

# Diagnosis of Agricultural Mechanization Competencies in the Central Zone of Manabí, Ecuador



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## Diagnóstico de Competencias de la Mecanización Agrícola en la Zona Central de Manabí, Ecuador

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**ABSTRACT:** Mechanization is of great relevance in the development of the agricultural sector, as a tool that facilitates agricultural activities with quality and speed and a significant increase in the productivity and competitiveness of this sector, in the case of the province of Manabí in Ecuador this aspect becomes more relevant because this sector has a substantial weight in its economic and social life. The objective of the research was to carry out a diagnosis of agricultural mechanization competencies in the cantons of the central zone of Manabí. The methodology used consisted of several stages, which made it possible to evaluate the factors that characterize the competencies of agricultural mechanization in the area under study: human factor, machinery, operating conditions and infrastructure and financing. For the collection of information, surveys based on the factors under analysis were prepared and applied to agricultural producers and owners/entrepreneurs who provide mechanization services in the central zone of Manabí. The results of the diagnosis in the selected sample show that only 41% of the agricultural activities are being carried out with the use of agricultural machinery and that 20% of the producers have their own means to carry out agricultural activities, among other relevant aspects. As a whole, the results allowed concluding that the agricultural mechanization skills in the central zone of the province of Manabí present undesirable low levels that limit its productivity.

**Keywords:** Diagnosis, Competences, Agricultural Mechanization.

**RESUMEN:** La mecanización es de gran relevancia en el desarrollo del sector agrícola, como una herramienta que facilita las actividades agrícolas con calidad y rapidez y un incremento significativo de la productividad y competitividad de este sector, en el caso de la provincia de Manabí en Ecuador este aspecto se hace más relevante por tener este sector un peso sustancial en su vida económica y social. El objetivo de la investigación fue realizar un diagnóstico de las competencias de mecanización agrícola en los cantones de la zona central de Manabí. La metodología utilizada consta de varias etapas, las que permitieron evaluar los factores que caracterizan las competencias de la mecanización agrícola en la zona objeto de estudio: factor humano, maquinaria, condiciones de operación e infraestructura y financiamiento. Para la recolección de la información se elaboraron y aplicaron encuestas basada en los factores objetos de análisis dirigidas a los productores agrícolas y a los propietarios/empresarios prestadores de servicios de mecanización de la zona central de Manabí. Los resultados del diagnóstico en la muestra seleccionada muestran que solo el 41 % de las actividades agrícolas se están realizando con el uso de la maquinaria agrícola y que un 20 % de los productores tienen medios propios para realizar las actividades agrícolas, entre otros aspectos relevantes. En su conjunto, los resultados permitieron concluir que las competencias de mecanización agrícola en la zona central de la provincia de Manabí presentan niveles bajos no deseados que limitan su productividad.

**Palabras claves:** Diagnóstico, Competencias, Mecanización Agrícola.

### INTRODUCTION

Agriculture is intimately associated with the health and hope of populations and particularly poor societies to subsist through it, since agriculture is the basis for

guaranteeing food security. To this end, the efficient use of all resources must be encouraged without damaging the environment. Sustainable agricultural production is based on increasing yields, minimizing

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production costs and using environmentally friendly technologies. These aspects have a direct impact on the economic growth of their communities (Bautista-Robles *et al.*, 2020). The paradigm of sustainable agriculture seeks to simultaneously meet the objectives of the productive, economic, sociocultural and ecological dimensions (Montero *et al.*, 2020).

Agriculture is characterized by a great variety and diversity of farming systems, which require a wide range of variables adapted to heterogeneous production conditions. The Republic of Ecuador is a fundamentally agricultural country, with an eminently rural population, mostly concentrated in the highlands. The importance of the agricultural sector in the national economy has been demonstrated throughout Ecuador's economic and social history. The drivers of change that drive production and its development are: efficiency in the system, product quality, product differentiation, and favorable business environment (Analuja-Aroca *et al.*, 2020). Efficiency includes the appropriate use of mechanization, however, it must be considered that mechanization can negatively impact soil conservation and sustainability (Gómez-Calderón *et al.* (2018), where compaction is one of the fundamental elements to take into account (Acosta & Magariño, 2019).

Ecuadorian agriculture has been very uncompetitive at the international level in terms of quality, quantity, hygiene, prices and markets, and will continue to be so until infrastructure is upgraded and policies that favor it are implemented. Infrastructure improvements, particularly productive investments in land improvements, water supply and control, markets, processing facilities and technologies, as well as roads, are the key to overcoming the constraints imposed by high levels of population growth, combined with a shift in the ratio of rural to urban population. In this context, it is mechanization that will completely revolutionize Ecuadorian agriculture (Intriago-Mendoza, 2019).

The agricultural sector, after oil, is the most important foreign exchange generator and its contribution to the Ecuadorian Gross Domestic Product (GDP) is relevant. Agricultural exports, both primary goods (bananas, coffee, cocoa, shrimp, timber, flowers, etc.) and processed goods (coffee, cocoa and others), have contributed an average of around 30% of total exports in recent years. However, no positive changes have been achieved for society as a whole, especially for small family subsistence agriculture, national supply and food security (Peralta *et al.*, 2018).

In the Republic of Ecuador, agriculture employs about 30% of the labor force and is the main means of subsistence for rural households. Its share in the national GDP has ranged from 8 to 9%, making the sector one of the main pillars of the national economy. Family farms have an average of 3.48 hectares of land,

totaling more than 2.4 million hectares belonging to this type of agriculture, compared to commercial farms, which have an average of 14.7 hectares of land, totaling more than 12.3 million hectares. In addition, family farming contributes more than 40% of the value of all agricultural production, supplying 85% of onions, 70% of corn and 64% of potatoes produced in Ecuador (Loo-Sácido *et al.*, 2019).

Manabí ranks fourth among the provinces with the largest extension with 7.59% with respect to the total national territory, third place in areas of agricultural use with 12.34%, first place in areas of mixed agricultural use with 11.99% of the national total, first place in livestock use with 19.15%, 13.71% of its total extension is agricultural use (fourth place), first place in mercantile production system with 19.40% of the national total. As for the areas dedicated to cultivation by crops, corn is in second place (23.67%), cocoa third (13.58%), bananas first (46.16%), and coffee first (65.19%). Overall, Manabí has 14.67% of the areas under cultivation in Ecuador (third place). An important characteristic that distinguishes Manabí according to this source is that it occupies the first place with 14.32% of the total areas without suitability for agricultural machinery and the third of the areas with low and medium suitability for the use of agricultural machinery with 9.25% and 12.61% respectively (MAG-Ecuador, 2020).

These elements show the importance and the need to pay attention to the factors that limit the adequate use of agricultural machinery in order to minimize production costs, raise the performance of mechanized means, reduce energy consumption, as well as damage to soil and plantations. Knowledge of these factors facilitates decision-making in the management of resources and the appropriate use of agricultural machinery.

Agricultural development involves three approaches: biochemical, socioeconomic and engineering (the biochemical approach includes the development of improved animal and plant species, animal and plant nutrients, and plant and animal protection). The socioeconomic approach includes financial packages and management programs. The engineering approach refers to the provision of agricultural machines and equipment for production and post-harvest systems, handling and storage systems and farm structures, erosion control measures, development of water resources, as well as irrigation and drainage (Intriago-Mendoza, 2019).

Mechanization in the process of agricultural production constitutes a fundamental way for the further development of agriculture and the satisfaction of the demands for agricultural products. The intensification of agricultural production, aiming at an efficient and sustainable productivity per hectare of land under exploitation, is concomitant with mechanization and with the implementation of a

progressive technology of machines in plant cultivation and livestock, is the fundamental engine of efficient agricultural production (Demera & Gil, 2022; Hernández-Ávila et al., 2022). In addition, agricultural mechanization, as a practical application tool for the better use of resources destined to agriculture, has had far-reaching effects by making agriculture more efficient and productive also allowing the population to be available for other occupations (Ávila et al., 2020).

In that sense Shkiliova et al. (2014), states that appropriate mechanization can improve energy efficiency in agricultural production, which in turn favors sustainability and productive capacity, in addition to reducing harmful effects on the environment. The agricultural mechanization sector comprises all self-propelled, trailed, mounted and semi-mounted mobile machines that are widely used in agriculture, livestock, forestry, gardening and green spaces.

In developing countries, it is common that a group of capitalized producers cultivate commodities for export with the use of high quality machinery and on the other hand most family farmers have no or minimal technology, this among other things causes poor yields. With this background, the Ecuadorian agricultural sector shows significant lags in the incorporation of machinery and new technologies for small and medium producers, who lack the financial resources to acquire the machinery they need. Most of them hire, for lack of financial resources, soil preparation services to informal contractors that offer a rudimentary and general service to all farmers. There is also, the lack of machinery adaptable to the ecological and topographic conditions of the country, especially small-scale farms, on hillsides and dedicated to horticulture (Loor-Sácido et al., 2019).

Other causes of the slow development of mechanization in Ecuadorian agriculture are related to topographic conditions that are not very conducive to the use of large-scale machines; the abundance of cheap labor; permanent cocoa, coffee and banana plantations in the Coast region, which do not require much mechanization; the shortage of operators and personnel prepared to select and/or adapt machines to the various types of tillage and cultivation (Cevallos-Mera & Shkiliova, 2016).

This problem is not limited to Ecuadorian agriculture, the same is manifested in countries such as Mexico where field producers also face the lack of liquidity for the purchase of machinery, particularly the small ones and the lack of professionalism, incorrect adjustments of the different agricultural implements and machines, also have an influence. Another aspect is the lack of machinery adaptable to small farming extensions Gutiérrez-Rodríguez et al. (2018); Khumbulani-Sithembiso Nxumalo et al. (2020) gives an account of similar situations in sub-

Saharan Africa where smallholder agriculture is considered one of the main pillars of agricultural and economic growth. Also in Nepal these effects are more visible in the case of labor-intensive crops, such as rice, and the promotion of higher levels of rural mechanization has emerged as the main response option and has highlighted the need to foster the emergence of an associated service economy that allows smallholder farmers access to capital-intensive machinery (Paudel et al., 2019).

As can be seen, small farmers represent in different contexts an important stratum in agricultural production, however, they have the least access to new technologies and present low levels of mechanization, among other aspects due to the lack of financial resources and the unavailability of machinery adapted to small and medium-sized crop areas. It is essential to understand their needs in order to design strategies that will help improve their yields and develop sustainable agriculture in their communities.

Based on the above, the objective of the research was to carry out a diagnosis of agricultural mechanization skills in the cantons of the central zone of Manabí, in order to identify opportunities for improvement in the mechanization processes in the zone.

## DEVELOPMENT OF THE TOPIC

### METHODS

Based on the methodology proposed by Pérez-Guerrero, et al. (2010), the research logic was conceived. This methodology consists of four interrelated and interdependent work stages: task precision, diagnosis of local capabilities, determination of the local demand for machinery, and analysis and interpretation of the results. In each of the stages, a set of tasks are defined that essentially represent the generalities for the determination of agricultural mechanization competencies or capabilities. Its contextualization in the central zone of Manabí allowed defining the objectives and the characteristics of the context, as well as the scope of the field work. The variables or factors directly involved in the diagnosis of agricultural mechanization competencies in the area were specified, namely, the human factor, machinery, operating conditions and infrastructure and financing; and values were assigned, by the expert method, to each item corresponding to each factor and the weighting values. For data collection, two instruments were designed for producers and mechanization service providers.

In order to determine the mechanization competencies, it should be taken into consideration that the methodology assumes that there are four possible levels, in relation to the degree of competence

of the locality, for each of the variables to be studied (total capacities, capacities with limitations, few capacities, no capacities), giving each level a consecutive rank, considering the last scale the one with the lowest score and the first one the one with the highest score (Table 1).

**TABLE 1.** Agricultural Mechanization Competency Ratio.

| Capacity Level                | Capacity Coefficients ( $\phi$ ) |         |
|-------------------------------|----------------------------------|---------|
|                               | Minimum                          | Maximum |
| Total capacities              | 0.86                             | 1.00    |
| Capabilities with limitations | 0.71                             | 0.85    |
| Few capabilities              | 0.56                             | 0.70    |
| No capabilities               | 0.00                             | 0.55    |

Source: Pérez-Guerrero, et al. (2010)

According to the influence of each factor on the result, the degree or factor of influence was determined using the expert method ( $\beta$ ): 3, high influence on the process, 2 medium influence on the process and 1 low influence on the process.

The maximum total score that each variable can contribute to the determination of the local mechanization competences is then determined using the expression 1.

$$P_I = P_V \times \beta \quad (1)$$

where:

$P_I$  Total influence score;

$P_V$  Total variable score;

$\beta$  Variable Influence Factor.

To determine local competition in agricultural mechanization, we use the expression 2

$$C = \frac{(\beta \times V_1 + \beta \times V_2 + \beta \times V_n)}{P_I} \quad (2)$$

where:

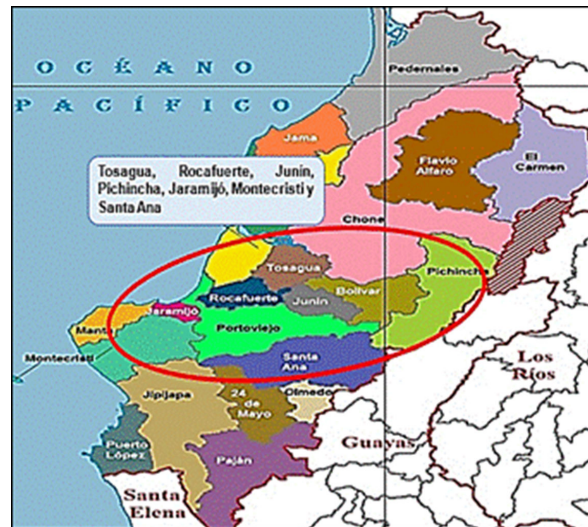
$C$  Competence of agricultural machinery;

$V_1; 2; n$  Scores achieved by the variables.

It is then compared with the preset values in their ranges and the level of competence of the area is determined.

## RESULTS AND DISCUSSION

The central zone of Manabí, composed of the cantons of Rocafuerte, Tosagua, Junín, Montecristi, Jaramijó, Santa Ana and Pichincha (Figure 1), is characterized by a tropical climate that is warm and humid throughout the year, with a marked rainy season and a dry season, with a varied relief that differentiates the coast with an area of plains and the mountains with irregular mountainous relief. These characteristics give rise to a great diversity of crops among the most common are rice, corn, banana, cassava, beans, sugar cane, cocoa, coffee, passion fruit, tomato tree, among others; and different



**FIGURE 1.** Central zone of Manabí.

possibilities of mechanization, with limitations in the application of agricultural machinery in areas of difficult access and also given the limited resources. Despite the great agricultural potential and the fact that this is an essential activity for subsistence and economic development, they still face challenges such as the lack of adequate structure, rural poverty and other elements that do not favor their development.

For the analysis of the results, based on the data from the instruments applied to producers and mechanization service providers, the competency calculations for each factor were made for each of the groups. Table 2 shows this procedure for the Human Factor, and similarly for each of them. As can be seen in this table, the competency coefficient of this factor is classified as Limited Capabilities (LC) as defined in Table 1.

When plotting the coefficient of competence for each item, it was observed that the items that most negatively influence the Human Factor are the items related to the training of human capital: general training, training in the handling of machinery and the training of operators.

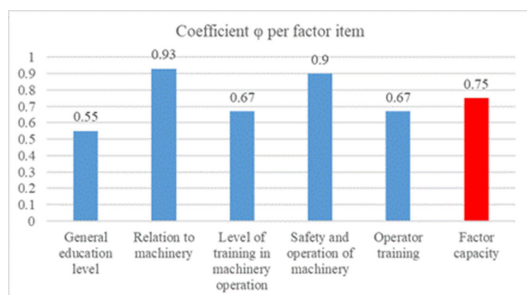
The machinery factor (Figure 3) had a value that placed it at the upper limit of the classification without competencies (SC), where the items use and mode of use of the machinery, together with the type of energy medium used, were the ones that most influenced the low levels of this factor.

In the operating conditions (Figure 4), which qualifies as low skills (PC), the extension of the land is the most influential item that is also associated with family subsistence agriculture. Also the type of climate and in particular the relief that influences the possibility of applying machinery in the agricultural activities developed in the area.

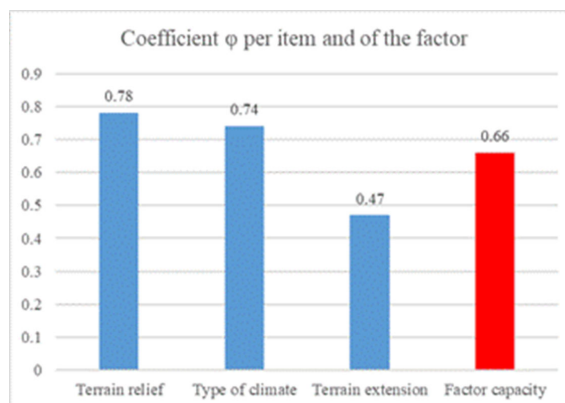
In the infrastructure and financing factor (Figure 5), which presents limited mechanization skills (CL), the greatest difficulties are related to the financing

**TABLE 2.** Agricultural Mechanization Competence Coefficients by item and total for the Human Factor variable

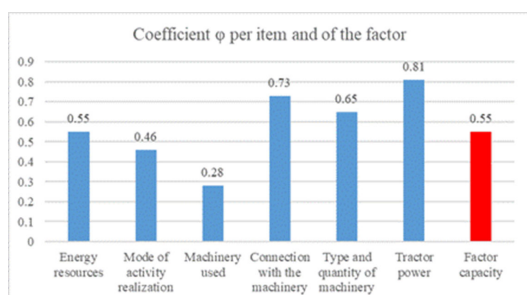
| Variables/Indicators                                                       | Score     |              | Coefficient ( $\phi$ ) | Competence level |
|----------------------------------------------------------------------------|-----------|--------------|------------------------|------------------|
|                                                                            | To obtain | Reached      |                        |                  |
| <b>HUMAN FACTOR</b>                                                        | <b>25</b> | <b>18,75</b> | <b>0,75</b>            | <b>CL</b>        |
| Relationship with the crop area                                            | 3.00      | 2.79         | 0.93                   | CT               |
| General training level                                                     | 4.00      | 2.18         | 0.55                   | PC               |
| Relationship with agricultural machinery                                   | 3.00      | 2.79         | 0.93                   | CT               |
| Level of training in the operation of agricultural machinery and equipment | 6.00      | 4.03         | 0.67                   | PC               |
| Safety and operation of agricultural machinery                             | 4.00      | 3.60         | 0.90                   | CT               |
| Training of machinery owners and operators                                 | 5.00      | 3.35         | 0.67                   | PC               |



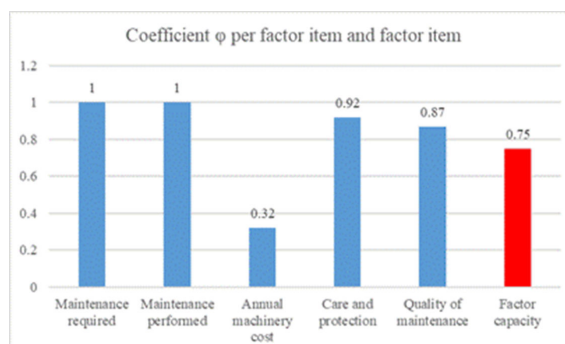
**FIGURE 2.** Mechanization competency coefficients by items and total for the Human Factor.



**FIGURE 4.** Mechanization competency coefficients by items and total for the operating conditions.



**FIGURE 3.** Mechanization competency coefficients by items and total for the Machinery Factor.

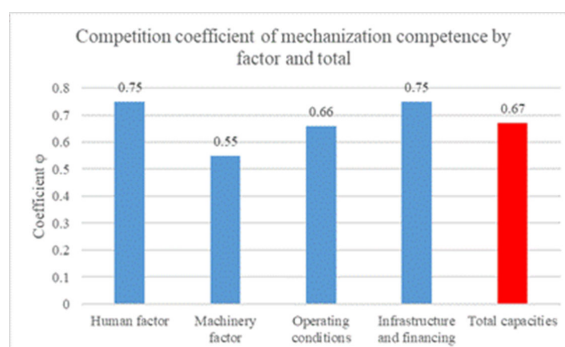


**FIGURE 5.** Mechanization competency ratios by item and total for infrastructure and financing.

allocated for the use of machinery in the different agricultural activities carried out by producers. There were also limitations in the access to credit with accessible interest rates for producers, particularly for owners of small plots of land.

Figure 6 shows the results obtained for each of the factors defined to assess competencies in agricultural mechanization in the central zone of Manabí. As can be seen, the total competencies or capacities reach a value of 67% (0.67), which places them in the scale defined in this methodology as Low Competencies (PC), where the machinery factor presents the lowest level of competency with 55% (0.55) (SC).

In general, the items with the lowest levels of competence include insufficient use of agricultural machinery in the different tillage activities, insufficient training of producers and service providers in the handling and use of agricultural machinery, excessive parceling that limits the use of medium and high-powered tractors, and the lack of



**FIGURE 6.** Coefficients of mechanization competencies for each factor and total in the analyzed area.

machinery on the market that is adapted to the conditions related to the area's characteristic relief. The use of agricultural machinery is basically limited to the use of tractors in primary tillage activities, together with limited financial resources for the use of agricultural machinery in the most common crops in the area.

The results obtained in this research are consistent with those obtained in other as [Loor-Sácido et al. \(2019\)](#); [Demera & Gil \(2022\)](#), which, in addition to corroborating the results obtained here, show a slow development in the application of agricultural mechanization in the area and in general in the province of Manabí.

### CONCLUSIONS

Mechanization is of great relevance in the development of the agricultural sector; it is a tool that facilitates agricultural activities with quality and speed and a significant increase in the productivity and competitiveness of this sector, to a greater degree for those regions in which it is one of the fundamental items of their economy, such as the province of Manabí.

The diagnosis of skills for agricultural mechanization in the central zone of Manabí shows low levels, being in the Low Skills category (0.67), where the use of agricultural machinery is limited, fundamentally, to primary soil tillage activities.

The small size of the plots, the poor financing for mechanization, as well as the unfavorable relief conditions and the inadequate levels of training in their operation, limit the introduction and development of mechanization in agricultural activities in the area under study.

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