ORIGINAL ARTICLE

Diagnosis of the Use of Agricultural Machinery by Mechanization-Service Providers

Diagnóstico del uso de la maquinaria agrícola por los prestadores del servicio de mecanización

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ABSTRACT: Farmers in Catamayo Canton, Loja Province, who do not have agricultural machinery for soil preparation, hire mechanization services locally. The general objective of this research was to diagnose the use of agricultural machinery by mechanization-service providers in the parishes of San Pedro de la Bendita, Catamayo and El Tambo, through interviews and surveys of 9 mechanization-service providers and 12 farmers. The research was field-based, cross-sectional and descriptive. The mechanization-service providers are small farmers who maintain their tractors and implements personally and consider that the use of machinery is due to the predominant soil texture in the canton. The mechanization indexes determined indicate the existence of a very diverse crop pattern and soil aeration is necessary for better yields: clay texture and the presence of stone is predominant in the area. The most used implements in the soil preparation are disk plow, furrower and harrow and tractors have an average power of 95 hp, of varied brand and year of manufacture 1987-2019. The group of mechanization-service providers served 610 producers corresponding to an equal number of production units in 2019 with a range of 20-500 ha. There is a ratio of 142.09 ha/tractor, as well as seven tractors/100 ha, the area harvested with machinery is 0% and the power used per area is 0.42 kW/ha.

Keywords: Agricultural Mechanization, Mechanization Provider, Agricultural Mechanization indexes.

RESUMEN: Los agricultores del cantón Catamayo, provincia de Loja, que no disponen de maquinaria agrícola para la preparación del suelo, contratan servicios de mecanización localmente. Este trabajo de investigación tuvo como objetivo general realizar un diagnóstico sobre el uso de maquinaria agrícola de los prestadores del servicio de mecanización en las parroquias de San Pedro de la Bendita, Catamayo y El Tambo, efectuándose entrevistas y encuestas a nueve prestadores del servicio de mecanización y 12 agricultores. La investigación fue de campo, de corte transversal y de carácter descriptivo. Los prestadores del servicio de mecanización son pequeños agricultores, el mantenimiento de su tractor e implemento lo efectúa personalmente y considera que el uso de maquinaria se efectúa por la textura del suelo predominante en el cantón. Los índices de mecanización determinados señalan la existencia de un patrón de cultivos muy diverso y la aireación del suelo es necesaria para un mejor rendimiento: la textura arcillosa y la presencia de piedra es predominante en la zona, los implementos más utilizados en la preparación del arado de disco, el surcador y la rastra, los tractores tienen un promedio de potencia de 95 hp, de marca variada y año de fabricación 1987-2019, El grupo de prestadores del servicio de mecanización atendieron 610 productores que corresponde a igual número de unidades de producción en el año 2019 con un rango comprendido entre 20-500 ha. Existe una relación de 142,09 ha/tractor, como también siete tractores/100 ha, la superficie cosechada con maquinaria es del 0% y la potencia utilizada por superficie es de 0,42 kW/ha.

Palabras clave: mecanización agrícola, prestador de mecanización, índices de mecanización agrícola.

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INTRODUCTION

Agriculture over the course of time has been and will be the inexhaustible source of food for humans and other species. FAO - United Nations - ECLAC (2020), point out that ¨...the pandemic has shown that agriculture is an essential activity, because it produces essential goods¨. Likewise, Pacheco-Florez & Melo-Poveda (2015), mention that ¨History shows that the evolution of humanity and the economy have been determined particularly by the availability of natural and energy resources¨.

In order to meet the demand for food worldwide, man has had to invent machines that allow him to carry out farming activities with greater efficiency and effectiveness in agricultural production, and he has had to develop what is known today as agricultural machinery. In this sense, Araujo V & Fraiz B (2017) note that "...agricultural production will have to increase by 60% over the next 40 years in order to meet the growing world demand for food, (OCDE-FAO, 2013).

The world economy is based on agriculture and this, in turn, on the use of agricultural machinery and its availability, depends on the brands of several international companies producing agricultural equipment with forefront technology, which anticipate further growth. All these companies, in turn, have formed corporations that manage the trade of agricultural machinery in the world, as stated by Donoso (2007) global trends in the sector are associated with high concentration, intensive use of technology and a shift towards no-till farming".

In Latin America, agricultural mechanization has not reached the same level of development. However, there are some countries such as Mexico, Brazil and Argentina, which have shown great progress for having areas suitable for agricultural production on a larger scale.

Donoso (2007) states ¨...the most important trade flows are from Brazil, Mexico and the USA to the rest ofthe region¨. Other Latin American countries are also contributing to agricultural mechanization, through policies implemented by their governments and private initiatives that seek agricultural growth to guarantee food for their populations.

Agricultural activities in Ecuador with the use of tools and machines are identified in its three regions of productive-economic importance, Shkiliova *et al.* (2019) point out, "…soil preparation operations are the most mechanized activities in most cultivations, according to data provided by ESPAC (2017)". "…in 2017, 80.02% of people producing transitory crops, have carried out at least one activity in which they use agricultural machinery for soil preparation, sowing and crop development¨.

The peasant family settled in the rural area of Loja Province, throughout its history, has experienced changes due to major climatic, economic, social and political events; but thanks to its character and temperance has moved forward, with a productive or extractive vision of natural resources, but without neglecting the conservationist ideas that contribute to the sustainability of production processes.

Activities in the field, such as soil preparation, require energy, which is first provided by human beings, and then, depending on the availability of labor and the area to be planted, man has moved on to the use of greater amounts of energy with animal power and agricultural mechanization of the farm. In this area of energy consumption, the use of the agricultural tractor is analyzed by Instituto para Diversificación y Ahorro de Energía (2006) (Institute for Energy Diversification and Saving). "…in small plots and without land consolidation, difficult "irregular" plots can be found, whose tillage is more expensive in time and of course in diesel, 40% more turns" (Instituto para Diversificación y Ahorro de Energía, 2006).

Agricultural mechanization in Loja Province is very low and it is attributed to several elements like its topography as predominant factor, land tenure, profitability of production and the presence of markets that can assimilate the production. In addition to the aforementioned, national policies through community support institutions do little or nothing for the agricultural sector. With respect to the previous statement, Prado-Perez *et al.* (2018) conclude: "the limiting factors for sugarcane mechanization in Manabí are related to topography (50 - 70% slope)".

Catamayo Canton in Loja Province, has five parishes of which three (San Pedro de la Bendita, Catamayo and El Tambo), have agricultural machinery (tractor + implements). They consist of three groups of private owners and the Parish Council of El Tambo that provides the service of soil preparation for planting vegetables, short-cycle and semi-permanent crops whose production is oriented to local markets and coastal provinces. These mechanization-service providers face several problems that affect their work, such as the lack of recognition as a labor force in agricultural production and the lack of knowledge about the parameters for measuring their work. Some of those parameters are: what crops require greater attention with machinery, what implements are available for production, what type of soil and its potential, number and power of available tractors, how much area is covered each year, number of owners served, level of expenses, among others, and their relationships, which prevents them from improving their working conditions.

Considering that, it is proposed to carry out a diagnosis on the conditions of use of agricultural machinery in the three parishes of Catamayo Canton, in order to support the group of agricultural mechanization providers to detect their needs for

change and improve their situation through work proposals to benefit the canton and the province.

MATERIALS AND METHODS

Location of the Study Area

Catamayo Canton has an extension of 651.84 km^2, in which 35 961 inhabitants live, according to GAD Catamayo (2021). The boundaries are to the north with El Oro Province and Loja Canton (parishes of Chuquiribamba, El Cisne and Chantaco), to the south with Gonzanamá Canton (parishes of Purunuma and Nambacola) and Loja Canton. To the east: Loja Canton (cantonal capital and Taquil) and to the west: Chaguarpamba Canton (El Rosario Parish and Chaguarpamba cantonal capital) (Figure 1). The altitudinal range is between 700 and 3,000 masl. The average annual precipitation is 401.9 mm/year and the average temperature in the canton's capital is 22 ºC (Ríos Chamba, Luis, 2014).

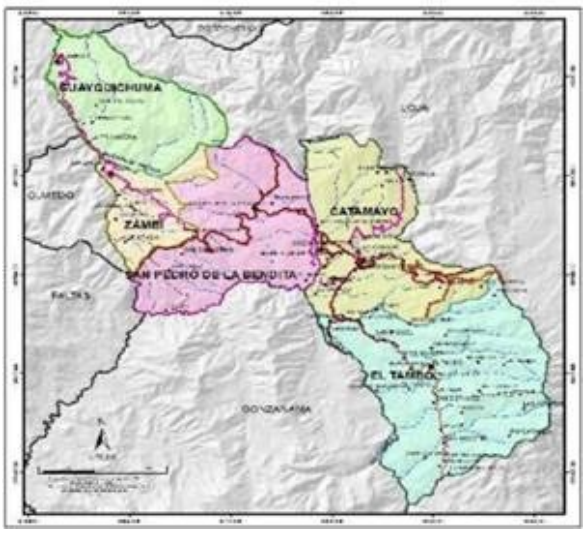

FIGURE 1. Location of the diagnostic area. Source: Municipal Decentralized Autonomous Government of Catamayo Canton. GAD Catamayo (2021).

Field Methodology

In order to strengthen the study and due to its characteristics, it is considered that this fits as a transversal and integrative field research of several disciplines and descriptive in nature, which seeks to determine a situation based on qualitative aspects (Salas, 2020).

The same was aimed at collecting information provided by the mechanization-service providers in the parishes of San Pedro de la Bendita, Catamayo and El Tambo, whose basic characteristic is to have an agricultural tractor with which they contribute to the development of each of their parishes. To this group (9 people), object of the research, after the socialization and identification of the present problems, the collaboration was requested for the application of a survey (made up of 25 questions), with which parameters linked to their activity in benefit of the agricultural sector can be identified. The sampling technique was developed in the total population (finite) according to Di Rienzo *et al.* (2008), constituted by nine people N= 9: In San Pedro with 2, Catamayo with 4 and El Tambo with 3.

Mechanization Factors

For each of the agricultural production stages, five factors were determined (human talent, crops, soils, implements-equipment and wheel tractor), which made it possible to establish the mechanization parameters at local level:

- In the typological characterization of the mechanization-service provider.
- Crop-related criteria
- Soil-related criteria
- Criteria related to implements
- Criteria related to the agricultural tractor

RESULTS AND DISCUSSION

Mechanization-service providers in the three parishes have small extensions of land to work in the rural sector, with a predominance of 1,897 properties between 1 and 5 ha at the rural level. GAD Catamayo (2021).

Preventive and corrective maintenance of agricultural machinery is carried out by the owner-operator of the machine himself, with the knowledge based on his experience and with the tools at his disposal. In the event of a major breakdown, the part(s) are taken to local automotive mechanics or to the city of Loja.

The mechanization-service provider considers that in soil preparation (depending on the type of soil and preparation area), the agricultural tractor should be used, replacing human and animal power.

Crops and Application of Agricultural Machinery

The crop pattern in Catamayo is diverse and its purpose is family consumption and commercialization (Figure 2). Maize is the most important crop due to its high demand for fresh maize for human consumption and as animal fodder. Prefectura de Loja (2019), notes that in 2015 the area cultivated with corn was 65 766.81 ha which corresponds to 52.34% of the total area. In addition, the cantons of Pindal and Celica have yields of 8.60 and 8.59 t ha-1, respectively, exceeding the national average of 6.55 t ha-1

It is observed that there is a great tendency expressed by agricultural producers that, without the

process of soil aeration, it is not possible to have a better yield in production. The 100% of the producers ratifies this need (Table 1). Rivera H. & Medina G. (2017), conclude in their evaluation of mechanized production and its impact on tomato, potato and corn productivity that "... mechanization and inputs show favorable behavior in potato, tomato and corn production, improving the purchasing power of the population dedicated to this activity".

Soil and the Application of Agricultural Machinery

The mechanization-service providers indicate that the predominant soil texture is clayey, while other types of texture are present in smaller quantities in different areas of the canton (Figure 3). A determining factor is the robustness of the implements to be used in soil preparation. As it is described in the canton development plan GAD Catamayo (2021), soils are established on 8 geological formations, especially Sacapalca formation that is in the center of the canton and occupies 129,43 km^2. And according to the soil taxonomy classification in the World Reference Base for Soil (WRB) (2006), *Entisols* soils predominate in the canton with 28.44% corresponding to a surface area of 185.73 hectares.

Soil preparation with agricultural machinery generally requires the absence of obstacles that would prevent a good job. In the production areas of the canton, there are three obstacles of consideration: stones, humidity and slope (Table 2). Pérez (2018) states that: "...the limiting factors of soil use for tillage decisions in the UEB are rockiness, with 46.24%, and slope, with 26.73%, while 23.07% of the area is without limitations for mechanized tillage".

Agricultural Implements for Soil Preparation

In Catamayo Canton, the nine mechanization-service providers do not have the same number of implements. The most common implement is the disk plow, followed by the furrower and the harrow, as shown in Figure 4. Pereira *et al.* (2011) refer that farming is "the activity of intervening in the soil to establish the biophysical conditions that promote plant growth and development" and "its purposes are to aerate the soil, increase moisture retention, mobilize soil nutrients, eliminate competition from weeds, eliminate mechanical impediments and maintain structure and bulk density at their optimum point".

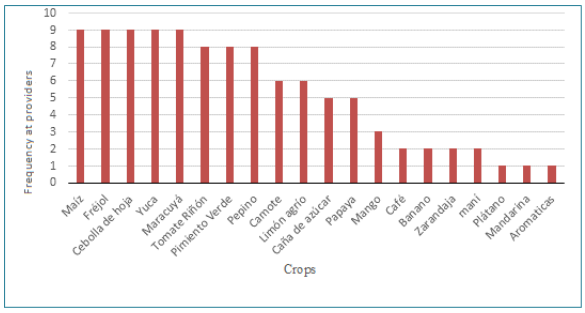

FIGURE 2. Crops with the application of mechanization in the year.

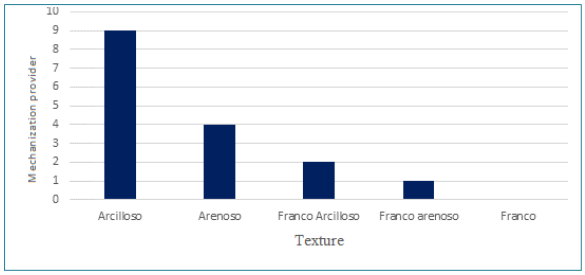

FIGURE 3. Knowledge of soil texture.

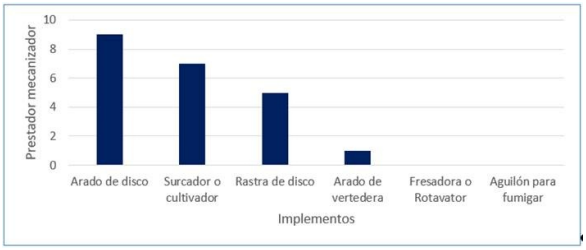

FIGURE 4. Mechanization implements.

TABLE 1. Summary of the most significant results with the culture criterio

Criteria	Unit	Formula	Result
Prepared cultures	crop/year	$\frac{Number\ of\ crops}{Planting\ period}$	20
Impact of mechanization on performance	%	$\frac{Servers}{Performance\ Opinion} \times 100$	100

TABLE 2. Summary of the results achieved with the soil preparation criteria

Criteria	Unit	Formula	Result
Soil texture	%	$\frac{Number\ of\ providers}{Opinion\ of\ the\ provider} \times 100$	100 Clayey
Barriers to preparation	%	$\frac{Opinion\ of\ provider}{Number\ of\ providers} \times 100$	88.89 Stone Humidity

It is not very clear for the conditions for the mechanization-service provider, the working speed when plowing, raking or furrowing the soil, due to several factors such as the difference in the gearbox system between tractors and the slope conditions of the terrain where the tractor must circulate (Figure 5). The Ministerio de Medio Ambiente y Medio Rural y Marino (2008) (Ministry of the Environment and Rural and Marine Affairs) recommends using the disc plow with the soil in a deformable state at speeds between 4 and 8 km/h, it also indicates that in dry soils it is difficult to penetrate and in wet soils it becomes a chaos, its tractive effort is between 350 and 750 N/dm^2 of worked section (slightly lower than the moldboard plow), with an efficiency between 0.65 and 0.85.

A summary of the significant results with the implement criteria is presented in Table 3.

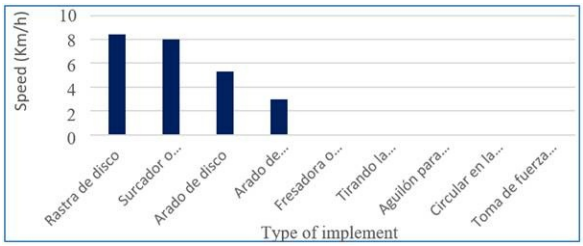

FIGURE 5. Tractor plus implement speed

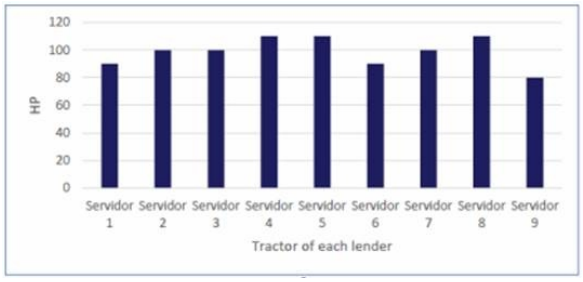

FIGURE 6. Tractor power.

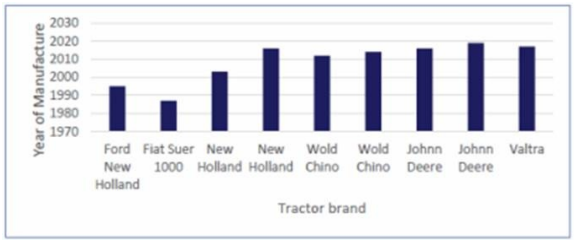

FIGURE 7. Year of manufacture of tractors.

Characteristics of Agricultural Tractors

Figure 6 shows the information on tractor power, which ranges from 80 hp to 110 hp. Noya (2005) mentions that the tractor power experiences losses due to several factors inherent to its structure and elements used for its operation. In addition to skidding and rolling resistance. The former ranging from 7 to 12%, which can be caused by the condition of the tire, inflation pressure, ballast and forward speed, among others; while rolling resistance consumes power due to the very undulating micro relief, as in the case of plowed land on which secondary tillage is performed, the losses are in the order of 10 to 25%. (p.48).

The tractor model is the opportunity to acquire a more modern machine with better operating characteristics and availability for work. The agricultural mechanization-service providers are not people with high economic resources or credit opportunities that would allow them to access tractors that are more modern. Figure 7 shows a variety of tractor models ranging from 1987 to 2019. Bailon (2018) mentions in his study that in the Municipality of Zinacantepec "...the average useful life of tractors is approximately 7.73 years and its concentration is located in 77.3% of areas less than 10 ha, which indicates underutilization coupled with an inadequate maintenance program that leads to the deterioration of the tractor".

A summary of significant results with the agricultural tractor criteria is presented in Table 4.

TABLE 3. Summary of the significant results with the criteria of the implements

Criteria	Unit	Formula	Result
Implement of greater use	(%)	$\frac{Opinion\ of\ use}{Number\ of\ providers} \times 100$	100 Disc Plow
forward speed	(km/h)	$\frac{State\ opinion}{Number\ of\ providers} \times 100$	8,4

TABLE 4. Summary of significant results with the criteria for agricultural tractors

Criteria	Unit	Formula	Result
Average tractor power	hp	$\frac{Power\ difference}{2}$	95
Year of manufacture of the tractor	Año	$Recent\ Year - Old\ Year$	32 1987- 2019

Tractor plus Implement Performance

The group of mechanization-service providers attended 610 producers, which corresponds to the same number of production units in 2019. Figure 8, shows that the number of producers ranges between 20 and 200 per year. Vargas (2019) who cites INEGI, (2007), points out that in the Municipality of Santa María Rayón, 656 production units were registered and it has 42 tractors, which gives a ratio of 16 producers/tractor, a value due to a greater supply of tractors in that municipality.

The service is evidenced by the number of hectares covered during the year of work preparing the land by each mechanization server. In Figure 9, the number of hectares serviced is shown. Bailon (2018) indicates that, in the Municipality of Zinacantepec, there is a ratio of 13.08 ha/tractor.

Table 5 shows a summary of the results achieved with the service delivery criteria.

On the technical side, the farmers emphasize that machinery is necessary for production; they take advantage of the rainy season to harvest one crop per year, complemented with hand tools (shovel, machete, rake, sacks and harvesting drawers) and concluded with the support of donkey transport, horses and small rented pickup trucks.

International Agricultural Mechanization Indexes

For a better understanding, international organizations have created several indexes that allow to know and compare mechanization and its incidence on agricultural production between regions and countries. (Negrete, 2006). The available area (1 563 ha) in the three parishes and number of existing tractors (11) give a rate of 142.09 ha tractor-1 (Table 6), a rate higher than 50 ha tractor-1, recommended by FAO Gutiérrez-Rodríguez *et al.* (2018), which indicates an intensive use of the tractor in the parishes.

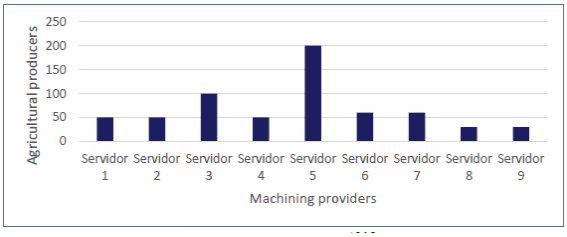

FIGURE 8. Producers in 2019.

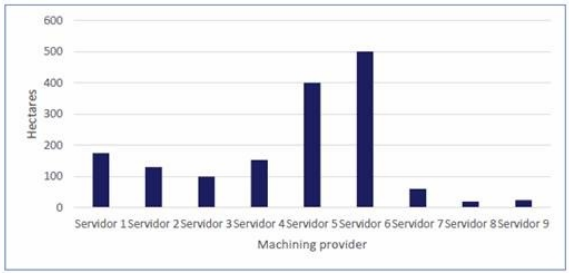

FIGURE 9. Area worked.

The mechanized surface allows the construction of other indexes, such as the number of tractors per 1,000 ha in the three parishes, estimated at 7tractors/ 1,000 ha. This is a very low value, since it represents the investment made for the benefit of agriculture.

The area harvested with agricultural machinery is not a common practice; in general, it is done manually according to the state of maturity and market demand. In the three parishes it is 0%.

The ratio of power used per unit area shows the need or demand for mechanical power required to prepare one hectare of land in the three parishes of Catamayo Canton. For 663.94 kW available and 1,563.00 ha, a value of 0.42 kW/ha is evident (Table 6). This value is considered high when working on small areas, according to Negrete (2006). In addition, Loor-Sacido *et al.* (2019), p.1 point out that this index in four communities of Manabí reaches a value of 1.75 kW/ha, and conclude that this value is due to the presence of agricultural tractors with higher power than needed.

TABLE 5. Summary of the results achieved with the service provision criteria

Criteria	Unit	Formula	Result
Producers by provider	Pro/Pres	$\frac{Producers}{agricultural\ provider}$	68
Prepared area	ha	$Maximum\ value - Minimum\ value$	Range 20 - 500

TABLE 6. International mechanization rates in the three parishes of Catamayo

Índice	Unidad	Fórmula	Valor
Cultivated area* for each unit of power	(ha/tractor)	$\frac{Cultivated\ area}{tractor}$	142, 09
Power used per surface	kW/ha	$\frac{Totalpowerused}{Area\ under\ production}$	0,42

CONCLUSIONS

The mechanization-service providers are agricultural producers who have reached an economic status of survival that allows them to support their families. Their main objective is to provide the service to small farmers who have land dedicated to subsistence, contributing to their economy.

The work expressed in the mechanization indicators is also reflected in underlying aspects, among these can be pointed out the crop yield, in soil preparation the presence of moisture and the percentage of stoniness decrease the effectiveness for the development of the activity. Soil preparation implements must possess a level of robustness that allows overcoming unforeseen events on the ground. Finally, the agricultural tractor must provide two relevant facts: its power and the application of charging policies for the sale of working hours, which make possible the subsistence of the service.

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