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Study of Mechanized Agricultural Services Needs in the Rural Communities of Béréba and Koumbia in the Cotton-Growing Region of Western Burkina Faso

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Executive Summary

Although predominantly an agricultural country (40% of GDP), Burkina Faso continues to import cereals to feed its population. Farmers in Burkina Faso still use rudimentary tools to produce in unpredictable climatic conditions. Late rains, shorter seasons, and farm labour shortage are all challenges that are difficult to overcome through draught power and manual work. And yet, the population engaged in agriculture in Burkina Faso consists largely of smallholder producers (75%). As a result, only 25% of farmers are deemed to have the means to acquire a tractor to mechanize farming operations in order to modernize the agricultural sector and address the issues of productivity and labour shortage, as well as the need to plough at the right time to keep up with the crop calendar.

Seventy-five per cent of producers are assumed to be unable to afford a tractor to deal with the numerous challenges mentioned above. The aim of the study of the needs for mechanized agricultural services in the cotton-growing area of western Burkina Faso was to analyse the need and demand for mechanization services in order to put forward appropriate solutions that address the concerns of most agricultural producers.
The study shows that demand for tractor services was quite low (30%). The main crops of the area were maize, cotton, sorghum and millet respectively. Sixty-five per cent of total demand was met. Prices for services varied between 15,000 and 30,000, whereas willingness to pay was between 10,000 and 17,500. This translates into a sharp imbalance between supply and demand for mechanized agricultural services.

Key words:

Mechanization; Motorization; Demand; Services; Tractor; Ploughing; Transportation; Ginning

Introduction

Agriculture remains the mainstay as well as the primary source of food and income for most countries in Sub-Saharan Africa (IFPRI 2003, Zhou 2016). Family farming accounts for 75% of agriculture and is considered by FAO (2014) as an avenue to boost local economies. According to The SEED Foundation (2009), family farming provides the bulk of rural incomes in sub-Saharan Africa (Alpha and Castellanet, 2007). Sadly, this part of the African continent remains one of the regions where food insecurity is on the rise (FAO, IFAD, WHO, WFP and UNICEF, 2017). Despite the importance of agriculture for African economies, food crises persist in almost 40 countries, including 23 in sub-Saharan Africa (Josserand, 2006). The reasons for this precarious state of agriculture and the agri-food sector in sub-Saharan Africa (SSA) include climatic factors, lack of agricultural financing, modernization of agriculture (notably farm mechanization), and shortage of farm labour (Leffort, 1988, Lecomte, 1988). These food crises are linked to productivity crises, mainly driven by shortfalls in agricultural inputs. According to FAO (2014), agricultural mechanization is a key agricultural input with the potential to transform the livelihoods of millions of rural families by facilitating the production of higher value products while eliminating the physical arduousness associated with agricultural practices involving muscular power. In sub-Saharan Africa, however, a set of constraints affect agricultural mechanization, and indeed mechanization across the food system (FAO, 2014). Yet, studies conducted on the use of tractors show that the equipment is cost effective under optimal conditions. As a matter of fact, internal rates of return are around 69.9% (Elbashir et al., 1983) in Sudan, and more than 100% (Eponou, 1983) in Côte d'Ivoire. Binswanger (1976) reported that tractors are cost-effective due to their drudgery-reducing and post-harvest-related benefits, and because they induce the development of a labour force that is freed from manual farming operations to serve in more productive activities. However, access to agricultural mechanization is limited owing to lack of resources (Matlon, 1983, Side, 2013). Consequently, FAO (2014) proposed to identify the constraints and develop strategies to ease them in order for all farmers, especially smallholders and others involved in the agri-food value chain, to benefit from the development of mechanization services. Given the centrality of agriculture in Sub-Saharan economies, agricultural mechanization is key to improved productivity and a remedy to the labour shortage in agriculture (Bordet, 1997), considering the fact that muscular strength continues to play a key role in the agricultural economy because, according to (Clarke and Bishop, 2002, FAO, 2006), the energy used in agricultural production in *SSA* comes from humans (65%), animals (25%), and engines (10%). Unfortunately, it seems the situation is not getting better (Mrema et al., 2008, FAO, 2008, Havard, 2011).

In West Africa, FAO (2001) estimated the sources of farm power at 70% for manual, 22% for animals and 8% for tractors. These reflect a low level of mechanization, modernization, productivity and food production in this part of Africa. Yet in 2003, the Heads of State and Government of the African Union adopted the Comprehensive Africa Agriculture Development Program (CAADP), whereby they committed themselves to a range of initiatives and spending priorities aimed at achieving 6% annual growth in agriculture (AfDB 2016). The performance is rather disappointing, since, according to (AfDB 2016), thirty-seven (37) countries are still contending with food deficits and a quarter of Africa's population still lacks secure access to food. This seems to explain the sharp rise in global food prices with a knock-on impact on the food crisis of 2008. As a result, many governments have realized the need to reinvest in agricultural production, particularly mechanization of family farming (Side and Havard 2013, Janin 2009, Mousseau 2010, Bachelor 2010, Delcourt 2014). Development of mechanization is a must in Africa (Pingali et al., 1988) and has become a recurrent theme of rapid development (Guibert, 1985; Zerbo, 1991).

In Burkina Faso, agriculture contributes 35% to 40% of GDP, engages more than 80% of the working population (INSD, 2006), and contributes substantially towards meeting the food and economic needs of the population. However, food security is still not assured and a poverty incidence of 40.1% (UNDP, 2016) remains paradoxically high in rural areas where agriculture is the main activity and source of income and food. This poor performance of the agricultural system is due to various constraints including extensive farming systems, inadequate rural infrastructure, and insufficient rainfall (SP/CPSA, 2016). The dearth of infrastructure (nearly 70% of farmers still practice manual farming) entails strong demand for agricultural labour on farms within a new context of climate change and shorter and unpredictable farming seasons. However, due to gold mining, rural depopulation, mass schooling, and the arduous nature of manual agricultural work, agricultural labour is becoming a scarce agricultural input (Eastman, 1982, Bordet 1997, Fonteh 2010, Sanon 2013). The intense demand for agricultural labour involving rudimentary technologies has clearly scared off most young people in sub-Saharan Africa, forcing most of them to move to urban areas in search of jobs that are not easy to come by (Mrema et al., 2008). Shorter and late rains mean that tillage has to be done quickly and at the right time. Smallholders are most vulnerable and at risk of food insecurity and poverty, shut off from any poverty reduction research system (Faure et al., 2010) and unable to attain food security, if agriculture is not mechanized to reduce drudgery, increase productivity and adhere to the crop calendar (Tersiguel 1995; Bordet 1997, Vall et al. 2006, Zougmoré et al. 2006). In such circumstances, mechanization could play an important role in tackling food insecurity and rural poverty. According to FAO (...), inadequate equipment is one of the key factors constraining farm productivity. The use of tractors increases acreage and profitability for farms. (Zerbo 1991, Ouédraogo 2012). Agricultural mechanization also includes animal draught power, which has also not been widely adopted to improve the productivity of poor households in West Africa. About 53% of the working animal population was found in Ethiopia, 25% in parts of four other countries (Zimbabwe, Kenya, Tanzania and Uganda), and the remaining 22% in the semi-arid regions of West Africa, Sudan and Madagascar (Mrema et al., 2008). In the current context of shorter rains, this technology appears not to be unanimously accepted by researchers as far as productivity is concerned. According to Sanogo (1991), animal-drawn cultivation has limitations, notably inadequate veterinary care, frequent rinderpest epidemics, physical inability of animals to work when the rains set in.

Given the importance of mechanization in achieving agricultural prosperity, hunger eradication and poverty reduction, it is necessary to develop policies and strategies that make mechanization accessible to "smallholders" (nearly 75%), who cannot afford a tractor. Expanding the provision of paid mechanized services for land preparation, post-harvest activities and crop residue management could therefore have a significant impact on food security and income for smallholder farmers. The diagnosis of actual demand for mechanized agricultural services among smallholders is a solution that lies with the Government of Burkina Faso and its development partners. The outcome can lead to a rural development strategy through the implementation of a mechanized agricultural service delivery mechanism to alleviate the struggles of smallholders by reducing poverty and hunger, and by keeping young people in rural areas through the creation of decent jobs. The Program of Accompanying Research for Agricultural Innovation (PARI) and the Forum for Agricultural Research in Africa (FARA), working towards "A hunger-free world ", are supporting the government of Burkina Faso in the pursuit of food security and poverty reduction in rural areas.

Objectives of the study

This study seeks to:

- Identify the needs for mechanized agricultural services (type, significance);
- Determine the willingness of farmers to pay for the services;
- Propose a mechanism for developing local farm mechanization services

Expected deliverables

- The need for mechanized agricultural services (type, significance) are identified;
- The willingness of farmers to pay for the services is determined;
- A mechanism for developing local farm mechanization services is proposed and validated.

Methodology

Overview of the study area

Geographical location

The province of Tuy lies between latitudes 11 and 12 degrees N and longitudes 3 and 4 degrees W. It combines with the provinces of Houet and Kénédougou to make up the “Hauts Bassins” region.

It is bounded by the provinces of Balés and Mouhoun to the north and east, by the province of Houet to the west, and by the provinces of Bougouriba and Ioba to the south. The Province covers an area of 5,632 sq. km, representing 2.07% of the national territory and 22.1% of the regional territory.

Administrative status

The province of Tuy was created pursuant to Act No. 009/96 / ADP of 24 April 1996 creating 15 new provinces. It was formed out of the old boundaries of the provinces of Houet and Bougouriba.

Tuy is made up of seven (07) departments consisting of five (05) departments from the former province of Houet and two departments from the former province of Bougouriba (Koti and Founzan), 99 villages and an urban municipality (Houndé). The municipal area covers 25 sq. km and includes 05 sectors.

Table 1: Departments and number of villages in the Province of Tuy.

Departements	Area (sq. km²)	Number of villages
Békuy	594	04
Béréba	569	29
Boni	416	10
Founzan	874	15
Houndé	1196	16
Koti	629	11
Koumbia	1354	14
Total	5632	99

Source : IGB, Haut-commissariat du Tuy

Nature

a. Climate

The province of Tuy has a Sudan type climate characterized by two major seasons: a wet season from April to October and a dry season from November to March. In between these two major seasons, there are minor climatic variations, i.e. a cool period from December to February and a warm period from March to May. With isohyets between 800 and 1000 mm, the province benefits from relatively good rainfall. Rainfall is unevenly distributed across the Province. Cumulative annual rainfall decreases from the south of the Province (Koumbia) to the north (Bereba). The Province records an average of 62 days of rain per year. The table below details the rainfall amounts recorded over the last ten years:

Table 2: Rainfall of the last ten years

Year	Weather station											
	Béréba		Békuy		Koti		Founzan		Houndé		Koumbia	
	H(mm)	D	H(mm)	D	H(mm)	D	H(mm)	DJ	H(mm)	D	H(mm)	D
2006	1062,3	60	1072	60	867	59	966,3	55	1041,4	63	1111,4	84
2007	729,2	46	692,5	40	1037,5	57	626,7	50	787,8	50	822,2	75
2008	906,5	59	941	54	1070,5	53	1109,8	60	916,9	59	1009,5	72
2009	689,2	49	802,4	60	998	58	1009,2	62	740,3	55	954,2	65
2010	1206,7	73	1063,2	53	887	60	1147	67	866,6	55	1110,6	73

2011	850,7	56	629,4	46	1053,5	45	898,5	53	1037,9	58	775,1	70
2012	828,4	55	1017,7	55	872,5	45	1007,0	52	761,8	55	1175,7	63
2013	1014,2	60	849,1	48	1015,9	45	958,5	51	891,8	57	816,8	61
2014	788,5	59	1017,6	56	1102	50	947,5	62	916,8	59	1047,1	66
2015	874,5	42	1016,5	43	951	44	873,5	53	888,7	51,8	940,1	44

Source: DRAHRH/Hauts-Bassins, 2015

b. Relief and soils

The topography generally consists of small hills (450 m above sea level) located in the areas of Kongolekan, Kari and Boni; plains (320 m) located in the departments of Koumbia, Founzan, Koti, Béréba and Bèkuy; valleys in Great Balé and Son; and plateaus.

Much of the territory (20%) is characterized by ironstone and rock outcrops. These areas are unsuitable for agriculture. The arable land represents 50% of the provincial area.

The following geological formations can be found sandstone formations in the department of Békuy; birrimian formations composed of volcanic and metamorphosed rocks in the central part of the Province; granite formations in the departments of Founzan and Koti; and granodiorite formations in the department of Koumbia.

c. Hydrography

Hydrography is concentrated around the sub-basins of Tuy (Grand Salé), Bougouriba and upper Mouhoun.

The major water courses are the Tuy river (Grand Salé), which flows north-west and south-east towards lower Mouhoun, with an intermittent regime.

The Mouhoun river, a perennial stream flowing south-north to the extreme north-west of the Province in the department of Békuy.

d. Vegetation and wildlife

The vegetation of the Province consists of relatively dense savanna woodlands and shrublands from north to south.

There are many woody species. The following are the most common: *Vitellaria parkii, Parkia biglobosa, Anogeisus leicarpus, Lannea microcarpum, Afzelia africana, Pterocarpus erinaceus, Prosopus africana, Termilia sp, Daniela oliveri* and various combretaceae. The grass cover is made up of *Loudetia togoensis, Penisetum pedicelatum, Andropogon acinodis* and *Andropogon gayanus*.

The Province has had forest reserves since the colonial era. There are currently 8 forest reserves covering an area of 149,140 ha. Many of those forests are occupied by farmers and cattle farmers. It should be noted that some of those forest reserves straddle several provinces. They include:

- The Tuy forest reserve (47,000 ha), more than half of which is found in Mouhoun and Balé;

- The Maro forest reserve with 50,000 ha, occupies a small part of the Province of Tuy. The largest part is located in the province of Houet;The Dibon forest reserve, which is contiguous to the Balé forest reserve, covers 10,000 ha, part of which is located in the Balé province.

Furthermore, all villages have one or more sacred forests with taboos surrounding them.
The natural vegetation is under great pressure as a result of indiscriminate clearing for new fields and logging and charcoal burning. This may ultimately result in a monospecific vegetation consisting only of useful species such as *Parkia biglobosa* and *Vitellaria parkii,* which are also under threat.
With regard to wildlife, there is still great potential, relatively speaking. Game can be found in forest reserves, particularly in the concession area of Mou in Koumbia and along streams, notably Tuy and Mouhoun.
Species found include elephants, buffaloes, antelopes, waterbucks, hartebeests, oribis, warthogs, and antelopes. There are also monkeys, porcupines and significant bird fauna. The fauna is seriously threatened by poaching, overgrazing by domestic herds, and the occupation of forest reserves by farms.

Socio-economic data

a. Population

The General Population and Housing Census (RGPH) of December 2006 showed that Tuy had 228,458 inhabitants, representing 15.6% of the regional population. According to INSD, the region will have an estimated population of 314,556 in 2016 (PRD, 2010).
The ethnic groups living in the Province include the Bwaba, Pougouli, Dagara, Mossé, Peulh, Marka, Bambara, Samo and Gourounsis. The indigenous ethnic groups are the Bwaba, found in 92% of the villages. The Pougouli, represented in 11% of the villages, are mainly found in the departments of Founzan and Koti. The main non-indigenous ethnic groups are the Mossé, who started arriving in the Province in the 1970s. They make up 43% of the population. The Peulh (Fulanis) are the oldest non-indigenous community and are found in all the departments.
The main religions practiced in Burkina Faso are all represented in the Province. Islam is the predominant religion and practiced by 53.3% of the population. Animism is practiced by 34.5% of the population, and Christianity (Catholics and Protestants), by 11.79% of the population. DÔ worship is prevalent among the Bwaba, regardless of their religion.

b. Agriculture

Good rainfall and good soils combine to make Tuy conducive to the development of agriculture, which is by far the most important activity in the Province. In 1998, more than 85% of the working population in the Province were engaged in agriculture.
Agriculture is therefore the main economic activity in the Province, with traditional and extensive farming as the cultivation methods. The technique used is slash and burn, which is space-consuming. Cotton and maize are the dominant crops.

Tuy as an agricultural province produces several crops. The main crops are: cereals (sorghum, maize, rice, millet); tubers (yams, cassava, potato); cotton; and oilseeds (peanut, sesame).
The main cereal crops in order of importance are: maize, white sorghum, sorghum, millet and rice. Grain surpluses are recorded in the Province every year: 158,928 tonnes in 2011, 224,836 tonnes in 2012, 242,436 tonnes in 2013, 169,034 tonnes in 2014 and 226,260 tonnes in 2015 (DGESS, 2015). However, due to the huge demand for those surpluses in Bobo and Ouagadougou, the Province sometimes experiences shortage of cereals on the local markets. Production is overall on the increase, although it fell in 2014 due to changing climate conditions. The main cash crop is cotton. Between 2001 and 2015, cotton production almost doubled, increasing from 45,281 tonnes in 2001 to 98,646 tonnes in 2015 (DGESS, 2015). Cotton is produced throughout the Province. Other cash crops include peanut and sesame.
Areas sown (cash crops and cereals) increased from 158,624 ha in 2011 to 223,742 ha in 2015, an increase of 65,118 ha in five years. This shows that agriculture in Tuy is land-intensive. During the 2015-2016 crop year, cereal crops covered 112,445 ha of the total area sown, as against 111,297 ha for cash crops (DGESS, 2015).

c. Mines

The Province boasts significant mineral deposit sites, including gold and manganese. These deposits have remained marginally developed. Mining has now become one of the main income streams of the people of Tuy. (PRD, 2010).

d. Livestock

Livestock production is the second most popular activity in the Province (after agriculture). It remains largely traditional and relies on available natural resources. It includes cattle, small ruminants, pigs, horses, insects and poultry. Like agriculture, the livestock sector still faces a number of challenges, such as:

- Low productivity due to the low genetic potential of local breeds, especially dairy;
- Challenges with feeding and watering, especially during the dry season;
- Poor animal health linked to endemic animal trypanosomiasis;
- Poor spatial organization;
- Poor development of infrastructure, equipment and pastoral amenities;
- Inadequate technical and organizational capacity of stakeholders;
- Land pressure, which limits availability and livestock access to natural resources. (PRD, 2010).

Data collection methodology

Preparation

Collection involved several phases, the first of which entailed contacting local officials, namely the provincial department of agriculture and the union of cotton producers, to have a database on agricultural mechanization. The aim was to record the number of tractors per village for the purpose of selecting villages for the survey. It was also to enlist the support of agricultural officers as field workers. In this phase, a preparatory survey was also conducted to capture any issues missed during literature review, in order to refine research assumptions and questionnaires.

Inventory phase
This involved developing an inventory of all tractors found in the province of Tuy during the reporting period. An inventory sheet indicating the farmer's details, the year of acquisition of the tractor, its power, brand, condition at the time of purchase and how it was acquired was used for this exercise. The exercise was led by the provincial department of agriculture, together with extension officers.

Training phase
The first step was to recruit data collectors. We selected eight (08) field workers, four (04) for each municipality. The field workers were then trained on how to administer and complete the quantitative and qualitative questionnaires entrusted to them.

Selection of study villages
Villages were selected in conjunction with agricultural workers in each municipality. It should be noted that mechanized agricultural services refer to exclusive tractor services. Three (03) villages were selected in each municipality based on the following criteria:

- First village with the highest number of tractors;
- Second village with an average number of tractors (average of the three (03) villages in terms of number of tractors); and
- Third village with no tractors. The following villages were therefore identified:

Table 3: Selected villages and number of tractors

Municipality	Villages	Number of tractors
BEREBA	Wakuy	08
	Boho-béréba	01
	Débéré	00
KOUMBIA	Sébédougou	10
	Wally	04
	Man	00
Total		**23**

Collection of field data
In each village, 30 farm households were surveyed. The step method was used to administer the questionnaires. The number of steps is determined by the ratio of number of households in the village to number of households to be surveyed. This method provides a representative sample of the village taking into account all communities and hamlets.

In addition to the questionnaires, we developed interview guides that we administered to PO officials, tractor traders, MFIs and other entities involved in the facilitation of tractor procurement.

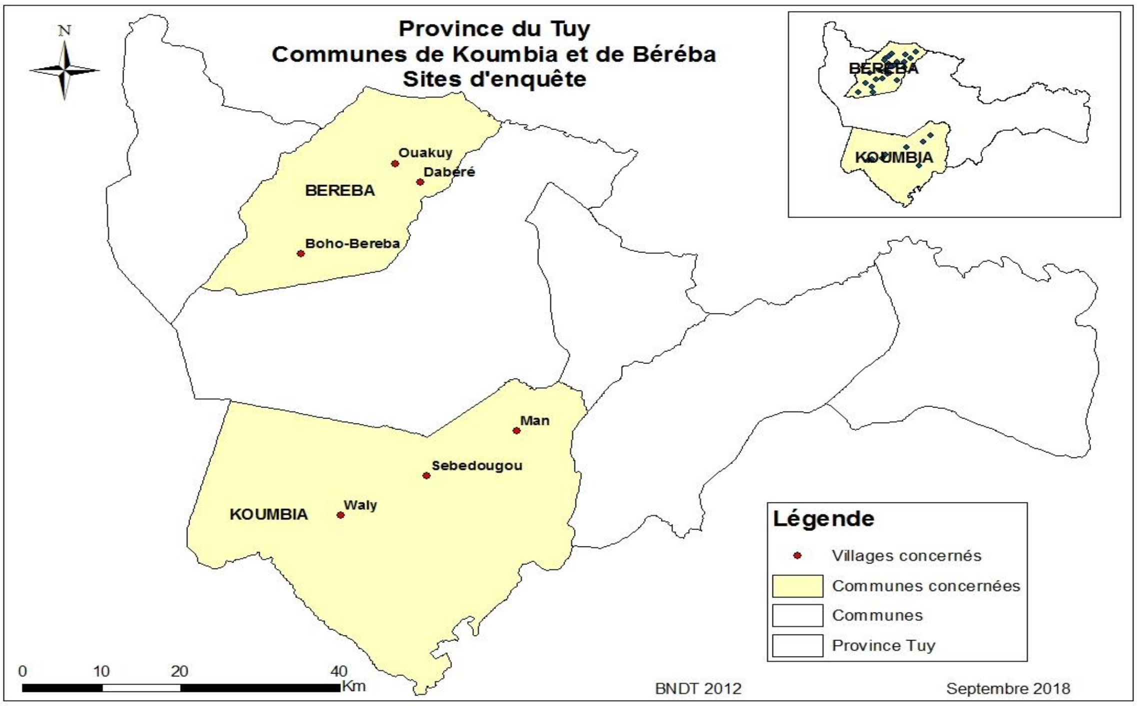


Figure 1: Study area
Source: 2018 survey data

Data processing and analysis
The data collected was recorded, processed and analyzed by computer using Excel and SPSS 22.

Theoretical framework

Some theoretical references for the adoption of agricultural innovation
a. Agricultural innovation
Innovation is any idea, object or practice considered by members of the social system as new (Mahajan & Peterson, 1985), or anything that calls for behavioral change (Rouveyran, 1972).
As human needs grow, "subsistence economy beyond a certain threshold no longer meets needs in the desired quantities and range: it shrinks." Increased surplus requires increased production, which can only be achieved through improved combination of the factors of production, i.e. changes in behavior, innovation. Given their potential for extreme sluggishness, an external and prescriptive approach is required to provide the drivers needed for the subsistence economies to "progess" (Maboudou, 2003).
Innovation can be defined as the application or ownership of an invention by producers (Muchnik, 1998). In the agricultural sector, innovation is conceived as the introduction of a new practice, sometimes a change in a traditional practice (Chantran, 1972). For this study,

we retained Adams' (1982) definition of innovation as a new idea, a practical or technical method for significantly increasing agricultural productivity and income in a sustainable manner. This supports FAO's (2016) statement that "agricultural mechanization" is a key agricultural input in sub-Saharan Africa (SSA) with the potential to transform the lives and economic circumstances of rural families. As such, agricultural mechanization, like improved seeds, fertilizers, labour and insecticides, is viewed as an innovation that can improve agricultural productivity and yield. As a matter of fact, technological innovation in agriculture is considered as a driver of change in Africa’s agriculture. New technology and innovation are considered synonymous here (Chaabouni 2007).
This new research is largely based on Schumpeter's work, but also on institutional approaches regarding the process or conditions for supporting innovation. From an economic standpoint, innovation is generally supposed to lead to progress and therefore can have one of the following three meanings (Adebgidi, 1995):
implementation of changes in production, i.e. changes in the production function;
market introduction of new types of goods, i.e. the emergence of new supply functions;
introduction of procedural changes to markets or the economy as a whole, i.e. social reform.
The adoption of technological innovation in agriculture is a rational course of action for the agricultural producer who gives more preference to innovation when it is most useful to him. This is how he chooses between various chemical, organic, biological and mechanical innovations.
The adoption of innovation corresponds to the need for it, since the decision to adopt or the demand for mechanized agricultural services is based on the same rational decision-making process through cost-benefit analysis. As a result, the producer only makes a choice when the benefits attached to that choice outweigh the cost of procuring it (Cournot 1838).

b. Demand for agricultural services

The analysis of demand for services falls under microeconomics, a discipline that studies the material well-being of individuals and concerned with the way of in which wealth is produced and used to satisfy human needs. Microeconomics refers to a study of processes whereby scarce resources are allocated to alternative and competing needs in order to achieve maximum satisfaction. Thus, faced with a multitude of needs and limited resources, the economic actor makes an economically rational choice to ensure maximum satisfaction or usefulness (Cournot, 1838, Debreu, 1954). According to traditional economic theory (Jevons 1875, Menger 1892 Walras 1874), innovation in mechanized agriculture can only be adopted when the individuals concerned are convinced, based on information available to them, of the value or gains they can derive from it. Individual rationality is determined by a person’s own interest through the invisible hand (Smith, 1776). From the perspective of a consumer requesting goods or services to satisfy his needs within his resources, a farmer, who decides to adopt a new technology, would select an option (innovation) based on technical specifications and the state of the environment, in accordance with his selection criteria. Campagne (1988) noted that a farmer will adopt mechanization or motorization as a technology only when he considers it the most appropriate means of ensuring greater satisfaction of his needs.

Model specification and selection of variables

a. Adoption model specification for agricultural innovation

Several empirical studies (Nkamleu and Coulibaly 2000, Adésina et al 2000) have been conducted on the adoption of agricultural innovations. Various methods of analysis have been applied, including the use of econometric models. The literature review of adoption studies found three types of models commonly used to analyze the decision to adopt agricultural technology: linear probability, Logit and Probit models (Ayuk, 1997, Adeline et al. 2000, Mazvimavi and Twomlow, 2009). These models use binary variables as dependent variable (Blazy et al., 2011). There are drawbacks to the first model as the probability is often higher than 1. Although the Logit model is often used in most adoption studies, we wanted to use the Probit model. A binary Probit model was deemed appropriate to specify the linkage between the probability of adoption and the determinants thereof. The advantage of a Probit model over a Logit model is that the former produces positive probabilities. In this study, we opted for the Probit model. This model was used by Maboudou (2003) to study the adoption of maize storage technology in Benin. It was also used to study the adoption of improved varieties of maize. Zoungrana (2004) used the Probit model to analyze the adoption of soil conservation technologies.

Let's assume an individual (peasant maize producer) having to choose between "mechanized agricultural services and traditional tillage techniques". The decision to adopt the use of mechanized services occurs only when the combined effect of the factors reaches a value at which he agrees to use the services. Assuming that the impact is measured by an unobservable index I_p for the producer p, with I^*_p being the switching value of the index at which the producer uses the mechanized services, we have, according to Manyong et al. (1996): If I_p is greater than or equal to I^*_p, then he uses the mechanized services and the adoption variable Y_p has the value 1. The higher the index I_p, the higher the probability that the producer will adopt the mechanized services. In all other cases, he will reject the mechanized services and Y_p is equal to 0.

In mathematical formulation, we have:

$$Y_p = \begin{cases} 1, \text{si } I_p \geq I*_p \\ 0, \quad \text{si } I_p < I*_p \end{cases} \quad (1)$$

The index I_p for an individual p is a linear combination of variables that determine adoption with unknown β coefficients to be estimated. The formula is as follows:

$$Ip = \sum_{n=1}^{N} \beta\, nXnp \quad (2)$$

where X_{nd} represents the nth independent variable that explains the use of mechanized agricultural services by an individual p with βn as the parameter to be estimated and corresponding to X_{nd}.

If β is a vector of the parameters to be estimated and X a vector of the independent variables, the second equation becomes: $Ip = \beta X$

Then the likelihood P_p of an individual adopting the innovation of the use of mechanized agricultural services is P_p = P(Y=1)

With Ip as a random variable and F (*) as its cumulative probability function, we have:

$$\mathrm{P(Y = 1) = P(I * p \leq Ip) = F(Ip) = F(BX)} \quad (3)$$

$$\mathrm{P(Y = 0) = 1 - F(Ip)}$$

In this Probit model chosen as one of two probabilistic options on the one hand, and for simplification on the other, the probability of use of mechanized agricultural services by an individual p is: $\mathrm{Pp} = P\mathrm{(Y = 1) = F(Ip)}$

According to Hurlin (2003), this probability is defined as the value of the standard normal distribution function *N(0.1)* considered under I_p:

$$\mathrm{P(Y = 1) = P(I * p \leq Ip)} = F\mathrm{(Ip)} = \int_{-\infty}^{id} \frac{1e^{-t^2/2}}{\sqrt{2\pi}}\, dt \quad (4)$$

where t is the standard normal variable and e a constant with a value equal to 2.71828.

The model will be estimated using the maximum likelihood method.

b. Definition of variables:

Dependent variable, whether or not demand for mechanized services will be used.

Characteristics of households and individuals without motorized equipment were used as independent variables:

Table 4 : Summary table of study methodology

Specific objectives	Type of data/information to be collected	Place and target audience	Method for obtaining data
Analyze supply and demand	Quantitative and qualitative data	Municipalities of Koumbia and Béréba, from producers	Survey questionnaires
Estimate the willingness to pay	Quantitative and qualitative data	Municipalities of Koumbia and Béréba, from producers	Survey questionnaires
Diagnosis of service opportunities	Qualitative data	Municipalities of Koumbia and Béréba, from producers	SWOT

Findings

Status of agricultural tractors in the province of Tuy

According to the census results:

- A total of 341 tractors of more than 31 makes were found in the study area, with MASSEY FERGUSON, FARMTRAC and DTE as the leading makes (Fig.1);
- Tractor powers ranged from 40 to over 100 hp

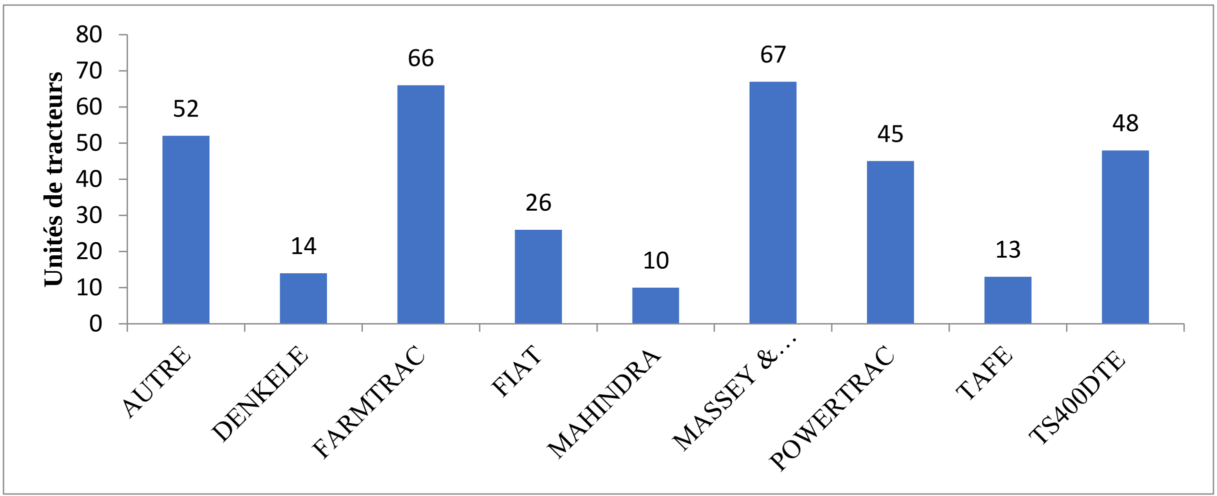


Figure 1. Breakdown by make of tractors recorded in the province of Tuy in Burkina Faso

The existence of too many different makes created problems of spare parts availability, causing mechanics to make adaptations to tractors. Some reported that they travelled to neighboring Ghana specifically to look for spare parts that could not be found on the local market. Such challenges could result in longer tractor downtime and if it occurred during peak demand for field preparation, tractor owners were greatly affected.

The number of tractors procured each year increased sharply as of 2008, with peaks in 2010, 2013 and 2017 (Fig. 2.). This development can be described as exponential with a very high correlation coefficient (R^2) of 0.76.

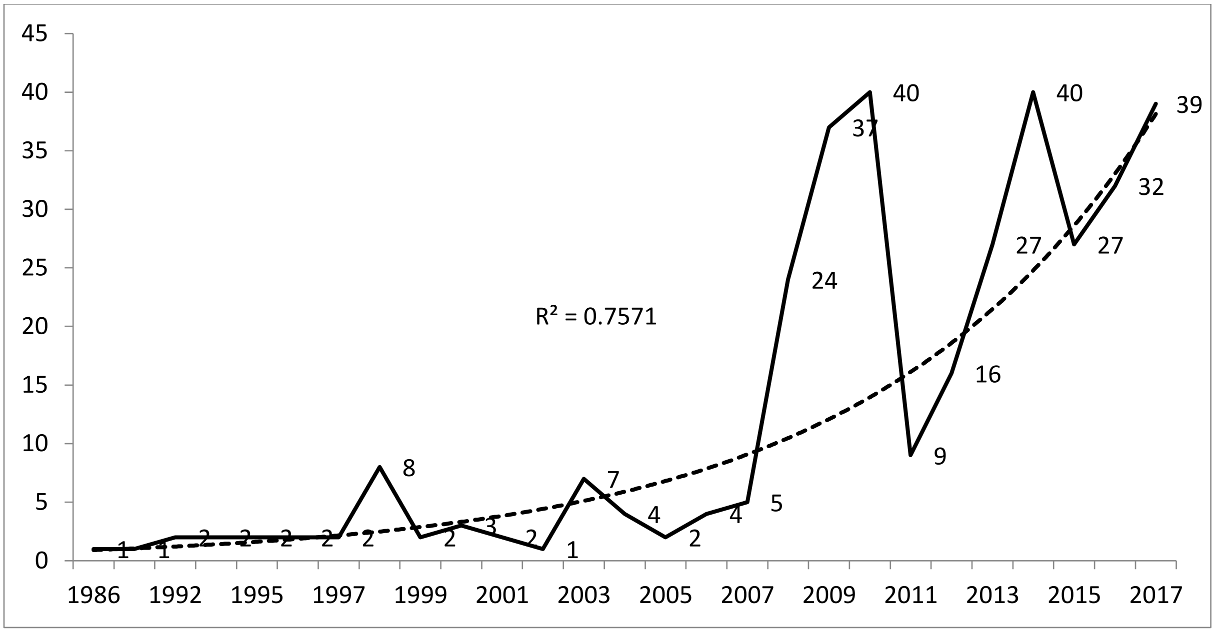


Figure 2. Annual trend of tractor procurements in the province of Tuy in Burkina Faso

Two-thirds of the tractors procured were new (67% of cases), whereas one-third were second-hand (Fig. 3).

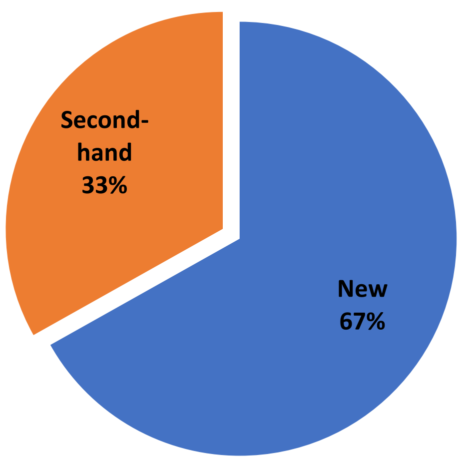


Figure 3. Condition of tractors procured by farmers in the Province of Tuy in Burkina Faso

The breakdown of these tractors by municipality shows a strong concentration in the provincial capital of Houndé (99), followed by the municipalities of Koumbia (45) and Béréba (27).

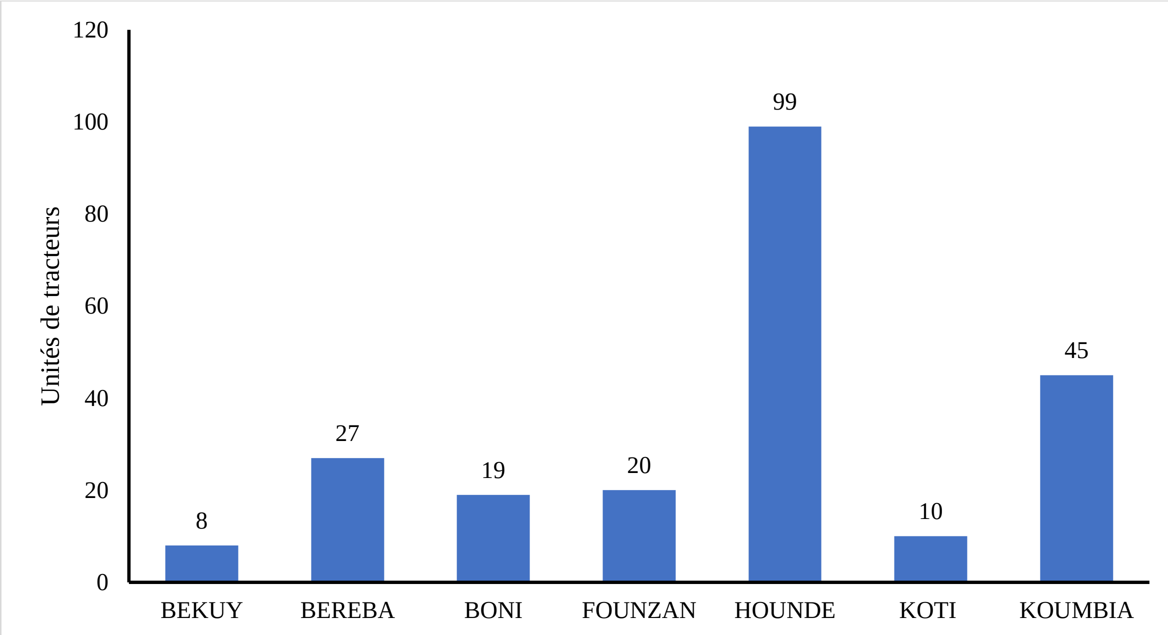


Figure 4. Breakdown of farm tractors by municipality in the province of Tuy

The results also show that 40 hp tractors are the most representative (Figure 5), followed by tractors with 50 to 60 hp, then those with more than 60 hp.

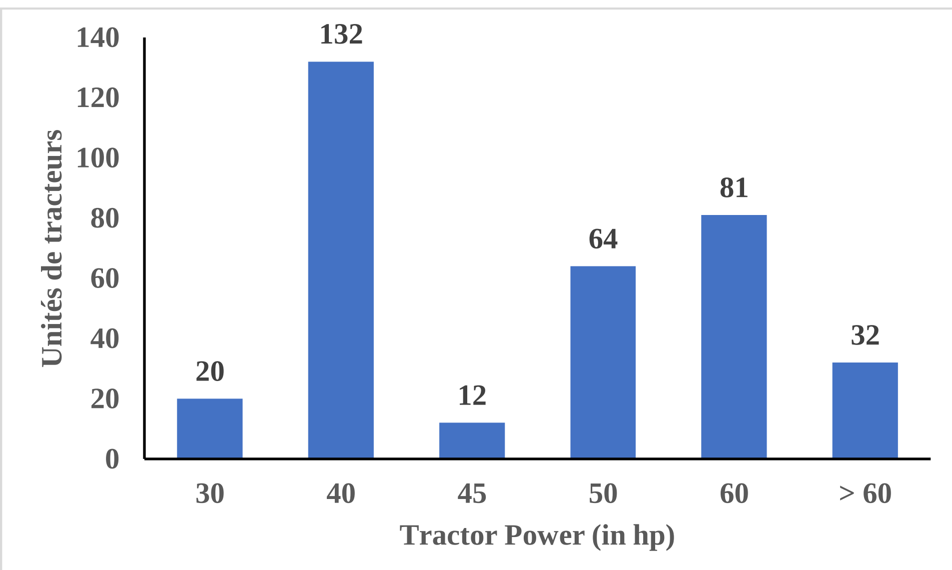


Figure 5. Available tractor power in the province of Tuy

This relatively low power seems better suited to the low financial capability of farmers but also the fragile nature of most soils. This can be a limitation when it comes to leveraging certain heavier equipment.

Socio-economic characteristics of respondents and structure of their holdings

Our study sample consisted of 180 farm households, 95% of which resorted to various mechanized services on their farms and for post-harvest or primary processing activities, with only 5% not using any of the services in their farming and post-harvest operations.

3.2.1 Social and personal characteristics of household heads

The farm managers interviewed were practically all men (97%), with an average age of 46 years. The youngest was 25 years old while the oldest was 74 years. The level of education of household heads in our survey sample is generally low. 41% of the respondents had had no education; only 23% had primary education and 5% secondary education; 13% were literate and 18% had received instruction in Arabic. Overall, there were low levels of education in the study area (72%). The study of the ownership status of the population showed that our survey population was predominantly landowners. It should be noted that landowners included immigrants who became landowners after a long period of residence among the natives. 63% of respondents were landowners, 26% borrowed land for farming, and 11% farmed on rented land and paid rent. The study reveals a high proportion of migrants. 48% of our survey population in the study area were migrants, while 52% were natives. It was also noted that more than a third (35%) of the migrants owned their farms. This is evidence of the smooth integration of migrants and the peacefully coexistence between indigenes and non-indigenes in the area.

Structural features

This section highlights the demographic structure of households as well as the land structure of farms.

The demographic structure varies significantly from one household to another. Our study shows varied household sizes ranging from a minimum of 2 to nearly 50 people in a household. Thus, in the study area, the largest household had 43 people and the smallest 2, with an average of 13 people per household. The large size of the households may be due to the fact that in the context of farming, one often finds clusters of family households.

The average number of assets per household was 6. This number is quite interesting for a high agricultural production area where agricultural labour is becoming scarce for reasons already discussed in the background of this study.

The primary sector, like other sectors of the economy (secondary and tertiary), requires production factors to create wealth and support its actors. The main factors of production are the inputs used in the agricultural production process. These are often grouped into broad categories such as land, physical and financial capital, and labour. Thus, in economic terms, agricultural production is a function of land, capital and labour, and is expressed in mathematical terms by the formula $y = f(t, k, l)$. These elements are important, even necessary for some, for agricultural production. Land, created without human labour, is the first agricultural input, and as such, its value varies greatly depending on the nature of the soil, the climate, the potential for

irrigation and fertilization, etc. (GUY, 1973). Land is deemed the first agricultural input (means of production) because agricultural production and other production inputs depend on it.
The average size of the farms surveyed was 9.9 hectares. This is well above the national average, estimated at 4 ha by the 2012 continuous agricultural survey (EPA in French). The gap may be due to the fact that this is a cotton-growing area, most suited for agricultural activity in the country. As a result, large areas are needed to take advantage of the favorable soil and ecological conditions. In certain locations, the surveyed farms often exceeded 50 hectares, with the largest covering 56 hectares. By crossing size with demand for ploughing services, we had nearly 72% of farms with an area greater than 7 hectares.
Firstly, it could be said that ploughing services by tractors lead to more acreage for producers. Secondly, large acreage creates demand for ploughing services. Thirdly, it is safe to say that the uncertainty and unpredictability of the first rains cause large farm owners to be very quick in ploughing to ensure prompt cultivation in the light of shorter and unpredictable rains. Lastly, it may be said that large owners are in better stead to afford mechanized ploughing services due to their higher financial capability compared to owners with small acreages. Here, we are not dealing with intensification, which remains a challenge that needs to be addressed in agricultural production in Burkina Faso. So, the large size of the areas cultivated points to the types of farm, which can be cash crop oriented or for subsistence consumption. Large acreages in our study area were predominated by commercial crops. As a matter of fact, cash crops were the most important, with 83% producing cotton, 98% maize, 13% rice and 32% peanut, as shown in the graph below. Other crops such as cowpea, millet and sorghum were grown by 9%, 19% and 36% of households respectively. In the study area, the results show that nearly 72% of the requesting farms have more than 7 hectares of farmland.

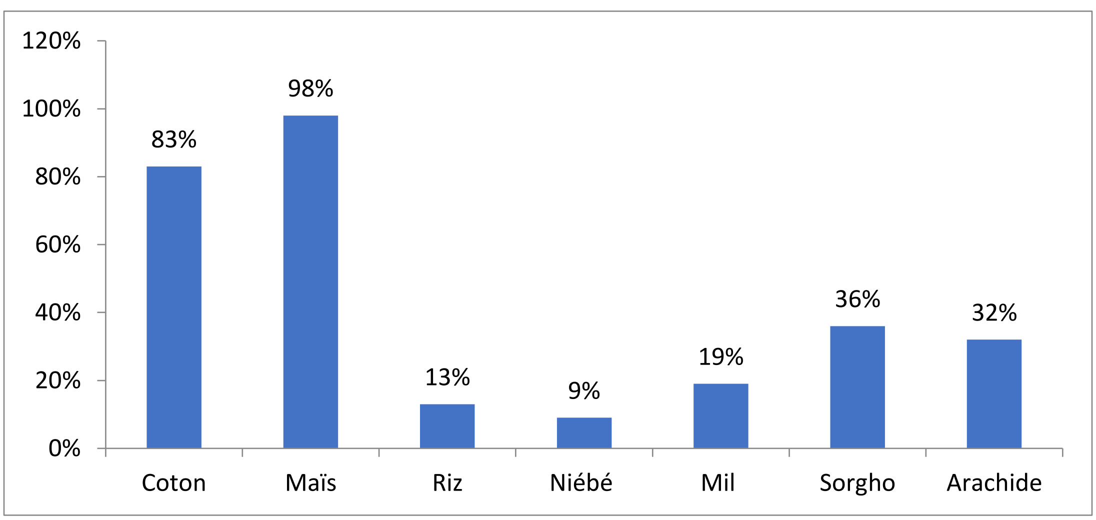


Figure 6. Graph of major crops

Tractor and draught animals: Substitution or complementarity

The results of the study suggest there is no exclusive demand for tractor services for ploughing. Indeed, data show that demand for tractor services for ploughing is not exclusive but rather complementary. We did not come across any producer requesting ploughing services from tractors who used tractors only. However, the study shows substantial quality in the tillage work done by tractors. The demand for mechanized ploughing services highlights the ease and speed of tillage by tractors.

The seeming paradox, however, is that while tractor services were lauded, draught animals were being used alongside tractor services (89% of households had draft oxen and 19% donkeys, with an average of 3 and 1.44 per farm, respectively).

The combined use of animals and tractors was due to the difference between the cost of tractor services and the prices those requesting them were willing to pay. Furthermore, there was no assurance of availability of tractors to plough all plots of farms in need of tractor services. Finally, plots requiring mechanized ploughing services were not all clear of stumps to allow the use of tractors on the whole area. But the main reason was that the price of mechanized ploughing services was well above the price people were willing to pay. The imbalance between the price of supply and that of demand is as a result of the mismatch between supply and demand. In our study area, supply was less than demand (19 owners with 25 tractors).

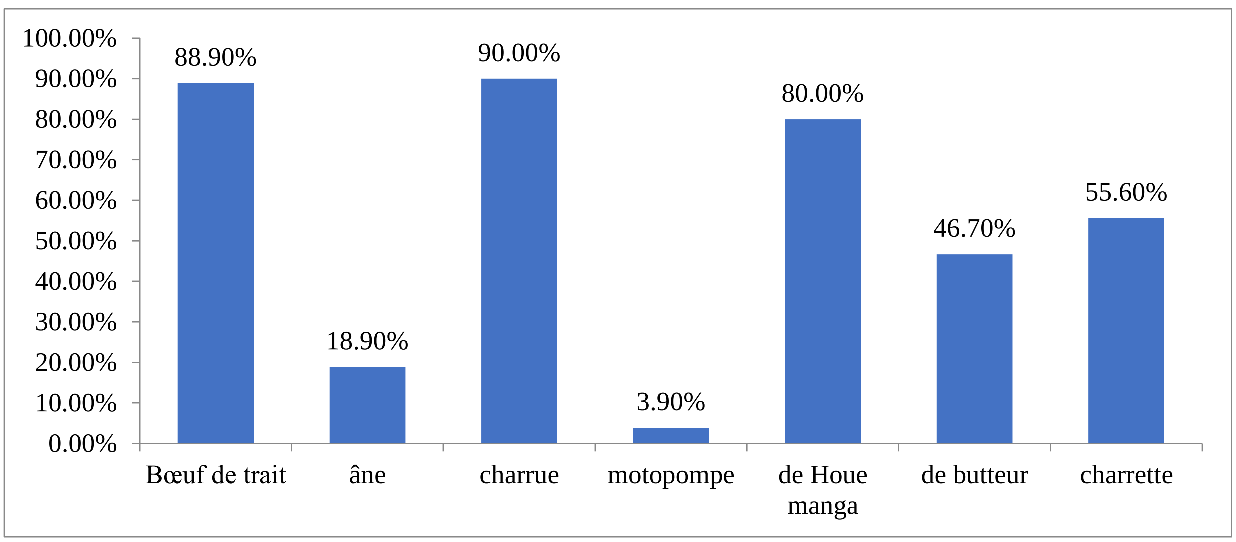


Figure 7. Ownership of agricultural equipment (Source: Survey data)

Figure 6 and Table 7 reflect the ownership of agricultural implements.

Nearly 90% had draft oxen and far fewer donkeys than draft oxen. Only 19% of producers in the area owned donkeys.

That oxen are the favourite draught animals in the area is understandable. The presence of tractors and motorcycle taxis could explain the low proportion of donkeys in the animal park of producers in the area.

The number of plough owners was slightly higher than the number of owners of draft oxen. This study reveals that some producers who did not have the means to purchase draft oxen still acquired ploughs. Such producers resorted to draught animals from animal owners to plough their fields.

Table 5. Ownership of agricultural implements

Number/household	Owners	Proportion	Minimum	Maximum	Average	Standard deviation
Cart	100	55,6%	1	3	1,14	0,377
Plough	162	90,0%				
Houe manga (type of hoe)	144	80,0%	1	5	1,27	0,628
Ridging plough	84	46,7%	1	2	1,17	0,375
Draft ox	160	88,9%	0	8	2,87	1,622
Donkey	34	18,9%	1	3	1,44	0,660
Motor pump	7	3,9%				

The table shows that farmers could own up to 8 oxen for draught power. This is indicative of the high volume of agricultural work in the study area. The cost of maintaining the physical fitness of the animals for the beginning of the season, their slow nature, and diseases must be taken into account.

Institutional features

In Burkina Faso, the role of farmers' organizations is to organize the rural community through professionalization and capacity building to achieve food security and sovereignty. They are therefore intermediaries between decision-makers and the farming community. In this study, 91% of producers surveyed were members of farmers' organisations. This rate may be explained, on the one hand, by the fact that producers are highly aware of the essence and benefits of professional organisations, and on the other hand, by the propensity of our study area towards cotton production, coupled with the fact that cotton producers are automatically organised into OPs or GPCs by the umbrella organisation of cotton producers in Burkina Faso, for better coordination of cotton production. For Matumo (2009) therefore, the overall objective of organisations is one of change: every organisation therefore aims to create something new. This study shows that 91% of organised producers surveyed were cotton producers. We note that membership rate in a farmers' organisation is the proportion of cotton producers among the target producers of the survey.

a. Producer training and supervision

Data show that producers had inadequate technical capacity. In the specific case of Burkina Faso, producers had no propensity to train themselves in approved agricultural training centres. Furthermore, the literacy rate among producers in Burkina Faso was very low. Consequently, the rural community needs guidance and training in farming practices in order to have successful cropping seasons which are unpredictable within the West African context. Unfortunately, only 9% of respondents were trained in soil tillage, 7% in technical itinerary, 2% in water and soil conservation, 1% in seed production and about 3% in other areas such as composting, draught power and semi-manual. As far as technical assistance is concerned, 41% of producers said they had been visited in their fields by a technical officer from the ministry of agriculture, or from SOFITEX, a cotton company. According to the producers interviewed, the supervision included phytosanitary treatment (for 5.5%, of respondents), maintenance of fields (30%), field measurement, technical itinerary (23%) and soil tillage (4%).

Table 6. Demand for mechanized agricultural services and PO membership

Particulars		PO membership		Total
		No	Yes	
Demand for mechanized agricultural services	No	7	2	9
	Yes	10	161	171
Total		17	163	180

Source: données de l'enquête

b. Tractor service demand in the study area

Tractors are used for various farming operations. It emerged from the study that tractors were currently required for only three operations, i.e. ginning or threshing, transportation and ploughing. Operations such as weeding, sowing, hilling, threshing and scarification were done manually or by animal draught power. Operations for which there was no demand were presumably due to a lack of tools to carry them out, but also to the cultivation systems used by producers. The most-in-demand operation was ginning. Ginning was required by almost all maize producers. Of the three operations required, ginning was first (95% of farmers), followed by transportation (43.8%) and ploughing (30%).

There was a strong demand for mechanized services by households, if only for shelling. However, it should be noted that this strong demand for mechanized agricultural services is a recent occurrence. Figure 3 shows that 69% of farmers surveyed resorted to mechanized services for the first time in the last ten (10) years, with the longest experience with tractor services being 25 years or more. This is reflected in the fact that mechanized agricultural services have begun to permeate farming practices among farmers. Availability of mechanized agricultural services was cited as one of the drivers of demand. However, access remains low, as 22.8% reported that they did not receive a positive response to their request for mechanized services. For households that had access, they had to request 1.37 times on average before they were successful. In other words, not all requests were met (22.8%). Moreover, among those whose requests were satisfied, an average of more than one request was necessary to hope to have one's requirement met.

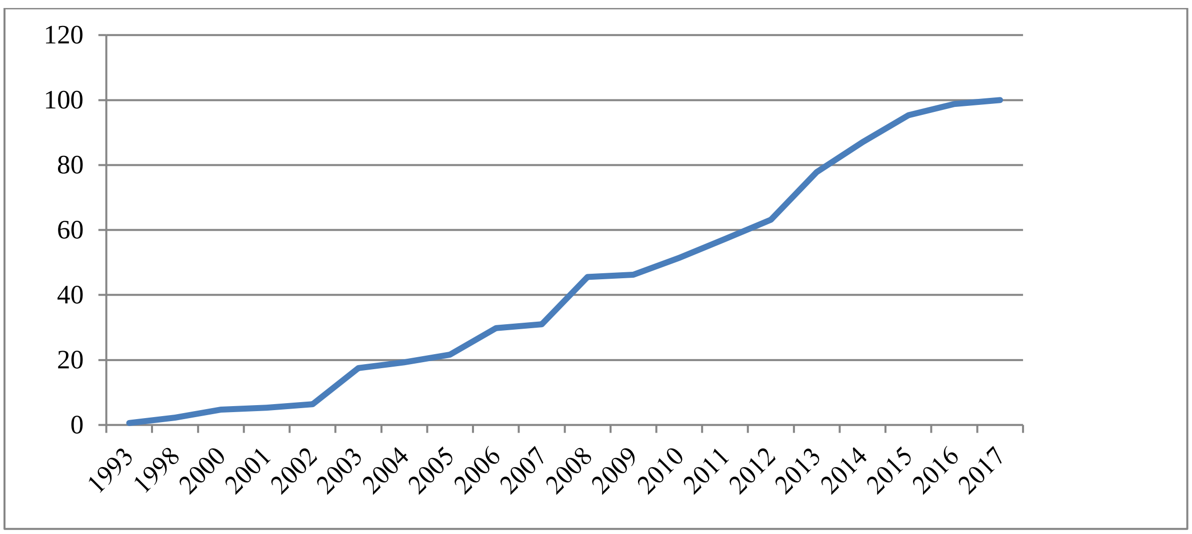


Figure 8. Trends in demand for mechanized agricultural services from 1993 to 2017

Determinants of Demand

Key demand drivers for mechanized agricultural services

In this study, we noticed that all producers who owned tractors offered mechanized agricultural services to non-owners. According to Sanou (2016), virtually all farms that owned tractors provided services including soil tillage, shelling and transportation of inputs and organic manure, with a very small number providing transportation services for construction aggregate. As a result of unpredictable seasons and rains, producers are compelled to consider resorting to mechanized services to keep up with an unstable crop calendar. The late onset of the first rains resulted in shorter periods for soil tillage. This led to an increase in the demand for mechanized services to plough faster in order to quickly sow (Side, 2013). It emerged from our study that some producers who did not own motorized agricultural equipment were applying for mechanized agricultural services. What then are the demand drivers for mechanized agricultural services?

This study highlights the main factors driving demand for mechanized agricultural services. Several reasons led producers to request tractor services. These included speedy execution of farming operations and drudgery. 77.8% of requesting producers cited speed of service as the reason while 73.7% cited reduced drudgery. Quicker farming operations and reduced drudgery lead to increased work productivity and transfer of the labour force to the most productive activities. According to (Havard and Side, 2015), mechanization allowed the extension of cultivated areas and offers labour savings per hectare, resulting in work productivity gains. Technological innovation, which underpins increased labour productivity in the agricultural sector, is not conceived in abstraction from the technical system and the prevailing technological mind (Mounier 1992, Perez 2009).

Other reasons, such as increased yields, larger acreages and weaker oxen were cited in 64%, 20% and 13.33% of cases respectively. However, (Side and Havard, 2015) believe that switching to animal draught power and / or mechanization in rain-fed crops does not improve the quality of tillage and has little impact on yields. Larger acreages through the use of mechanized ploughing resulted in increased production and extra labour and labour demand in non-mechanized crop tending operations. According to (Roupsard 1984, Bordet, 1997), the transition to mechanized ploughing leads to an increase in work per farm for seeding, weeding and harvesting as these often continue to be done manually. According to (Sanou 2016), the condition of some plots makes the use of seeders or motorized weeders that work in several rows difficult (risk of major breakage). This may be explained by the fact that farmers often do not have sufficient resources to acquire seeding and crop tending equipment in addition to tillage and transportation equipment, (Sanou, 2016).

On the impact of mechanized soil preparation on agricultural production, all producers thought that the use of mechanization made tillage quicker, sowing easier, and created better conditions for crop germination and emergence than human and animal power. They believed that tractor ploughing allowed the soil to hold water long enough to avoid pockets of drought when rains become scarce. This has a beneficial effect on crop growth and may affect yields.

The study shows that the use of mechanized agricultural services has benefits, i.e. makes the work easier and less arduous, and partly solves the bottleneck of farm labour shortage. However, not all producers without tractors made use of mechanized agricultural services.

What could explain the lack of interest in mechanized agricultural services?

For non-users of mechanized agricultural services, their small production acreage and low outputs are a disincentive to the use of mechanized farm equipment. These "small producers" (33.3% of households) reported that maize output, when it is low, is easier to store even with the cob, preventing storage losses.

Some producers found the cost of the service exorbitant, with 60% citing the high cost of ploughing. Generally, ploughing was done for cotton and corn, since other crops did not require much ploughing. For the most part, those who did not require mechanized ploughing services were not cotton or maize producers. Among non-users of ploughing services, those who produced neither maize nor cotton accounted for 44.6% and 89.9% respectively. On the other hand, those who did not require mechanized ploughing services but grew cash crops (maize and cotton) used small areas. For such producers, acreages remained small, 2 ha maximum for cotton and maize.

Feedback on mechanized services

Producer feedback on innovation is crucial because it determines their attitude towards innovation, Lawin (2006). The feedback on tractor services differs from one farmer to another and depends on the service required. For users, tractors make soil tillage easier, reduce drudgery, and increase acreage. Tractors, unlike animal draught power, allow them to cultivate a large area in a single day. Mechanized tillage services ensure quick execution of farming operations. This allow producers to keep up with the crop calendar. With crop periods becoming shorter and the winter season increasingly unpredictable, the race is on from the very first rains to ensure the crop calendar was adhered to.

With regard to ginning, the performance of the technology and innovation were again highlighted. For our target audience, thanks to that innovation, it is no longer necessary to mobilize the entire family workforce for several days for ginning operations. With a gin/sheller therefore, work has become much easier and considerable time is saved, leading to increased labour productivity and transfer of the idle labour force to a more productive area. As a result, an entire production can be processed and packaged in a single day.

Transportation using tractors is another aspect of the innovation. Connected to trailers, tractors have become a convenient means of transportation in rural areas, where roads are barely motorable. In fact, owing to the poor state of the roads, tractors are commonly used to transport inputs (crop seed, chemical and / or organic fertilizers, etc.) during the winter period. At the end of the season, these “new means of transportation” are used for transporting wood and harvested crops. Well appreciated by those requiring such tractor services, this technology has come to alleviate the struggles of producers who cannot afford to own one on their farm, notably producers with not-easily-accessible fields who are very much appreciative of these tractor services that facilitate the transportation of their production inputs and produce.

Although mechanized services are largely appreciated, producers have raised the issue of cost of ploughing, which for them remains high and a barrier to many. This would partly explained the low adoption rate for mechanized ploughing services.

While non-users do not resort to mechanized services, they still recognize that mechanized services considerably reduce the arduous nature of the work and help move quicker according to the crop calendar. However, some of them think that inverting the soil can lead to soil depletion.

Determinants of demand for mechanized services

Determinants of demand for ginning services

As pointed out above, of all the mechanized agricultural services available in the study area, ginning is the most patronized (95% of farmers surveyed use this service). It should be noted that the services offered and requested by farmers are: ploughing (30%), transportation services (43.8%) and ginning services (95%). This high demand for ginning services compared to other services can be explained by the fact that the services are not only cheaper but are paid for, in most cases, in kind (in 99.4% of cases). Through this method of payment, the service becomes accessible to all, in so far as it is agreed to withhold some of the produce to compensate for the costs of the ginning operation. Farmers have sound reasons for adopting this technology. The ginning operation involves a fairly high opportunity cost for farmers. This opportunity cost is expressed in terms of the difficulty of the operation, the time taken to do it, and the opportunity to be able to use this time to do something more productive. In addition, the service is relatively affordable for everyone, and the fees are not payable necessarily in cash. Finally, this technology relieves the pain of a certain category of people, namely women and children. This massive adoption could also be attributed to the fact that recent measures in favour of women and children have also promoted the protection of women, thereby relieving them of strenuous tasks. It is worth mentioning that due to education, children cannot be counted on for these operations, as harvest seasons coincide with the beginning of the school year.

As a result, household workforce is reduced to only those who are not in school. It is absolutely worth noting that schooling is an important factor resulting in the reduction of household workforce, hence the need to adopt innovations for labour-intensive operations.

In order to facilitate the ginning process, farmers requesting the services are grouped by suburbs, at the request of service providers in order to satisfy the maximum number of farmers at a time. This arrangement is to avoid the movement of small quantities to and fro.

Another reason is that after harvest, farmers can at any time request for the services. This means that the service is available all year round, and request can be made at any time of the year. This is contrary to a ploughing service, which is time-bound and dependent on rainfall. The data show that the surveyed households shelled their maize between October and January with a high rate of 27.2% in November and 51.7% in December.

The frequency analysis shows differences between the two types of users only in terms of maize production and the real quantity produced. As a matter of fact, 96% of maize producers use the service of maize shellers, with an average quantity of 5743.96 kg, compared to 928.7 kg for those who do not use shellers.

Table 7. Maize production and demand for shelling services

Demand for shelling services	Respondents		Production (in kg)			
	Number	% of total number	average	Min	Max	Standard deviation
No	7	4.0%	929	300	2000	750
Yes	169	96.0%	5744	300	30000	5819
Total	**176**	**100.0%**	**5552**	**300**	**30000**	**5781**

Source : 2018 Survey

Determinants of demand for transportation services

43.8% of households surveyed use transportation services. Most transport operations take place after shelling, especially when the shelling is done on the field. All (100%) of those who had their maize transported by tractors, had it shelled by tractors. Indeed, those without means to carry their crops also request owners of shellers to transport their maize for them. In some cases, crop owners have modes of transportation such as oxen and/or donkeys to convey their produce.

It should be noted that demand for transportation services is not limited to conveying produce from fields to homes. It also involves the transportation of inputs (seeds, fertilizers, organic manure) to the fields, as well as other agricultural produce such as cotton to depots. Other produce for which tractors are used include cotton (6.1%) and millet (0.6%). These low tractor adoption rates for cotton and millet transportation are due to the fact that for most cotton producers, production is directly removed from site, without the need to move it to another location before SOFITEX comes for it. Also, some producers, when it becomes necessary for them to transport their production to SOFITEX-approved sites, use animals (donkeys and/or oxen). Regarding millet, the low rate tractor adoption for its transportation is due to the massive ownership of draught animals among farmers (88.90%) and sorghum production is not as significant as maize to request transportation by tractor. The average sorghum production is 930 kg with a median of 500 kg. Average maize production is 5.5 tons with a median of 3.100 tons. Owing to the numbers, draught animals are used for the transport of larger production, such as maize and cotton.

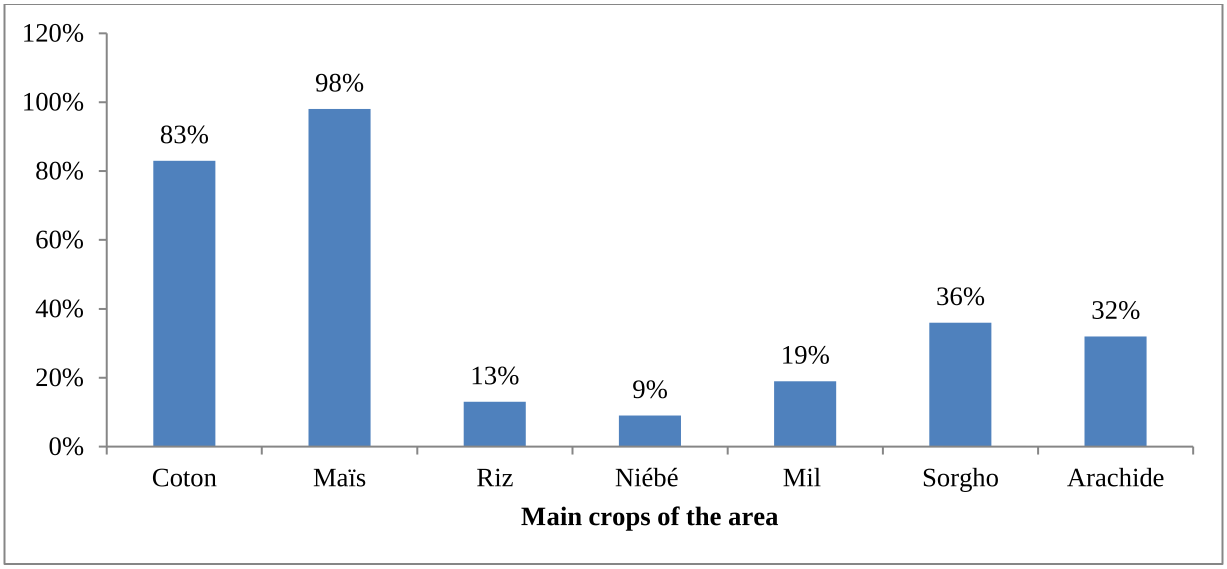


Figure 9. Major crops in the area

Figure 8 shows the significance of crops produced based on the number of people who grow them. Therefore, maize is the major crop in terms of the number of farmers who grow it. This may be due to the fact that maize is both a staple food and an important source of income for producers due to the availability of ready market for the crop. Indeed, the study reveals that maize production plays a dual function (food and trade).

Table 8. Production quantity per crop

Crop	Average production (Tons)
Maize	5521
Cotton	4173
Sorghum	930
Millet	888

Soya	514
Sesame	234
Cowpea	163

The table above shows the seven major crops of the area according to production quantity. Of the seven crops, maize comes first with an average production quantity of 5.5 tons, despite poor rainfall in the 2017-2018 crop year.

a. Determinants of demand for ploughing services

The results contained in the table below show that there are very significant differences between the averages of certain variables for the two groups of users. Indeed, farmers using ploughing services, with an average age of 44.89 are relatively younger than non-users (46.52 years). Therefore, young farmers are more inclined to use tractors to plough their fields than the older ones.

The younger generation is more sensitive to entrepreneurship. Agricultural entrepreneurship is adapting to the increase in land area. The use of tractors to increase production for entrepreneurial purposes also helps to avoid animal weakness at the beginning of the rainy season (Tapsoba 2013, FAO 1994). As a result, young entrepreneurs who are concerned about farming on large acreages and also about timing the rainy season tend to use tractors to save time and optimize production.

With regard to household size, the average is higher among users of mechanized ploughing (16.11 people compared to 12.52 people for those who don not use the service). The same is true for the number of workforce (12.01 people compared to 6.41 people).

The areas cultivated by households requesting ploughing services are larger, with an average of 9.65 ha and 5.6204 ha for cotton and maize respectively, as against 4.37 ha and 2.8197 ha for non-users of the service. The total area for users of the service is 17.69 ha compared to 7.19 ha for non-users. It is clear that users of ploughing services have large household sizes and the largest cultivated areas. This could therefore mean that in order to increase their farming area, some large households resort to the use of tractor services. This hypothesis could be confirmed by the econometric analysis since the correlation coefficient gives us 0.391 and 0.446 for (household size - cotton area) and (household size - maize area) respectively.

It is also clear from the results of the frequency analysis that landowners are the highest users (around 74.1%). With regard to land tenure system, natives have higher land proportions than migrants. There are also more farmers with livestock as a secondary activity. This could be explained by the fact that livestock farming provides additional income to households to meet the demand for ploughing services.

Table 9. Ploughing demand periods for cotton and maize

Periods	Cotton fields	Maize farms
April	5.3%	-
May	68.4%	21.1%
May to June	15.8%	15.8%
June	10.5%	57.9%
July	-	5.3%
Total	100%	100%

Ploughing services are mainly patronized in May (68.4%). However, given the demand for the service and the priority use of tractors in owners' farms, some requests are not met. Hence the massive use of draught animals for ploughing. According to the table below, nearly 90% of farmers who do not own tractors own draught oxen.

Table 10. Request for paid services

Type of operation	Requested service (ha)	Delivered services (ha)	Diff.	Satisfaction rate (in %)
Ploughing with a disc plough	60	38	-22	63%
Ploughing with a mouldboard plough	0	0	0	0
Ploughing with a Sprayer	206	136	-70	66%
Total ploughing demand	**266**	**174**	**-92**	**65%**
Ginning	578	445	-133	77%

It appears that only 65% of the demand for mechanized ploughing services are met by providers. This indicates the limited availability of agricultural machinery for ploughing. The study shows that only 30% of the population request tractor services for ploughing. 22% of such requests cannot be met. If this demand had been met, it would have brought satisfied demand to 52%, slightly above the average. Fonteh (2010) argued that the major constraint of poor farmers is agricultural mechanisation. In the same vein, Top (2014) also stated that the vulnerability of African farmers, especially those in sub-Saharan Africa, is increasing as their economies are poorly mechanized and undiversified and consequently require a large labour force. Rabemananjara (2014) uses the same analysis to affirm the significant reduction in the recruitment of external workeforce. This leads us to believe that agricultural mechanisation is a key driver of productivity, increased production and higher income for farmers, particularly the poor ones.

What can be the factors behind the lack of mechanization on the living standards of farmers? To answer this question, the FAO (2013) tried to describe a vicious circle based on low levels of agricultural mechanisation.

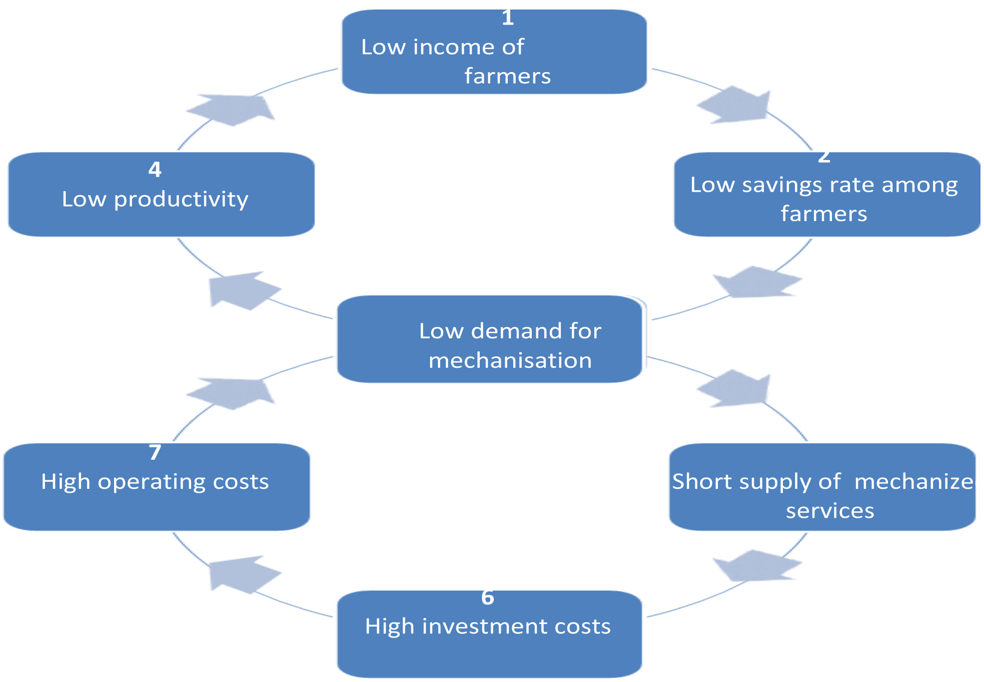


Figure 10. Factors affecting supply and demand for agricultural mechanisation (FAO, 2013)

We realize that low demand for mechanisation (4) leads to low productivity and low income, the latter leads to low savings that are not conducive for investment.
According to the AfDB (2016), agriculture is at the heart of Africa's development. Millions of people depend heavily on this sector for their livelihoods and lifestyles, and millions more consume products grown on African soil. However, as the population grows, production remains desperately low, calling for new investments and innovative approaches to revitalize the sector.

Strategy for increasing farmers' income

With sustainable intensification of agricultural production through mechanization and strong marketing, the previous situation of a vicious spiral can be turned into an opportunity based on the following FAO strategy (2013):

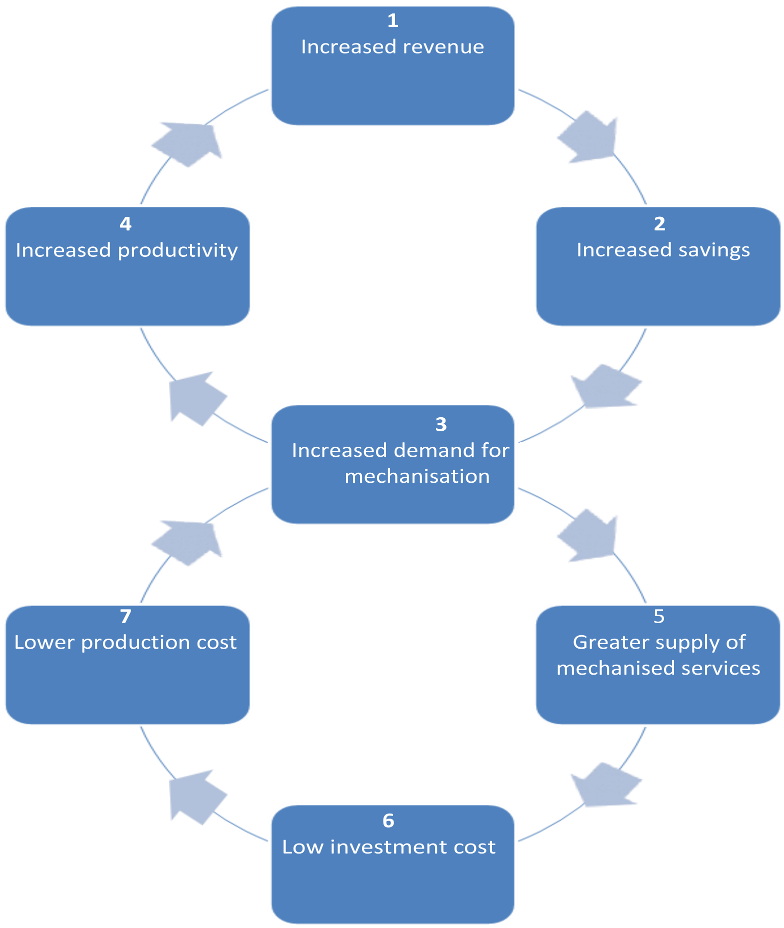


Figure 11. Virtuous circle resulting from sustainable intensification of agricultural production (FAO, 2013)

Table 11. Overview of demand features for mechanized services

Variables	Non-users	Users
Social and personal variables		
- Age	46.50	44.89
- Level of education	18.25%	48.14%
- Height	12.51	16.11
- Ownership status	58.73%	74.07%
▪ *Owners*		
- Residential status	45,24%	68.52%
▪ *Local*		
▪ *Migrant*	54,76%	31.48%
- Secondary activity	50,00%	81.48%
▪ *Livestock*		
▪ *Trade*	14.29%	12.6%
Structural variables		
- Number of agricultural labour	6.41	12.01
- Cotton acreage	3.38	9.72
- Maize acreage	2.76	6.93
- Total cultivated area	7.19	17.69
- Farm implements		
▪ *Plough*	88.89%	92.59%
▪ *Cart*	47.62%	74.07%
▪ *Number of plough*	1.11	1.59
▪ *Number of carts*	.5	.94
▪ *Number of draught oxen*	2.36	3.31
Institutional variables		
- Transfer	4.76%	12.96%
- PO membership	87.30%	98.15%
- Training received	13.49%	18.52%
- Support received	26.98%	74.07%

Econometric analysis of demand for ploughing services

The model estimation results are recorded in the table below. The dependent variable is essentially the demand for ploughing operation. The sign associated with the independent variables indicates whether they have a negative or positive influence on the demand for ploughing operation. Therefore, t-statistics makes it possible to appreciate the significance of the variables. As for the coefficient itself, its interpretation will not be directly taken into account in this study. The probability associated with the F statistics leads to the conclusion that the independent variables used are generally significant to explain the demand for ploughing operation.

Of all the independent variables tested, nine significantly explained the demand for ploughing. They include the following variables: social and personal variables (level of education (+),

secondary activity, livestock (+)), structural variables (household size (-), number of farm assets (+), area farmed by households (+), number of carts owned by households (+), number of oxen per farm (-) and institutional variables (training received (-), technical assistance (+)).
The analysis shows that only cotton and maize fields have a significant influence on demand for ploughing. The more farmers wish to increase their fields, the more they tend to request tractor services.

Table 12. Econometric analysis of demand for mechanized services

dde_lab	Coef.	P>|z|
Age	-.0093194	0.561
Instruction	1.410223	0.004***
Owners	-.5891568	0.217
Natives	.3243486	0.521
Livestock	1.385346	0.002***
Population size	-.4284865	0.000***
Number of agricultural workers	.6517918	0.000***
Number of ploughs	-.2345104	0.371
Number of carts	1.167988	0.004***
Number of draught oxen	-.3156802	0.027**
Total Area	.1197652	0.003***
Training received	-1.364985	0.034**
Technical support received	1.819437	0.000***
PO membership	.9973748	0.393
Transfer of funds received	-.4197831	0.564
Consumption	-3.583773	0.021**

Number of obs = 180 LR chi2(18) = 145.43 Prob > chi2 = 0.0000 Log likelihood = -37.238284 Pseudo R2 = 0.6613
* p < 0,1 ; ** p < 0,05 ; *** p< 0,01

Willingness (propensity) to pay for mechanized services

Here, we needed to establish whether the costs of the various ploughing services (ploughshare, sprayer and disc) match the levels of satisfaction of the farmers. Also, the question was whether those who are not requesting ploughing services at this time will want to do so and at what cost. The study shows that tractor ploughing is quite well appreciated by both farmers requesting the services and those who do not yet. However, as noted above, for a farmer to accept the mechanized ploughing service, the amount he spends on the service must equate the level of his satisfaction. Are farmers who do not request mechanized services willing to request tractor services and at what cost? The results of the study show that producers are willing to pay between CFA F 10,000 and 17,500 for mechanized agricultural services. This seems to explain the rather low adoption rate in the area (30%), when the price of the service is at least CFA F 15,000. Rice is an exception because it is not very much produced in the area.

Table 13. Cost of ploughing services

Service type	Agreed cost			
	Minimum	Maximum	Average	Standard deviation
Ploughing of cotton/maize farm	15000	30000	22117.65	2,620.024
Ploughing of rice farm	11250	22500	16875.00	7,954.951

On average, people are willing to pay CFA F13,750. The low patronage of ploughing services can therefore be explained by the high cost of the service.

Considering the main crops for which mechanized ploughing is used (maize and cotton), the average ploughing price (22,000) is well above the average amount people are willing to pay in the area (13,750).

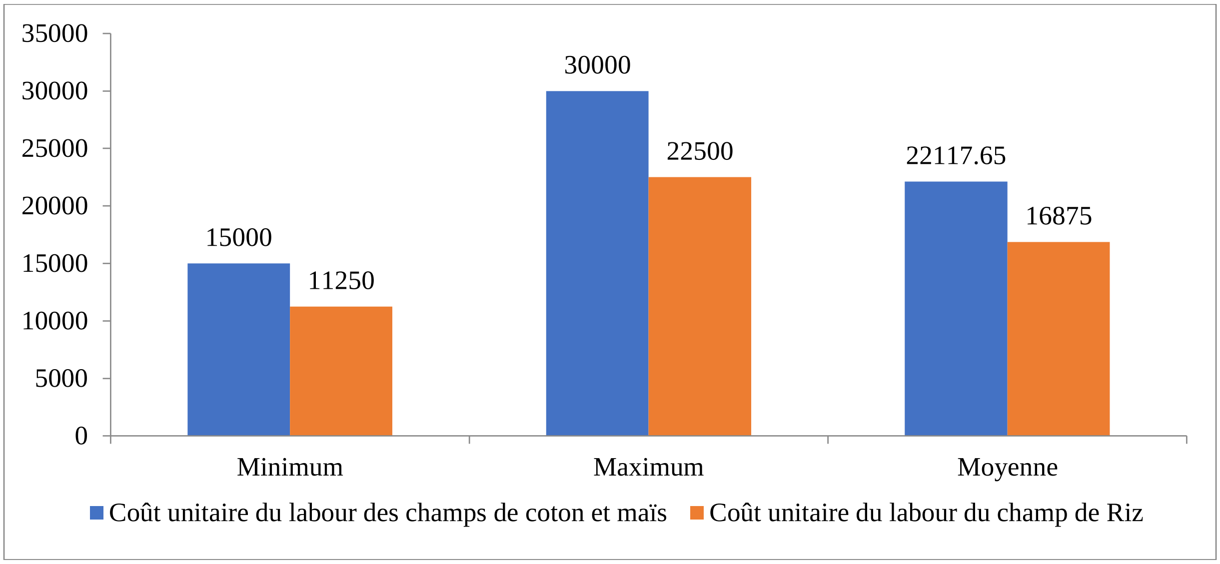


Figure 12. Costs of ploughing services

SWOT/FFOM analysis of the status of mechanized agricultural services

The analysis of strengths, weaknesses, opportunities and threats to the provision of mechanised agricultural services in the province of Tuy is outlined in Table 14.

Table 14. SWOT analysis of mechanized agricultural services in the province of Tuy

Strengths	Weaknesses
- Existence of tractors (23); - Ability to plough for more than 65% of farmers requesting the service; - Existence of tractor drivers.	- Inadequate number of machines (only 65% of applicants are satisfied); - Tractor operators are not often trained (deterioration of agricultural plots) or equipment failures; - Unavailability of spare parts for certain types of tractors; - Low level of qualification of tractor operators.
Opportunities	**Threats**
- Existence of bank credit for investors; - Existence of credit lines for rural equipment; - Existence of demand for mechanized agricultural services; - Existence of importers of motorised agricultural equipment; - Existence of trained repairers; - Support from the State for the procurement of equipment (Subsidy); - Existence of manpower to operate the equipment; - Create a CUMA-type association; - Cost of maintaining draught animals; - Shorter winter season.	- High cost of motorised agricultural equipment; - High cost of the service; - The quality of the equipment is often questioned; - Lack of involvement of buyers by the State in the procurement project; - Lack of spare parts, in case of breakdown; - DTE is not represented in the provinces or regions; - Failure by some clients to pay for the cost of the service; - Bureaucracy at CUMA is an obstacle to its development; - Competition between mechanized services and draught animals.

Conclusion and Recommendations

The purpose of this study was to analyse the demand for mechanized agricultural services in the cotton-growing area of western Burkina Faso. The relevance of this study stems from the fact that although agriculture is practiced by nearly 80% of the working population, and accounts for 40% of the GDP, it still does not meet the nutritional needs of the entire population. Despite the crucial role of agriculture in the country’s economy, food imports are required to make up for the shortfall. This situation has been exacerbated by labour shortage as well as changing and shorter seasons caused by climate change.

Therefore, modernisation of agriculture in Burkina Faso in general and in this part of the country is necessary, through agricultural mechanisation as a remedy for low productivity. Unfortunately, 75% of Burkinabe producers are small-holder farmers and therefore lack the financial resources to address their concerns.

This study made it possible to understand from farmers who do not own tractors that there is demand for mechanized agricultural services (ploughing, ginning, transportation, etc.). The unsatisfied share of this demand can be estimated at 30% of the farmers in the study area. The requests for ginning and transportation are 95%. The study also reveals a mismatch between demand and supply (demand greater than supply). This results in high costs of service. The market prices for services vary between CFA F 15,000 and 30,000, while farmers requesting the services are willing to pay between CFA F 12,500 to 17,500.
The study also reveals that ploughing is the only operation that is mechanized through the use of tractors. Neither seeding, nor weeding, nor land clearing are carried out by tractors. However, 90% of farmers surveyed have draught oxen that can fill this gap, often due to lack of suitable equipment. The results show that seeding is still done manually but land clearing is done by animal draught power. Even those without equipment request the services of animals; either for financial or in-kind compensation (working days on the owner's farm).

Annex 1: 1. Flat tabulation of the survey

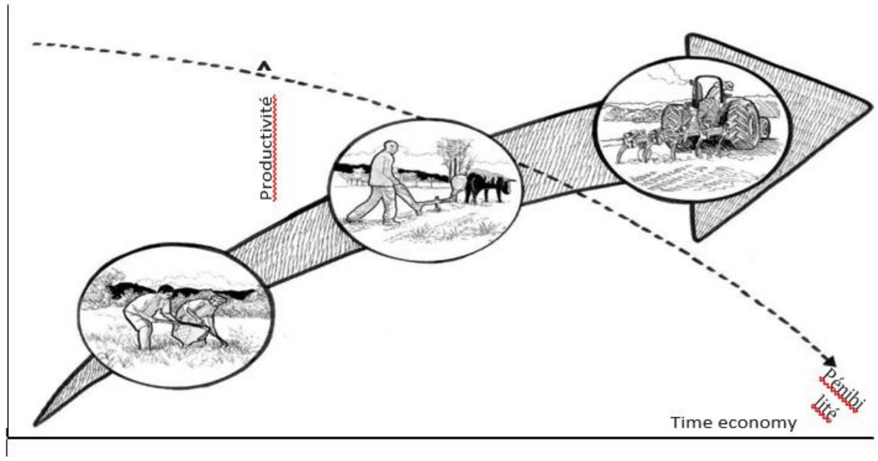
```
Iteration 0:   log likelihood = -109.95557
Iteration 1:   log likelihood = -43.592517
Iteration 2:   log likelihood = -37.546551
Iteration 3:   log likelihood = -37.238997
Iteration 4:   log likelihood = -37.238284
Iteration 5:   log likelihood = -37.238284

Probit regression                               Number of obs   =        180
                                                LR chi2(15)     =     145.43
                                                Prob > chi2     =     0.0000
Log likelihood = -37.238284                     Pseudo R2       =     0.6613
```

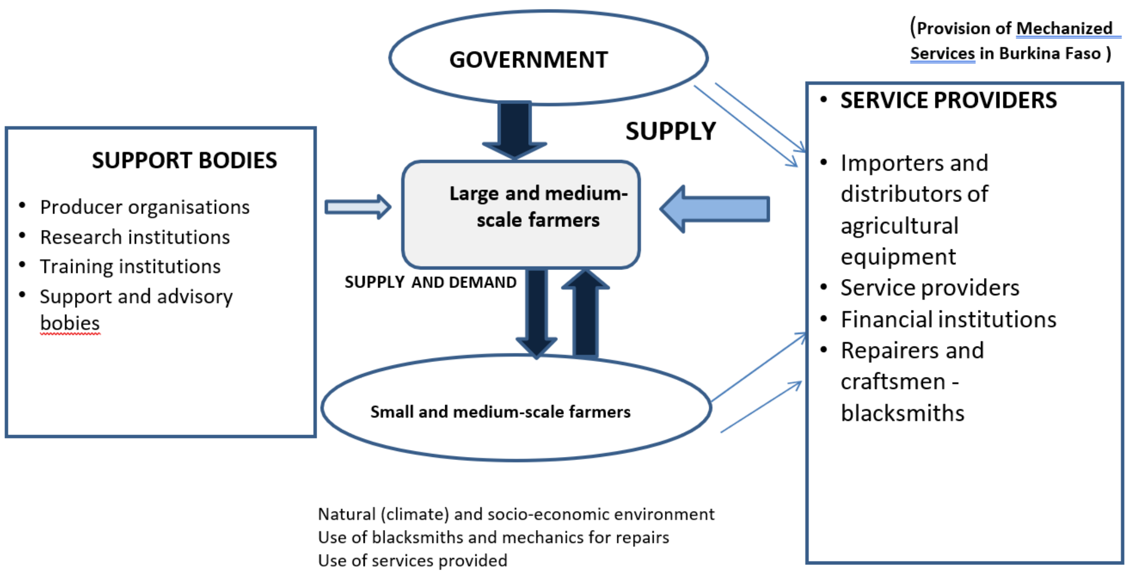
dde_lab	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	-.0093194	.0160417	-0.58	0.561	-.0407605	.0221217
instru	1.410223	.4880371	2.89	0.004	.453688	2.366758
propritaire	-.5891568	.4767171	-1.24	0.217	-1.523505	.3451916
autoch	.3243486	.5054388	0.64	0.521	-.6662932	1.31499
elevagsecod	1.385346	.4370937	3.17	0.002	.5286582	2.242034
taille	-.4284865	.0946961	-4.52	0.000	-.6140875	-.2428856
actifs	.6517918	.1383951	4.71	0.000	.3805423	.9230412
charu_nbre	-.2345104	.2621587	-0.89	0.371	-.7483321	.2793112
chare_nbre	1.167988	.4101746	2.85	0.004	.3640605	1.971916
formation	-1.364985	.6448363	-2.12	0.034	-2.628841	-.1011292
oui_enca2	1.819437	.4679636	3.89	0.000	.9022448	2.736628
op	.9973748	1.168113	0.85	0.393	-1.292085	3.286835
transfert	-.4197831	.7285117	-0.58	0.564	-1.84764	1.008074
btraitnbre	-.3156802	.1431215	-2.21	0.027	-.5961932	-.0351672
sup_totale	.1197652	.0398801	3.00	0.003	.0416016	.1979289
_cons	-3.583773	1.549392	-2.31	0.021	-6.620526	-.5470207

Note: 8 failures and 8 successes completely determined.

Annex 2: Trends in agricultural practices (FAO, 2013d)



Annex 3: Current Process Flow Of Mechanized Agricultural Services In Burkina Faso



Rijk (1989) defined seven levels of development of agricultural mechanisation (both on historical and factual grounds), namely:

1) The substitution of human energy by mechanical energy for fixed station operations (paddy hulling, grain milling, water pumping, grain threshing),

2) The substitution of human energy by mechanical energy for mobile station operations (tillage),

3) The substitution of human control for know-how-intensive agricultural operations (harvesters),

4) Adaptation of cropping systems to the machines (monoculture, seedling in line, constant spacing),

5) Adaptation of the production system to the machines (specialisation of agricultural holdings, decline in speculation that is difficult to mechanise, land consolidation and land development),

6) The adaptation of plants (or animals) to the equipment (resistance to lodging and threshing of cereals, resistance to bruising of potatoes and tomatoes in mechanized harvesting, sensitivity of cows to mechanical milking) and

Automation of agricultural production (automated poultry feeding, automated sprinkler irrigation systems activated by soil moisture, automated and computerised rationing of concentrated feed for individual dairy cows based on their milk production

Power sources for soil preparation (% of total)

	Muscular power	**Animal power**	**draughtMotive power**
Sub-Saharan Africa	65	25	10
East Asia	40	40	20
South Asia	30	30	40
Latin America and the Caribbean	25	25	50

Source: FAO, 2006.