) with average knowledge of the cooling systems was higher than those of PTOs (25.33%). More than 12% of PTOs and 6% of GTOs had very good level of knowledge of the cooling systems.
of the data also show that GTOs with limited knowledge (32.67%) of the lubrication system was significantly higher than that of PTOs (25%). Also, 17% PTOs had had very good knowledge of the system, compared to their GTO counterparts, with 7.33%. With regard to knowledge of the fuel system, less than 30% of the sampled farmers had limited knowledge; only 11% of PTOs and 6.67% of GTOs very good knowledge of the fueling system.
Moreover, 51.33% of GTOs and 47.33% of PTOs had some level of knowledge of the electrical system, while 4.00% of GTOs and 6.67% of PTOs had very good level of knowledge of same system.
Furthermore, 19.33% and 12.67% of private tractor owners and 18.0% and 6.0% of government tractor owners had good and very good knowledge of the PTO system, respectively.
Regarding the engine, 37% of all farmers had limited knowledge; while 8.0% of PTOs and 5.33% of GTOs had very good knowledge of same.
Moreover, 18.0% of PTOs had good knowledge of the steering mechanism and tires maintenance; 22.7% of PTOs and 15.3% of GTOs had good knowledge of driving mechanisms.
The proportion of GTOs (19.33%) with good knowledge of the profitability of tractor operations was higher than that of their PTO counterparts (14.67%).

Table 13. Machinery knowledge

Characteristics	State-imported	Privately-purchased	Statistical difference
Hydraulic system			
*Really	4.00	13.33	20.42***
*Limit	38.00	26.00	
*Medium	36.00	26.67	
*Well	16.67	18.67	
*Very well	5.33	15.33	
Cooling system			
*Really	6.67	8.67	10.43**
*Limit	32.00	30.00	
*Medium	39.33	25.33	
*Well	16.00	24.00	
*Very well	6.00	12.00	
Lubrication system			
*Really	3.33	11.33	18.47***
*Limit	32.67	25.33	
*Medium	40.00	26.00	
*Well	16.67	20.67	
*Very well	7.33	16.67	
Fuel system			
*Really	2.67	9.33	15.85***
*Limit	30.00	29.33	
*Medium	40.67	23.33	
*Well	20.00	26.67	
*Very well	6.67	11.33	
Electric system			
*Really	4.00	10.67	6.35
*Limit	51.33	47.33	
*Medium	30.67	26.67	
*Well	10.00	8.67	
*Very well	4.00	6.67	
PTO			
*Really	8.67	14.00	7.80*
*Limit	36.00	30.00	
*Medium	31.33	24.00	
*Well	18.00	19.33	
*Very well	6.00	12.67	

Engine			
*Really	12.67	11.33	11.31**
*Limit	37.33	36.67	
*Medium	31.33	18.67	
*Well	13.33	25.33	
*Very well	5.33	8.00	
Steering mechanism and tires			
*Really	8.67	7.33	3.89
*Limit	32.67	28.67	
*Medium	33.33	28.67	
*Well	18.67	24.00	
*Very well	6.67	11.33	
Maintenance			
*Really	7.33	12.00	8.36*
*Limit	37.33	27.33	
*Medium	31.33	26.67	
*Well	14.67	16.67	
*Very well	9.33	17.33	
Driving			
*Really	5.33	5.33	4.25
*Limit	25.33	22.00	
*Medium	24.00	17.33	
*Well	30.00	32.67	
*Very well	15.33	22.67	
Machinery economics			
*Really	6.00	7.33	5.98
*Limit	24.00	17.33	
*Medium	29.33	28.67	
*Well	19.33	14.67	
*Very well	21.33	32.00	

Constraints

The majority of farmers believed that high prices of operations / unavailability of operators was a huge challenge to the mechanization efforts. The statistical difference on the data for both categories of tractor owners show a higher proportion of GTOs than PTOs, at $p<0.05$; while 32.6% of GTOs placed high priority on this criterion, 21.33% of PTOs considered it a priority (Table 14). As far as spare parts were concerned, 64.0% of GTOs and 44.7% of PTOs consideres their availability a priority.

Also, 38.67% of PTOs and 30.0% of GTOs rated low demand as a huge challenge to agricultural machinery operation. In fact, 20.0% of GTO considered it the highest challenge.
Low level of skills of operators was considered by 31.0% of the sample as a serious challenge, while 46.7% of GTOs considered it a significant challenge and 38.7% of PTOs rated it as an average challenge. Moreover, high price of machines accessories, as well as unavailability of spare parts were also observed by more than 50.0% of GTOs as significant challenges to mechanization.
The lack of knowledge about mechanized operations was considered a serious challenge also by a little less than half of GTOs.

Table 14. Constraints to machinery operations

Characteristics	State-imported	Privately-purchased	Statistical difference
High prices/ unavailability of operators			
*No	0.67	0.67	11.84**
* Small	2.67	10.67	
*Way	26.00	32.00	
* Large	38.00	35.33	
*Very large	32.67	21.33	
High prices / unavailability of technicians			
*No	3.33	1.33	22.74***
* Small	3.33	13.33	
*Way	16.00	27.33	
* Large	35.33	34.67	
*Very large	42.00	23.33	
Lack of genuine spare			
*No	1.33	2.00	14.45***
* Small	3.33	4.00	
*Way	6.67	18.00	
* Large	24.67	31.33	
*Very large	64.00	44.67	
Low demand			
*No	13.33	13.33	10.28**
* Small	16.67	21.33	
*Way	30.00	38.67	
* Large	20.00	18.67	
*Very large	20.00	8.67	
Lack of access to fuel			
*No	7.33	23.33	24.35***
* Small	18.00	19.33	
*Way	34.00	35.33	

* Large	18.67	14.67	
*Very large	22.00	7.33	
Low quality of operators			
*No	1.33	0.00	30.93***
* Small	4.00	8.67	
*Way	17.33	38.67	
* Large	30.67	31.33	
*Very large	46.67	21.33	
Low quality of technicians			
*No	2.00	0.00	36.28***
* Small	2.00	9.33	
*Way	16.67	38.67	
* Large	27.33	26.00	
*Very large	52.00	26.00	
High prices / unavailability of spare parts			
*No	2.00	0.00	20.48***
* Small	2.00	8.67	
*Way	8.67	18.67	
* Large	22.67	27.33	
*Very large	64.67	45.33	
Machine / attachment too expensive			
*No	2.67	0.67	7.26
* Small	1.33	2.00	
*Way	12.00	22.00	
* Large	30.67	29.33	
*Very large	53.33	46.00	
Lack of knowledge on mechanized operations			
*No	2.00	2.67	10.94**
* Small	3.33	7.33	
*Way	20.67	24.00	
* Large	29.33	38.67	
*Very large	44.67	27.33	

Other constraints found by the study related to:

- Non-adaptation of accessories (plows etc.) according to tractor power
- Non-sharing of experiences with peer producers
- Non-frequent support of extension agents
- Operation outcomes not relevant to producers' expectations
- Non-existence of after-sales services

- Non-involvement of mechanics in scientific research on agricultural machinery
- Inadequate spare parts
- Absence of permanent service centers
- Poor facilitation of access to agricultural creditPoor promotion efforts on mechanization benefits

Aspirations

Using a scale where 10 represents the highest income level in the community, and 1 the lowest income level, the average income level of all farmers was estimated at 5. No significant statistical difference was observed between the two classes of producers. Consequently, the level of income they wished to achieve was 9. As for the level of income they wished to achieve in ten years, the significant differences observed showed that PTOs indicated 9, while GTOs indicated 8. Meanwhile, the current social status level of PTOs was 5.27, while that of GTOs was 4.82 (Table 15).

Table 15. Aspirations

Characteristics	State-imported	Privately-purchased	Statistical difference
What is the level of income that you have?	4.85 (1.66)	4.94 (1.79)	-0.46
What is the level of income that you would like to achieve?	8.78 (1.92)	9.08 (1.53)	-1.52
What is the level of income that you think you will reach within ten years?	8.3 (1.94)	8.98 (1.89)	-3.09***
What is the level of social status you have at present?	4.82 (2.01)	5.27 (2.30)	-1.78*
What is the level of social status that you would like to achieve?	8.62 (2.01)	8.72 (1.76)	-0.45
What is the level of social status that you think you will reach within ten years?	8.22 (1.92)	8.80 (2.12)	-2.47**

Tractor Assessment

Table 16 shows that less than 22% of the sampled farmers had machine coolant level that was considered too low (below C). The proportion of PTOs with normal level of fluid (52%) was higher than that of GTOs (34%) at $p<0.05$. More than 41.33% of GTOs and 24.0% of PTOs could not see the coolant level.

The majority of PTOs (78.0%) and 43.3% of GTOs started their engines without help. This implies that many GTOs often failed to start their engines unassisted.
Moreover, 51.33% of GTOs had non-functional hydraulic systems, compared to the 78.0% of PTOs with functioning hydraulic systems. Also, the proportion of private tractor owners with functional PTO (74%) was statistically higher than that of government tractor owners (56.67%).
The proportion of private tractor owners with too high hydraulic oil level (42.00%) was higher than that of government tractor owners (30.67%). More than 36% of GTOs and 28% of PTOs failed to visualize their hydraulic oil levels. Also, over 36% of PTOs had yellowish/ brownish hydraulic oils at the last change; 48.67% of GTOs and 40.67% of PTOs had black oils at the last change More than 31% of GTOs and 23% of PTOs failed to visualize the color of their oils.
The PTOs using draft control for plowing were 31.33%, while GTOs were 24.0%.
Also, 46.7% of PTOs and 28.7% of GTOs had high engine oil levels, 36% of GTOs and 19.33% of PTOs failed to visualize their levels of motor oil.
More than half (54%) of PTOs had no sediments in the sediment tank. Conversely, 14.0% of GTOs and 6.0% of PTOs had much sediments in their tanks. The proportion of government tractor owners (44.67%) who were unable to visualize sediments in the tank was slightly higher than those of the private sector (40%).
With regard to the lubrication points, the proportions of GTOs with very humid (13.33%) and very dry / hard (20%) lubrication points were statistically higher than those of PTOs (8.67% and 12.67%, respectively) at *p<0.01*. On the other hand, 64.67% of PTOs had their points of lubrication somewhat wet and dry; less than 44% of the sampled farmers could not show their grease gun. The proportion of PTOs who showed their grease gun (49.33%) was higher than that of GTOs (35.33%). The proportion of PTOs with functional grease gun (72.0%) was higher than that of GTOs (51.33%).
Moreover, nearly half of PTOs had a 50-75% clean radiator; 8.67% of PTOs and 20.0% of GTOs had their radiator 0-25% clean. More than 14% of GTOs and 5.0% of PTOs had their radiators 75-100% clean.
More than half of all the sample had their fan belts in good condition; 5.55% of them also had fan belts that were too tight. PTOs with fan belts in good condition (65.33%) were significantly more than GTOs (56.67%) at p<0.01. Similarly, GTOs had very loose fan belts (11.33%). Note that Moreover, 6.67% of PTOs and 12.67% of GTOs had very dirty air filters. More GTOs (31.33%) than PTOs (18.0%) had no idea of the state of their air filters. The proportion of PTOs with good air filters (53.33%) was higher than their GTO counterparts (25.33%).
Furthermore, 61.33% of PTOs and 58.67% of GTOs tractors had no roll bar. The average hours of operation of PTOs' engines was 8.46, compared to the 7.54 hours of GTOs.
With regard to dashboard indicators on transmission, 26% of PTOs and 24% of GTOs had them properly functioning. On the indicator lights for engine oil pressure, 32.0% of PTOs and 37.3% of GTOs had them properly functioning

Table 16. Tractor assessment

	State-imported	Privately-purchased	Statistical difference
How is the coolant level? (Repeat for all options)			
* Too high (above B)	4.67	2.67	13.43***
* Too low (below C)	20.00	21.33	
* Ok (between B & C)	34.00	52.00	

* Not applicable / not visible	41.33	24.00	
Does engine start? (Repeat for all options)			
* Yes. without help	43.33	78.00	41.27***
* Yes. with help	16.00	10.67	
* No	40.67	11.33	
Does hydraulic system work?			
*Yes	48.67	78.00	27.78***
*No	51.33	22.00	
Is PTO functioning?			
* Yes	56.67	74.00	16.22***
* No	24.67	8.00	
* Not applicable / not visible	18.67	18.00	
What is the level of the hydraulic oil? (Repeat for all options)			
* Too high	30.67	42.00	4.28
* Too low	33.33	29.33	
* Not applicable / not visible	36.00	28.67	
What was the color of hydraulic oil when last changed? (Repeat for all options)			
* Yellow / brown	20.00	36.00	9.68***
* Black	48.67	40.67	
* Not applicable / not visible	31.33	23.33	
Do you use draft control for ploughing?			
* Yes	24.00	31.33	2.10
* No	42.00	39.33	
* Not applicable / not visible	34.00	29.33	
How is oil level? (Repeat for all options)			
* Too high	28.67	46.67	14.01***
* Too low	35.33	34.00	
* Not applicable / not visible	36.00	19.33	
Which date does the oil cartridge indicate? (Repeat for all options)			
* Non applicable/ not visible	100	100	
Are there sediments in the bowl?			
* Yes	14.00	6.00	7.71**
* No	41.33	54.00	
* Not applicable / not visible	44.67	40.00	

How are the greasing points? (Repeat for all options)			
* Very wet	13.33	8.67	20.76***
* Some wet but some dry / hard	38.67	64.67	
* Very dry / hard	20.00	12.67	
* Not applicable / not visible	28.00	14.00	
Can respondent show his/her greasing gun?			
* Yes	35.33	49.33	10.90***
* No	44.00	42.00	
* Not applicable / not visible	20.67	8.67	
Does it work?			
*Yes	51.33	72.00	13.55***
*No	48.67	28.00	
Is grease in it?			
*Yes	44.00	65.33	13.77***
*No	56.00	34.67	
How is the radiator?			
* 75-100% clean	14.67	4.67	35.21***
* 50-75% clean	20.67	49.33	
* 25-50% clean	18.00	20.00	
* 0-25% clean	20.00	8.67	
Not applicable / not visible	26.67	17.33	
How is the fan belt?			5.20
* Too tight	5.33	5.33	
* Too loose	11.33	4.67	
* Ok	56.67	65.33	
* Not applicable / not visible	26.67	24.67	
How is the air filter?			
* Very dirty	12.67	6.67	26.09***
* Dirty	17.33	14.67	
* Somehow own	25.33	53.33	
* Very clean	13.33	7.33	
* Not applicable / not visible	31.33	18.00	
Does tractor have roll bar or cabin?			
* Yes	20.67	16.00	1.11
* No	58.67	61.33	
* Not applicable / not visible	20.67	22.67	
Please write down engine hours?	7.54 (1.55)	8.46 (0.99)	-2.04**

Are any warning lights on when the engine is running? (Repeat for all options)			
* Oil pressure transmission / hydraulic too low	24.00	26.00	8.53*
* Engine oil pressure	37.33	32.00	
* Indicator of the alternator	25.33	34.67	
* Air filter indicator	8.00	6.67	
* Transmission oil filter	5.33	0.67	

Discussion

Farmers who purchased their tractor through the government (GTOs) were older and more educated than those who purchased privately (PTOs). Their main source of income was agriculture, and they mainly belonged to either a cooperative/association or a producer organization. The part of annual income from formal / informal activities, and attributed to the provision of services, was higher among PTOs than GTOs. The average area planted by GTOs (51ha) was more than that of PTOs (about 33ha).
The main reason for purchasing a tractor was to develop their farms. The most choice criteria for tractors were tractor price and horsepower. The most common tractor brands of GTOs were Mahindra, Farmtrac, Massey Ferguson, and Sonalika; while among PTOs, these were Massey Ferguson, Farmtrac, and Mahindra.
About 69% of PTOs had tractors of 60hp, while only 21% of GTOs had 60hp tractors.
The average price of a tractor at the time of purchase, excluding insurance, registration and transportation costs, was CFA6,208,839 for GTOs and CFA5,779,140 for PTOs. Generally, those who got subsidies provided a quarter of the price of the tractor.
The majority of operators (about 95%), regardless of class, did not use a particular credit service to purchase the tractor. GTOs heard about government mechanization program through agricultural extension and public authorities (town hall, etc.).

It took an average of 20 days to finalize the formalities of applying for the machine; thereafter, to receive the machine took an average of 45 days. Only a few operators (18.00%) made a payment in the application process; in other words, the the process was largely free. Most GTOs (63.33%) would have preferred that they purchased their tractors outside government program. About 91% of them had not previously received any machine from government program.
More than 72% of PTOs had never applied for a machine in any government program, because of the belief that such programs were not transparent enough or the belief that they were not influential enough to to get a chance at the opportunity.
When purchasing their tractor, a minority of the surveyed operators had after-sales services included. Most of the surveyed operators, especially GTOs, said maintenance / servicing was done at mechanical workshops, and were satisfied with the maintenance services. The maintenance services related to change of engine oil, filter and tractor lubrication, etc. PTOs had more regular tractor maintenance than the GTO counterparts. Other problems faced by operators regard fuel and ignition, transmission, hydraulic, tires, rolling bars, drive shafts, cooling system, PTO, tooth, and beater and bolt, among others. Repairs were done mainly by independent technicians and, sometimes, by tractor owners themselves or their assistants. The majority of functional tractors

belonged to PTOs. Non-functionality of tractors was blamed on unavailability of spare parts and the lack of competence in tractor repair.
Tractor plows and trailers were mainly sought by producers. Also, a few farmers were interested in planters (seeders), sprayers, combine harvesters and gins. The brand of agricultural machinery sought the most were Massey Ferguson and Mahindra. Horsepower, quality or durability, availability of spare parts, mastery of repair by mechanics, and hourly capacity were the main criteria for selecting the Massey Ferguson brand. Generally, too, tractors and combine harvesters with 60-70hp were the most desirable. The operations were mainly plowing (use of plow, tractor) and transport (use of trailer and tractor). These results are similar to those of Gibigaye (2013), who showed that the tractor is often used for plowing operations and transportation services throughout the year. Moreover, the proportion of PTOs (93.33%) involved in tillage activities was higher than that of their GTO counterparts (76.0%).
A few respondents also prepare seedbeds (use of harrows), clearing (using a rotary cutter), ginning, and harvesting (with hay harvester). Notwithstanding, plowing, transportation, clearing, harvesting, and ginning were the main services offered to customers.
The proportion of GTOs providing plowing services was higher than those of PTOs; while the reverse was the case with transportation services. The average area plowed by PTOs (33.08 ha)was higher than that of GTOs (29.72ha); however, the latter borne more load (31,754.89 kg) than the former (28,970.3kg). The average area planted through GTO tractor services in the previous season (484.62 ha) for plowing was more than that of PTOs (147.5 ha); but the latter provided more transportation services, equivalence of 82,606.25kg, compared to the former's 74742.42kg. The study sample indicated that they met their customer's demands for clearing, harvesting and ginning operations; but the demand on plowing was not fully met by PTOs.

Plowing service customers were located at a distance greater than 10 kilometers, while those of transportation, land clearing, and preparation of the seedbed were located about 7km. This affirmed the earlier finding on on inadequate access to agricultural machinery in rural communities. Generally, majority of the sampled customers were men with an average of 2ha farm. However, PTOs had more female than male clients, compared to their GTO counterparts, with regard to transportation and clearing operations.
About 58% of GTOs did not provide some services the previous season in areas withheavy presence of strains and stones. Also, more than 44% of tractor owners did not provide credit service, but preferred full payment in advance; a little less than 32% granted full payment after harvest (full credit).
There were about 8 competitors with GTOs, while PTOs had 7 competitors. These competitors came from neighbouring regions and areas. The study found the general lack of government-led / supported mechanization service provision in the rural areas. About 27% of the machine owners operated their machines themselves without any assistant, while more than half of PTOs and 46% of GTOs used at least one worker as assistant. The majority of assistants had no previous experience / certificate of conduct on tractor operation; they, however, received informal training on the use / maintenance of machines. The proportion of GTOs with good knowledge of the hydraulic, cooling, lubrication, fuel and electrical systems was lower than that of PTOs. The same trend was observed for power take-off (PTO), engine, steering and tire mechanisms, maintenance and driving, and economic and profitability aspects.

- Moreover, inadequate technical skills, high prices of tractors, unavailability of original spare parts, high cost of machine / accessories, and unavailability of technicians, among others, constituted challenges to mechanization. There were also the challenges of fuel shortage, low demand, high price / unavailability of operators, among others.

Study 2: Opinions and Policy Beliefs with Regard to Policy Instruments and Effects Related to Mechanization, Youth and Digitalization

In many West African countries, the lack of jobs in rural areas has led to the exodus of young people to large cities in the region or to Europe (CTA, 2019). This is a far-reaching loss, as young people are a dynamic workforce, while the agricultural sector is desperately short of support (CTA, 2019). The two-year project launched by CTA in early 2018 on "Promoting youth entrepreneurship and job creation in the rice sector in West Africa" (PEJERIZ) tackles the problem: it encourages young Malians and Senegalese to stay in the countryside and increase the productivity of rice. The project has two components. The first is to train young people in the techniques used in the rice value chain and it is managed by AfricaRice. The second component, managed by Syngenta Foundation, aims to create mechanized service centers and promote a mobile app for farmers. This app, designed by AfricaRice in Mali and Nigeria, is a decision support tool that farmers can download for free on an Android smartphone. It sends out recommendations that help farmers better utilize mineral fertilizers and accurately determine when to plant and harvest. Nigerian rice farmers using the app report a significant increase in yields and income, up to 200 euros per hectare.

Sampling, data collection and study sites

In order to identify the experts/ representatives of different stakeholder groups involved in agricultural mechanization in Benin, an exhaustive census of the different centers / institutions, where these targets can be found throughout the national territory, was carried out. Experts/ representatives of different stakeholder groups were found at the levels of national and local government agencies, intergovernment organizations, agricultural research centers, nongovernment organizations (NGOs), technical and financial partners (TFPs), projects, and producer's associations. Internet research, literature reviews, and discussions with researchers, university professors, and institutional directors were also carried out in order to identify the contact details of the people targeted, and to make appointments for interview.
In total, 50 experts / representatives of institutions involved in agricultural mechanization were surveyed. The data were collected from August to September 2019, with an application loaded into the tablet that housed the numeric version of the questionnaire. Table 17 presents the quality of the experts surveyed according to the type of establishment and the municipality.

Table 17. Presentation of the quality of the experts/trainers surveyed by type of institution

Type of establishment	Targeted Centre Name	Town	Quality of identified resource person
Local decision-makers (National Government Agency; Local government agency)	Ministry of Higher Education	Cotonou	Director of Programming and Foresight (DPP)
		Calavi	Director of the Faculty of Agricultural Sciences (FSA)
			Director of Studies at the Ecole Polytechnique (EPAC)
		Parakou	Director of the Faculty of Agronomy (FA)
	Ministry of Technical and Secondary Education	Cotonou	Director of Programming and Foresight (DPP)
		Savalou	Director of Kpataba agro-pastoral technical school
		Sekou	Director of the agricultural school Médji of Sékou (LAMS)
		N'Dali	Director of the Agricultural High School of N'dali (INA)
		Natitingou	Director of the Agricultural High School of Natitingou

Type of establishment	Targeted Centre Name	Town	Quality of identified resource person
		Tchaourou	Director of the Agricultural High School of Kika
		Klouékanmè	Director of the Agricultural High School of d'Adjahonmey (dep.Couffo)
	Ministry of Agriculture, Livestock and Fisheries (MAEP)	Cotonou	Director of Programming and Foresight (DPP)
			Secretary General of the Ministery
			CTAER (Technical Advisor in Rural Development)
	Territorial Agency for Agricultural Development (ATDA) Pôle 1	Mallanville	Director of agency
	ATDA Pôle 2	Kandi	Director of agency
	ATDA Pôle 3	Natitingou	Director of agency
	ATDA Pôle 4	Parakou	Director of agency
	ATDA Pôle 5	Bohicon	Director of agency
	ATDA Pôle 6	Pobe	Director of agency
	ATDA Pôle 7	Calavi	Director of agency
	AIC (Interprofessional Association of Cotton growers)	Cotonou	Director
	Benin tracteur	Ouidah	Director
Intergovernmental Organization	FAO (Food and Agriculture Organization)	Cotonou	Mechanization Program Manager
	International Institute of Tropical Agriculture (IITA)	Calavi	Researcher
	AfricaRice/WARDA	Calavi	Researcher
Researchers (Research)	National Institute of Agricultural Research of Benin (INRAB)	Calavi	Scientific Director
	Agricultural Research Center (CRA) Cotton fiber /INRAB	Parakou	Director
	CRA (agonkanmey) /INRAB	Calavi	Director
	PTAA/INRAB	Porto-Novo	Director
	CRA SUD Niaouli /INRAB	Allada	Director
	CRA Centre/INRAB	Savè	Director
	CRA INA/INRAB	N'Dali	Director
	Center for Agricultural Research Perennial Plants (CRAPP /INRAB)	Pobè	Director
	CRA Nord ouest/INRAB	Natitingou	Director
ONG/PTF	DEDRAS	Parakou	Responsible for mechanization
	REDAD (Sustainable Agriculture Development Network)	Calavi	Director
	GIZ	Cotonou	Responsible for mechanization
	ENABEL (Profit) UFR Atacora_Donga	Natitingou	Technical Adviser
	Helvetas	Cotonou	Technical Adviser
	ACMA-IFDC (Community Approach Program for Agricultural Market in Benin)	Cotonou	Director
Project	PADA/PROCAD	Cotonou	Coordinator
	PPAO/PROCAD	Cotonou	Coordinator
	PAPAPE	Calavi	Coordinator
	Support Food Production and Resilience Reinforcement Project in Alibori Borgou and Collines Departments (PAPVIRE-ABC)	Cotonou	Coordinator
	Agricultural Infrastructure Support Project (PAIA-VO)	Kokoye /Porto-Novo	Coordinator
	ADEMA	Calavi	Coordinator

Type of establishment	Targeted Centre Name	Town	Quality of identified resource person
	COBEMAG (Beninese Cooperative of Agricultural Materials)	Parakou	Director
Private enterprise	Forging workshop of adjustment and welding (AFAS)	(Bohicon)	President
Association of farmers	Federation of Producers Unions of Benin (FUPRO)	Bohicon	Director
	PNOPPA-Benin (National Platform of Farmers Organizations and Agricultural Producers)	Cotonou	Director
	Union of Machinist Farmers of Benin		President

Results

General

Table 18 shows the share of the efforts devoted to agricultural policy at the different organizational, structural and institutional levels. The Table shows that all organizations / structures / institutions gave a significant share to agricultural policy (more than 85%), compared to social policy, labor, etc. The observed differences show that four (4) organizations (producers associations, local government agencies, intergovernment organizations, and research) had devoted much efforts to agricultural policy. These four organizations were followed by nongovernment organizations (95%), and development organizations (90%). National organizations devoted more efforts to agricultural policy than private firms.

Table 18. Percentage of efforts directed at agricultural policy

Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
100	-	-	85.45 (25.44)	100	95 (12.24)	100	-	100	83.33 (15.27)	90 (22.36)

Table 19 shows the distribution of agricultural expenditure allocated to the different programs according to the organizations / structures / institutions. Producer associations estimated that the largest share of agricultural expenditures was allocated to input subsidy programs (30%); followed by youth (20%), ICT in agriculture (20%), and agricultural mechanization (15%). Contrary to the views of farmers' organizations, all other organizations (intergovernment, national, local government, research, NGOs, private center, and development organizations) estimated that the largest share of agricultural expenditure was on extension / mentoring programs (over 28%). Agricultural mechanization programs received moderate attention from national (20%), local (13.84%), intergovernment (21.66%), development (16.6%), and research (13.75%) organizatioms, as well as the private sector (11.6%), and NGOs (13.33%). The same trend was observed for policies related to environment. The observed differences showed that they felt little attention was given to youth-related policy and ICTs in agriculture. Local government agencies (19.15%), NGOs (15.83%), and the private sector (18.33%) showed that the share of spending allocated to input subsidy policies was small. Organizations also dedicated their agricultural expenditures to other programs, such as those related to hydro-agricultural development, research, rural infrastructure, electrification, and market access.

Table 19. Distribution of agricultural expenditure allocated to the different programs according to the organizations / structures / institutions

Particulars	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Input subsidies	30	-	-	9.54 (4.71)	19.15 (12.75)	15.83 (16.85)	8.33 (5.77)	-	10.375 (6.52)	18.33 (14.43)	6.6 (2.30)
Extension services	10	-	-	26.81 (9.55)	28.84 (9.16)	28.33 (6.83)	33.33 (12.58)	-	28.375 (10.26)	28.33 (2.88)	35.6 (13.01)
Agricultural mechanization	15	-	-	20 (11.18)	13.84 (5.06)	13.33 (4.08)	21.66 (2.88)	-	13.75 (2.31)	11.66 (2.88)	16.6 (6.54)
Youth	20	-	-	10.90 (5.83)	10.76 (7.31)	9.16) (4.91)	13.33 (14.43)	-	9.375 (3.20)	9.66 (5.50)	10.8 (5.31)
ICTs in Agriculture	20	-	-	9.54 (4.15)	8.92 (7.34)	6.66) (4.08)	10 (5)	-	8.75 (5.82)	7.33 (6.80)	5.4 (2.88)
Environmental Sustainability	5	-	-	16.36 (5.04)	14.08 (5.40)	17.5 (9.35)	16.66) (7.63)	-	19.375 (6.23)	21.33 (2.30)	14 (4.18)
Others	0	-	-	10 (2.67)	10.14 (8.19)	16.25 (4.78)	10	-	16 (6.51)	15	11 (4.18)

Agricultural Mechanization

Table 20 shows that all organizations / structures / institutions (producer association, national government agencies, local government agencies, non-government organizations, intergovernment organizations, research, private enterprises and development agencies) were for agricultural mechanization. They indicated that times are changing, and agriculture would need to be modernized. In addition, they showed that human strength is not enough to ensure good productivity that can meet the current and future challenges of food security and safety.

Table 20. Attitude towards agricultural mechanization

	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Pro	100	-	-	100	100	100	100	-	100	100	100
Contra											
Neutral											

Table 21 presents the preferred allocation of organizations / structures / institutions for animal traction and motorized traction. The Table shows that all organizations gave a significant share to the use of motorized traction (more than 80%) compared to animal traction. The data show that they preferred motorized traction than animal traction, to varying degrees. Indeed, all organizations / structures / institutions, except producers associations and development organizations, paid little attention to animal traction (less than 19%). They showed that producers in the central and northern regions are used to animal traction. Moreover, the majority of farmers, given their low purchasing power, have difficulties in appropriating agricultural machinery. Thus, going from one day to the next, in favor of motorized traction is not advisable. The introduction must be carried out in a progressive way, with gradual authorization. The best way is to make a survey, and make available equipment more adapted to the environment and relatively cheaper.

Table 21. Preferred allocation of organizations / structures / institutions for animal traction and motor traction

	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Mechanical traction	100.00			93.63 (8.96)	84.61 (16.64)	99.16 (2.04)	81.66 (16.07)		90 (17.72)	80 (26.45)	100
Animal draught	0.00 (0.00)			6.36 (8.96)	15.38 (16.64)	0.83 (2.04)	18.33 (16.07)		10 (17.72)	20 (26.45)	0

Table 22 presents the preferred allocation of organizations / structures / institutions, in terms of imports, supply and machinery subsidies and the provision of supportive infrastructure (eg, development of knowledge and skills). The analysis shows that producers' associations allocated an equal share to importing, distributing and subsidizing machinery (50%), and capacity building (developing knowledge and skills) (50%). The share allocated to the capacity building program by national government agencies (55.45%), intergovernment agencies (56.66%), research (57.5%), and the private sector (81.66%) seemed to be slightly higher than that related to the import, supply and subsidy of machinery. The differences show that those in the private sector (81.66%) were entirely for this program, compared to other institutions. It is necessary to import, but it is also necessary to give priority to training (good use of existing structures). The capacity building of users (producers, technicians, mechanics and researchers) must take over to facilitate the sustainability of the machines. In the past, tractor owners were faced with tractor drivers' incompetence problems, which affected tractor driving efficiency; this led to repeated breakdowns. When the tractors were down, the mechanics, given their low level of skills, could not fix them. The mechanics tried to juggle and guesswork; a situation worsened by unavailability of original spare parts.

On the other hand, local government agencies (51.53%) and nongovernment organizations (51.66%) considered that expenditure on machinery import / distribution / subsidy programs, as well as capacity building should be proportionally allocated. They showed that these two items must be prioritized at all times, because one strengthens the other. They believed that it is first necessary to strengthen the capacities, and to make machines available, as the level of industrialization in Benin is low, limiting the capacity to manufacture machines at the local level.

Table 22. Preferred allocation of organizations / structures / institutions, in terms of machinery imports and provision of knowledge and skills.

	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Machinery imports, distribution and subsidies	50			44.54 (16.94)	51.53 (21.05)	51.66 (14.71)	43.33 (27.53)		42.5 (17.52)	18.33 (16.07)	46 (11.40)
Supportive infrastructure (e.g. knowledge and skills development)	50			55.45 (16.94)	48.46 (21.05)	48.33 (14.71)	56.66 (27.53)		57.5 (17.52)	81.66 (16.07)	54 (11.40)

Table 23 presents the opinions of organizations / structures / institutions and statements relating to agricultural mechanization. The data show that all organizations / structures / institutions agreed with the statement that "*agricultural mechanization is the best way to make agriculture attractive to young people*". The observed differences show that all organizations / structures / institutions

except local government bodies, NGOs, private companies, and development organizations were in disagreement with this statement. They believed that modernizing agriculture through mechanization is a way, but not the best, because young people seek prosperity in activities that can enable them to have money quickly. The problems of market access arise, but it is the last step to get money. So mechanization does not solve the whole problem of agriculture; market access is also essential. The statement, "If an agricultural product sells well, even if there is no mechanization, young people will invest in it" should define policies to subsidize inputs, to allow small producers increase production and access to the market. This will help them increase their purchasing power, investment, and access to credit.

On the statement, "*moving from manual farming to mechanization should be a priority,*" all organizations / structures / institutions, except private enterprises, and local government agencies, showed complete agreement. These organizations considered that the use of motorized traction is good when provisions are made to mitigate the negative effects. It saves energy, saves time, and increases productivity in large areas.

On the other hand, all organizations / structures / institutions strongly disagreed with the statement: "*As modern tractors are robust, easy to handle and require little maintenance, there is no program to develop knowledge and skills for users, tractors and technicians are not necessary*". They felt that this statement is incorrect because tractors require a lot of maintenance, and users need to be trained. The training must be a priority, as "*even the drones that fly by themselves need to be guided*". Regarding the statement, "the private sector has failed to promote mechanization. *Therefore, the state has to import / supply machines,"* the producers' associations were in complete agreement. However, the opinion differred with regard to other organizations / structures /institutions. Moreover, intergovernment organizations did not disagree with this statement; and so was it with national, government, local, development, NGOs, and private sector agencies, who showed that the state must introduce policies to support the private sector in the supply of machinery. On the other hand, some did not agree with import because they favored the consumption of locally manufactured products. They showed that it is necessary to make a franchise with the Japanese to manufacture adaptable machines to increase access, availability of spare parts, and capacity of technicians.

Regarding the statement, *"The lifespan of machines imported during previous government programs was generally short*", the opinions of producers associations were mixed. They claim that the machines imported by the government in previous programs were of Chinese origin and, therefore, had very short lifespan. On the other hand, national agencies, local government agencies, non-government organizations, intergovernment organizations, research, private companies, and development organizations disagreed with the statement. They argued that the previous government program did not choose to import machines that were short-lived; but that the policy implementation (monitoring, training, management, etc.) was simply ineffective. The tractor owners and operators lacked conventional training skills and repairers. As a result, the machines were misused, causing breakdown and desadoption.
All organizations/ structures/ institutions agreed with the statement, "G*iven the government challenges to import / distribute machinery, the private sector should be the leader in mechanization*". However, only respondents belonging to development organizations were in complete agreement, as they stated that the state should establish conditons to favor the private sector in the import and supply of machinery; and that the government should not compete with

the private sector, but should support the sector and players at all levels to access and supply better machines.
All organizations / structures / institutions, however, disagreed with the statement, "*The private sector should provide knowledge and skills to tractor users and technicians because they sell for-profit machinery and equipment*". The data showed some form of disagreement among intergovernment organizations, who stated that the provision of machinery must be accompanied by after-sales services (capacity building, etc.) to promote its use.

All organizations / structures / institutions disagreed with the affirmation, "*The private sector is not encouraged to develop knowledge and skills in mechanization. The government should do these activities".* The data, however, showed that this assertion was true, because the private sector was already undertaking actions in favor of mechanization in Benin. Moreover, the respondents considered that the state must initiate the training to favor the private sector.
Regarding the statement, "the government's current efforts to develop the knowledge and skills needed for mechanization are sufficient", the producer associations were not in agreement. The data also show that local government organizations and research disagreed with the statement. Other organizations / structures / institutions shared a mixed position, but agreed that current policies emphasized mechanization.

Not all organizations / structures / institutions agreed with the statement, "*Further encouraging agricultural mechanization will lead to rural unemployment*". The variations observed, however, show that development organizations totally disagreed with the statement; they considered that the development of good mechanization policy will increase agricultural production and, consequently, industrialization and transportation. This can create opportunities for young people, especially in processing and marketing.
All organizations / structures / institutions disagreed with the statement, "*The use of tractors and plows has caused major problems of soil erosion*". They showed that erosion was rather the product of misuse of tractors and plows. The data, however, showed mixed positions of local government agencies, intergovernment agencies, and research centers: that although erosion is not very pronounced in the country, the use of tractors presupposes some level of deforestation and stain removal, which causes erosion.
With regard to the statement, "*It is very easy to develop business models that smallholders can also benefit from,*" producer associations had some disagreement, while other organizations / structures / institutions research centers, and private companies completely disagreed with it, given the scale of agribusiness in Benin.

Moreover, on the statement, "*Strategies enabling farmers to buy tractors without subsidies are possible*", there were varying views. While national government agencies and intergovernment organizations strongly disagreed with the assertion, private companies slightly disagreed. Given the difficulties in accessing agricultural credit, agricultural machinery and inputs, producers formed groups (for example, National Federation of Agicultural Machinists, the CUMA, farmers' cooperatives) that would facilitate easy access to these services. . In fact, should there be means of accessing tractor services on credit, they would have explored them even if not subsidized.
All organizations / structures / institutions agreed with the statement that "*Banks do not provide sufficient means to finance mechanization*". The differences observed show that producer associations, NGOs, and intergovernment organizations were in complete agreement with the affirmation. Indeed, banks are reluctant / do not provide sufficient means to fund agriculture, given

the current climate change phenomena in the country. Also, the majority of farmers do not meet the conditions (guarantees, etc.) to participate in agricultural credits.

Table 23. Opinions of organizations / structures / institutions, statements about agricultural mechanization.

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Agricultural mechanization is the best way to make farming attractive for the youth.	6			6.18 (0.75)	6.38 (0.86	6.5 (0.83)	6 (1.73)		6 (1.19)	6.66 (0.57)	6.4 (0.89)
Overcoming hoe and cutlass types of farming should be a top priority.	7			6.27 (1)	6.61 (0.65	6.83 (0.40)	7		6.5 (1.06)	6 (1.73)	7
As modern tractors are robust, easy to handle and require little maintenance, no knowledge and skills development programs for tractor operators and technicians are needed.	1			1.09 (0.30)	1.07 (0.27	1.16 (0.40)	1.33 (0.57)		1.125 (0.35)	1	1
The private sector has failed to promote mechanization. Therefore, the state needs to import/distribute machinery.	7			4.45 (1.75)	4.69 (1.49	4.5 (1.22)	3 (2.64)		4.12 (2.10)	4.66 (2.08)	4.6 (1.51)
The lifetime of machinery imported during past government programs was typically short.	4			5.54 (1.91)	5.38 (1.55	6	5		5.37 (1.18)	6.33 (0.57)	5.6 (0.89)
Given the challenges of government efforts to import/distribute machinery, the private sector should lead mechanization	5			5.18 (2.08)	6.15 (1.14	5.83 (0.75)	6 (1.73)		5.62 (0.91)	6	6.8 (0.44)
Providing knowledge and skills for tractor operators and technicians should be done by the private sector because they make profit selling machines and equipment	1			2.09 (2.02)	2.53 (2.22	1.5 (0.54)	3.33 (2.08)		2.12 (1.72)	1.66 (0.57)	2 (2.23)

The private sector has no incentive to provide knowledge and skills development for mechanization, therefore the government should do these activities	6			4.81 (2.31)	6.53 (1.12	6 (0.63)	4.66 (2.08)		5.125 (1.80)	5.66 (1.15)	5.4 (2.07)
Current government efforts to provide knowledge and skills development for mechanization are sufficient	5			3.63 (1.62)	2.84 (1.46	3.66 (1.63)	3.66 (1.52)		3 (0.92)	3.66 (0.57)	3.6 (1.34)
Pushing agricultural mechanization too much will cause rural unemployment	3			1.36) (0.50	1.69 (1.18	1.83 (0.98)	3 (1.73)		1.62 (1.06)	1.33 (0.57)	1
Using tractors and ploughs has led to big problems with regard to soil erosion.	5			5.18 (1.32)	4 (2.12	5.83 (0.98)	4.33 (1.15)		4 (1.85)	5 (2)	5.6 (0.89)
It is very easy to develop business models by which smallholder farmers can also benefit	3			5.09 (1.22)	5.38 (1.60	4.66 (1.36)	6 (1)		3.62 (1.84)	4.33 (1.15)	4.8 (0.83)
Strategies that allow farmers to buy tractors without subsidy are possible	4			4.54 (1.69)	4 (2.08	3.66 (1.21)	4.66 (1.52)		3.75 (1.83)	2.66 (2.08)	4.4 (0.89)
Banks do not offer enough and good ways to finance mechanization	7			6.36 (0.92)	5.76 (2.27)	6.5 (0.54)	6.66 (0.57)		6.125 (0.99)	6.33 (0.57)	6 (1.73)

The results presented in Table 24 show that producers' associations asserted that the development of cooperatives, the renting of agricultural machinery, associations of service providers, land consolidation and ICT-based solutions have high potential to promoting the mechanization of smallholders. All other organizations / structures / institutions were in favor of all these programs, but at relatively different degrees. In fact, the development of cooperatives already allowed members to benefit from services. This is the case of CUMA, which had been very successful. Moreover, the development of service delivery infrastructures and service providers' associations will help increase access to machinery by smallholders.

The differences observed show that development and intergovernment organizations believed that the development of cooperatives has little potential for promoting the mechanization of smallholders. The same was true for national and local government organizations, NGOs, research centers, and private companies for the development of ICT-based solutions. The respondents showed that, very often, the Beninese likes individualism, because some cooperatives do not render services to their members. Concerning ICT, the low level of education of smallholders in rural areas will be a challenge.

Table 24. Rate of the potential of the following ways to promote smallholder mechanization.

characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Cooperatives	7			6 (1.41)	5.46 (1.39)	5.5 (1.04)	5 (2)		5.5 (0.98)	6 (1.73)	5.2 (1.09)
Machinery hire markets	7			6.54 (0.82)	6.30 (1.65)	6.33 (0.81)	6.66 (0.57)		6.25 (1.03)	7	7
Machinery associations	7			5.81 (2.22)	6.30 (1.54)	6 (1.09)	6.66 (0.57)		6.25 (0.88)	6.66 (0.57)	7
Land consolidation	7			5.63 (1.91)	6.07 (1.89)	5.83 (0.98)	5.33 (2.88)		6.37 (1.06)	7	7
ICT based solutions like apps	7			4.81 (1.88)	4.92 (2.25)	5.16 (1.47)	5.66 (1.52)		5.25 (1.28)	5 (1.73)	6 (1.22)

Rural youth

Table 25 shows that all organizations / structures / institutions agreed with the statement, "*Young people find agriculture unattractive in current conditions*". The differences observed show that development organizations were totally in agreement with the affirmation, given the difficulties in gaining access to agricultural credit, the market, etc. All organizations / structures / institutions also agreed that: "*Designing good agricultural policies can become attractive to young people"*. The differences observed show that farmers' associations, development agencies, NGOs, research centers, and private companies were totally in agreement with the affirmation. Thus, defining good policies to encourage agricultural entrepreneurship could help make agriculture attractive to young people.

However, all organizations / structures / institutions had little disagreement with the fact that "*We should not worry if young people leave agriculture to find work in urban areas*". The variations observed show that all the intergovernment organizations were in strong disagreement with the claim. In addition, research centers expressed that it is not agriculture that usually has problems, but the places where young people go.

All organizations / structures / institutions also slightly agreed with the fact that "*Young people are not sufficiently involved in agricultural policy processes*". The differences observed show that NGOs were in strong disagreement, claiming that there were already policies to support young people in their startups.

All organizations / structures / institutions, except farmers' associations and private companies also had slight agreement with the fact that "*Young people lack models in agriculture*". These farmers' associations and private companies disagreed, stating that agribusiness was gaining momentum in Benin, as young graduates were gradually investing in entrepreneurship, given the high unemployment rates.

All organizations / structures / institutions, with the exception of farmers' associations, slightly disagreed that "*Increasing the level of training of young people would unnecessarily raise their aspirations, which can become dangerous when the number of jobs created is insufficient*". Given the current unemployment rates, especially among young people in Benin, basic training is important to enable individuals to make good decisions. The differences observed show that farmers' associations were in strong agreement with the statement.

Furthermore, all the organizations / structures / institutions sampled slightly disagreed with the fact that "*Today's education system prepares young people well for the job market*." The respondents pointed to the fact that the time allocated to practical sessions is insufficient.

Table 25. Opinion concerning Rural youth

	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
The youth finds farming unattractive under current conditions	6			6 (1.26)	6.15 (1.46)	6.33 (0.81)	6.33 (0.57)		6.25 (1.16)	6 (1)	6.6 (0.54)
Designing the right policies farming can become attractive for the youth	7			6.72 (0.64)	6.92 (0.27)	6.5 (0.83)	6.33 (0.57)		6.62 (0.51)	6.66 (0.57)	5.8 (1.30)
We should not be concerned if the youth leave farming to find work in urban areas	2			2.72 (1.90)	3.30 (2.21)	2.66 (2.25)	1.33 (0.57)		4.5 (2.13)	2 (1)	3 (1.41)
Youth are not involved enough in agriculture policy processes	4			5 (1.48)	5.53 (1.50)	6.83 (0.40)	6.33 (0.57)		5.75 (1.28)	5.33 (1.15)	5.2 (1.78)
Youth lack role models in agriculture	3			4.45 (1.91)	4.38 (2.14)	5.33 (1.36)	4.66 (1.52)		5.25 (1.38)	3 (1)	3.4 (1.51)
Providing too much education unnecessarily raises the aspirations of the youth, which can become dangerous when not enough jobs are created for them	2			2.36 (1.12)	2.53 (1.66)	2.66 (1.03)	1.33 (0.57)		2.12 (1.64)	5 (2)	3.6 (1.34)
Today's education system prepares the youth well for the job market	3			2 (1.09)	3.61 (2.32)	3 (2.28)	2 (1)		2.875 (1.12)	2.66 (1.52)	2.2 (0.83)

Table 26 presents an assessment of the potential of different policies to making agriculture attractive to young people. The data show that all the organizations / structures / institutions considered that policies related to the development of agricultural mechanization, ICT, education and vocational training programs have high potential to making agriculture attractive to young people. The same trend was observed for policies related to active labor market programs, access to land, credit, and infrastructural development. Farmers' associations believed that all these policies have very high potential. The observed differences show that non-government and intergovernment organizations believed that agricultural mechanization has low potential to making agriculture attractive to young people. The same was true for the development of ICTs for all organizations / structures / institutions, except farmers' associations. Indeed, the ICT-based solutions can help tractor owners to track their operators and activities, as well as machine management and access to information (prices of agricultural products, etc.). The use of phones and tablets for agricultural activities is in full expansion among rural and urban youth, thus making agriculture youth-friendly.

For national government and development agencies, private enterprises, research centers, education-related programs and vocational training have very high potential for modernizing agriculture. Some respondents believed, however, that the development of agricultural high schools only attracted a few young people to agriculture.

Active labor market programs (eg, public works) have high potential, according to development agencies. Other organizations believed that if good policy is defined, people will start their own businesses without looking for a job in the public sector.
Land-related programs were attractive to the sampled organizations / structures / institutions, except for NGOs, research centers, and development organizations, which stated that they have low potential in agricultural development. Indeed, access to land is keyto agricultural production. In Benin, young graduates have difficulties in accessing land, hence, increased access will definitely impact on productivity. However, access to land may not sufficiently impact on production if it is not accompanied wih access to credit and inputs.

Programs related to access to agricultural credit was also attractive to the sampled organizations / structures / institutions, except for research centers, which indicated that they were low in potential. Indeed, many young people do not have access to credit / grant to undertake, which increases unemployment rate, especially among young graduates.
Furthermore, programs on improving rural infrastructure were affirmed as attractive by the sampled organizations / structures / institutions, which claimed that they can sufficiently facilitate transportion of products to markets, and make young people interested in agriculture.

Table 26. Potential of selected policies in making agriculture attractive to the youth

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Agricultural mechanization	7			6.54 (0.52)	6.53 (0.66)	6.16 (0.75)	6		6.5 (0.53)	6.66 (0.57)	6.6 (0.54)
ICTs	7			5.81 (1.16)	5.61 (1.66)	6 (0.89)	5.33 (1.15)		6.125 (1.12	6.33 (1.15)	5.4 (1.81)
Education and skills training programs	7			6.72 (0.46)	6.30 (0.85)	6.33 (1.21)	5.66 (1.15)		6.5 (1.06)	6.66 (0.57)	7
Active labour market programs (e.g. public work)	7			5.18 (1.53)	5.30 (1.65)	5.83 (1.47)	6 (1)		5 (1.30)	5.66 (0.57)	6.8 (0.44)
Access to land	7			6.36 (0.67)	6.61 (0.65)	6.16 (2.04)	6.66 (0.57)		5.75 (1.28)	6.66 (0.57)	6 (1)
Access to credit	7			6.27 (0.90)	6.53 (0.77)	6.5 (0.83)	7		5.62 (1.18)	6.66 (0.57)	6.6 (0.54)
Improved rural infrastructure	7			6.72 (0.64)	6.69 (0.63)	6.66 (0.81)	6.66 (0.57)		6.5 (0.92)	6.66 (0.57)	7

ICT In Agriculture

The data in Table 27 show that all the organizations / structures / institutions, agreed with the statement that "*ICT applications and the use of mobile phones offer enormous potential for agricultural development*". Further analysis shows that producers' associations, local government agencies, intergovernment organizations, NGOs, and private companies were fully in agreement with the statement. The same trend was observed for the assertion that "*Low network connectivity still limits the ability of many households to use ICT applications and cellphone services*". The data further show that local government bodies were totally in agreement with the statement, claiming that ICTs were not fully operational in Benin, given the low coverage rate.
The analysis in Table 27 shows that all the sampled organizations / structures / institutions strongly agreed with the statement that "*We need better quality control of ICT applications and*

mobile phone services". The same trend was observed for the statement that "*ICT applications can help improve good governance by improving the management of agricultural agencies and enabling farmers to demand better services*."
More so, all farmers' associations srongly agreed that "*ICT applications and mobile phone services are already helping farmers*". The observed differences show that national government agencies and NGOs agreed with this statement., However, research centers, private companies and development organizations somewhat agreed with the statement. Indeed, ICT applications and mobile phone services were already helping some farmers, but the lack of smartphones and low level of education were limiting usage. The data also show that driving drones from applications installed on mobile phones and tablets allowed some educated farmers to mechanize farming activities (such as planting and chemical application).
Further, all the sampled organizations / structures / institutions agreed with the statement that "*Rich and educated households benefit more from ICT applications and mobile phone services*". The observed differences show that national government agencies, NGOs and farmers associations disaagreed with this statement and stated that only a few agricultural households used andriod applications due to their low level of education. Also, all the organizations / structures / institutions, with the exception of farmers' associations, fully agreed with the statement that "*ICT applications use sensitive and personal data and we need to focus more on the confidentiality and sovereignty of data*". Farmers' associations disaagreed with this statement.

Table 27. Appreciation of Opinions concerning ICT in agriculture

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
ICT applications and mobile services provide tremendous opportunities for agricultural development	7.00 (0.00)			6.36 (1.02)	6.61 (0.65)	6.83 (0.40)	6.66 (0.57)		6.37 (1.40)	7	6.4 (0.54)
Low connectivity still limits the possibilities of many households to use ICT applications and mobile services	5.00 (0.00)			5.90 (1.37)	6.46 (0.77)	5.16 (2.22)	6 (1)		6.37 (0.74)	5 (1)	6.4 (0.54)
We need more quality control of ICT applications and mobile services	6.00 (0.00)			6.81 (0.60)	6.53 (1.39)	6.66 (0.51)	7		6.62 (0.74)	6.66 (0.57)	7
ICT applications and mobile services are already helping farmers	7.00 (0.00)			3 (1.34)	4.23 (1.83)	3 (1.41)	4 (2.64)		4.75 (1.75)	4.66 (3.21)	5 (1.22)
Wealthy and educated households benefit more from ICT	5.00 (0.00)			5.54 (1.21)	5.61 (1.32)	5.5 (1.37)	6 (1)		5.62 (1.30)	5.66 (0.57)	6 (1)

applications and mobile services											
ICT applications use personal and sensitive data and we should care more about data privacy and sovereignty	5.00 (0.00)			6.90 (0.30)	6.46 (1.66)	6.66 (0.51)	6.33 (1.15)		6.87 (0.35)	6.66 (0.57)	7
ICT applications may help to increase good governance by improving the management of agricultural agencies and by empowering farmers to demand better services	7.00 (0.00)			6.72 (0.46)	6.76 (0.59)	6.83 (0.40)	6.66 (0.57)		6.62 (0.74)	7	6.8 (0.44)

Table 28 shows data on mobile payments and savings, credit supplies, insurance, weather and price data, extension service, machine rental markets and ICT marketing. All the sampled organizations / structures / institutions found the having high potential in making agriculture attractive to young people. The farmers' associations totally agreed with the development of these policies. With regard to mobile payments and mobile savings, the increase in points of sale and transfer of money by GSM networks favored increasing mobile payments. Today, everyone has mobile accounts. You hardly finds a young person without a bank account.

Agricultural credit services and ICT insurance had low potential, according to all organizations / structures / institutions, except farmers' associations. These services may be limited to rural youth, given their low level of education, and access to android devices. The development of weather information service and price data has proven to have high potential for all organizations / structures / institutions.

Table 28. Rate the potential of the following policies to make agriculture attractive for the youth

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Mobile payments and mobile saving	7			6.54 (0.68)	6.84 (0.37)	5.33 (1.86)	6.33 (0.57)		6.62 (0.51)	6.66 (0.57)	6.6 (0.89)
Credit provision	7			5.36 (1.74)	4.30 (2.25)	5 (1.78)	6 (1)		5.62 (1.06)	6.33 (0.57)	6 (1.22)
Insurance	7			5.45 (1.57)	4.15 (2.19)	5 (1.78)	6 (1)		5.37 (1.06)	6.33 (1.15)	6.4 (0.54)
Whether and price data	7			6.90 (0.30)	6.30 (1.25)	6.5 (0.83)	7		6.75 (0.46)	6.66 (0.57)	7
Agricultural extension service	7			6.54 (1.21)	6 (1.68)	6.33 (0.81)	6.33 (1.15)		6.5 (0.92)	6.66 (0.57)	7
Machinery rental markets	7			6.45 (1.03)	5.53 (2.25)	5.83 (1.60)	6 (1)		6.87 (0.35)	6.66 (0.57)	7

Marketing	7			6.54 (0.93)	5.38 (2.02)	6.33 (1.21)	6.66 (0.57)		7	6.66 (0.57)	7

General Information

Table 29 shows that the the oldest organizations / structures / institutions were: farmers organizations (59 years old), development organizations (57 years old), research centers (55 years), intergovernment organizations (54 years); and National Government Organizations and NGOs (each 50 years old). The majority of the respondents were male, and the only institutions with female respondents were: national government bodies (9.1%), research centers, and development organizations (each 12.5%). Moreover, over 66% of the respondents were from the rural areas. In fact, all the sample drawn from farmers' associations and 44.4%of those from local government agencies, private companies and development organizations grew up in farm settlements About 62% of the sample from all organizations / structures / institutions, except those from intergovernment organizations, had a farm.

Moreover, the majority of the sample from organizations / structures / institutions, except farmers' associations and private companies, had a postgraduate degree. Members of producers' association had skills only in agriculture. About 54% of respondents from national governmental organizations had a master's degree and 36% had PhD in agriculture (54%), engineering (27%) and economics and social sciences (18%). Furthermore, 53% of the respondents from local government agencies hadcompleted an engineering degree; 38% had a master's degree, and 7.69% had BTS in agriculture (84%), engineering (7.69%) and mechanics (7.69%). Among non-government organizations, there holders of master's degree (83%) and bachelor's degree (16.67%) in engineering, economics and agriculture. Intergovernment organizations had more PhD holders (66.67%) than Masters' (33.33%) with specialization in Agriculture. The researchers had in their ranks PhD holders (87.50%) focused in agriculture. Private sector workers mostly had advanced degrees (66.67%), and a few Masters' (33.33%) in agriculture (66.67%) and economics and social sciences (33.33%).

In development organizations, the respondents had both master's degrees and first degrees (40%) in engineering; a few had PhD (20%) in agriculture, and political and social sciences.

All the sample from producers' associations, the private sector, and development organizations studied in Africa. This was also the case for the majority of respondents from research centers (87%), local government bodies (84%), and non-government organizations (83%). Those who studied abroad were mostly from intergovernment organizations (66%).

The majority of sample from organizations / structures / institutions, except farmers' associations, consulted a few scientific articles or policy documents . Only sample from intergovernment organizations regularly consulted scientific articles and policy documents (more than 56 articles).

Note that all the sampled organizations / structures / institutions collaborated with each other. The observed differences showed that the farmers' associations interacted predominantly with other cooperatives (more than 100 others), government corps (more than 60 in the past year), and with development organizations and the private sector (over 40). The national government corporations interacted predominantly with heads of academic corporations (over 86), government bodies (over 76), private sector (over 54), and producers' organizations (more than

46). Local government and intergovernmental organizations, research centers, private enterprises, and development agencies frequently collaborated with all the other sampled organizations / structures / institutions, except civil society organizations. Moreover, NGOs interacted mainly with producers' organizations (more than 76), private sector organizations (more than 50), academic corporation leaders (over 86), government corporations (over 49), and development organizations (more than 39).

Table 29. General information

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Age	59			53.18 (6.17)	50.23 (5.50)	49.83 (5.56)	54.33 (4.50)		55.5 (3.89)	53.33 (0.57)	57 (3.16)
Gender (% male)	100.00			90.91	100.00	100	100.00		87.50	100.00	87.50
Origin (% rural)	100.00			73.73	69.23	66.67	33.33		100.00	66.67	80.00
Origin (% farm)	100.00			25.00	44.44	0.00	0.00		25.00	50.00	50.00
Farm (% owning)	100.00			36.36	69.23	66.67	0.00		62.50	100.00	60.00
Level of education (repeat for all options)											
Primary											
First Cycle (College) 1											
Second cycle (high school)	100.00			0.00	0.00	0.00	0.00		0.00	66.67	0.00
BTS	0.00			0.00	7.69	0.00	0.00		0.00	0.00	0.00
Licence											
Engineering course	0.00			9.09	53.85	16.67	0.00		0.00	0.00	40.00
Master	0.00			54.55	38.46	83.33	33.33		12.50	33.33	40.00
Ph.D.	0.00			36.36	0.00	0.00	66.67		87.50	0.00	20.00
Background (repeat for all options)											
Economic / Social Sciences	0.00			18.18	0.00	50.00	0.00		12.50	33.33	20.00
Agriculture	100.00			54.55	84.62	50.00	100.00		87.50	66.67	80.00
Engineering	0.00			27.27	7.69	0.00	0.00		0.00	0.00	0.00
Business Administration											
Public administration											
Other (mechanical)	0.00			0.00	7.69	0.00	0.00		0.00	0.00	0.00
Place of degree (repeat for all options)											

Characteristics	Farmer org.	Youth assoc.	Women assoc.	Nat. gov.	Local gov.	NGO	Intergov. org.	Donor	Research	Private c	Development org.
Country of origin (Africa)	100.00			63.64	84.62	83.33	33.33		87.50	100.00	100.00
Country of origin (excluding Africa)	0.00			27.27	15.38	16.67	66.67		0.00	0.00	0.00
Foreign country	0.00			9.09	0.00	0.00	0.00		12.50	0.00	0.00
Average of scientific papers read	2			19.63 (19.42)	24.23 (39.59)	22.33 (13.14)	56.66 (16.07)		26.12 (14.49)	12.33 (15.37)	24.2 (11.71)
Interactions with academia	30			86 (67.89)	73.92 (65.51)	28.16 (18.87)	31.66 (34.03)		52.25 (34.89)	26.66 (29.95)	35 (30)
Interactions with governments	60			76.90 (61.85)	71.69 (66.34)	49.5 (25.40)	63.66 (84.67)		141.25 (43.89)	22.66 (32.34)	118 (24.89)
Interactions with private sector	40			54.27 (34.03)	65 (52.24)	50.5 (35.46)	55 (42.72)		95 (25.07)	31 (42.46)	82 (16.43)
Interactions with civil society	20			15.63 (19.75)	6.69 (8.93)	10 (8.96)	5.33 (4.50)		15.25 (15.50)	3.33 (5.77)	23.4 (26.54)
Interactions with farmers /farmer organizations	100			46.54 (33.64)	64.61 (35.32)	76.16 (45.03)	68.33 (36.17)		93.12 (54.30)	146.66 (105.03)	106 (56.39)
Interactions with development organizations	40			43 (27.87)	49 (40)	39.66 (26.54)	35.66 (24.82)		61.87 (48.98)	30.66 (42.73)	51 (33.61)

Discussion

The majority of respondents were male; and had a postgraduate degree (PhD and Master) inengineering, agriculture, economics and social sciences, and engineering, except those of farmers' associations. Respondents from private companies did agricultural high schools. All organizations / structures / institutions gave significant attention to agricultural policy, as agriculture is the base of the national economy. Most agricultural expenditures were allocated to extension services; Not much funding was allocated to youth, ICT in agriculture, agricultural mechanization, and agricultural inputs.

Given the modernization of agriculture, all the respondents favoured agricultural mechanization, but indicated that measures should be taken ease the negative effects. They affirmed that human strength alone cannot sufficiently ensure increased productivity and food security. Some respondents from producers' associations and development organizations remarked that motorized traction should be introduced gradually, in phases. The best way is to make a survey, and make available cheap and adaptable equipment.

Producers' associations slightly agreed that current government efforts to develop the knowledge and skills needed for mechanization were sufficient. The majority of the organizations showed that the capacity building of actors (producers, technicians, mechanics, tractor drivers, researchers) must take priority over the importation / distribution / the subsidy of machines, to facilitate the durability of the machines and avoid the failures of the past. The study found that tractor owners and operators lacked conventional training and repairers. As a result, the machines were misused, causing breakdowns and soil erosion. The belief is that tractors require a lot of maintenance; hence, the need for capacity building and availability of spare parts.

National, local, developmental government agencies, NGOs, and private companies wanted the state to implement policies that support the private sector to import and supply agricultural machinery, and provide after-sale services. A few of the respondents, however, preferred local fabrication to imports; these indicated that the government should liaised with Japanese companies to build capacity of Beninnese to develop assemble machines, fabricate new ones and provide spare parts to increase accessibility to mechinary and accelerate mechanization. . In fact, the private sector is already undertaking actions towards mechanization in Benin.

The respondents also stated that priority should be given to agricultural mechanization in ways that make agriculture attractive to young people. They affirmed that modernizing agriculture through mechanization should appeal to the youth. They also held that mechanization activities should encompass increased market accessand policies on input subsidization to facilitate smallholders' activities. This will help increase their purchasing power, investment opportunities, and access to credit.

The development of a mechanization policy will lead to an increase in agricultural production and, consequently, to industrialization and increased access to transportation of farm produce. This will also increase opportunities for young people in agriculture.

The respondents also believe that strategies for farmers to buy tractors without subsidies are possible. Given the difficulties in accessing agricultural credit services, farm machinery and other inputs, some respondents stated that producers are developing clusters to increase access to these services. Banks are becoming reluctant to fund agriculture in Benin, perhaps because many farmers cannot fulfill the conditions (guarantees, etc.) for loans.

The study also found that cooperative development, agricultural machinery leasing, service providers associations, land consolidation and ICT-based solutions have potential to promoting smallholder mechanization. Indeed, cooperatives allow members to benefit from several services that individuals may not be able to access. Given the difficulties in accessing agricultural credits, young people find agriculture unattractive. Therefore, designing agricultural policies which proactively develop agricultural entrepreneurship would go a long way in attractiving young people into the sector. The study further established that there are already policies in place to support young people in their startups in agribusiness, and that this population segment has begun to key into the opportunities to create employment.

The study also found that education of young does not necessarily raise their aspirations; hence, beyond training in schools, the skills of young people should be developed to help them make informed decision in life. The education system in Benin does not prepare young people well for the job market due to the shortness of time allocated for practical sessions.

The study further found that all policies related to the development of agricultural mechanization, ICT, education and vocational training programs have high potential to make agriculture attractive to the youth. ICT-based solutions would help tractor owners to track their operators, maintain the machine and increase access to market information. In addition, the use of phones and tablets is expanding rural and urban access to information.

Labor market program (eg public works) was found to impact on agricultural development. Also, land-related programs have proven to be attractive to all the respondents. The study found that the youth find it difficult to access this factor of production; hence, a policy in this regard would increase agricultural participation among the youth. Programs related to access to agricultural credit also gained the approval of respondents, as they were seen as having the potential to make agriculture attractive to young people.

Study 3: State of Skills Development for Mechanization

Introduction to the importance of skills development for agricultural mechanization

Building the skills and knowledge of farmers on how to use machinery and implements along the agricultural value chain is essential. Establishing training opportunities to build these skills still remains a major bottleneck for agricultural mechanization. This section provides evidence on the opportunities and challenges related to skills development to promote agricultural mechanization.

Sampling, data collection and study sites

In order to identify the trainers involved in the provision of training programs in agricultural mechanization in Benin, an exhaustive census of the different centers / institutions, where these targets are nationwide was carried out. Trainers were found at the university, agricultural high schools, research centers, and private training centers. Internet searches, literature reviews, and discussions with researchers, university professors, and institutional directors were carried out, in order to identify the contact details of the people targeted, and to make appointments for interview.
In total, 20 trainers in agricultural mechanization were surveyed. The data were collected in September 2019, with an application loaded on to the tablet that housed the numeric version of the questionnaire. Table 30 presents the quality of experts surveyed according to the type of establishment and municipality.

Table 30. Presentation of the quality of the experts/trainers surveyed by type of institution

Type of establishment	Targeted Center Name	town	Quality of the resource person identified
Universities	Polytechnic School of Abomey-Calavi / Department of Mechanical and Energetic Engineering (EPAC/GME)	Calavi	Professor- Researcher
	Faculty of Agronomic Sciences (FSA/UAC)	Calavi	Teacher Researcher
Research Structures	Research and Training Unit in Agricultural Machinery of Niaouli (UFMAN/PTAA/INRAB)	Porto-Novo	Teacher Researcher
Agricultural High Schools High School Level 1	Adja-Ouèrè Agricultural High School (dep. Plateau)	Adja-Ouèrè	Director-Censor
Agricultural High Schools High School Level 2	Agro-Pastoral Technical College of Kpataba (Savalou)	Savalou	Director-Censor
	Sekou Medji Agricultural College (LAMS)	Allada	Director-Censor
	Agricultural High School of N Dali (INA)	N'dali	Director-Censor
	Kika Agricultural High School	Tchaourou	Director-Censor
	Akodéha Agricultural High School (dep. Mono)	Come	Director-Censor
	Agricultural Technical College of Adjahonmey (dep.Couffo)	Klouékanmè	Director-Censor
	School of Agricultural Machinery and Mechanical Engineering (EMACOM)	Ketou	Teacher Researcher
Private training centers	Songhai Center of Porto Novo	Porto-Novo	Director
	COBEMAG of Parakou	Parakou	Director
	CAMEMEC of Godomey	Abomey-Calavi	Director

	CFTS – Training Center Mgr STEINMETZ	Ouidah	Director
	MBS of Tori-Bossito	Tori-Bossito	Director
	UNAMAB/GAMAB	Parakou	Director
	AFAS of Bohicon	Bohicon	Director
	Sèdjro Construction of Porto-Novo	Porto-Novo	Director
	CEFACOM of Azovè	APLAHOUE	Director

Results

Background of selected institutions and respondents

Table 31 presents information on institutions and respondents surveyed. It shows that agricultural secondary schools level 2 (66.67%), universities (22.22%), and research institutions (11.11%) were the public institutions offering courses in agricultural mechanization. There were also private institutions providing training in mechanization; but these are few. The age of private institutions (23.18 years) was slightly higher than those of the public (19.77 years). The majority of the respondents were surveyed at the headquarters of their institutions. The differences observed in the respondents' years of experience in the institutions showed that that of trainers of private institutions (16.91 years) was higher than that of the public (4.44 years) at $p < 0.05$. The respondents were predominantly managers in their institutions.

Table 31. Background of selected institution and respondent

Charactristics	Public	Private	Statistical difference
Type of institution:			
a. University	22.22	0.00	
b. Mid-level college			
c. TVET			
d. Local/village polytechnic			
e. Other			
f. Research centers	11.11		
g. Agricultural High School Level 1			
h. Agricultural High College Level 2	66.67		
i. Private Training Center		100.00	
Age of institution (years)	19.77 (17.66)	23.18 (13.22)	-0.49
Number of branches (including head branch)			
- Seat	100	90.91	0.86
- Annex	0.00	9.09	
Years worked in the institution	4.44 (5.34)	16.91 (13.47)	-2.60 **
Respondent’s post/role in this institution:			

a. Management	55.56	90.91	3.50
b. Administrative	33.33	9.09	
c. Teaching	11.11	0.00	
d. Support staff			
e. Other			

Historical Information of the Institutions

Tables 32, 33, 34, 35 present information on the history of the surveyed institutions (universities, research centers, agricultural colleges, and trainig centers). The analysis of the tables shows an increase in the number of people working in universities and agricultural colleges, since the year of creation (from 48 people) until 2018 (to 106 people). At the research centers and private training centers, the same trend was observed until 2016, with a small number (less than 10 people).
The number of employees at the training institutionsdecreased slightly: in 2018, there were 61 teachers in the universities, 3 in the research centers, 91 in agricultural colleges and 4 in private training centers.

There was an increase in the number of students enrolled at the agricultural school levels, from 63 in 2016 to 563 in 2018. The number of male students in agricultural high schools increased from 22 to 241 in 2017. There were no female students at the research centers. The data show that female participation in the educational program was much lower than that of the male. The proportion of students was generally low at the research centers and private training centers, compared to those in high schools and universities.

The sampled universities, research centers and majority of agricultural schools had documents detailing their visions. About 46% of the private training centers had their vision statements. Among the universities, the statement had not been updated the past one year; but agricultural colleges had updated theirs the past one year. At the research centers and private training centers, the statements had not been updated the past 10 years.
A needs assessment (in knowledge, skills and attitudes) was last conducted in 2017 at the university level; in 2015 at the high school level; in 2014 at the private training centers, and in 2019 at the research centers. About half of the universities and high schools also had a strategic plan. The strategic plans of universities and high schools were completed in 2019.

Table 32. Historical information of the Universities

Category 1: Universities	**2018**	**2017**	**2016**	**2015**	**2014**	**Year of establishment**
Number of people (irrespective of designation) work /worked in this institution in:	106,00 (108.89)	106.18 (0,00)	190.50 (113.84)	107.00 (111.72)	100.00 (96.16	76.00 (62.22)
Number of teachers/lecturers work/worked in this institution in:	61.5.00 (55.86)	62,00 (55.15)	62.50 (55.86)	60.5.00 (55.86)	62.00 (50.91)	42.50 (24.74)
Number of male students are/were enrolled in this institution in:	220.50 (255.26)	182.00 (193.74)	236.00 (261.62)	212.50 (237.58)	124.50 (106.77)	38.50 (13.43)
Number of female students are/were enrolled in this institution in:	58.00 (73.53)	65.00 (77.78)	49.00 (57.98)	45.50 (50.20)	34.50 (36.06)	8.5 (2.12)
Have a vision and/or mission statement	100.00					
Number of years since the vision and/mission statement was updated	0.00 (0.00)					

Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	2.00 (0.00)	
Have a strategic plan	50.00	
Number of years before current strategic plan run out	0.00 (0.00)	

Table 33. Historical information of the Research centers

Category 2: Research Centers	**2018**	**2017**	**2016**	**2015**	**2014**	**Year of establishment**
Number of people (irrespective of designation) work /worked in this institution in:	3.00 (0.00)	3.00 (0.00)	4.00 (0.00)	3.00 (0.00)	3.00 (0.00)	3.00 (0.00)
Number of teachers/lecturers work/worked in this institution in:	3.00 (0.00)	3.00 (0.00)	4.00 (0.00)	3.00 (0.00)	3.00 (0.00)	3.00 (0.00)
Number of male students are/were enrolled in this institution in:	2.00 (0.00)	5.00 (0.00)	9.00 (0.00)	14.00 (0.00)	20.00 (0.00)	15.00 (0.00)
Number of female students are/were enrolled in this institution in:	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Have a vision and/or mission statement	100.00					
Number of years since the vision and/mission statement was updated	10.00 (0.00)					
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	0.00 (0.00)					
Have a strategic plan	0.00					
Number of years before current strategic plan run out	-					

Table 34. Historical information of the Research Higher agricultural colleges

Category 3: Higher agricultural colleges	2018	2017	2016	2015	2014	Year of establishment
Number of people (irrespective of designation) work /worked in this institution in:	117.16 (55.87)	114.67 (56.21)	113.5 (57.62)	112.50 (55.88)	80.83 (31.28)	48.66 (31.15)
Number of teachers/lecturers work/worked in this institution in:	90.83 (42.19)	90.83 (43.32)	93.33 (50.16)	89.83 (46.41)	62.00 (24.71)	38.00 (24.00)
Number of male students are/were enrolled in this institution in:	563 (404.14)	551.83 (401.75)	550.5 (397.09)	526.16 (367.37)	365.00 (257.93)	63.50 (36.64)
Number of female students are/were enrolled in this institution in:	241.5 (290.18)	251.16 (283.85)	243.33 (261.09)	256.00 (286.21)	203.00 (304.33)	22.33 (16.37)
Have a vision and/or mission statement	83.33					
Number of years since the vision and/mission statement was updated	0.60 (0.89)					
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	4.50 (6.36)					
Have a strategic plan	50.00					
Number of years before current strategic plan run out	0.00 (0.00)					

Table 35. Historical information of the Private training centers

Category 4: Private training centers	2018	2017	2016	2015	2014	Year of establishment
Number of people (irrespective of designation) work /worked in this institution in:	7.63 (8.98)	7.64 (9.28)	9.36 (14.55)	11.54 (23.05)	9.64 (16.58)	5.36 (6.07)

Number of teachers/lecturers work/worked in this institution in:	4.54 (4.10)	4.45 (4.15)	7.45 (11.51)	6.09 (9.12)	6.27 (8.91)	3.09 (2.94)
Number of male students are/were enrolled in this institution in:	10.91 (3.01)	11.45 (21.51)	15.81 (35.27)	14.09 (29.60)	12.45 (26.56)	12.00 (22.40)
Number of female students are/were enrolled in this institution in:	0.90 (3.01)	0.73 (2.41)	3.63 (11.73)	2.82 (9.35)	1.91 (6.33)	1.18 (3.06)
Have a vision and/or mission statement	45.45					
Number of years since the vision and/mission statement was updated	10.00 (10.91)					
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	0.50 (0.71)					
Have a strategic plan	5.00					
Number of years before current strategic plan run out	0.00 (0.00)					

Historical information of the institution (public vs. private) in 2018

Tables 36, 37, 38, 39 present data on the surveyed institutions. The data show a slight decrease in the number of personnel working between 2014 and 2018 at public institutions, especially among research centers (from 3.25 to 3.00 people). Among private institutions, the number of people also reduced from 10 to 8 respectively.

Moreover, the number of teachers increased in public training centers, from 84 (in 2014-2017) to 81 (in 2018). Male student enrollment decreased in public institutions, especially research centres, from 12 (in2014-2017) to 2 (in 2018).

Table 36. Historical information of the Universities (public vs. private) in 2018

Category 1: Universities	**Public**	**Private**	**Statistical difference**
Number of people (irrespective of designation) working in 2018	106.00 (108.89)		
Average number of people (irrespective of designation) working in 2014-2017:	105.75 (107.48)		
Number of teachers/lecturers working in 2018	61.5 (55.86)		
Average number of teachers/lecturers working in 2014-2017:	61.75 (54.44)		
Number of male students are enrolled in 2018	220.500 (255.26)		
Average number of male students are enrolled in 2014-2017:	188.62 (199.93)		
Number of female students enrolled in 2018	58.00 (73.53)		
Average number of female students enrolled in 2014-2017:	48.5 (55.50)		
Have a vision and/or mission statement	100		
Number of years since the vision and/mission statement was updated	0.00 (0.00)		
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	2.00 (0.00)		
Have a strategic plan	100.00		
Number of years before current strategic plan run out	0.00 (0.00)		

Table 37. Historical information of the Research centers (public vs. private) in 2018

Category 2: Research Centers	Public	Private	Statistical difference
Number of people (irrespective of designation) working in 2018	3.00 (0.00)		
Average number of people (irrespective of designation) working in 2014-2017:	3.25 (0.00)		
Number of teachers/lecturers working in 2018	3.00 (0.00)		
Average number of teachers/lecturers working in 2014-2017:	3.25 (0.00)		
Number of male students are enrolled in 2018	2.00 (0.00)		
Average number of male students are enrolled in 2014-2017:	12.00 (0.00)		
Number of female students enrolled in 2018	0.00 (0.00)		
Average number of female students enrolled in 2014-2017:	0.00 (0.00)		
Have a vision and/or mission statement	100		
Number of years since the vision and/mission statement was updated	10.00 (0.00)		
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	0.00 (0.00)		
Have a strategic plan	100.00		
Number of years before current strategic plan run out	0.00 (0.00)		

Table 38. Historical information of the Higher agricultural colleges (public vs. private) in 2018

Category 3: Higher agricultural colleges	Public	Private	Statistical difference
Number of people (irrespective of designation) working in 2018	117.16 (55.88)		
Average number of people (irrespective of designation) working in 2014-2017:	105.37 (47.88)		
Number of teachers/lecturers working in 2018	90.83 (42.19)		
Average number of teachers/lecturers working in 2014-2017:	84.00 (39.32)		
Number of male students enrolled in 2018	563.00 (404.14)		
Average number of male students enrolled in 2014-2017:	498.37 (352.77)		
Number of female students enrolled in 2018	241.5 (290.18)		
Average number of female students enrolled in 2014-2017:	238.58 (282.24)		
Have a vision and/or mission statement	83.33		
Number of years since the vision and/mission statement was updated	0.6 (0.89)		
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done	4.5 (6.36)		
Have a strategic plan	50.00		
Number of years before current strategic plan run out	0.00 (0.00)		

Table 39. Historical information of the Private training centers (public vs. private) in 2018

Category 4: Private training centers	Public	Private	Statistical difference
Number of people (irrespective of designation) working in 2018		7.64 (8.98)	
Average number of people (irrespective of designation) working in 2014-2017:		9.54 (15.76)	

Number of teachers/lecturers working in 2018		4.54 (4.10)	
Average number of teachers/lecturers working in 2014-2017:		6.06 (8.14)	
Number of male students enrolled in 2018		13.64 (21.77)	
Average number of male students enrolled in 2014-2017:		13.45 (28.18)	
Number of female students enrolled in 2018		0.91 (3.01)	
Ave. number of female students enrolled in 2014-2017:		2.27 (7.45)	
Have a vision and/or mission statement		45.45	
Number of years since the vision and/mission statement was updated		10.00 (10.90)	
Number of years since the last needs (knowledge, skills, & attitudes) assessment was done		0.5 (0.71)	
Have a strategic plan		9.09	
Number of years before current strategic plan run out		0.00 (0.00)	

Program description (all programs)

Tables 40 and 41 present descriptions of the programs taught at selected institutions. The data show that all the programs were accredited, except the one on rural infrastructure and sanitation. The programs with the most applications in public institutions were: animal production (142 men and 52 women), and crop production (103 men and 27 women); these data show that, in both program, there were more men than women. The number of students enrolled was also the highest for the two programs: 140 men and 50 women for animal production, and 101 men and 26 women for plant production. This trend was the same for the number of graduates. The number of men and women currently enrolled and those graduated in the previous batch was higher for animal production than plant production. But there was high dropout rate among men in the following programs: rural engineering and agricultural mechanization (2), and mechanical engineering (2). For the women students, there was high dropout rate in: plant production (3) and rural engineering and agricultural mechanization (3).

All the programs ofprivate institutions were accredited, except automotive mechanics, training in the use and maintenance of equipment, technological research, and tinplate making and foundry. The programs with more male than female candidates were: metal constructions (7 male), mechanical manufacturing (4 male) and technological research (4 male). Automotive mechanics was the only program with 1 female candidate. There were more men in the programs on the use and maintenance of equipment (37 male). No female graduate had been previously registered in the various programs. The programs with high dropout rate were: automobile mechanics (2 male), farm tractor driving and accessory hitching (2 male). With regard to women, there was only one droupout incidence in the automotive mechanics program.

Table 40. Program description (all programs) according to the type of institution (public institutions)

List of programs offered in this institution	Total number of applicants		Total number enrolled		Number of those who completed the program (last graduation)		Number of those who dropped –out of the program in the last graduating group		Is this program accredited?
	Male	Female	Male	Female	Male	Female	Male	Female	

Vegetable production	103.4 44.95	27.2 9.67	101.2 41.17	26 7.90	89.2 43.66	48.6 32.02	1.6 2.30	3.2 4.08	100.00
Manufacture of agro-food processing equipment									
Automobile mechanic									
Metal construction									
Mechanical manufacturing									
Management of the environment and fauna	29	6	26	6	35	10	0	0	100.00
Agro equipment	14	1	14	1	20	0	0	0	100.00
Driving agricultural tractors and hitching accessories									
Manufacture of agricultural equipment	0	0	0	0	13	0	0	0	100.00
Animal Production	142.2 41.24	52.4 32.42	140.2 43.49	50 30.63	115.4 49.63	64.2 33.96	1.4 3.13	1.8 4.02	100.00
Agricultural Machinery	37	3	37	3	6	0	0	0	100.00
Technological Research									
Training in the use and maintenance of equipment									
Rural engineering and Agricultural Mechanization (GRMA)	54	11	54	11	45	7	2	3	100.00
Maintenance and repair of automobile tractors	0	0	0	0	1	0	0	0	
Computer Aided Design of Agricultural Machinery and Equipment									
Rural development and equipment (AER)	21 10.22	1.6 1.51	21 10.22	1.6 1.51	16.8 6.53	1.2 1.09	0.2 0.44	0.2 0.44	100.00
Rural Infrastructure and Sanitation	2	0	3	0	0	0	0	0	0
Foundry									
Maintenance of agricultural machinery	0	0	0	0	3	0	0	0	100.00
Mechanical Engineering Genetics	26	2	25	2	22	1	2	1	100.00
Nutrition and Food Technology	28.8 27.55	18.6 11.63	27.2 26.30	18.2 11.75	23.5 25.33	16.5 15.08	0 0	0 0	100.00
Forestry	20.75 15.92	5 4.39	18.75 16.37	4.75 4.27	17.66 22.50	4.66 5.03	0 0	0 0	100.00

Rural electrification and renewable energy	4	0	4	0	0	0	0	0	100.00
Tinsmith									
Renewable energy and electronics applied to agricultural machinery	0	0	0	0	0	0	0	0	100.00
Fishing and aquaculture	31.4 22.52	6 5.33	31.4 22.52	11.6 15.53	29.25 27.94	6 6.05	.75 1.5	.25 .5	80
Energetic Mechanical Engineering	11	0	11	0	10	0	0	0	100.00

Table 41. Program description (all programs) according to the type of institution (private institution)

List of programs offered in this institution	**Total number of applicants**		**Total number enrolled**		**Number of those who completed the program (last graduation)**		**Number of those who dropped –out of the program in the last graduating group**		**Is this program accredited?**
	Male	Female	Male	Female	Male	Female	Male	Female	
Vegetable production									
Manufacture of agro-food processing equipment	2	0	2	0	2	0	0	0	100.00
Automobile mechanic	3	1	1	1	0	0	2	1	0
Metal construction	7.87 8.64	0 0	7.87 8.64	0 0	4.5 7.13	0 0	.25 .46	0 0	62.50
Mechanical manufacturing	4.66 2.08	0 0	4.66 2.08	0 0	1.33 1.15	0 0	.33 .57	0 0	66.67
Management of the environment and fauna									
Agro equipment									
Driving agricultural tractors and hitching accessories	2 2.82	0 0	2 2.82	0 0	2.5 .70	0 0	2 2.82	0 0	50
Manufacture of agricultural equipment									
Animal Production									
Agricultural Machinery									
Technological Research	4	0	4	0	2	0	0	0	0
Training in the use and maintenance of equipment	0	0	0	0	37	0	0	0	0
Rural engineering and Agricultural Mechanization (GRMA)									
Maintenance and repair of automobile tractors	1 1.41	0 0	1 1.41	0 0	1 0	0 0	.5 .70	0 0	50

Computer Aided Design of Agricultural Machinery and Equipment									
Rural development and equipment (AER)									
Rural Infrastructure and Sanitation									
Foundry	0	0	0	0	0	0	0	0	0
Maintenance of agricultural machinery									
Mechanical Engineering Genetics									
Nutrition and Food Technology									
Forestry									
Rural electrification and renewable energy									
Tinsmith	0	0	0	0	0	0	0	0	0
Renewable energy and electronics applied to agricultural machinery									
Fishing and aquaculture									
Energetic Mechanical Engineering									

Table 43 shows that at the university level, the programs with the highest enrollments (2018-2019 school year) were: rural engineering and agricultural mechanization (54 men and 11 women), agricultural machinery (37 men and 3 women), environmental and wildlife engineering (26 men and 6 women), mechanical engineering production (25 men and 2 women), and mechanical engineering energy (11 men). There were more women enrolled in rural engineering and agricultural mechanization; and the last graduates of this program were more numerous (45 men and 7 women), as well as the dropout rate (2 men and 3 women). Other programs with appreciable number of graduates were: engineering of the environment and fauna (35 men and 10 women), mechanical engineering production (22 men and 1 woman), mechanical engineering energy (10 men and no women), and farm machinery (6 men and no women). The programs with high dropout rates were: rural engineering and agricultural mechanization (3 women and 2 men) and mechanical engineering (2 men and 1woman).

The programs in research centers were: manufacture of agro-food processing equipment and maintenance and repair of the automobile tractor. The data show no currentapplications or registrations, despite that the programs were accredited. The same was true for maintenance of agricultural machinery, renewable energy, and applied electronics for agricultural machinery programs. Nevertheless, the programs related to manufacturing of agri-food processing equipment (13 male) had the most graduates, than those related to the maintenance of agricultural machinery (3 male); and the maintenance and repair of automobile tractors had 1male.

On agricultural high school (Table 45), the programs with the highest number of applications were animal production (142 men and 52 women), crop production (103 men and 27 women), and

nutrition and food technology (28 men and 18 women). The same observation was made for fisheries and aquaculture (31 men and 6 women), forestry (20 men and 5 women), rural development and equipment (21 men and 1 woman), agricultural equipment (8 men and 5 women) and rural infrastructure and sanitation (2 men and 1 woman). The program with a good number of male and female enrollment was, therefore, animal production, while that with the least enrollment was rural infrastructure and sanitation. Consequently, theprograms with the highest number of recent graduates were animal production (115 men and 64 women), crop production (89 men and 48 women), nutrition and agro-food technology (23 men and 16 women), fisheries and aquaculture (29 men and 6 women), and forestry (17 men and 4 women). Animal production had the highest number of applications and entries, while rural infrastructure and sanitation had the least. The programs with student droupouts were plant production (1 man and 3 women) and animal production (1 man and 1 woman). Of all the programs, only rural infrastructure and sanitation was not accredited.

With regard to private training at the research centers, automotive mechanics was the only program for which women could registered (Tables 44 and 46). The programs with the highest number of applications and registrations at the centers were: metal construction (7 men), mechanical manufacturing (4 men), technological research (4 men). For automotive mechanics program, there were 3 male and 1 female students. The program on use and maintenance of equipment was not accredited and, thus, had no student at the time of the study. Nevertheless, the program had the highest enrollment in recent times, with about 37 all-male graduates. The programs with the highest dropout rates were: automotive mechanics (2 men and 1 woman), farm tractor driving and accessory hitch (2 men).

Table 42. Program description for selected universities

List of programs offered in this institution	Total number of applicants		Total number enrolled		Number of those who completed the program (last graduation)		Number of those who dropped –out of the program in the last graduating group		Is this program accredited?
	Male	Female	Male	Female	Male	Female	Male	Female	
Vegetable production									
Manufacture of agro-food processing equipment									
Automobile mechanic									
Metal construction									
Mechanical manufacturing									
Management of the environment and fauna	29	6	26	6	35	10	0	0	100
Agro equipment									
Driving agricultural tractors and hitching accessories									

Manufacture of agricultural equipment									
Animal Production									
Agricultural Machinery	37	3	37	3	6	0	0	0	100
Technological Research									
Training in the use and maintenance of equipment									
Rural engineering and Agricultural Mechanization (GRMA)	54	11	54	11	45	7	2	3	100
Maintenance and repair of the automobile tractors									
Computer Aided Design of Agricultural Machinery and Equipment									
Rural development and equipment (AER)									
Rural Infrastructure and Sanitation									
Foundry									
Maintenance of agricultural machinery									
Mechanical Engineering Genetics	26	2	25	2	22	1	2	1	100
Nutrition and Food Technology									
Forestry									
Rural electrification and renewable energy									
Tinsmith									
Renewable energy and electronics applied to agricultural machinery									
Fishing and aquaculture									
Energetic Mechanical Engineering	11	0	11	0	10	0	0	0	100

Table 43. Program description of selecgted research centers

List of programs offered in this institution	Total number of applicants		Total number enrolled		Number of those who completed the program (last graduation)		Number of those who dropped –out of the program in the last graduating group		Is this program accredited?
	Male	Female	Male	Female	Male	Female	Male	Female	

Vegetable production									
Manufacture of agro-food processing equipment	0	0	0	0	13	0	0	0	100
Automobile mechanic									
Metal construction									
Mechanical manufacturing									
Management of the environment and fauna									
Agro equipment									
Driving agricultural tractors and hitching accessories									
Manufacture of agricultural equipment									
Animal Production									
Agricultural Machinery									
Technological Research									
Training in the use and maintenance of equipment									
Rural engineering and Agricultural Mechanization (GRMA)									
Maintenance and repair of the car tractor	0	0	0	0	1	0	0	0	100
Computer Aided Design of Agricultural Machinery and Equipment									
Rural development and equipment (AER)									
Rural Infrastructure and Sanitation									
Foundry									
Maintenance of agricultural machinery	0	0	0	0	3	0	0	0	100
Mechanical Engineering Genetics									
Nutrition and Food Technology									
Forestry									
Rural electrification and renewable energy									
Tinsmith									

Renewable energy and electronics applied to agricultural machinery	0	0	0	0	0	0	0	0	100
Fishing and aquaculture									
Energetic Mechanical Engineering									

Table 44. Program description for higher agricultural colleges

List of programs offered in this institution	Total number of applicants		Total number enrolled		Number of those who completed the program (last graduation)		Number of those who dropped –out of the program in the last graduating group		Is this program accredited?
	Male	Female	Male	Female	Male	Female	Male	Female	
Vegetable production	103.4 44.95	27.2 9.67	101.2 41.17	26 7.90	89.2 43.66	48.6 32.02	1.6 2.30	3.2 4.08	100
Manufacture of agro-food processing equipment									
Automobile mechanic									
Metal construction									
Mechanical manufacturing									
Management of the environment and fauna									
Agro equipment	8.5 7.77	.5 .70	8.5 7.77	.5 .70	10 14.14	0 0	0 0	0 0	100
Driving agricultural tractors and hitching accessories									
Manufacture of agricultural equipment									
Animal Production	142.2 41.24	52.4 32.42	140.2 43.49	50 30.63	115.4 49.63	64.2 33.96	1.4 3.13	1.8 4.02	100
Agricultural Machinery									
Technological Research									
Training in the use and maintenance of equipment									
Rural Engineering and Agricultural Mechanization (GRMA)									
Maintenance and repair of the automobile tractors									
Computer Aided Design of Agricultural									

Machinery and Equipment									
Rural development and equipment (AER)	21 10.22	1.6 1.51	21 10.22	1.6 1.51	16.8 6.53	1.2 1.09	.2 .44	.2 .44	100
Rural Infrastructure and Sanitation	2	0	3	0	0	0	0	0	0
Foundry									
Maintenance of agricultural machinery									
Mechanical Engineering Genetics									
Nutrition and Food Technology	28.8 27.55	18.6 11.63	27.2 26.30	18.2 11.75	23.5 25.33	16.5 15.08	0 0	0 0	100
Forestry	20.75 15.92	5 4.39	18.75 16.37	4.75 4.27	17.66 22.50	4.66 5.03	0 0	0 0	100
Rural electrification and renewable energy									100
Tinsmith									
Renewable energy and electronics applied to agricultural machinery									
Fishing and aquaculture	31.4 22.52	6 5.33	31.4 22.52	11.6 15.53	29.25 27.94	6 6.05	.75 1.5	.25 .5	80
Energetic Mechanical Engineering									

Table 45. Program description for selected private training centers

List of programs offered in this institution	Total number of applicants		Total number enrolled		Number of those who completed the program (last graduation)		Number of those who dropped –out of the program in the last graduating group		Is this program accredited?
	Male	Female	Male	Female	Male	Female	Male	Female	
Vegetable production									
Manufacture of agro-food processing equipment	2	0	2	0	2	0	0	0	100
Automobile mechanic	3	1	1	1	0	0	2	1	0
Metal construction	7.87 8.64	0 0	7.87 8.64	0 0	4.5 7.13	0 0	.25 .46	0 0	62.50
Mechanical manufacturing	4.66 2.08	0 0	4.66 2.08	0 0	1.33 1.15	0 0	.33 .57	0 0	66.67
Management of the environment and fauna									
Agro equipment									
Driving agricultural tractors and hitching accessories	2 2.82	0 0	2 2.82	0 0	2.5 .70	0 0	2 2.82	0 0	50

Manufacture of agricultural equipment									
Animal Production									
Agricultural Machinery									
Technological Research	4	0	4	0	2	0	0	0	0
Training in the use and maintenance of equipment	0	0	0	0	37	0	0	0	0
Rural Engineering and Agricultural Mechanization (GRMA)									
Maintenance and repair of automobile tractors	0	0	0	0	1	0	0	0	50
Computer Aided Design of Agricultural Machinery and Equipment									
Rural development and equipment (AER)									
Rural Infrastructure and Sanitation									
Foundry	0	0	0	0	0	0	0	0	0
Maintenance of agricultural machinery									
Mechanical Engineering Genetics									
Nutrition and Food Technology									
Forestry									
Rural electrification and renewable energy									
Tinsmith	0	0	0	0	0	0	0	0	0
Renewable energy and electronics applied to agricultural machinery									
Fishing and aquaculture									
Energetic Mechanical Engineering									

Program description (agricultural mechanization program(s))

Tables 47 and 48 present the description of the mechanization programs in public and private institutions. Mechanization programs on manufacture of agroprocessing equipment and metal construction were provided in private institutions. The duration to complete these programs was 36 months or less. The number of teachers participating in the two programs was 2 and 4 respectively.

A revision of the program curricula was last carried out 17 months before the study.
Graduates of agrifood processing equipment manufacturing got jobs almost immediately, while those of metal construction program got job within 4 months after graduation.
Rural engineering and agricultural mechanization program and agro equipment program were provided in public institutions for an average duarion of 45 and 10 months, respectively.
The number of teachers in these programs was 15 and 10, respectively.
A revision in the program curricula was carried out 32 and 3.5 months before the study.
Agro equipment graduates got job about 1.5 months, compared to those of agricultural engineering and agricultural mechanization, who got theirs 3 months after graduation.
The manufacture of agricultural equipment program, rural development and equipment program and agricultural machinery program were provided in public institutions, for an average duration of 29, 3o and 15 months, respectively. The number of professors / teachers participating in the programmes was 40, 3 and 6, respectively. A revision of program curricula was done at least 10 months before the study. Moreover, graduates in the agricultural equipment manufacturing program got job almost immediately, unlike those of rural development and equipment, who waited up to 10 months before they secured a job.

The research and innovation program, training in the use and maintenance of equipment program, and maintenance and repair of tractor program were taught in private institutions for the average duration of 3, 43 and 1 month respectively. The number of teachers was 1, 4 and 2, respectively. The revision of training curricula program in the use and maintenance of equipment was last done 14 months before the research, while those of the other two programs (research and innovation, and tractor maintenance and repair) were about 3 months before the research. Graduates of the 3 programs secured a job almost immediately.

Maintenance of agricultural machinery program and computer-aided design program were provided in public institutions for a period of 1 month each. A change in the curriculum of agricultural machinery maintenance program was carried out 5 months before the study, that of computer-aided design about 1 month before the study. Graduates of both programs almost immediately secured job.
In public institutions, programs that ran for long period of time and, thus, required more teachers were rural engineering and agricultural mechanization, rural development and equipment, and agricultural machinery. Short duration programs were those related to the production of agricultural equipment.
Programs in public institutions with high labour market prospects were: manufacture of agricultural equipments, agricultural machinery, maintenance of agricultural machinery, computer aided design, agro equipment, and rural engineering and agricultural mechanization. Inprivate institutions, long duration programs were those related to metal construction, tractor maintenance and repair, mechanical manufacturing, and manufacturing food processing equipment. Short duration programs were those in training in the use and maintenance of equipment, driving tractor and coupling props, research and innovation. All programs of private institutions had high labour market prospect.

Table 46. Mecanisation Program description in public institutions

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment				
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization	45	15	32	3
Agro equipment	10.5 10.60	10 0	3.5 .70	1.5 2.12
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment	15	3	10	0
Rural development and equipment	29.2 10.25	6.4 1.51	8.6 5.63	9.6 13.14
Agricultural Machinery	30	40	10	0
Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery	1	2	5	0
Computer Aided Design	1	2	1	0

Table 47. Mecanisation Program description in private institutions

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment				
Manufacture of agro-food processing equipment	12	2	17	0
Metal construction	33.75 18.88	3.75 2.37	16.625 10.08	.375 .51
Rural Engineering and Agricultural Mechanization				
Agro equipment				
Mechanical manufacturing	12	3	18	1
Tractor driving and coupling of accessories	1.5 .70	2 1.41	20.5 4.94	.5 .70
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery				
Research and Innovation	3	1	2	0
Training in the use and maintenance of equipment	1	4	14	0
Tractor maintenance and repair	42 8.48	2 1.41	3 1.41	0
Maintenance of agricultural machinery				
Computer Aided Design				

Tables 49, 50, 51, 52 present the description of mechanization programs by the type of institution (university, research center, agricultural college, and private training center). The program for rural development and equipment was run at the upper secondary agricultural school level for a period of 29 months. The number of teachers participating in the was 6.
A review of training curriculum was done about 8 months before the survey. Graduates of the program secured a job within a period of 10 months.
At the university level (Table 49), the programs that require more time to be completed were rural engineering and agricultural mechanization (45 months), agricultural machinery (30 months).

These programs also employed a large number of teachers: Rural engineering and agricultural mechanization program had 15 teachers, while agricultural machinery program had 40. The participants in these programs secured jobs within 3 months after graduation. In addition, a curriculum revision of computer-aided design programme was carried out a month before this study.
At the research centers (Table 50), long-term program was that on manufacture of agricultural equipment (15 months), which also had about 3 teachers. Graduates of this course almost immediately got a job, just as those of computer-assisted design and farm machinery maintenance programs. A revision of the curriculum of manufacture of agricultural equipment was carried out about 10 months before this study.

At the level of higher agricultural schools (Table 51), long-term programs were rural development and equipment (29 months), and agro-equipment (10 months). The former had 6 teachers, while the latter had 10 teachers. Graduates of both programs also got jobs in the labour market soon after they completed the training. The curriculum of agro equipment was reviewed about 3 months before this study. Within private training centers, long-term programs comprised those on maintenance and repair of tractor (42 months), manufacture of food processing equipment (36 months), and metallic constructions (34 months), which also had not more than 4 professors in their employ. Participants in these programs also got jobs less than 1 month after graduation.

Table 48. Mechanisation Program description of selected Universities

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment				
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization	45	15	32	3
Agro equipment				
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery	30	40	10	0

Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery				
Computer Aided Design				

Table 49. Mecanisation Program description of selected research centers

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment				
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization				
Agro equipment				
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment	15	3	10	0
Rural development and equipment				
Agricultural Machinery				
Research and Innovation				
Training in the use and maintenance of equipment				

Tractor maintenance and repair				
Maintenance of agricultural machinery	1	2	5	0
Computer Aided Design	1	2	1	0

Table 50. Mecanisation program description of selected higher agricultural colleges

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment	29.2 10.25	6.4 1.51	8.6 5.63	9.6 13.14
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization				
Agro equipment	10.5 10.60	10 0	3.5 .70	1.5 2.12
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery				
Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery				

Computer Aided Design				

Table 51. Mecanisation program description of selected private training centers

Agricultural mechanization program	Number of months to complete the program	Number of teachers / lecturers for this program	Number of months since last content change for courses (curriculum review) was done	Average number of months for graduates of this program to get their first job
Rural development and equipment				
Manufacture of agro-food processing equipment	36	2	17	0
Metal construction	33.75 18.88	3.75 2.37	16.625 10.08	.375 .51
Rural Engineering and Agricultural Mechanization				
Agro equipment				
Mechanical manufacturing	12	3	18	1
Tractor driving and coupling of accessories	1.5 .70	2 1.41	20.5 4.94	.5 .70
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery				
Research and Innovation	3	1	2	0
Training in the use and maintenance of equipment	1	4	14	0
Tractor maintenance and repair	42 8.48	2 1.41	3 1.41	0
Maintenance of agricultural machinery				
Computer Aided Design				

Tables 53, 54, 55, and 56 present data on the jobs / professions of graduates of selected institutions. The data show that rural engineering and mechanization, and agricultural machinery programs allowed their graduates to secure employment in the public sector (100%), the private sector (100%), and as self-employed (100%) (Table 53). Among programs in research centers, agricultural equipment manufacturing and maintenance of agricultural machinery also allowed their graduates to work in the public sector (100%), private sector (100%), and as self-employment (100%) (Table 54).

Graduates of high agricultural colleges could also be employed in the public sector (100%), the private sector (100%), and also in entrepreneurial capacity (100%) (Table 55).
In private training centers, graduates of the use and maintenance of equipment, and research and innovation could primarily be employed in the public sector (Table 56). The mechanical manufacturing program promoted self-employment. The metal construction program offers low market access in the public sector (12.5%), and a strong private sector outlet (75%), as well as self-employment capacity (87.5%) (Table 56).

Table 52. Expected jobs/ occupations for graduates of selected Universities

Agricultural mechanization program	Expected types of jobs/ occupations for graduates			
	Government employment	Private-sector employment	Self-employment	others
Rural development and equipment				
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization	100	100	100	0
Agro equipment				
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery	100	100	100	0
Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery				
Computer Aided Design				

Table 53. Expected jobs/ occupations for graduates of selected research centers

Agricultural mechanization program	Expected types of jobs/ occupations for graduates			
	Government employment	Private-sector employment	Self-employment	others
Rural development and equipment				
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization				
Agro equipment				
Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment	100	100	100	0
Rural development and equipment				
Agricultural Machinery				
Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery	100	100	100	0
Computer Aided Design	100	100	100	0

Table 54. Expected jobs/ occupations for graduates of selected higher agricultural colleges

Agricultural mechanization program	Expected types of jobs/ occupations for graduates			
	Government employment	Private-sector employment	Self-employment	others
Rural development and equipment	100	100	100	0
Manufacture of agro-food processing equipment				
Metal construction				
Rural Engineering and Agricultural Mechanization				
Agro equipment	100	100	100	0

Mechanical manufacturing				
Tractor driving and coupling of accessories				
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery				
Research and Innovation				
Training in the use and maintenance of equipment				
Tractor maintenance and repair				
Maintenance of agricultural machinery				
Computer Aided Design				

Table 55. Expected jobs/ occupations for graduates of private training centers

Agricultural mechanization program	Expected types of jobs/ occupations for graduates			
	Government employment	Private-sector employment	Self-employment	others
Rural development and equipment				
Manufacture of agro-food processing equipment	0	100	100	0
Metal construction	12.50	75.00	87.50	0
Rural Engineering and Agricultural Mechanization				
Agro equipment				
Mechanical manufacturing	0	0	100	0
Tractor driving and coupling of accessories	0	100	100	0
Manufacture of agricultural equipment				
Rural development and equipment				
Agricultural Machinery				
Research and Innovation	100	0	0	0
Training in the use and maintenance of equipment	100	0		
Tractor maintenance and repair	0	100	100	0
Maintenance of agricultural machinery				
Computer Aided Design				

If you had the opportunity to restructure the program, would you recommend changes to content of courses of training within the program?

Tables 57, 58, 59 and 60 present data on the recommendations of respondents on course contents. The data show that agricultural machinery program would have a heavy (100%) restructuring at university levels (Table 57), while rural engineering program and agricultural mechanization program were exempted from restructuring. The change desired in the content of agricultural machinery program related to the increase in practical / applied sessions (Table 61). At the research centers (Table 58), agricultural equipment manufacturing, agricultural machinery maintenance, and computer-assisted design programs were exepmpt from restructuring.
Also, with regard to agricultural high schools (Table 59), 60% of the respondents believed that the content of rural development and equipment program should be restructured; the same goes for the agro-equipment program, where more than half of the trainers recommended restructuring. The changes desired for the programs related to an increase in practical / applied sessions, theoretical sessions, internships, link with the industry and rural development (Table 63). An increase in the time allocated to development and rural equipment and agro equipment program was also strongly advocated (Table 67).

In private training centers (Table 60), 100% of the respondents believed that research and innovation program, the use and maintenance of equipment program, and maintenance and repair of tractor program should not be restructured. Conversely, more than half of the respondents recommended structural changes to tractor driving and hitching accessories program. The respondents showed that the contents of manufacture of food processing equipment, mechanical manufacturing, and metal construction programs should be restructured (Table 60). The type of change desired in agri-food processing equipment manufacturing program related to the increase in the time allotted to practical / applied sessions (Table 64).

A little less than 25% of the respondents from private training centers suggested an increase to the time allotted to practical / applied sessions, program internships in metal construction activities (Table 64). Also, more theoretical sessions were recommended for mechanical manufacturing and tractor driving and hitching accessories programs (Table 64). An increase in the time allocated to the programs (manufacturing of food processing equipment, metal constructions, tractor driving and hitching of accessories, and maintenance and repair of tractor) was strongly advocated (Table 68).

Table 56. Recommendations on content of courses of training in universities

Agricultural mechanization program	If you had the opportunity to restructure program, would you recommend change to the content of training courses within the program?		
	YES, highly recommend	YES, recommend	NO, not recommend
Rural development and equipment			
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			100

Agro equipment			
Mechanical manufacturing			
Tractor driving and coupling of accessories			
Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery	100		
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			
Computer Aided Design			

Table 57. Recommendations on content of courses of training at the research centers

Agricultural mechanization program	**If you had the opportunity to restructure program, would you recommend change to the content of training courses within the program?**		
	YES, highly recommend	**YES, recommend**	**NO, not recommend**
Rural development and equipment			
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			
Agro equipment			
Mechanical manufacturing			
Tractor driving and coupling of accessories			
Manufacture of agricultural equipment			100
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			100
Computer Aided Design			100

Table 58. Recommendations on course contents of training in selected higher agricultural colleges

Agricultural mechanization program	If you had the opportunity to restructure program, would you recommend change to the content of training courses within the program?		
	YES, highly recommend	YES, recommend	NO, not recommend
Rural development and equipment	60		40
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			
Agro equipment	50		50
Mechanical manufacturing			
Tractor driving and coupling of accessories			
Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			
Computer Aided Design			

Table 59. Recommendations on course contents of training in private training centers

Agricultural mechanization program	If you had the opportunity to restructure program, would you recommend change to the content of training courses within the program?		
	YES, highly recommend	YES, recommend	NO, not recommend
Rural development and equipment			
Manufacture of agro-food processing equipment		100	
Metal construction		50	50
Rural Engineering and Agricultural Mechanization			
Agro equipment			
Mechanical manufacturing		100	
Tractor driving and coupling of accessories	50		50

Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			100
Training in the use and maintenance of equipment			100
Tractor maintenance and repair			100
Maintenance of agricultural machinery			
Computer Aided Design			

Type of content change recommended

Table 60. Type of content change recommended for universities programs

Agricultural mechanization program	Type of content change would be recommended				
	More hand-on /practical sessions	More theoretical sessions	More internships	More linkages with industry etc.	Others
Rural development and equipment					
Manufacture of agro-food processing equipment					
Metal construction					
Rural Engineering and Agricultural Mechanization					
Agro equipment					
Mechanical manufacturing					
Tractor driving and coupling of accessories					
Manufacture of agricultural equipment					
Rural development and equipment					
Agricultural Machinery	100	0	0	0	0
Research and Innovation					

Training in the use and maintenance of equipment					
Tractor maintenance and repair					
Maintenance of agricultural machinery					
Computer Aided Design					

Table 61. Type of content change recommended for research centers

Agricultural mechanization program	Type of content change would be recommended				
	More hand-on /practical sessions	More theoretical sessions	More internships	More linkages with industry etc.	Others
Rural development and equipment					
Manufacture of agro-food processing equipment					
Metal construction					
Rural Engineering and Agricultural Mechanization					
Agro equipment					
Mechanical manufacturing					
Tractor driving and coupling of accessories					
Manufacture of agricultural equipment					
Rural development and equipment					
Agricultural Machinery					
Research and Innovation					
Training in the use and maintenance of equipment					
Tractor maintenance and repair					
Maintenance of agricultural machinery					

Computer Aided Design					

Table 62. Type of content change recommended for higher agricultural colleges

Agricultural mechanization program	Type of content change would be recommended				
	More hand-on /practical sessions	More theoretical sessions	More internships	More linkages with industry etc.	Others
Rural development and equipment	80.00	0	20	20	20
Manufacture of agro-food processing equipment					
Metal construction					
Rural Engineering and Agricultural Mechanization					
Agro equipment	100	100	100	0	100
Mechanical manufacturing					
Tractor driving and coupling of accessories					
Manufacture of agricultural equipment					
Rural development and equipment					
Agricultural Machinery					
Research and Innovation					
Training in the use and maintenance of equipment					
Tractor maintenance and repair					
Maintenance of agricultural machinery					
Computer Aided Design					

Table 63. Type of content change recommended for programs in private training centers

Agricultural mechanization program	Type of content change would be recommended				
	More hand-on /practical sessions	More theoretical sessions	More internships	More linkages with industry etc.	Others
Rural development and equipment					
Manufacture of agro-food processing equipment	0	100	0	0	0
Metal construction	0	50	25	0	25
Rural Engineering and Agricultural Mechanization					
Agro equipment					
Mechanical manufacturing	0	100	0	0	0
Tractor driving and coupling of accessories	0	0	0	0	100
Manufacture of agricultural equipment					
Rural development and equipment					
Agricultural Machinery					
Research and Innovation					
Training in the use and maintenance of equipment					
Tractor maintenance and repair					
Maintenance of agricultural machinery					
Computer Aided Design					

Recommended change to the amount of time allocated to programs

Table 64. Recommended changes to the amount of time allocated to university programs

Agricultural mechanization program	Recommended change to the amount of time allocated to this program		
	No change recommended	Allocate more time	Reduce time allocated
Rural development and equipment			
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			
Agro equipment			
Mechanical manufacturing			
Tractor driving and coupling of accessories			
Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			
Computer Aided Design			

Table 65. Recommended changes to the amount of time allocated to programs in research centers

Agricultural mechanization program	Recommended change to the amount of time allocated to this program		
	No change recommended	Allocate more time	Reduce time allocated
Rural development and equipment			
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			
Agro equipment			
Mechanical manufacturing			
Tractor driving and coupling of accessories			

Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			
Computer Aided Design			

Table 66. Recommended changes to the amount of time allocated to programs in higher agricultural colleges

Agricultural mechanization program	Recommended change to the amount of time allocated to this program		
	No change recommended	Allocate more time	Reduce time allocated
Rural development and equipment		100	
Manufacture of agro-food processing equipment			
Metal construction			
Rural Engineering and Agricultural Mechanization			
Agro equipment		100	
Mechanical manufacturing			
Tractor driving and coupling of accessories			
Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair			
Maintenance of agricultural machinery			
Computer Aided Design			

Table 67. Recommended changes to the amount of time allocated to programs in private training centers

Agricultural mechanization program	Recommended change to the amount of time allocated to this program		
	No change recommended	Allocate more time	Reduce time allocated
Rural development and equipment			
Manufacture of agro-food processing equipment		100	
Metal construction		100	
Rural Engineering and Agricultural Mechanization			
Agro equipment			
Mechanical manufacturing			
Tractor driving and coupling of accessories		100	
Manufacture of agricultural equipment			
Rural development and equipment			
Agricultural Machinery			
Research and Innovation			
Training in the use and maintenance of equipment			
Tractor maintenance and repair		100	
Maintenance of agricultural machinery			
Computer Aided Design			

Information on the teaching/instruction staff

Tables 69, 70, 71 and 72 present the key personnel characteristics of the different training institutes in agricultural mechanization. Two types of teachers were presented: those under long-term contracts, working permanently in the institution (CDI), and those under fixed-term contract, working part-time in the institution (CDD).

At the university level (Table 69), the average age of permanent teachers was 49.5 years, working on the average of 7.5 years in the university and having a general average teaching experience of 21.5 years. Similar characteristics were observed for DFC teachers, but with the mean age of 53.5 years and an average of 20.5 years teaching experience. The results also indicate that there was no female teacher in the field of agricultural mechanization in the selected universities.

As for research centers, there were only long-term contract teachers (CDI) (Table 70), with an average age of 44.66 years and 18.33 years teaching experience. They worked on the average of 7 years in the institution. There was also no female teacher working in the field of agricultural mechanization.

The data on agricultural high schools (Table 71) show that teachers on permanent contracts had an average of 45.25 years, and 11.47 years of teaching experience. Unlike CDI teachers, CDD teachers were on the average younger (33.9 years), less experienced (4.1 years) and had worked

in the institution for 2.8 years. There were a few female teachers among their short-term contract staff (CDD) (Table 71).
Finally, for private training centers, CDI contract teachers were on the average younger (40.77 years), less experienced (15.58 years) and with less seniority in the institution (13.51 years) (Table 72). There was also female teacher in the field of agricultural mechanization in private training centers.

Characteristics of the teaching/instructing staff

Table 68. Characteristics of the teaching/instructing staff of Universities

Type of staff	Characteristics of the teaching/instructing staff			
	Ave. age	Gender (%female)	Years of teaching / instructing in current institute	Total years of teaching / instructing
Regular (long-term contracted / permanent)	49.5 (353)	0.00	7.5 (2.12)	21.5 (0.71)
Temporary (short-term contract) / part-time	53.5 (3.55	0.00	7.5 (2.12)	20.5 (7.77)
Other				

Table 69. Characteristics of the teaching/instructing staff of research centers

Type of staff	Characteristics of the teaching/instructing staff			
	Ave. age	Gender (%female)	Years of teaching / instructing in current institute	Total years of teaching / instructing
Regular (long-term contracted / permanent)	46.66 (19.08)	0.00	7.00 (5.19)	18.33 (15.82)
Temporary (short-term contract) / part-time	-			
Other				

Table 70. Characteristics of the teaching/instructing staff in higher agricultural colleges

Type of staff	Characteristics of the teaching/instructing staff			
	Ave. age	Gender (%female)	Years of teaching / instructing in current institute	Total years of teaching / instructing
Regular (long-term contracted / permanent)	45.25 (7.33)	0.00	6.05 (3.91)	11.47 (5.37)
Temporary (short-term contract) / part-time	33.9 (7.61)	20.00	2.8 (1.51)	4.1 (3.64)
Other				

Table 71. Characteristics of the teaching/instructing staff in private training centers

Type of staff	Characteristics of the teaching/instructing staff			
	Ave. age	Gender (%female)	Years of teaching / instructing in current institute	Total years of teaching / instructing
Regular (long-term contracted / permanent)	40.77 (12.51)	0.00	13.51 (11.84)	15.58 (12.26)
Temporary (short-term contract) / part-time	62.00 (0.00)	0.00	25.00 (0.00)	27.00 (0.00)
Other				

Highest level of education of respondents

At the university (Table 73), all long-term contract / CDI teachers had PhDs, while half of temporary (CDD)/ part-time staff had, at least, a postgraduate degree.
In research centers, high agricultural schools and private training centers (Tables 74, 75 and 76), all teachers under long-term contract / CDI had a university degree. The aggregate data show that 33.33% of the teachers with long-term contract / permanent contract had a doctorate, 33% had a master's degree and 33% had a bachelor's degree. At the high school level, 75% of teachers on long-term contract / open-ended contract had a master's degree, while 70% of those who worked temporarily (CDD) / on part-time had a bachelor's degree (or its equivalent).

Table 72. Highest level of education (university level)

Type of staff	Highest level of education				
	University post graduate (PhD)	University post graduate (Master or equiv.)	University graduate (bachelors or equiv.)	Technical training (higher diploma or equiv.)	Other
Regular (long-term contracted / permanent)	100.00				
Temporary (short-term contract) / part-time	50.00	50.00			
Other					

Table 73. Highest level of education (research centers)

Type of staff	Highest level of education				
	University post graduate (PhD)	University post graduate (Master or equiv.)	University graduate (bachelors or equiv.)	Technical training (higher diploma or equiv.)	Other
Regular (long-term contracted / permanent)	33.33	33.33	33.33		
Temporary (short-term contract) / part-time					
Other					

Table 74. Highest level of education (higher agricultural college level)

Type of staff	Highest level of education				
	University post graduate (PhD)	University post graduate (Master or equiv.)	University graduate (bachelors or equiv.)	Technical training (higher diploma or equiv.)	Other
Regular (long-term contracted / permanent)	6.25	75.00	18.75		
Temporary (short-term contract) / part-time	10.00	10.00	70.00	10.00	
Other					

Table 75. Highest level of education (private training center level)

Type of staff	Highest level of education				
	University post graduate (PhD)	University post graduate (Master or equiv.)	University graduate (bachelors or equiv.)	Technical training (higher diploma or equiv.)	Other
Regular (long-term contracted / permanent)	19.35	29.03	25.58	3.58	25.81
Temporary (short-term contract) / part-time	100.00				
Other					

Would you recommend further training for the staff?

At the level of all institutions, more than 80% of the respondents recommended additional training for regular teachers (long-term contract / CDI). The training recommended wasrelated to curriculum development (100% of respondents from the universities and research centers, Tables 77, 78, 81 and 82). At the agricultural school level (Tables 79 and 83), the training recommended concerned practical courses (46.15%) and curriculum development (38.46%). In private training centers (Tables 80 and 84), the respondents recommended training in basic technical skills (32.00%) and curriculum development (28.00%).

For those working temporarily (CDD) / part-time at the universities (Table 81), and agricultural high schools (Table 83), about half of the respondents recommended additional training. Also, 40% of higher agricultural college respondents strongly recommended additional training for teachers working on a temporary (CDD) / part-time basis. The courses recommended were curriculum development (75.00%) and basic technical skills (25.00%). In short, additional training was recommended for all teachers. The recommended courses were mainly in curriculum development and basic technical skills.

Table 76. Data on recommended further training for staff of uUniversity

Type of staff:	Would you recommend further training for the staff?			
	Highly recommend	Recommend	Indifferent	Not recommend
Regular (long-term contracted / permanent)		100.00		
Temporary (short-term contract) / part-time		50.00		50.00
Other				

Table 77. Data on recommended training for staff of research centers

Type of staff:	Would you recommend further training for the staff?			
	Highly recommend	**Recommend**	**Indifferent**	**Not recommend**
Regular (long-term contracted / permanent)		100.00		
Temporary (short-term contract) / part-time				
Other				

Table 78. Data on recommended training for staff of higher agricultural colleges

Type of staff:	Would you recommend further training for the staff?			
	Highly recommend	Recommend	Indifferent	Not recommend
Regular (long-term contracted / permanent)		81.25	18.75	
Temporary (short-term contract) / part-time	40.00	60.00		
Other				

Table 79. Data on recommended training for staff of Private training centers

Type of staff:	Would you recommend further training for the staff?			
	Highly recommend	**Recommend**	**Indifferent**	**Not recommend**
Regular (long-term contracted / permanent)		86.21	10.34	3.45
Temporary (short-term contract) / part-time				
Other				

Table 80. Types of further training recommended for staff of universities

Type of staff:	Type of further training recommend for the staff				
	Core / course technical competencies	Hands-on skills equipment / machine	Curriculum development	IT, communication & interpersonal skills	Other
Regular (long-term contracted / permanent)	0.00	0.00	100.00		
Temporary (short-term contract) / part-time	0.00	0.00			
Other					

Table 81. Types of further training recommended for staff of research centers

Type of staff:	Type of further training recommend for the staff				
	Core / course technical competencies	Hands-on skills equipment / machine	Curriculum development	IT, communication & interpersonal skills	Other
Regular (long-term contracted / permanent)	0.00	33.33	100.00		
Temporary (short-term contract) / part-time					
Other					

Table 82. Types of further training recommended for staff of higher agricultural colleges

	Type of further training recommend for the staff				
Type of staff:	Core / course technical competencies	Hands-on skills equipment / machine	Curriculum development	IT, communication & interpersonal skills	Other
Regular (long-term contracted / permanent)	15.38	46.15	38.46		
Temporary (short-term contract) / part-time	0.00	25.00	75.00		
Other					

Table 83. Types of further training recommended for staff of private training centers

	Type of further training recommend for the staff				
Type of staff:	Core / course technical competencies	Hands-on skills equipment / machine	Curriculum development	IT, communication & interpersonal skills	Other
Regular (long-term contracted / permanent)	32.00	4.00	28.00		
Temporary (short-term contract) / part-time					
Other					

Program content, admission, and delivery (regular courses)

Tables 85, 86, 87 and 88 present information on the content, admission and progress of courses in mechanization programs. The data show the regularly taught courses at the university (Table 85), higher agricultural college (Table 87), and private training center levels (Table 88). Short-term courses were exempted from research centers (Table 86) and private training centers.

All courses in regular curricula were treated as core modules at the university, agricultural college, and private training center. Short-term courses were also treated as compulsory at the private training centers (Table 88), and universities (Table 85). Half of the university trainers surveyed indicated, however, that these courses were optional.

The total number of students enrolled in regular training programs was higher for universities (25) than agricultural high schools (18), and private training centers (6). In the case of short-term training, 2 students were enrolled in private training centers

The number of students who completed regular training the previous school year was higher at the high agricultural school (13) than university (8). For short-term courses, the number was: 13 for private training centers (Table 88) and 7 for research centers (Table 86). There was negligible dropout rate among private training centers, mainly due to lack of money. For regular training, dropout was due mainly to lack of interest (75%) and lack of money for tuition (25%).

With regard to short-term courses, the proportion of practical courses was high at private training centers (50%) and research centers (78.33%). On training duration in private training centers, regular training was for an average of 24 months (and 15 months for agriculutural high school), while short courses generally lasted for about 2 months (Table 88). The relevance of all courses in terms of their ability to provide the required knowledge and skills was assessed; the results showed that they were relatively adequate.

Table 84. Program content, admission, and delivery (regular courses) (university level)

Particulars	Short	Regular	Difference
Nature of the course			
Compulsory (core)	50.00	100.00	-
Optional (selective)	50.00		
Total number of students signed for the course	0.00 (0.00)	25.5 (14.74)	
Total number of lecturers who can teach this course	0.00 (0.00)	1.63 (1.71)	
Number of students who completed (last academic year)	0.00 (0.00)	7.83 (2.52)	
Number of those who dropped–out of the course in the last graduating group	0.00 (0.00)		
Reasons for dropping out:			
Lack of fees			
Lack of interest			
Program difficult			
Program irrelevant			
Other			
Proportion of the course that is hands-on (%)		40.00 (0.00)	
Time it takes to complete (months)		1.63 (1.62)	
Adequacy of this course in terms of its ability to produce graduates with the required knowledge and skills			
Excessive			
Adequate		100.00	
Inadequate			

Table 85. Program content, admission, and delivery (regular courses) (research centers)

Particulars	Short	Regular	Difference
Nature of the course			
Compulsory (core)	0.00	-	
Optional (selective)	0.00		
Total number of students signed for the course	0.00 (0.00)		

Total number of lecturers who can teach this course	2.00 (0.81)		
Number of students who completed (last academic year)	7.00 (6.92)		
Number of those who dropped–out of the course in the last graduating group	0.00 (0.00)		
Reasons for dropping out:			
Lack of fees			
Lack of interest			
Program difficult			
Program irrelevant			
Other			
Proportion of the course that is hands-on (%)	78.33 (5.77)		
Time it takes to complete (months)	1.00 (0.00)		
Adequacy of this course in terms of its ability to produce graduates with the required knowledge and skills			
Excessive			
Adequate	100.00		
Inadequate			

Table 86. Program content, admission, and delivery (regular courses) (higher agricultural college)

Particulars	Short	Regular	Difference
Nature of the course			
Compulsory (core)	0.00	100.00	
Optional (selective)	0.00		
Total number of students signed for the course	0.00 (0.00)	17.84 (3.88)	
Total number of lecturers who can teach this course	0.00 (0.00)	1.60 (0.93)	
Number of students who completed (last academic year)	0.00 (0.00)	13.35	
Number of those who dropped–out of the course in the last graduating group	0.00 (0.00)		
Reasons for dropping out:			
Lack of fees			
Lack of interest			
Program difficult			
Program irrelevant			
Other			
Proportion of the course that is hands-on (%)		40.31 (2.5)	
Time it takes to complete (months)		15.18 (9.19)	
Adequacy of this course in terms of its ability to produce graduates with the required knowledge and skills			
Excessive			
Adequate		100.00	
Inadequate			

Table 87. Program content, admission, and delivery (regular courses) (private training centers)

	Short	Regular	Difference
Nature of the course			
Compulsory (core)	100.00	100.00	
Optional (selective)			
Total number of students signed for the course	1.6 (2.19)	6.38 (8.16)	-1.27
Total number of lecturers who can teach this course	2.2 (0.83)	2.27 (1.40)	-3.24 **

Number of students who completed (last academic year)	13.20 (15.80)	1.83 (0.78	
Number of those who dropped–out of the course in the last graduating group	0.80 (1.78)	0.22 (0.42)	-1.31
Reasons for dropping out:			
Lack of fees	100.00	25.00	-1.36
Lack of interest	100	75.00	-0.55
Program difficult			
Program irrelevant			
Other			
Proportion of the course that is hands-on (%)	50.00 (0.00)	86.94 (9.87)	
Time it takes to complete (months)	1.80 (0.44)	24.28 (16.28	-3.08 **
Adequacy of this course in terms of its ability to produce graduates with the required knowledge and skills?			
Excessive			
Adequate	100.00	100.00	
Inadequate			

Resources and finances

The analysis in Table 89 shows that universities providing mechanization courses averaged an annual budget of CFA 200 million in 2018. Compared to the CFA17 million of 2014- 2017, this budget was huge and significant. Specific budget allocations to the agricultural mechanization department / program, however, followed the same trend as the institutional budget, which experienced a sharp increase between 2014- 2017 (CFA 2,299,167) and 2018 (CFA 108,000,000). About 70% of this budget came as government grants. Other sources of funding were student tuition (20%) and contributions from third parties or donors (10%). These results indicate that training programs in agricultural mechanization occupies an important place in Benin. However, government efforts must be accompanied by those of universities and others to achieve some level of financial adequacy. More than 75% of university students financed their studies themselves, while the rest 25% received a form of state subsidy.

Table 88. Resources and finances (for universities)

Category 1: Universities	**Public**	**Private**	**Statistical difference**
Total budget in 2018	200000000 (2120000)		
Ave. Annual average total budget in 2014-2017:	17033330 (7039224)		
Annual total budget for agricultural mechanization department/program in 2018	108000000 (1240000)		
Annual average total budget for agricultural mechanization department/program in 2014-2017:	2299167 (1130000)		
Sources of institute's finances (%)			
Government grants	70.00		
Student fees/levies	20.00 (0.00)		
Bank loans	0.00 (0.00)		
Third-party funds (e.g. donors)	10.00 (0.00)		
Own-sources (e.g. business)	0.00 (0.00)		
Other			

Agricultural mechanization program only			
Proportion of students (%) financing (paying fees) their studies by:			
Government grants	25.00 (0.00)		
Own-sources	75.00 (0.00)		
Other scholar-ships	0.00 (0.00)		
Other			

The results in Table 90 indicate that research centers had a total budget of about 7 billion in 2018, a significant increase over the 329 million of 2014 - 2017. The agricultural mechanization department / program occupied a prominent place at these centres, with about 4 billion of the 2018 budget being allocated to it, a sharp rise from the 234 million of 2014-2017. This is proof that capacity building in agricultural mechanization is strategic to improving Benin's agricultural performance. Research centers got all their financial resources through government grants and projects. All students at the centers also pay for their studies through government grants and projects.

Table 89. Resources and finances (of research centers)

Category 2: Research centers	**Public**	**Private**	**Statistical difference**
Total budget in 2018	7000000000 (0.00)		
Ave. Annual average total budget in 2014-2017:	329000000 (12700000)		
Annual total budget for agricultural mechanization department/program in 2018	4000000000 (0.00)		
Annual average total budget for agricultural mechanization department/program in 2014-2017:	234000000 (90500000)		
Sources of institute's finances (%)			
Government grants			
Student fees/levies	0.00 (0.00)		
Bank loans			
Third-party funds (e.g. donors)			
Own-sources (e.g. business)			
Other	100.00		
Agricultural mechanization program only			
Proportion of students (%) financing (paying fees) their studies by:			
Government grants	0.00		
Own-sources	0.00 (0.00)		
Other scholar-ships	100.00 (0.00)		
Other			

With regard to agricultural high schools, there was a sharp increase in their budget between 2014-2017 (14 million) and 2018 (163 million) (Table 91). The mechanization departments / programs of these agricultural high schools were allocated more than half of the budgets. Financial resources of agricultural schools came from different sources: tuition fees for learners' (60%), grants and projects of government (30%), and school internally generated revenue (10%). A few students also received state grants (34%), while the majority (66%) finance their studies.

Table 90. Resources and finances (for higher agricultural colleges)

Category 3: Agricultural high college	Public	Private	Statistical difference
Total budget in 2018	163000000 (6510000)		
Ave. Annual average total budget in 2014-2017:	14000000 (65600000)		
Annual total budget for agricultural mechanization department/program in 2018	109000000 (4840000)		
Annual average total budget for agricultural mechanization department/program in 2014-2017:	7641559 (3610000)		
Sources of institute's finances (%)			
Government grants			
Student fees/levies	59.5 (19.73)		
Bank loans	0.00 (0.00)		
Third-party funds (e.g. donors)			
Own-sources (e.g. business)	10.00 (4.42)		
Other	30.50 (23.78)		
Agricultural mechanization program only			
Proportion of students (%) financing (paying fees) their studies by:			
Government grants	33.83 (30.33)		
Own-sources	66.16 (30.33)		
Other scholar-ships	-		
Other	-		

In private training centers, the total budget in 2018 was CFA 1,060,000,000, a significant increase the CFA 51,900,000 of 2014-2017. Unlike other institutions, most of the financial resources of private training centers come from internally generated revenue (service delivery) (95.63%); and about 80% of their student self-financed their studies. Only 20% of the students got training grants.

Table 91. Resources and finances (Private training centers)

Category 4: Private Training Center	Public	Private	Statistical difference
Total budget in 2018		1060000000 (23200000)	
Ave. Annual average total budget in 2014-2017:		51900000 (44000000)	
Annual total budget for agricultural mechanization department/program in 2018		1060000000 (23200000)	
Annual average total budget for agricultural mechanization department/program in 2014-2017:		51200000 (439000000)	
Sources of institute's finances (%)			
Government grants			
Student fees/levies		2.63 (3.22)	
Bank loans		0.00 (0.00)	
Third-party funds (e.g. donors)		1.72 (5.72)	
Own-sources (e.g. business)		95.63 (6.08)	
Other		0.00 (0.00)	
Agricultural mechanization program only			

Proportion of students (%) financing (paying fees) their studies by:			
Government grants		0.00 (0.00)	
Own-sources		80.00 (42.16)	
Other scholar-ships		20.00 (40.45)	
Other			

Tables 93, 94, 95 and 96 present information on the state of physical resources, materials and tools at each training institution. Physical infrastructures (eg, classrooms, workshops, tools / accessories / machines, manuals) were considered inadequate and very inadequate by half of the university respondents (Table 94). At the level of research centres, the respondents indicated that physical infrastructures were also inadequate. On the other hand, textbooks and print media considered being in a good state.

Regarding agricultural high schools (Table 95), 16.67% of the respondents stated that physical infrastructures were adequate, while 83.33% considered them inadequate. Textbooks and print media were also found to be inadequate, as indicated by 66.67% of the respondents. The audio-visual section of the school was adjudged inadequate by 83.33% of the respondents.

Among private training centers (Table 96), the physical infrastructures were found adequate by 45.45% of the respondents. They were considered inadequate by 45.5% and and very inadequate by 9.09% of the respondents. Tools / accessories / machines were considered adequate by 72.73% of the respondents. Textbooks and print media were considered inadequate and very indaadequate by about 45.5% and 9.09% of the respondents, respectively. Moreover, 27.27% of the respondents indicated that the condition of the audio-visual materials was adequate, while 36.36% considered them inadequate.

Table 92. Ranking of current status of the resources (for university)

Type of resource:	Ranking of current status of the resources			
	Excessive	Adequate	Inadequate	Very inadequate
Physical infrastructure (e.g. classes, workshops)			50.00	50.00
Tools, equipment, machinery			50.00	50.00
Textbooks, print media			50.00	50.00
Audio-visual			100.00	
Other				

Table 93. Ranking of current status of the resources (of research centers)

Type of resource:	Ranking of current status of the resources			
	Excessive	Adequate	Inadequate	Very inadequate
Physical infrastructure (e.g. classes, workshops)				100.00
Tools, equipment, machinery				100.00
Textbooks, print media		100.00		
Audio-visual				100.00
Other				

Table 94. Ranking of current status of the resources (for higher agricultural colleges)

Type of resource:	Ranking of current status of the resources			
	Excessive	Adequate	Inadequate	Very inadequate
Physical infrastructure (e.g. classes, workshops)		16.67	83.33	
Tools, equipment, machinery			83.33	16.67
Textbooks, print media			66.67	33.33
Audio-visual		16.67	50.00	33.33
Other				

Table 95. Ranking of current status of the resources (for private training centers)

Type of resource:	Ranking of current status of the resources			
	Excessive	Adequate	Inadequate	Very inadequate
Physical infrastructure (e.g. classes, workshops)		45.45	45.5	9.09
Tools, equipment, machinery		72.73	27.27	
Textbooks, print media		45.45	45.45	9.09
Audio-visual		27.27	36.36	36.36
Other				

Linkages with other stakeholders (private sector, companies / organizations, NGOs)

Tables 97, 98, 99 and 100 present the links with other stakeholders. The tables show that the research cdenters (Table 98) were more in collaboration with the private sector, companies, NGOs, and other public institutions, while the universities (Table 97) collaborated frequently with the private sector, and other companies for 7 years. The linkages with the private sector related mainly to the provision of internship and financial assistance.

Research centers (Table 98) had linkages with the private and public sectors, and were currently working linkages with selected companies and NGOs. The linkages are in areas of financial assistance, internship, Ttechnical collaboration, service delivery and technology solutions supplies.

Agricultural high schools (Table 99) hadrelationship different stakeholders in areas of financial assistance, student exchange, and internship. Private training centers (Table 100) had developed relationships with the private sector, companies, and NGOS for more than 15 years. Their areas of linkages were financial assistance, student exchange, technical collaboration, service delivery, and technology solutions supplies.

a.

Table 96. Types of linkages with stakeholders (university level)

Category of stakeholders	Ave. number of years of collaboration	Type of linkages with this stakeholder				
		Financial assistance	Providing students for training	Providing attachment / internships	Employment of students	Othe r
Private sector	7.00 (2.16)	0.00		100.00		
Companies	7.00 (0.00)	100.00		100.00		

NGOs						
Other (public)	6.7 (0.00)			100.00		

Table 97. Types of linkages with stakeholders (research centers)

Category of stakeholders	Ave. number of years of collaboration	Type of linkages with this stakeholder				
		Financial assistance	Providing students for training	Providing attachment / internships	Employment of students	Other
Private sector	5.50 (5.36)					100.00
Companies	1.00 (0.00)	100.00				100.00
NGOs	1.00 (0.00)					100.00
Other	6.66 (2.31)		66.67			33.33

Table 98. Types of linkages with stakeholders (higher agricultural college)

Category of stakeholders	Ave. number of years of collaboration	Type of linkages with this stakeholder				
		Financial assistance	Providing students for training	Providing attachment / internships	Employment of students	Other
Private sector	3.43 (2.99)		14.29	85.71		
Companies	2.8 (0.44)	100.00		80.00	20.00	
NGOs	4.5 (2.42)	100.00		100.00	16.67	
Other	4.75 (3.09)			100.00		

Table 99. Types of linkages with stakeholders (Private training centers)

Category of stakeholders	Ave. number of years of collaboration	Type of linkages with this stakeholder				
		Financial assistance	Providing students for training	Providing attachment / internships	Employment of students	Other
Private sector	15.00 (0.00)					100.00
Companies	16.66 (11.03)	100.00				100.00
NGOs	25.00 (9.34)	100.00				100.00
Other	0.00 (0.00)		36.36			63.64

Nature of Suggestions made

Table 100. Nature of Suggestion made (University level)

Category of stakeholders	Ever made suggestions concerning study curriculum, delivery methods etc. (%)	Nature of Suggestion made			Considered their suggestions (%)
		Curriculum contents	Course delivery	Other	
private sector	0.00				
companies	0.00				
NGOs	0.00				
Other	0.00				

Research centers

Table 101. Nature of Suggestion made **(**Research centers**)**

Category of stakeholders	Ever made suggestions concerning study curriculum, delivery methods etc. (%)	Nature of Suggestion made			Considered their suggestions (%)
		Curriculum contents	Course delivery	Other	
private sector	0.00				
companies	0.00				
NGOs	0.00				
Other	0.00				

Higher agricultural colleges

Table 102. Nature of Suggestion made (Higher agricultural colleges)

Category of stakeholders	Ever made suggestions concerning study curriculum, delivery methods etc. (%)	Nature of Suggestion made			Considered their suggestions (%)
		Curriculum contents	Course delivery	Other	
private sector	0.00				
companies	0.00				
NGOs	0.00				
Other	0.00				

Private Training Centers

Table 103. Nature of Suggestion made (Private training centers)

Category of stakeholders	Ever made suggestions concerning study curriculum, delivery methods etc. (%)	Nature of Suggestion made			Considered their suggestions (%)
		Curriculum contents	Course delivery	Other	
private sector	0.00				
companies	0.00				
NGOs	0.00				
Other	90.91			100.00	100.00

Inventory and inspection of physical resources, equipment and tools

Tables 105, 106, 107, and 108 present the results of the physical inspection of machines and accessories at the sampled institutions. At the university (Table 105), the accessories used were: milling machine, mechanical machines and tractors and accessories. These facilities were all in averagely good working condition. For the research centers (Table 106), the respondents indicated that the milling machines and lathe were not in good working conditions. On the contrary, the drill, bender, welding machine, rolling machine, apron and didactic tractors were in average conditions.

In higher agricultural colleges (Table 107), the gyrobrushers, machinery of mechanical manufacture and pulverizer were in good working condition, while the tiller was in bad condition. Tractors and accessories in the colleges were also in poor condition, according to 40% of the respondents.

At the private training centers (Table 108), boring machine, gyoline, didactic motor and accessories of coupling were in relatively good working conditions. The forge, gruletine, mortiser, mono-cylinder engine, planer, rolling machine, and didactic tractor were in good condition (100%). The milling machine, hacksaw and conventional lathe were in an average condition for 25% of the respondents, and acceptable condition for 75%. The mortisers at the centers were in good condition (according to 83.33% of the respondents). Drills and welding machine were also in very good working condition.

Table 104. Inventory and inspection of physical resources, equipment and tools (University level)

Particulars	Condition of work				
	Very bad	Bad	Average	Good	Excellent
Tractor accessories					
Boring machine					
Wrought					
Milling			100.00		
Gruletine					
Gyoline					
Forestry mulcher					
Mechanical manufacturing machines			100.00		
Grinder					
Slotting					
Teaching motor and coupling accessories					
Mono cylinder engine					
Tiller					
Drill					
folding machine					
Welding machine					
Hydraulic press					
pulverizer					
dresser					
Rolling					
Mechanical saw					

Apron					
Conventional lathe					
Digital Tower					
Didactic tractors					
Tractors and accessories			100.00		

Table 105. Inventory and inspection of physical resources, equipment and tools (Research centers)

Particulars	Condition of work				
	Very bad	Bad	Average	Good	Excellent
Tractor accessories					
Boring machine					
Wrought					
Milling		100.00			
Gruletine					
Gyoline					
Forestry mulcher					
Mechanical manufacturing machines					
Grinder					
Slotting					
Teaching motor and coupling accessories					
Mono cylinder engine					
Tiller					
Drill			100.00		
folding machine			100.00		
Welding machine			100.00		
Hydraulic press					
pulverizer					
dresser					
Rolling			100.00		
Mechanical saw					
Apron			100.00		
Conventional lathe		100.00			
Digital Tower					
Didactic tractors			100.00		
Tractors and accessories					

Table 106. Inventory and inspection of physical resources, equipment and tools (Higher agricultural colleges)

Particulars	Condition of work				
	Very bad	bad	Average	Good	Excellent
Tractor accessories			100.00		
Boring machine					
Wrought					

Milling					
Gruletine					
Gyoline					
Forestry mulcher			100.00		
Mechanical manufacturing machines			100.00		
Grinder					
Slotting					
Teaching motor and coupling accessories					
Mono cylinder engine					
Tiller		100.00			
Drill					
folding machine					
Welding machine					
Hydraulic press					
pulverizer			100.00		
dresser					
Rolling					
Mechanical saw					
Apron					
Conventional lathe					
Digital Tower					
Didactic tractors					
Tractors and accessories		40.00	60.00		

Table 107. Inventory and inspection of physical resources, equipment and tools (Private training centers)

Particulars	Condition of work						
	Very bad	bad	Average	Good	Excellent		
Tractor accessories							
Boring machine			100.00				
Wrought				100.00			
milling			25.00	75.00			
Gruletine				100.00			
Gyoline			100.00				
Forestry mulcher							
Mechanical manufacturing machines							
grinder			16.67	83.33			
Slotting				100.00			
Teaching motor and coupling accessories			100.00				
Mono cylinder engine				100.00			

tiller							
Drill			22.22	77.78			
folding machine			33.33	66.67			
Welding machine			28.57	57.14	14.29		
Hydraulic press							
Pulverizer			50.00	50.00			
dresser				100.00			
Rolling				100.00			
Mechanical saw			25.00	75.00			
Apron							
Conventional lathe			25.00	75.00			
Digital Tower					100.00		
Didactic tractors				100.00			
Tractors and accessories							

Tables 109, 110, 111, and 112 present the results of the physical inspection of workshop tools in the sampled institutions.
At universities (Table 109), all the mechanical manufacturing equipment were 100% functional, while all the woodwork tools in research centers (Table 110) were in average working condition. The physical inspection of workshop tools at agricultural high schools (Table 111) showed that small working tools, such as keychain and teodolite were 100% functional. With regard to private training centers (Table 112), garage equipment for tractor maintenance were found to be in average working condition, while the engine and grease pump were in good condition. Small work tools and keychain were in average working condition (50% of the respondents) and good working condition (another 50% of the respondents).

Table 108. Physical inspection of tools in the workshops of universities)

Particulars	Condition of work				
	Very bad	bad	Average	Good	Excellent
Garage equipment for the maintenance of tractors					
Level					
Mechanical manufacturing tools			100.00		
Small work tools					
Grease pump					
Keyring					
Keychain and small workshop tools					
Theodolite					

Table 109. Physical inspection of tools in the workshops of research centers

Particulars	Condition of work				
	Very bad	Bad	Average	Good	Excellent
Garage equipment for the maintenance of tractors					
Level					
Mechanical manufacturing tools					
Small work tools			100.00		
Grease pump					
Keyring					
Keychain and small workshop tools					
Theodolite					

Table 110. Physical inspection of tools in the workshops of higher agricultural colleges

Particulars	Condition of work				
	Very bad	bad	Average	Good	Excellent
Garage equipment for the maintenance of tractors					
Level			100.00		
Mechanical manufacturing tools					
Small work tools			100.00		
Grease pump					
Keyring			100.00		
Keychain and small workshop tools			100.00		
Theodolite			100.00		

Table 111. Physical inspection of tools (in the workshops of private training centers

Particulars	Condition de travail				
	Very bad	bad	Average	Good	Excellent
Garage equipment for the maintenance of tractors			100.00		
Level					
Mechanical manufacturing tools					
Small work tools				100.00	
Grease pump			50.00	50.00	
Keyring				100.00	
Keychain and small workshop tools			50.00	50.00	
Theodolite			33.33	66.67	
Garage equipment for the maintenance of tractors					

Discussion

Public institutions offering training in agricultural mechanization in Benin include agricultural secondary schools, universities and research centers. There are also private training centers. The public center category experienced a slight decrease in the number of staff between 2014 and 2018, especially among research centers. The same trend was observed for private institutions. The number of teachers increased in public institutions, especially among agricultural high schools. Also, while the number of male students during the period, that of the female students decreased significantly.

All programs of public institutions were accredited, except that on rural infrastructure and sanitation. The programs with the most applications, enrollments, and graduates in public institutions were: animal production and plant production.

Furthermore, this study found that all programs were accredited in private institutions, except those related to the automotive mechanics, training in the use and maintenance of equipment, technological research, tinsmith and foundry. The programs with the most applications were: metallic constructions, mechanical manufacturing and technological research. Automotive mechanics was the only program with a female student.

Programs with the most number of male dropouts were: automotive mechanics, agricultural tractor driving, and accessory hitching. There was only one female dropout in automobile mechanics.

Mechanization programs that took long to complete public institutions were: rural engineering and agricultural mechanization, rural development and equipment and agricultural machinery. The short-term ones were agricultural equipment manufacturing and agroequipments.
Programs in public institutions with very high market value were: Manufacture of agricultural equipment, agricultural machinery, maintenance of agricultural machinery, computer-aided design, agricultural equipment, and rural engineering and agricultural mechanization.
In private institutions, long-term programswere metal construction, tractor maintenance and repair, mechanical manufacturing, and equipment manufacturing, and agro-processing transformations. Short-term programs included: Training in the use and maintenance of equipment, tractor driving and hitching accessories, and research and innovation.
Mechanization programs with course contents in dire need of restructuring at the university level was agricultural machinery. The area of change related to increase in practical / applied sessions.
With regard to agricultural high schools, rural development and equipment programs were recommended for content review, especially increasing the time allocated ti practical / applied sessions, theoretical sessions, internships, and link with the industry.
At the private training centers, the programs on manufacturing of agro-processing equipment, mechanical manufacturing, and metal construction were recommended for restructuring in the areas of curriculum, practical / applied sessions, and internships.
Two types of teaching staff were present in universities, agricultural colleges and private training centers: long-term contract staff/ permanent staff and teachers with fixed-term contract/ part-time staff. The research centers had only long-term contract teachers. There were no female teachers in the field of agricultural mechanization in universities, research centres and private training centers.
At the university level, all long-term contract / CDI teachers had PhDs, while half of the part time staff had a postgraduate degree. At the research centers, high schools, and private training centers, all teachers under long-term contract had a university degree.
Additional training was recommended for all teachers in the areas of curriculum development and basic technical skills. Both long-term and short-term courses were taught regularly at the universities, agricultural colleges, and private training centers. The total student enrolment in regular programs was higher foruniversities than agricultural schools and private training centers.
The number of graduates of regular programs the previous year was higher at agricultural high schools and universities than the other two training centers. The dropout rate was least in private training centers.
The proportion of practical short-term courses was higher in private training centers and research centers than universities and high schools. All the courses were assessed and found relevant in terms of being adequate in providing the required knowledge and skills.
The larger chunk of universities' annual expenditures were from government grants or projects, while a smaller portion came from student tuition and donations from third parties. The budgets of agricultural colleges and private training centers were sourced mainly from tuition and government grants and projects. Most of the financial resources of private training centers were from internally generated revenues, through services rendered.
Both public and private training centers established and managed linkages with relevant stakeholders. The research centers collaborated a great deal with the private sector, companies, NGOs, and other public sector institutions. Universities also collaborated the private sector and companies. Areas of collaboration were in the provision of internship, student exchange, financial assistance, technical collaboration, service delivery, and technology solutions supplies.

Based on these findings and conclusion, therefore, the following are recommended to promote the development of training centers:
- Provide the different training institutions with the appropriate materials and equipment,
- Organize open days to publicize the training centers to the public,
- Promote financial and technical support for research,
- Restructure training contents/ activities and strengthen the capacity of teachers for effectiveness,
- Build classrooms and equip mechanical workshops,
- Strenthen the curricula with emphasis on practical than theoretical learning,
- Renovate the centers, and provide new modern machines / tools,
- Create an adequate framework for teaching and learning in tractor mechanics,
- Build capacity by recruiting permanent staff,
- Institute a course on leadership and personal development
- Develop a strategy for transferring technologies and knowledge from developed countries (India, Germany and China)

Effects of agricultural mechanization on rural communities

Sampling, data collection and study sites

The methodology consisted of focus group discussions in ten (10) INRAB research-development (R-D) villages and ten (10) control villages. In total, twenty (20) villages in three (3) of seven (7) Agricultural Development Hubs (ADH) were sampled. The selection of villages was made from: a list containing residential addresses of buyers of agricultural equipment of Beninese government; the characterization and evaluation study of the 7 Agricultural Development Hubs (ADH)); and research documents on Benin (MAEP, 2018). Study villages constituted the framework for the operational implementation of agricultural development policies, programs and projects. From the list of buyers/beneficiaries of agricultural equipment of government, each buyer was associated with the ADH and home commune.
The regions of Central and North Benin were characterized with the high use of agricultural machinery and animal draught. Thus, the ADHs in these regions were purposively selected, making ADHs 2, 3 and 4.
The weights of the selected ADHs were calculated based on the number of government beneficiaries in each ADH. At the pilot stage, interviews were conducted in 20 villages (for mean and women). Thus, in line with the operational framework of agricultural development policies, programs and projects, the number of RD villages explored at the selected ADH levels was calculated proportionally to the weight of government tractor beneficiaries in each ADH. That is, the number of government tractor beneficiaries, with $n = \{2, 3, 4\}$:

$$Number\ of\ village\ RD\ sampled\ in\ \mathrm{ADH}_n = 10 \times \frac{X_n}{\sum X_n}$$

Consequently, 3 villages at ADH2, 2 villages in ADH3, 5 villages in ADH4 were selected. The control villages associated with the selected RD villages were systematically selected for the study. This made 20 villages in total (ie, 10 RD villages and 10 control).

Table 112: Distribution of the sampled communes and villages

PDA	Number of beneficiaries per ADH	Number of beneficiaries at the level of the 3 ADH selected	Number of R & D villages sampled by beneficiary weights per ADH	Communes	district	Villages	
						R-D	Control Villages
1	3						
2	230	**230**	**3**	Banikoara	Kokey	kokey	Bensekou
				Gogounou	Bagou	Badou	Dougoulaye
				Pehunco	Ouassa-Pehunco	Soaodou	Ouenagourou
3	78	**78**	2	Materi		Pingou	N'dahonta
				Boukombe	Korontiere	Kouya	Koumagou B
4	233	**233**	**5**	N'dali	Ouenou	Ouenou Centre	Gbegourou
				Ouake	Ouake	Awanla	Mone
				Tchaourou	Tchaourou	Guinirou	Sanson
				Bante		Akatatou	Kpakpavissa
				Dassa	Soclogbo	Miniffi	Gome
5	64						
6	48						
7	216						
Total	872	541	10				

The participants of group discussions were the users, and not owners of the village's agricultural machinery. Also, the owners of the tractor (or tractors) were not present during the discussion, to ensure that the respondents freely expressed their views.
The focus group discussion was organized in two (2) stages in each village in December 2019. First, men and women were separately interviewed; thus, forty (40) focus group discussions were conducted in the sampled villages, ie twenty (20) discussions with women, and twenty (20) with men. Each group consisted of ten (10) participants. Participants were contacted and grouped through local authorities (agents of town halls, village chiefs, agents of DDAEP, ATDA) while the research assistants were factory workers, producers, supervisors of NGOs and leaders of producer groups.

Results

Figures 1, 2, 3, 4, 5, 6 and 7 show the impact of tractors on the farming community or household. The analysis in Figure 1 shows that the introduction of tractor led to considerable reduction in the time allocated to farming operations. At the level of all ADHs, men and women showed that the time saved was generally used to rest, develop leisure activities, off-farm activitie (trade, crafts, etc.), and in value addition (Table 107). The available time also afforded them opportunity to bond with the family and involve members more in decision-making. This enhances family cohesion and positively impacts entrepreneuring spirit of all family members.
The respondents also showed that time saving has favored the reduction of incidences of diseases in the community (Table 107). Moreover, increased off-farm activities improved their income and socioeconomic prosperity, being able to live better life through enhanced access to such assets as television set, radio, mobile phone, etc. This facilitated, therefore, the modernization of their community, with real change occurring at the level of men, women and children. Such improved

prosperity is also noticeable in the birth rate, farm assets, school enrollment, death rate, and agricultural outcomes.

The impact on increasing the number of farm workers was observed by ADH2 men (68%), and ADH3 men (63%) and women (90%) (Table 107).

More than 75.71% of the men in ADH4 showed that the increase in schooling rate has led to an increase in the proportion of business executives from their villages, who then re-invest in the development of their localities (rural electrification, development project, modernization, etc.).

Over 90% of the respondents (men and women) considered that the diversification of cultures favors increased participation of especially women in processing activities, hence the increase in the number of processors in community and the availability of derived / processed products. This implies not only the creation of value-added to basic agricultural products, but also contribution to household food security (diversification of food consumed, improvement of the diet and reduction of the malnutrition rate, especially for children).

The respondents in all the ADHs also indicated that the use of tractor guaranteed farming operations (Figure 2). Indeed, the availability of tractor on a farm was itself an assurance of a good production season ahead; it also stimulated increased agricultural production, and sales contracts in ADH2, ADH3 and ADH4 (more than 80%), and ADH4 (more than 97%) (Table 107). Also, the tractor remains a source of motivation for producers in the sense that they develop the spirit of solidarity, a change of mentality, as opposed to individualism. This made them organize themselves into groups or cooperatives. The majority of respondents (more than 90%) thus expressed that this situation led to increase in agricultural groups or cooperatives in their communities. Increased use of of tractors also increased access to agricultural loans/ credits (Table 107) and number of microfinance institutions in their communities. During an interview, producers affirmed that: "Tractor represents great investment; Achieving thisfeat often help open doors to various banks".

Among other impacts, tractor use reduced drudgery in farming operations (Figure 3). The immediate result of this reduction is the increase in cultivated area and, therefore, productivity, income and improved livelihoods. All respondents in ADH2, ADH3, ADH4, and ADH4 reported this impact (Table 107).

In addition, increased tractor use had facilitated increased market access and exports of produce, thus stimulating local economic growth and development of social and community infrastructures, (reported in ADH2, ADH3 and ADH4). However, the statistics showed that men (82%) were more impacted than women (78%).

Increase in income gave tractor owners financial autonomy, so that they were more able to manage various risks and other contingencies related to production (tractor failure in full service, accidents, etc.). This also gave them the opportunity to diversify into other income-generating activities, and meet family needs: child training, food, etc.

Mechanization impacted positively on the food security need of the various communities. Over 70% of the respondents stated that increased mechanization activities impacted on their food and nutritional security,

Mechanization also positively affect the ecosystem, as reduced drudgery increased such agricultural works as land clearing and machine plowing and, therefore, reduced bush fire which harms the environment and soil fertility. This impact was reported by over 72% of the respondents (Table 107).

Mechanization also allowed farmers to farm with much more precision, with regard to plowing depth, planting, weeding, etc; hence, quality of work and output are enhanced (Figure 4). These also improve the level of fertility of cultivated plots. All the respondents reported this impact in ADH2, ADH3 and ADH4 communities (Table 107).

Mechanization was also found to have created job opportunities for the teeming young population by at least 66% of the respondentsat the study sites. The use of tractor to clear and prepare large areas of land would necessarily result in demand for more manpower to carry out certain non-mechanized operations like fertilizer application and harvesting. The capacity of youth was also enhanced in tractor operations (Figure 5), such as driving and repairing. Consequently, rural-urban migration, as well as incidences of social vices/ insecurity drastically declined in the study sitea. (Table 107).

Conversely, increased mechanization activities affected soil compaction or destruction of the soil layers in the study area (Figure 6). This was closely followed by increased incidences of flooding and / or erosion, which consequently reduced soil fertility and farm yield. Reduced yield meant reduced profit for the farmers.

The excessive desire to increase production using mechanization often drove farmers to pull down trees and open up fallow lands. Such asctivities result in deforestation, which favors desertification. Majority of the respondents at all ADHs pointed to this impact of tractor use (Table 108). Deforestation, declining soil fertility, flooding and erosion are inimical to the ecosystems, and should never be encouraged, especially in this era of climate change.

Furthermore, deforestation impacts on the availability of rural energy source (fuel wood). More than 65% of the respondents stated that activities to cultivate more lands reduced the availability of domestic energy sources for the people.

Moreover, increases in planting and other inputs create new requirements in terms of cost of stump removal and tractor maintenance services; these push up costs of production and push down profits (Figure 7). To meet the rising cost of production, more than 67% of the respondents stated that some producers sold off their livestock and other assets (Table 108), while some borrowed. This implies the risk of indebtedness, failure to repay loans and, ultimately, imprisonment. The impact on herd size is explained by the fact that in rural areas, the availability of livestock is a form of security for peasants in times of unforeseen danger.

The majority of producer respondents (95% of men and 94% of women) showed many tractor owners failed in their contractual agreement with farmers due to poor tractor maintenance regimes (Table 108), which made farmers to fall short of theagricultural calendar. Indeed, tractor breakdown could be caused by unavailability of quality spare parts, or the lack of qualified machinists and mechanics, or non-compliance with technical standards (for example, accessories not adapted to the tractor power). Consequently, some farmers abandoned the use of tractors in subsequent seasons and returnedto animal traction or manual tools.

More than 60% of the respondents also indicated that increased use of tractor had somewhat supported gender inequalities (against women), which fuelled social tensions / disagreement between men and women (Table 108). Tractor owners or service providers tended to prioritize men and large producers over women and smallholders, thus marginalizing the latter.

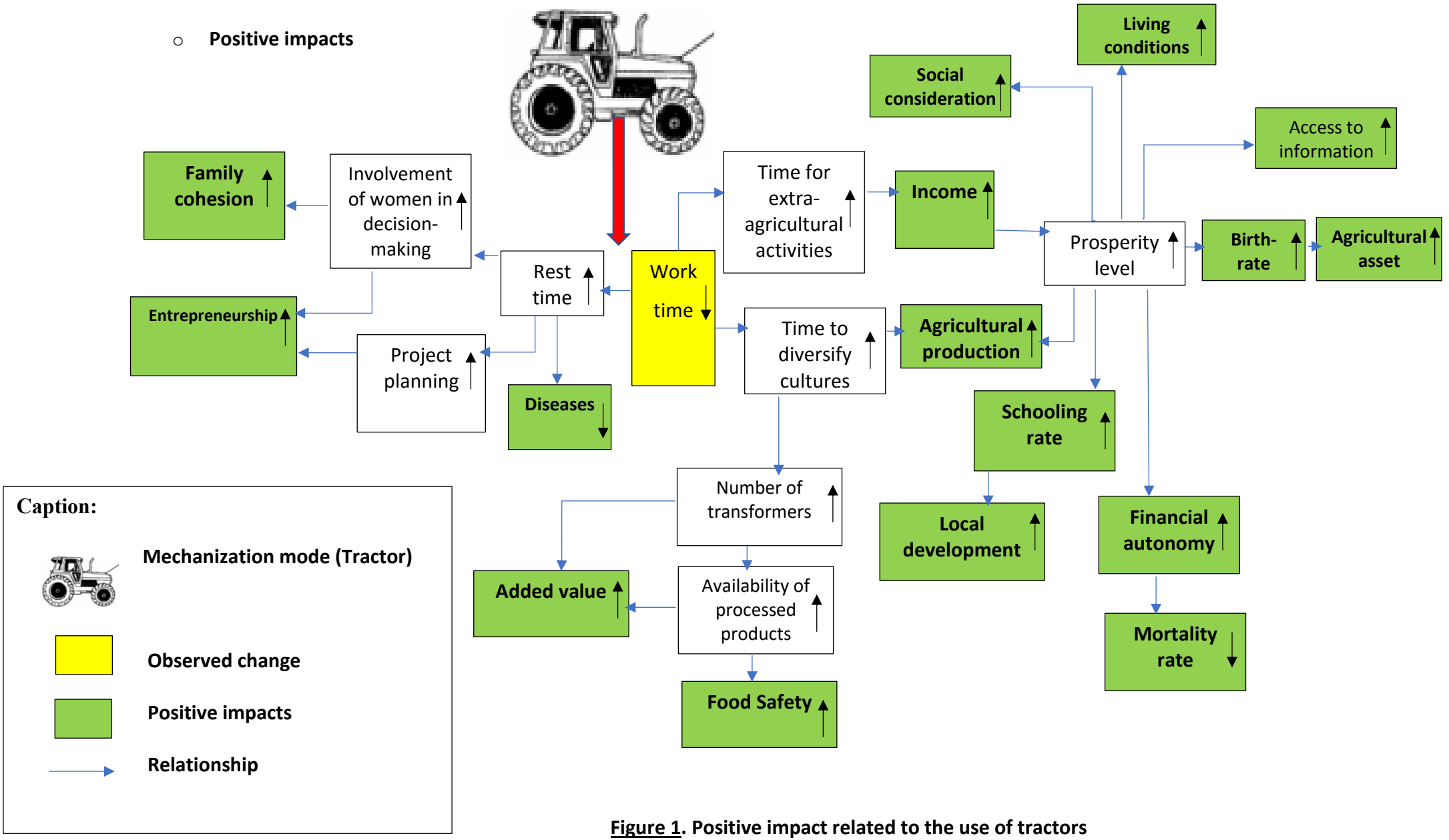


Figure 1. Positive impact related to the use of tractors

- **Positive impacts**

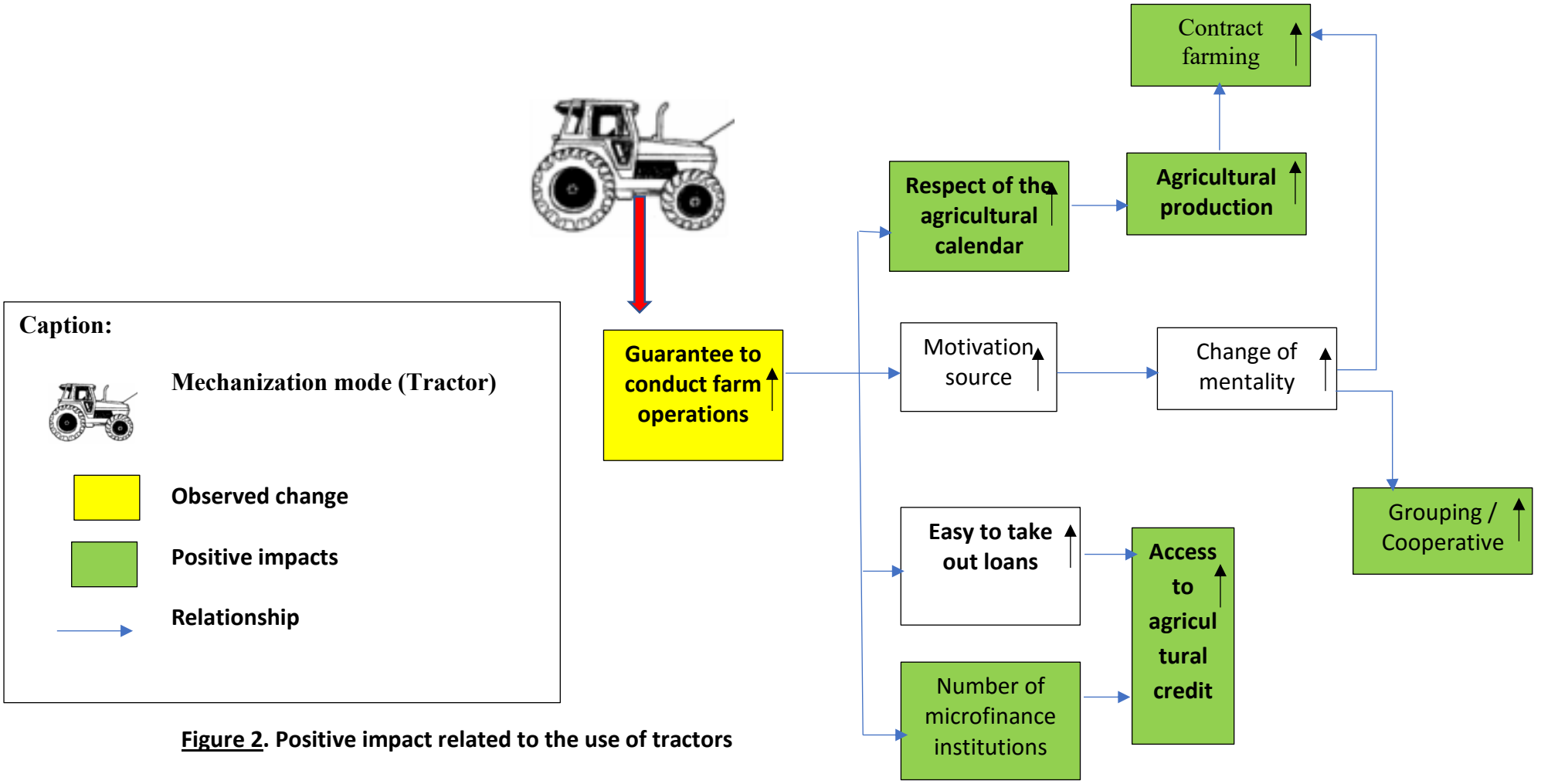


Figure 2. Positive impact related to the use of tractors

- **Positive impacts**

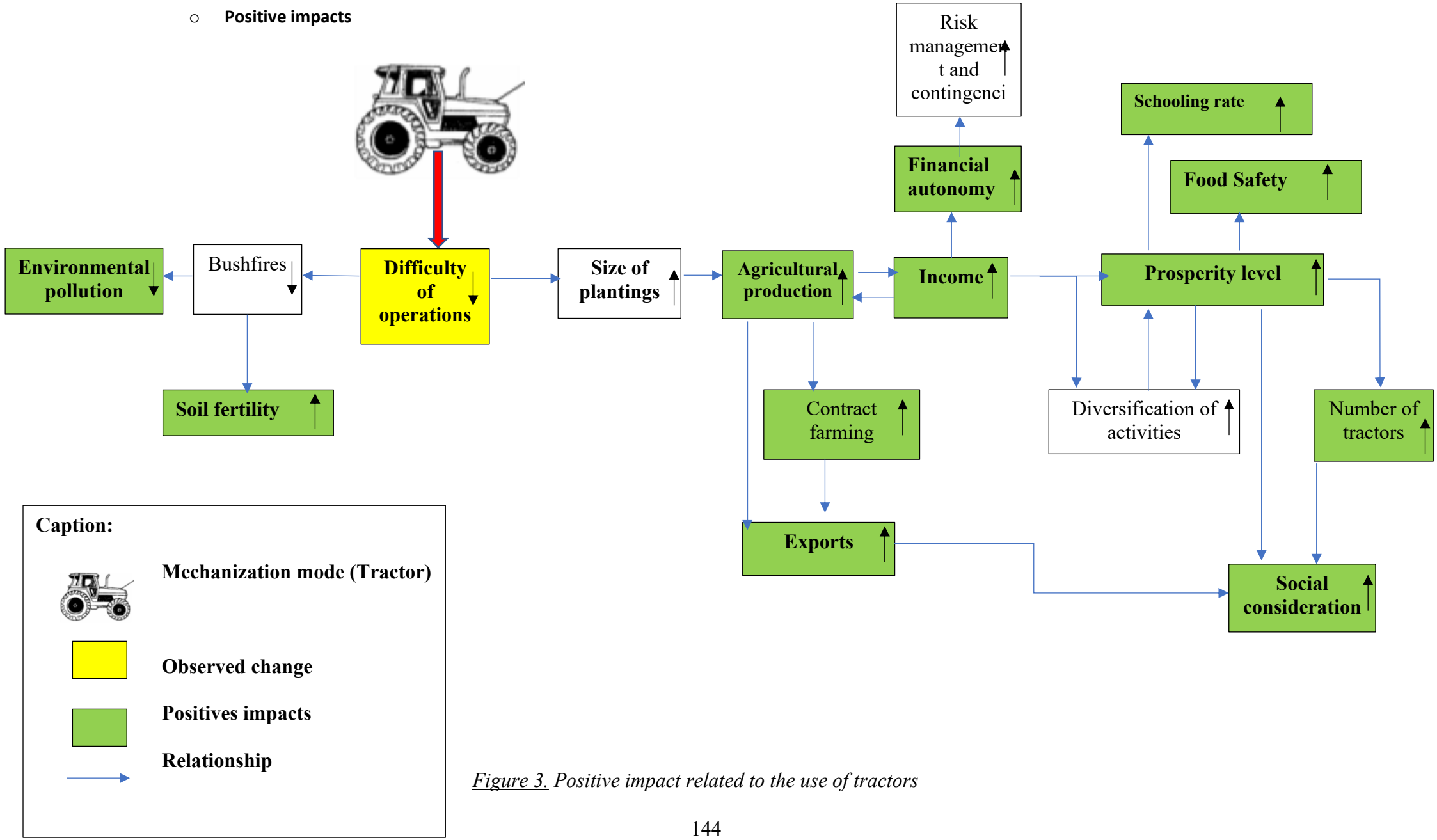
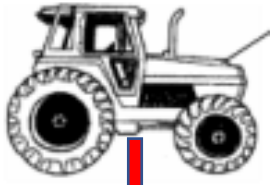
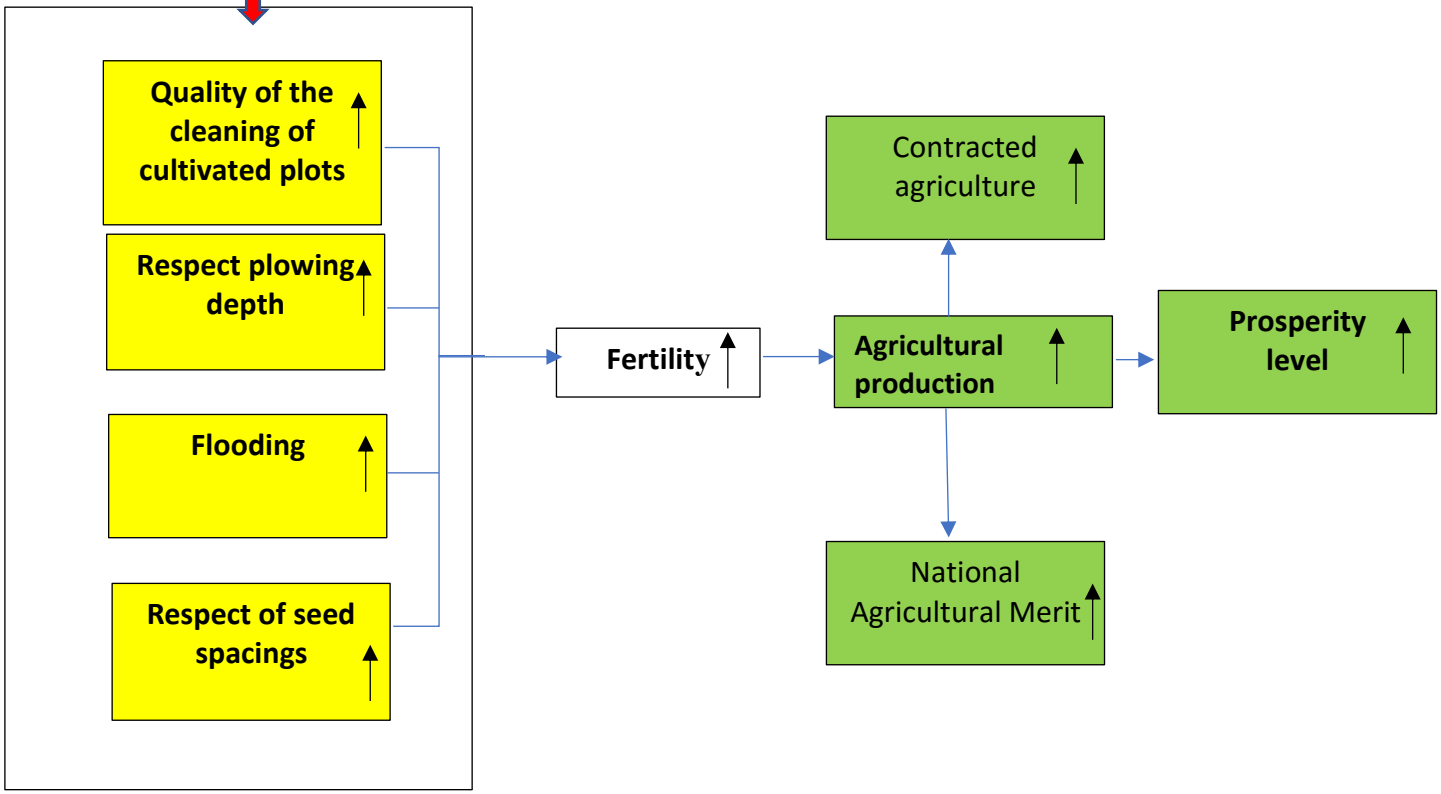


Figure 3. Positive impact related to the use of tractors

- **Positive impacts**





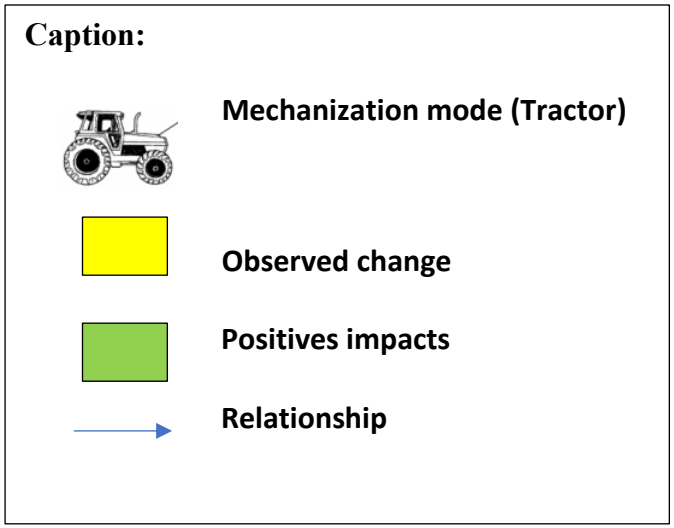
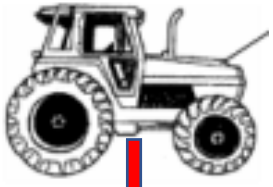


Figure 4. Positive impact related to the use of tractors

- **Positive impacts**



Youth involvement

Number of tractor drivers

Jobs

Insecurity

Rural exodus

Migratory movements to the tractor holding area

Agricultural assets

Agricultural benefits

Income

Social consideration

Caption:

Mechanization mode (Tractor)

Observed changes

Positive impacts

Relationship

BV

Figure 5. Positive impact related to the use of tractors

- **Négative impacts**

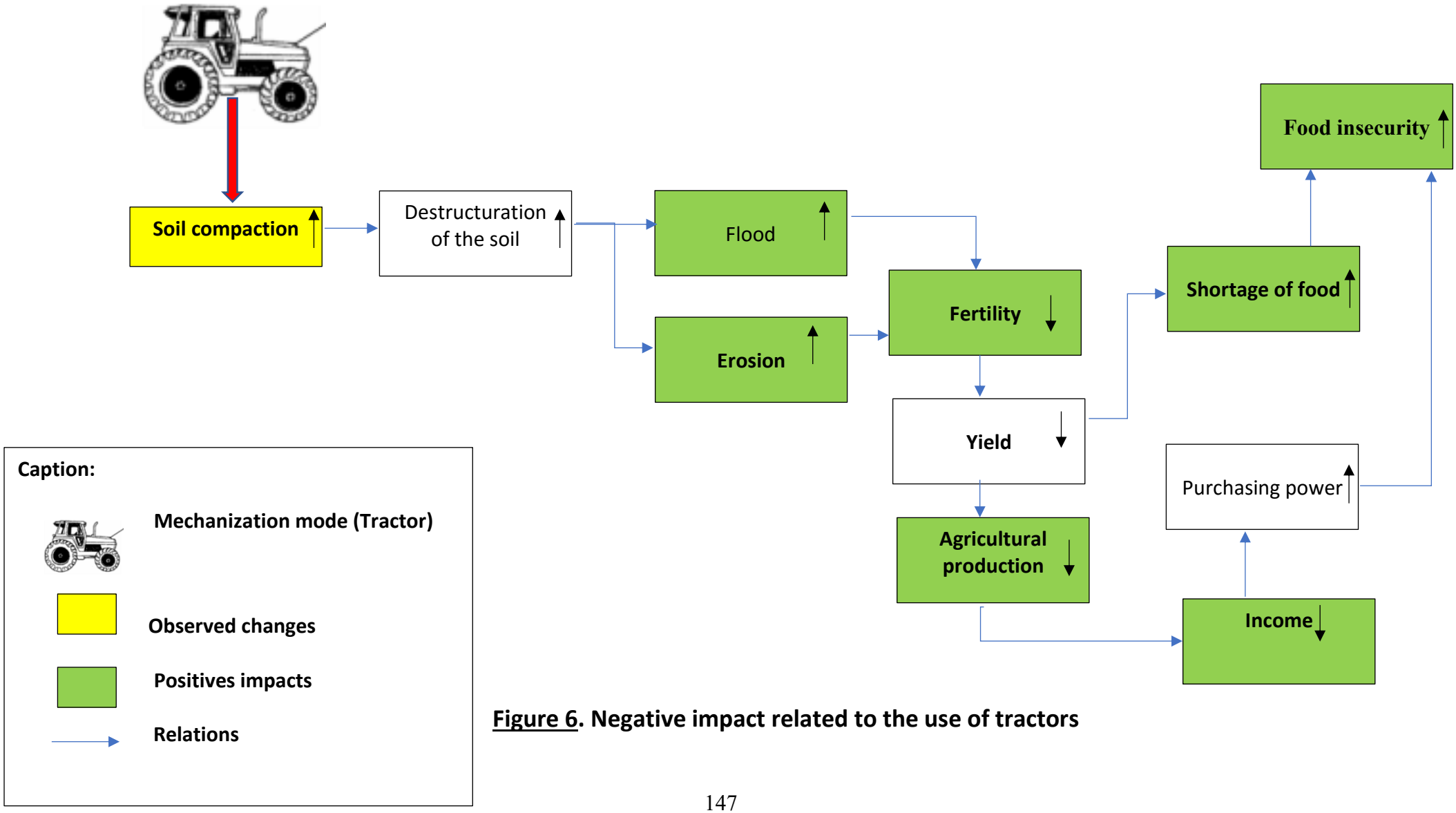


Figure 6. Negative impact related to the use of tractors

○ Negative impacts

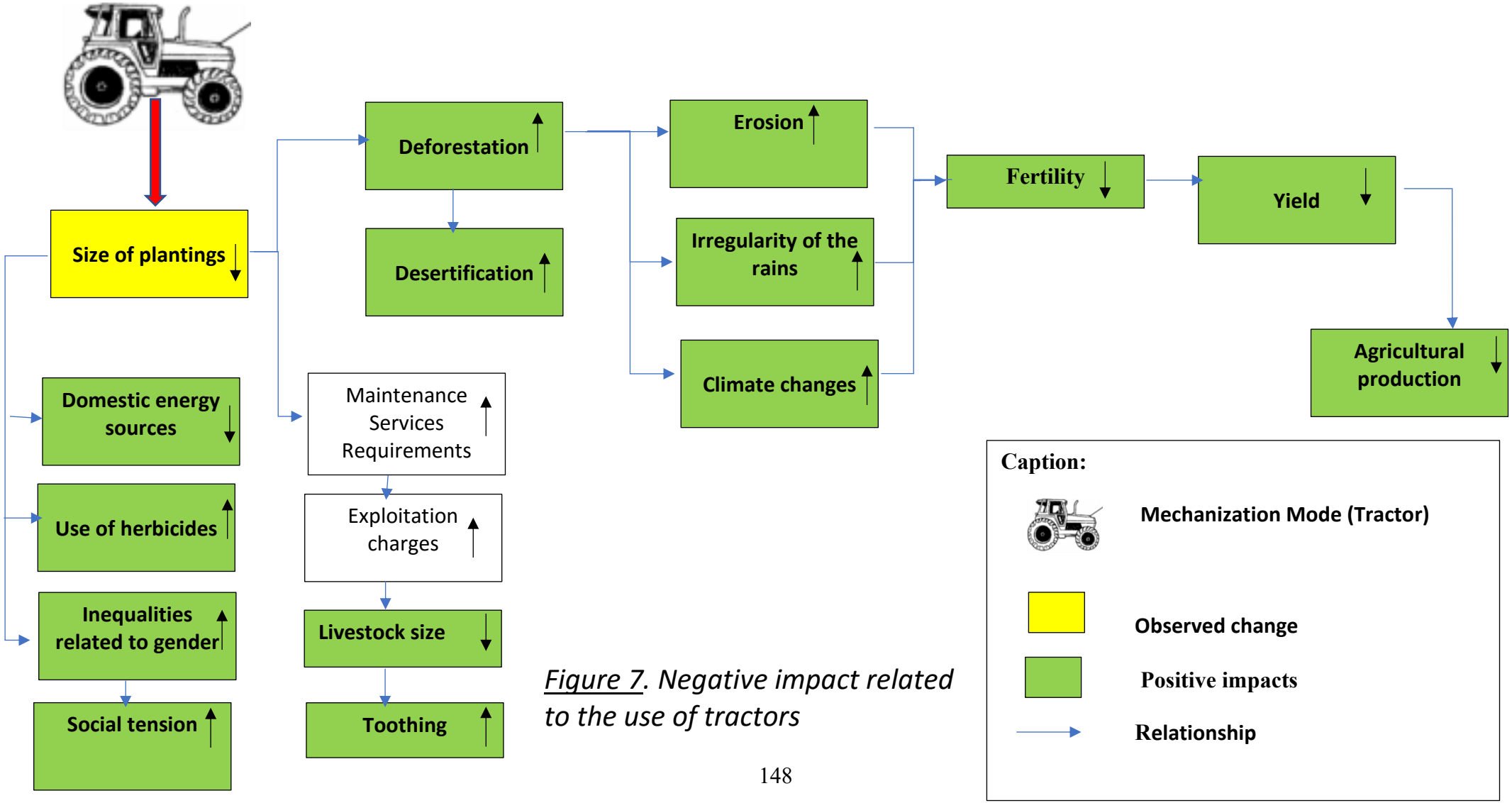


Figure 7. Negative impact related to the use of tractors

Count recurring positive impacts mentioned and present the information in the following table:

Table 113. Positive impacts of mechanization on the study sites

Impacts	Percent of male groups identifying this impact (%)	Percent of female groups identifying this impact (%)	Quotes from the interviews that illustrate the perceptions of the community members
Agronomic			
Reduction of bushfires	72.5	72.64	The reduction of the level of difficulty of the operations and the working time lead to the reduction of the use of rudimentary tools and the adotption of bush fires to carry out the first operations of production, which maintains *a priori* the fertility of the grounds and reduces the risks of environmental pollution.
Fertility level	93.88	93.42	The use of tractors accessories facilitates the respect of cultural standards (depth, plowing, etc.), the burial of soil residues. This facilitates the maintenance of soil fertility of cultivated plots. This has a positive impact on agricultural production, the level of agricultural contracting, the level of prosperity of producers, and the recognition of the agricultural merit of the locality concerned at the national level.
Socio-economic			
Entrepreneurship		100	The fact of going faster in carrying out cultural operations with the tractor makes it possible to gain free time. This free time allows them to spend more time with their families, to discuss projects with their wives and children. This positively impacts the level of entrepreneurship of men, especially women and young people.
Birth-rate	88.5	90.5	The improvement of the level of prosperity, and the fact of saving time in the implementation of the farming operations with the tractor allows them to blossom. What is noticeable on indicators such as the birth rate.
Schooling rate	69.5	72	Improving the level of prosperity allows the diversification of income-generating activities, an increase in the schooling rate of children, and their level of food security.
Number of assets	62.77	90	Improving the level of prosperity is also noticeable on indicators such as birth rate, farm assets, school enrollment, death rate, and even agricultural production.
Mortality rate	87	83	The improvement in the level of prosperity is also noticeable on indicators such as a decline in the mortality rate.
Proportion of national executives	75.71	0	The increase in the enrollment rate has led to an increase in the proportion of executives who are nationals of their village (especially men). These executives in return invest in the development of their locality (rural electrification, development project, modernization, etc.).

Number of agricultural product processors in the community	90	93.57	The diversification of cultures favors the participation of men, especially women in processing activities, hence an increase in the number of processors in the community and the availability of derived / processed products.
Access to information	100	100	An increase in the level of prosperity favors access to tools facilitating communication (purchase of television set, radio, telephone, etc.). This implies an increase in the rate of access to information. This facilitates the modernization of their community.
Household food security	100	100	An increase in agricultural production, the creation of value added to basic agricultural products, and the level of prosperity contribute to household food security (diversification of food consumed, improvement of the diet and reduction of malnutrition rate especially in children).
Production and sales contracts	89.23	97.5	These agricultural performances realized with tractors allow an increase of the opportunities of contracts of production and sale.
Frequency of diseases	100	100	All men and women of PDAs show that the availability of rest time, and the increase in income have also reduced disease frequency mainly at the men's level of their community.
Number of agricultural group or cooperative	95.5	92	The introduction of tractors favors the grouping of small producers to benefit from services.
Access to credit	98	93.5	The changes resulting from the introduction of the tractor were also related to the ease of contracting agricultural loans or credits, taking into account the assets (tractors, accessories, etc.) that can be pledged.
Number of microfinance institutions	37.33	29.23	The use of tractors has led to an increase in the rate of male or female loan or credit access, and the number of microfinance institutions in their communities.The tractor represents a great investment and the person who has achieved this feat can open the doors of all banks if needed.
Export boosting local economic growth	82.35	78.57	The agricultural performance achieved with tractors also facilitated increased production, agricultural processing, and hence the level of exports, thereby stimulating local economic growth, increasing the number of social and community infrastructures, and better social recognition of producers by their peers.
Number of social and community infrastructures	56.66	48.57	The agricultural performance achieved with tractors also facilitated increased production, agricultural processing, and hence the level of exports, thereby stimulating local economic growth, increasing the number of social and community infrastructures, and better social recognition of producers by their peers.
Number of farm machinery owners	66.76	73.75	Improving the level of prosperity makes it possible to have the means to increase the level of mechanization
Recognition of the agricultural merit of the locality concerned at national level	88	85.55	Agricultural performance with tractors promotes recognition of community agricultural merit at the national level
Number of jobs	67.25	66.5	Indeed, the tractor makes it possible to increase the size of the plantings. This increase generates a higher

			demand in terms of manpower to carry out operations not yet mechanized.
Reduced insecurity (theft, delinquency, etc.)	62.85	61.11	The possibility of driving a tractor and providing services to earn money is a source of interest or motivation of young people. We are witnessing an increase in the number of tractor drivers, a reduction in the rural exodus to young men, an increase in income, and the reduction of insecurity (theft, delinquency, etc.).

Table 114. Negative impacts of mechanization on the study sites

Impacts	Percent of male groups identifying this impact (%)	Percent of female groups identifying this impact (%)	Quotes from the interviews that illustrate the perceptions of the community members
Agronomic			
Flood and / or erosion	42.22	55.71	There is an increase in the rate of soil compaction / soil compaction given the weight of the tractor and the accessories, which is heavy. This implies a destructuring of the soil layers. Then follows respectively the problems of floods and / or erosions
Deforestation	92	94.5	In order to intensify agricultural activities and optimize available areas (when using a tractor), the size of the area is increasing. This situation leads to deforestation which favors the advance of the desert
Climate changes	92.5	94	Deforestation facilitates the erosion and irregularity of rainfall and therefore climate change. These influence on soil fertility, yield and agricultural production.
Reduction of livestock size	68.33	66.66	An increase in plantings creates new requirements in terms of expensive stump removal and maintenance services (maintenance, etc.) that increase operating costs. To meet these requirements, men and women show that some producers sell their animals (livestock, etc.). This implies a reduction in the size of the herd,
Use of herbicides involving soil depletion	80	82.14	The misuse of herbicides for clearing, is observed in case of breakdown of agricultural machinery
Socio-economic			
Food insecurity	48.5	57	Both men and women show that poor performance is responsible for food security or scarcity, especially for food crops, a decline in the purchasing power of farm households, leading to increased food insecurity (malnutrition, famine, etc.).
Indebtedness	87.5	70	In the event of breakdown with the tractor, reduction or extinction of the herd, producers are forced to resort to other producers or generally traders of agricultural products, and to cope with the intransigence of the conditionalities.
Home energy source	65	75.27	Men and women show that increasing the size of additional areas reduces the availability of domestic energy sources (firewood, etc.) due to deforestation.
Decrease in agricultural mechanization by the	95	94	The breakdowns caused by the tractors, or the lack of means to ensure the maintenance / the maintenance cause a non-respect of the agricultural calendar, a

abandonment of tractors			decrease of the agricultural mechanization by the abandonment of the tractors which results in an increase of the use of animal traction / rudimentary tools.
Social tension / disagreement	62	60	The introduction of the tractor also creates inequalities related to gender (small farmers, women, etc.), jealousy, which causes, and feeds strong social tensions / disagreement at the level of men and women.

Discussion

Mechanization has led to a considerable reduction in the working time allocated to farming operations. At the level of all ADHs, respondents have shown that this time saving is generally used to rest, develop leisure activities, extra-agricultural activities (trade, crafts, etc.), and diversify the crops produced.

The available rest time also allows them to devote more time to the bedside of their families, in particular to discuss with their spouse(s), their children, and involve them in decision-making and plan possible projects. They believe that this involvement of women not only leads to cohesion within families, but also promotes a positive impact on the level of entrepreneurship of men, especially women and young people.

On the one hand, all men and women in the ADHAs show that the availability of rest periods has also helped to reduce the incidence of diseases, mainly at the level of men in their community. On the other hand, they show that the diversification of extra-agricultural activities improves their income and consequently their level of prosperity. This allows them to improve their living conditions, to enjoy a better social reputation in the community and to have access to information (purchase of television set, radio, etc.). This facilitates the modernization of their community. This change had occurred at the level of men, women and children.
Improving the level of prosperity is also noticeable on indicators such as birth rate, farm assets, school enrollment, death rate, and even agricultural production. Statistical differences show that the impact on increasing the number of farm workers was raised by ADH2 men (68%), ADH3 (55%), and men (63%) and women (90%).

More than 75.71% of the men in the ADH4 have shown that the increase in an schooling rate has led to an increase in the proportion of executives who are nationals of their village (especially men). These executives in return invest for the development of their locality (rural electrification, development project, modernization, etc.). The majority of men and women (more than 90%) consider that the crop diversification favors the participation of men, especially women in processing activities, hence the increase in the number of processors in community and the availability of derived / processed products. This implies not only the creation of value added to basic agricultural products, but also contributes to household food security (diversification of food consumed, improvement of the diet and reduction of the malnutrition rate, especially for children).

The men and women in all the PDAs show that the introduction of the tractor was also a source of guarantee for carrying out farming operations. Indeed, the availability of the tractor on a farm has the main corollary respect for the agricultural calendar. The latter stimulates the increase in agricultural production, and the rate of production and sales contracts mainly in the ADH2, ADH3 and ADH4 (more than 80%), and ADH4 (more than 97%) because of the agricultural performance achieved. Also, the tractor remains a source of motivation for the producers in the sense that they develop the spirit of solidarity and understanding which is a form of change of mentality according to the producers. This is opposed to the individualism pushed by some operators. This leads them to organize themselves into a group or a cooperative. As a result, the majority of men and women (more than 90%) express that this situation implies an increase in the number of agricultural groups or cooperatives in their community.

Among other things, the changes that resulted from the introduction of the tractor were also related to the ease of contracting agricultural loans or credits. More than 90% of men and women in ADHs show that this situation has led to an increase in the rate of male or female loans or credit access, and the number of institutions of microfinance in their community. As an illustration, during an interview, the producers affirmed that: "The tractor represents a great investment and the person who was able to achieve this feat can open the doors of all the banks if necessary".
Among other impacts that would result from the introduction of the tractor, there is the reduction of the difficulty of the farm operations. The immediate result of reducing this hardness is the increase in the size of the area planted, which stimulates agricultural production, income improvement and prosperity. These achieved agricultural performances also allow an increase in the opportunities of contracts of production and sale. Community members affected by these changes were predominantly male ADH2, ADH3, ADH4, and ADH4 women (more than 80%).
In addition, these agricultural performances have also facilitated the level of exports, thus stimulating local economic growth, increasing the number of social and community infrastructures and better social consideration of producers by their peers. The beneficiaries of this change were mostly members of the ADH2, ADH3 and ADH4 communities. Regarding the impact of increased exports, gender-based statistical differences show that men (82%) were mostly affected compared to women (78%).

The increase in income / level of prosperity gives tractor owners financial autonomy, and the ability to manage the various risks and contingencies related to production (tractor failure, full benefits, accidents, etc.). The improvement of the level of prosperity allows the diversification of income-generating activities, an increase in the schooling rate of children, the food security within households, an increase in the number of holders of agricultural machinery (tractors, tillers, etc.) and also the improvement of the level of social consideration.
The impact related to food security is perceptible at the level of all the communities (men, women, young people, children). Likewise, the majority of men and women (over 70%) show that the relative impact of the increase in the proportion of holders of agricultural machinery was observed mainly at the male level.

Reducing the level of difficulty of operations and working time leads to the reduction of bush fires, which *a priori* maintains the fertility of the soil and reduces the risk of environmental pollution. This impact was perceptible at the male and female levels (over 72%).
According to the producers, the use of the tractor makes it possible to make adjustments to obtain various depths of work and various finishing results (quality of the cleaning of the plots, respect of plowing depth, reversal of the ground, respect of seedind spacings, etc.). All of these elements

improve the level of fertility of the cultivated plots. This has a positive impact on agricultural production, the level of agricultural contracting, the level of prosperity of producers, and the recognition of the agricultural merit of the locality concerned at the national level. Beneficiaries affected by the impact of recognition of agricultural merit were mostly members of the ADH2, ADH3 and ADH4 communities.

More than 66% of men and women show that the other impact resulting from the introduction of tractors would be the creation or increase in the number of jobs in the locality mainly at the young male levels of ADH2, ADH3 and ADH4. Indeed, the tractor increases, as mentioned above, the size of the plantings. This increase generates a higher demand in terms of manpower to carry out operations not yet mechanized. Also, the possibility of driving a tractor and providing services to earn money is a source of interest or motivation for young people. They learn to drive the tractors on the job. We are witnessing an increase in the number of tractor drivers, a reduction of the rural exodus to the level of young men, an increase in income, a better social consideration and the reduction of insecurity (theft, delinquency, etc.). More than 61% of men and women show that this positive change related to the decline in insecurity was visible mainly at the male level. It should be noted that the availability of a tractor in a locality generates farm assets from adjacent areas to the tractor holding area to meet the demand for labor expressed, given the large acreage planted by these tractor users. This impact related to the increase of agricultural assets in the community was perceptible especially at the men's level.

Beyond these different positive impacts identified in a participatory way with the various actors, some negative setbacks inherent to the introduction of the tractor have been identified. This includes an increase in the rate of soil compaction / soil compaction given the weight of the tractor and accessories. This implies a destructuring of the soil layers. This is followed respectively by the problems of flooding and / or erosion which considerably reduce the fertility of the areas cultivated and consequently the yield. This level of yield negatively influences agricultural production, the income and therefore the purchasing power of the producers. The change related to flooding and / or erosion problems was noticeable at ADH3 and ADH4 level.
Less than half of men and women show that poor performance is responsible for food security or scarcity, especially for food crops, a decline in the purchasing power of farm households, leading to increased food insecurity (malnutrition, famine, etc.).
In order to intensify agricultural activities and optimize available areas (when using a tractor), the size of the area is increasing. This situation leads to deforestation, which favors the advance of the desert (desertification). This negative impact was raised by the majority of men (92%) and women (94.5%) at the level of all ADHs.

On the one hand, they show that deforestation also facilitates the erosion and irregularity of rains and therefore climate change. This change was noticeable at all ADH levels. These influence on soil fertility, yield and agricultural production. On the other hand, the increase in plantings creates new requirements in terms of expensive stump removal and maintenance services (maintenance, etc.) that increase operating costs.
To meet these requirements, more than 67% of men and women show that some producers sell their animals (livestock, etc.). This implies a reduction in the size of the herd, and further favors the debt and the risks of imprisonment. The impact of reduced herd size was apparent mainly at the male level. This debt situation is explained by the fact that in rural areas, the availability of livestock is a form of securing peasant assets to manage the various unforeseen events. In the event of reduction or even extinction of the herd, producers were forced to resort to other

producers or generally traders of agricultural products, and to face the intransigence of the conditionalities with profit charactistics of these operations.
More than 65% of men and 75.27% of women show that increasing the size of plantings reduces the availability of domestic energy sources (firewood, etc.) due to deforestation. This change was noticeable mainly at the women's level. It also creates the misuse of herbicides for land clearing, where there is no agricultural machinery and difficulties in using casual labor. This impact was reported by more than 81% of men and women.
The majority of producers (95% of men and 94% of women) shows that the majority of tractor owners fail to meet tractor requirements for use and maintenance. This causes not only a failure to respect the agricultural calendar, but also a decline in agricultural mechanization by the abandonment of tractors, which results in an increase in the use of animal traction / rudimentary tools. This impact linked to the decline in agricultural mechanization was noticeable especially at the men's level.

Indeed, they are confronted with the constraints related to the accessibility of quality spare parts, the lack of qualified machinists and mechanics, the non-compliance with technical standards (abuse of use, non-adaptation of accessories according to the tractor power), no tractors owner follow-up policies resulting in repeated breakdowns.
More than 60% of men and women show that the introduction of the tractor also creates gender inequalities (smallholders, women, etc.), which causes and fuel strong social tensions / disagreements at the level of men and women. Producers are showing that they are facing problems related to the lack or inadequacy of tractors and delivery / rental services in their community. Tractor owners or service providers tend to prioritize men and large producers for the purpose of providing services and leasing during major production periods. Thus, women and smallholders are often marginalized.

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