Technical and economic evaluation of establishing an agricultural machinery bank in Granada, Meta, Colombia*

Evaluación técnico-económica de la creación de un banco de maquinaria agrícola en el municipio de Granada, Meta, Colombia

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Abstract

The proposal to create an agricultural machinery bank for small and medium-sized producers in the municipality of Granada (Meta), Colombia, aims to improve agricultural competitiveness and productivity through efficient access to modern machinery. This project arises in response to the lack of access to adequate machinery in the region, a situation that negatively affects the production and profitability of local farmers. The design of the proposal is based on the assessment of the specific needs of producers, carried out through structured surveys; subsequently, the technical and economic criteria for the creation of the machinery bank were identified. The proposal includes several phases: assessment, planning, implementation, and monitoring. The diagnostic phase identified the agricultural areas most in need of machinery and examined the types of equipment required; the planning phase covered the

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definition of necessary resources and the acquisition of machinery; and the implementation phase involved the acquisition and distribution of equipment to producers.

Keywords:

agricultural machinery, rural productivity, sustainability, small producers, economic evaluation.

Resumen

La propuesta de creación de un banco de maquinaria agrícola para los pequeños y medianos productores del municipio de Granada (Meta), en Colombia, tiene como objetivo mejorar la competitividad y la productividad agrícola mediante el acceso eficiente a maquinaria moderna. Este proyecto surge como respuesta a la falta de acceso a maquinaria adecuada en la región, situación que afecta negativamente la producción y la rentabilidad de los agricultores locales. El diseño de la propuesta se fundamenta en un diagnóstico de las necesidades específicas de los productores, realizado a través de encuestas estructuradas; posteriormente, se identificaron los criterios técnicos y económicos para la creación del banco de maquinaria. La propuesta incluye varias fases: diagnóstico, planificación, implementación y seguimiento. En la fase de diagnóstico se identificaron las áreas agrícolas más necesitadas de maquinaria y se indagó sobre los tipos de equipos requeridos; la fase de planificación abarcó la definición de los recursos necesarios y la adquisición de maquinaria; y la fase de implementación comprendió la adquisición y distribución de los equipos a los productores.

Palabras clave:

maquinaria agrícola, productividad rural, sostenibilidad, pequeños productores, evaluación económica.

Introduction

Given the current context of food security and the growing demand for efficiency in agricultural production, mechanization has become a fundamental pillar for promoting rural development, especially considering that agriculture is one of the main sources of income in many regions (Food and Agriculture Organization of the United Nations, 2018). In many Latin American countries, mechanization has been adopted as a development strategy to strengthen the agricultural sector, with the aim of ensuring sustainability.

The strategy known as agricultural machinery banks has proven to be an effective way to improve the productivity of small and medium-sized producers. For example, in Brazil, the Mais Alimentos program facilitated the acquisition of machinery through soft loans and subsidies, which had a positive impact on agricultural productivity (Da Silva, 2023). In Mexico, similar initiatives were developed through the Direct Support for Agriculture program, which enabled farmer cooperatives to access modern machinery, thereby improving agricultural practices (Gallo and Tapia, 2020). In Ecuador, the impact of access to machinery on the production of short-cycle crops was evaluated, and significant differences in productivity were found between those who had access to machinery and those who did not (Ramírez, 2023). These scenarios show how agricultural machinery banks contribute to the modernization of agricultural practices, reduce operating costs, and improve the producers' competitiveness in the market.

In Colombia, several initiatives have been implemented as agricultural machinery banks; however, in many regions, the entities promoting the sector lack a comprehensive approach, or the productive capacity of these areas is overlooked (Adefila et al., 2024). This is the case in municipalities such as Granada (Meta), which are characterized by a strong agricultural vocation and play a central role not only in generating employment but also in ensuring food security and strengthening the social fabric. However, despite the importance of the sector, small and medium-sized producers face barriers that limit their productive capacity and competitiveness.

Lack of access to modern agricultural machinery has been identified as one of the most significant obstacles, as it directly affects the efficiency and sustainability of production practices (Berdegué and Escobar, 2001). In addition, the lack of effective public policies to facilitate access to technology has created a significant gap in the agricultural sector, affecting the country's competitiveness in a context of globalization and climate change (Giraldo, 2018; Adefila et al., 2024). Restricted access to modern technology and the lack of adequate agricultural machinery has a direct impact on the livelihoods of rural families (Tagarakis et al., 2021).

Therefore, this research focuses on the technical and economic evaluation of the proposal to establish an agricultural machinery bank. The relevance of this proposal lies in its potential to offer a viable alternative through a machinery bank operating as a shared service among producers. A phased operational model is proposed, consisting of diagnosis, planning, implementation, and monitoring. Each phase is supported by data collection, statistical analysis, and financial evaluation, allowing for the design of a comprehensive strategy that optimizes the use of resources and contributes to the sustainable development of the sector (World Bank, 2021). This sector has a high percentage of SMEs that are part of it and, in some cases, "due to the financial muscle they have, are forced to carry out strategies with scarce resources to sustain themselves in the market". Molano, JCO, Quiroga, ALR, Garzón, CA, León-Castro, E. (2024).

Furthermore, the implementation of the machinery bank has not only economic but also social and environmental implications. From a social perspective, it is expected to improve working conditions and enhance farmers' quality of life by reducing their workload and providing training in the use and maintenance of equipment. From an environmental perspective, technological modernization could contribute to more sustainable farming practices by minimizing the excessive use of inputs and promoting more responsible management of natural resources.

In this regard, the research aims to analyze in detail the feasibility of the proposal to establish a machinery bank that not only meets the technical and economic needs of producers but also integrates into a rural development framework that promotes innovation and sustainability.

Methodology

Area of intervention of the proposal

For this proposal, the municipality of Granada (Meta), located in the Colombian Orinoquía region, was selected as the priority area. This municipality has an average altitude of 372 m above sea level and is strategically located in the foothills of the plains, which gives it a humid tropical climate favorable for various agricultural activities.

Proposal design

First, field research was conducted, in which structured surveys were administered to 200 rural producers. The questionnaire design was based on a review of existing literature, including studies by the Food and Agriculture Organization of the United Nations (2018), Tagarakis et al. (2021), among other relevant research addressing mechanization and rural development.

The questionnaire was divided into several sections: 1) demographic characteristics of producers, 2) land tenure, 3) types of crops and production systems, 4) current use of machinery and availability of implements, and 5) perception of technological needs. Each section was designed to obtain general and comparable information, allowing for statistical analysis of the data.

Sample selection

The sample was selected using criterion sampling, as the aim was to reach representative producers, considering the diversity of crops and the different forms of land tenure in the region. Data were collected during field visits, which made it possible to capture the seasonal and operational variability of agricultural activities.

Data analysis

Once collected, the data underwent statistical analysis, in which measures of central tendency (mean, median, and mode) were calculated. In addition, similarity analyses were performed to identify possible relationships between farm size, crop type, and machinery availability. This analysis made it possible to identify usage patterns and detect areas where the lack of technology directly impacts productivity (Torres, M., 2023).

In the evaluation component, a financial analysis was conducted, including the calculation of key indicators such as the Internal Rate of Return (IRR), Net Present Value (NPV), and payback period. To this end, the costs of acquisition, maintenance, and operation of the machinery were estimated, as well as the projected income from the shared use of the machinery bank.

Subsequently, a financial simulation model was developed, integrating all the parameters collected during the study. This model enabled long-term projections and the evaluation of different investment and financing scenarios, thus providing a tool to support decision-making. The model

was validated through sensitivity tests and compared with similar studies in other regions, ensuring its robustness and applicability (Ramírez, 2023; Gallo and Tapia, 2020).

Therefore, based on the proposed methodology, a general framework for the implementation phases of an agricultural machinery bank was developed, as described below:

1. **Diagnosis and analysis:** Information was collected on farm characteristics, crop distribution, and the condition of machinery in the region. The survey made it possible to determine the frequency of use of agricultural implements, the condition of the equipment, and the availability of machinery. This, in turn, facilitated the identification of the main needs of producers, as well as the prioritization of actions for the machinery bank. The operating costs of existing equipment were also evaluated, which supported the estimation of the costs of acquiring new machinery.

2. **Planning and design:** The technical and logistical aspects required to establish the machinery bank were defined. A business plan was developed, including the acquisition of machinery suited to the identified needs, and criteria for selecting beneficiaries were established, prioritizing producers with the highest demand and the lowest economic capacity to acquire their own machinery. An accessible financing system was also designed, based on an economic analysis of the associated costs.

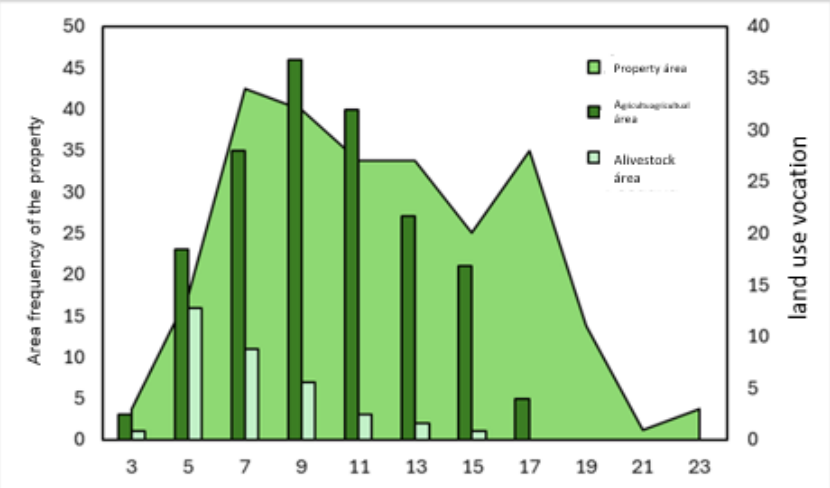
3. **Implementation:** The acquisition of modern machinery, such as multifunctional tractors and harvesters adapted to the characteristics of the predominant crops (corn, plantains, cassava, and cocoa), was planned.

4. **Evaluation and monitoring:** An evaluation system based on key performance indicators was implemented, which, under the proposed machinery bank model, allows for monitoring machinery use and improvements in crop productivity. These indicators include the number of hectares served, the frequency of equipment use, the impact on crop yields, and beneficiary satisfaction

Results

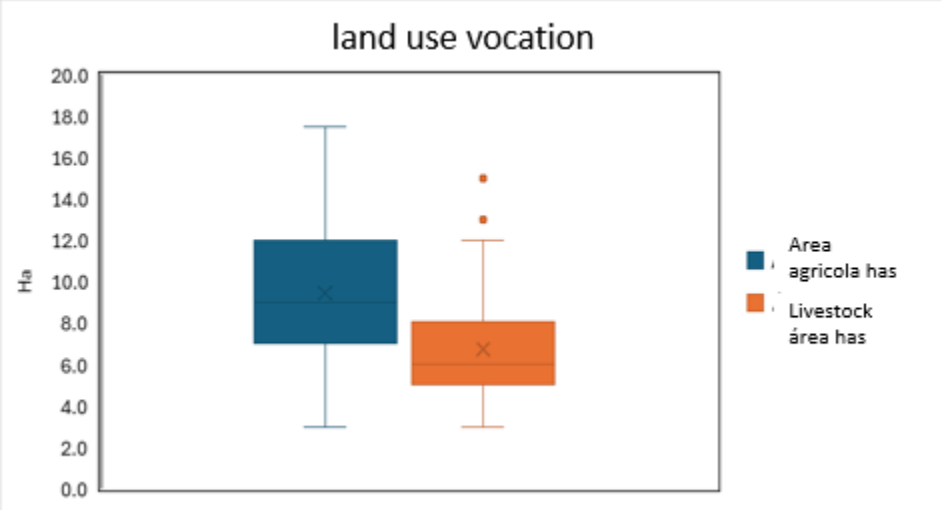
The demographic characteristics showed that most of the surveyed producers have farms ranging from 7 to 17 hectares, with an average size of 11 hectares (figures 1 and 2). This reflects the diversity in farm size and, consequently, in the machinery and technological support needs depending on land use.

Figura 1. *Distribution of farm size and land use patterns*



Source: own elaboration.

Figura 2. *Comparison of agricultural and livestock land area*



Source: own elaboration.

Statistical analysis revealed that the use of machinery on farms is limited and, in many cases, equipment is in poor condition. According to surveys, 80 % of producers have machinery in optimal condition, while 20 % use equipment in fair condition (table 1). This translates into longer task execution times and a significant increase in operating costs.

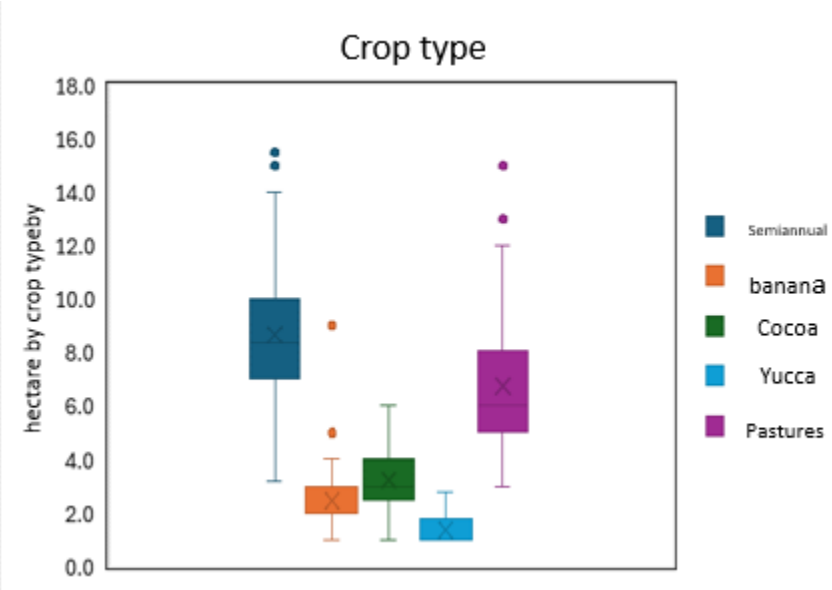
Tabla 1.
Condition of agricultural machinery in Granada (Meta)

Machinery	Good condition (%)	Fair condition (%)
Tractor	80	19
Harvester	-	1

Fuente: Pellentesque porttitor.

With regard to machinery demand, the results indicate a critical need for soil preparation operations, especially for crops cultivated twice a year such as bananas, cassava, and cocoa (figure 3).

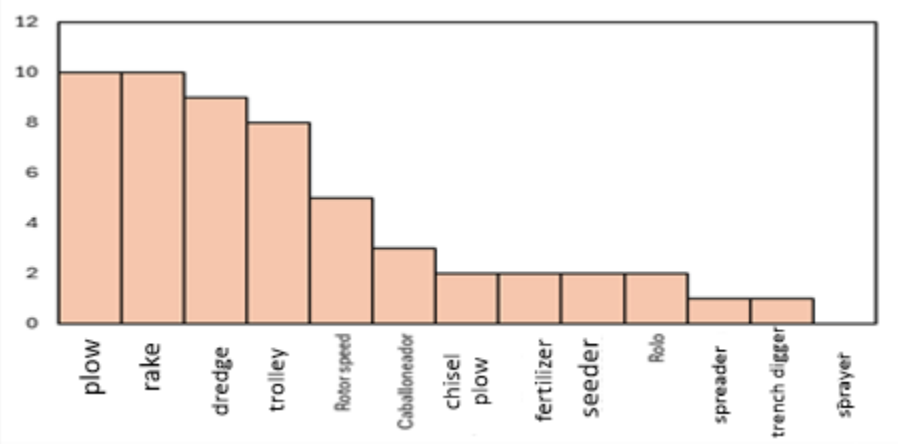
Figura 3. *Comparison of agricultural and livestock land area*



Source: own elaboration.

The financial study estimated that the initial investment required for the project is 1.606 billion COP, including the purchase of tractors, implements, and other necessary equipment (figure 4). Based on 12-year cash flow projections, an Internal Rate of Return (IRR) of 38.2 % and a Net Present Value (NPV) of 2.22 billion COP were obtained, while the payback period was estimated at between three and four years. These financial indicators show that, despite the high initial costs, the project is profitable and allows for a rapid return on investment.

Figura 4. *Comparison of agricultural and livestock land area*



Source: own elaboration.

The analysis segmented by crop type showed that producers growing crops cultivated twice a year are more dependent on machinery, as they must prepare the soil more frequently. On the other hand, in crops such as bananas and cassava, plowing and drainage ditch construction are critical to prevent waterlogging, which increases the need for specialized equipment. Respondents emphasized that lack of access to adequate machinery is the main obstacle to improving efficiency and competitiveness, which translates into higher costs and lower profitability for producers.

Finally, the development of the financial simulation model made it possible to evaluate different investment scenarios and demonstrate that, even under conservative conditions, the proposal to establish a machinery bank would generate significant returns. Taken together, these results confirm the technical, economic, and social viability of the project and provide a solid basis for future interventions in the agricultural sector. Cost estimates were based on supplier quotations and historical agricultural market price data. In addition, variables such as fuel consumption, repair and maintenance costs, and financing costs were considered, using current interest rates (Indicador Bancario de Referencia (Banking Reference Rate), IBR + 6.7 %).

Analysis of results

Based on the information collected, relevant patterns were identified in land distribution, land use, and the frequency of use of agricultural implements. In this regard, it was found that most plots were used for agricultural activities and had a defined purpose. The existing machinery was found to be in poor condition, with limited availability of modern equipment. This highlighted the urgent need for intervention in the sector through the creation of an agricultural machinery bank. In this phase, the operating costs associated with the use of existing machinery were also evaluated. This analysis made it possible to accurately estimate the costs involved in acquiring new equipment, considering aspects such as maintenance, operation, and replacement.

The project analysis established a set of selection criteria to ensure that the beneficiaries of the agricultural machinery bank had the technical, economic, and social capacity to optimize their production processes. The technical feasibility of applicants was assessed by considering their experience in the management and maintenance of agricultural equipment, as well as the availability of adequate infrastructure for its storage and upkeep. A detailed evaluation was conducted to determine whether the production units had facilities that would allow for the sustained and efficient use of the equipment, which was considered essential for the successful implementation of the project (Garay and Cardona, 2023).

A criterion based on commitment to environmental and social sustainability was also incorporated, analyzing whether applicants' agricultural practices were aligned with sustainable management strategies and assessing their capacity to reduce input use and minimize the ecological impact of intensive machinery use. This component also considered applicants' willingness to participate in technical training programs promoting responsible and efficient use of equipment, which was deemed essential for achieving a more sustainable production model (Food and Agriculture Organization of the United Nations, 2018).

The selection process also emphasized equity and inclusion, prioritizing small and medium-sized producers who, due to financial constraints, are in more vulnerable situations. Prioritization mechanisms were established to favor farmers with lower investment capacity, ensuring that access to technology contributes to a more equitable distribution of resources in the agricultural sector (Piñero and Trigo, 2024). This inclusive approach responds to the need to promote equitable access to technological tools that enhance productivity and competitiveness in rural areas.

The productive potential of each unit was also evaluated by considering the size of cultivated land, crop diversity, and the capacity to generate higher yields following the modernization of agricultural processes. This analysis was based on empirical data obtained from surveys and field studies, which identified cases in which the incorporation of modern machinery would result in significant improvements in efficiency and productivity. The selected producers showed clear potential for yield increases, as evidenced by higher crop performance in scenarios where advanced technology had been implemented (Gallo and Tapia, 2020; Ramírez, 2023).

In summary, the selection criteria integrated technical, economic, environmental, and social equity aspects, making it possible to identify producers with the greatest capacity and willingness to benefit from the agricultural machinery bank. This strategy, based on a multidimensional analysis, resulted in the selection of beneficiaries who not only possessed the necessary technical and economic skills but also contributed to the modernization and overall sustainability of the agricultural sector, optimizing productivity and strengthening competitiveness in rural areas (Adefila et al., 2024; Szegedy-Maszák, I., 2017).

The proposed agricultural machinery bank offers multiple benefits with a positive impact on the sector, notably increasing operational efficiency by enabling the shared use of modern equipment that would otherwise be inaccessible to many producers. In addition, investment and maintenance costs are reduced, as the collective financing model promotes resource optimization and the

diversification of financial risk. The bank also fosters technical training and skill development in the operation and maintenance of machinery, strengthening farmers' competitiveness and promoting more sustainable and environmentally responsible production practices (Food and Agriculture Organization of the United Nations, 2018; Binswanger and Mkhize, 2019).

The implementation of this model is not only economically viable but also leads to tangible improvements in productivity and quality of life for producers by promoting greater integration of advanced technologies into agricultural practices. Overall, the results are consistent with successful international experiences, demonstrating that the creation of an agricultural machinery bank represents an innovative and effective strategy for modernizing the agricultural sector, optimizing resource use, and promoting sustainable rural development (Adefila et al., 2024; Castañeda and Ávila, 2005).

Discussion

The results obtained in this study highlight the importance of the proposal to establish an agricultural machinery bank as a tool for modernizing the agricultural sector. The data reveal low availability and poor condition of existing machinery, which leads to operational inefficiencies and higher costs for producers. This finding is consistent with previous research documenting the challenges of mechanization in rural areas of Colombia (Food and Agriculture Organization of the United Nations, 2018; Tagarakis et al., 2021).

The financial indicators obtained, such as the IRR of 38.2 % and a positive NPV, indicate that investing in a machinery bank is financially profitable and offers a rapid return on invested capital. These results, in line with those of Piñero and Trigo (2024) and Delgado, M. (2019), suggest that technological modernization is crucial to increasing the competitiveness of producers.

The integrated analysis of the data provides a framework for understanding current limitations and opportunities for improvement. The low quality of machinery and high dependence on obsolete equipment demonstrate the urgency of renewing the machinery stock, which would not only optimize production processes but also reduce operating costs and improve profitability. In addition, the implementation of training and technical assistance programs is essential to ensure that producers can fully benefit from new technologies (Gallo and Tapia, 2020).

The social impact of the proposal also deserves special attention. The reduction in physical workload and operating times can significantly improve farmers' quality of life, allowing them to devote more time to managing and planning their productive activities. This social benefit is a fundamental complement to economic viability and supports the need for interventions that integrate financial, technical, and social aspects.

However, the discussion also highlights significant challenges. Securing adequate financing, ensuring efficient machinery maintenance, and enabling producers to adapt to new operational models are critical issues that must be addressed to ensure the success of the project. Coordination

between government and private entities will be essential to overcome these barriers and implement policies that promote investment in agricultural technology.

The results and their analysis confirm that the proposal to establish an agricultural machinery bank in the municipality of Granada (Meta) is a necessary and viable intervention capable of transforming the region's productive dynamics. The integration of financial, technical, and social perspectives strengthens the proposal and provides a solid basis for the formulation of public policies aimed at sustainable rural development.

Further research is recommended to explore the long-term impact of technological modernization and the replicability of the model in other regions, which would contribute to the transformation of the agricultural sector at the national level (World Bank, 2021).

Conclusions

The study supports the proposal to establish an agricultural machinery bank in the municipality of Granada (Meta) through a detailed analysis of the infrastructure, availability, and condition of the machinery used in the region.

It was found that existing machinery presents maintenance deficiencies and limited availability of modern equipment, highlighting the need for intervention in the sector to optimize the production processes of small and medium-sized agricultural producers. Likewise, the operating costs associated with equipment use were evaluated, making it possible to accurately estimate the expenses required for the acquisition of new machinery. The financial results are particularly noteworthy, highlighting key indicators—an IRR of 38.2 % and a positive NPV—which confirm the economic viability of the project, establishing a payback period of between three and four years.

A comparative analysis with international experiences revealed that similar initiatives in Brazil, Mexico, and Ecuador have significantly improved agricultural productivity through the implementation of machinery banks.

The proposal incorporated selection criteria that integrated technical, economic, and environmental sustainability aspects, while prioritizing producers with lower investment capacity and greater financing needs. This approach ensured a more equitable distribution of resources and promoted technical training and the responsible management of machinery. Overall, this strategy strengthened the competitiveness of the agricultural sector by fostering the modernization and sustainability of agricultural practices.

Establishing an agricultural machinery bank in this region not only optimizes resource use and reduces operating costs, but also promotes comprehensive and sustainable rural development. The transformation of machinery management is presented as an innovative solution to enhance producer's productivity and resilience, contributing to the structural modernization of the agricultural sector in a context of high competitiveness and technological change.

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