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Factors That Influence The Application Of Precision Livestock Farming Techniques

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Abstract:

Factors that influence the application of precision livestock farming techniques were identified and classified. Methodologically, it was a mixed study with a cross-sectional, non-experimental, correlational and descriptive design. For data collection and analysis, a systematic review on precision farming was carried out and then the MICMAC technique was implemented, for which the assistance of specialists was sought who, with their collective reflection, facilitated the structural analysis to be carried out. The results showed eleven factors that were directly classified as key, among which the investment capacity of the producer, qualified personnel, the type of cattle to

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be raised, among others. It is concluded that the adoption and adaptation of precision livestock farming is a procedure that must take place in stages, starting with the understanding of the concept itself and gradually moving towards the use of techniques and technologies that facilitates its implementation, likewise, it is highlighted that the use of information and communication technologies provides multiple benefits, including automatic, precise, and real-time monitoring of animal behavior.

Key Words: livestock, technology, innovation, agriculture 5.0, economy.

1. Introduction

The productive efficiency of the livestock farming system is key to the competitiveness and sustainability of the sector and is measured through productive indicators. However, traditional and mechanized livestock farming, in addition to being expensive compared to the economic advantages it generates, is extremely harmful to the environment, since greenhouse gases are continuously and cumulatively emitted (Parra-Cortés, et.al, 2019). In this sense, technology becomes one of the best allies for this process, since their development forces the transition to Agriculture 5.0 (Comisión Europea, 2021), where through automation and the introduction of recent technological solutions, traditional agricultural practices are modified and improved.

Precision livestock farming (PLF) is a new sustainable system to generate food of animal origin through information and communication technologies (Jo, et al., 2018). Its application facilitates the increase in production and animal welfare, the reduction of environmental impact and investment costs, and the resolution of difficulties through the examination of information (Ocampo & Santa Catarina, 2018). In this sense, in a highly demanding context such as livestock production, the primary goal must be to maximize the efficiency of production systems, where proper management of the data that is produced every day on livestock farms is essential (Callejo, 2014).

One of the main characteristics of these technologies is that they are developed and applied to provide data in real-time so that decision-making derived from these can be very fast and thus prevent inconveniences (Callejo, 2015). To apply these technologies, it is necessary to know them in depth to get the most out of them and to identify the variables that facilitate the monitoring of livestock processes (Halachmi, 2015). There are key factors that must be taken into account if the PLF techniques need to be implemented, this research seeks to classify the determinant, key, result, and autonomous factors, to provide a guide to the producer and can focus on the factors classified as key.

Among the key factors for the application of the PLF, the economic factor stands out, which represents the greatest restriction for the development and adoption of these technologies, so achieving cheap devices that use low electricity is imperative (Belanche, et al., 2019). However, more and more people around the world are joining the adoption of PLF, and research on the matter is increasing. Schuetz, et al. (2018) digitize select catalogs of overlapping patterns with Big data, acquired from different sensors on some farms, with semantic technology. Likewise, Becciolini and Ponzetta (2018) measure aspects such as rest, food, and walks with movement sensors (GSM) and GPS to infer control exercises that contribute to improving production, and in (Zheng, et al.,2018), a quantitative evaluation of the behavior of the herd during animal-birth is carried out, with an automatic kinesic sensor that records images in the computer equipment, without the person in charge approaching the maternity, since it could affect the natural position of the animal.

Due to the above, the adoption of PLF techniques is key to overcome restrictions and take advantage of the livestock sector potential and, consequently, of the agricultural, agri-food, and the agro-industrial system as a whole.

2. Methodology

In the investigation, a mixed methodology was applied; because qualitative and quantitative approaches were used (Sampieri, 2018). Regarding the design, the non-experimental, cross-sectional, correlational and descriptive design was chosen. Literature and specialists were consulted on the factors that affect the use of PLF techniques, literature on these same factors, and a structural analysis (SA) was carried out to determine the particularities of the situation in the system of relationships between these factors and their dynamic structure with a qualitative approach (Herrera, 2017). The MICMAC technique was used to carry out the AS. This technique implements quantitative and qualitative aspects that promote the identification of key variables (KV) or factors through an n x n matrix, facilitating their classification in a four-quadrant plane (PQP) in variables: determinants (DV), of results (RV), keys, and autonomous (AV) (Arango & Cuevas, 2014). The stages of this technique are described below.

Stage I. Definition of the list of factors

The initial stage involves the identification of the variables that make up the system to acquire a list of internal and external variables to it. It is necessary to elaborate a detailed description of each variable to promote the location in the plane, the description, and the evaluation of the relationships between them.

Stage II. Description of relationships between factors

In stage II the matrix is filled out, formulating the questions: can a direct relationship be observed between the variables i and j? if it does not exist, the qualification will be 0, in the opposite case, the question is whether said relationship of direct influence (ID) is weak (1), medium (2), strong (3) or potential (4). By solving these questions the matrix is filled.

Stage III. Factor classification

This stage allows the KV to be identified and categorized in an indirect, direct, and potential way, which shows the relevance of certain variables and the presence of others that indirectly play an important role but cannot be observed through direct classification (DC). The classification shows in a PQP, where in Quadrant I, the KV are located; in Quadrant II, the VD are located; in Quadrant III, the AV are located and in Quadrant IV the RV are located.

3. Results

The results obtained for this research are displayed below. In the first place, 11 (eleven) factors were obtained from the literature, indicated as the most important when wanting to apply the PLF techniques and which are described below: Investment capacity of the producer, Comparison of the observed data against the estimates, Compatibility between hardware-software, Clear data on the cost-benefit relationship, Delimitation of objectives in the short, medium and long term, Skill in the use of new technologies by producers, Standardization for the exchange of data between devices, Periodic evaluation of the production process, Qualified personnel, Type of livestock to be raised, and Livestock use.

After reviewing the literature, the group reflection (GR) of the specialists was used, who were shown the list of the 11 factors and agreed with each listed factor. Next step to apply the MICMAC technique, the coding of each factor and its description in a table were carried out, as part of stage I. In Table 1, characteristics such as the code, number, and name of the factors are displayed.

Table 1. Factors that affect the application of PLF techniques

Number	**Code**	**Variable**	**Description**
1	ICP	Investment capacity of the producer	The producer must have investment capacity to be able to apply the techniques.
2	COE	Comparison of the observed data against the estimates	Observed and estimated data must be analyzed in order to influence the desired results.
3	CHS	Compatibility between hardware-software	It is important to take into account the compatibility of the devices used
4	CDCB	Clear data on the cost-benefit relationship	It implies having the necessary information to consider the purchase or sale of producers when making decisions.
5	DO	Delimitation of objectives in the short, medium and long term,	The time in which the results need to be obtained must be defined.
6	STP	Skill in the use of new technologies by producers	Producer skills to handle new technologies.
7	SED	Standardization for the exchange of data between devices	The existence of standard forms in the exchange of data between the devices used must be taken into account.
8	PEPP	Periodic evaluation of the production process	Evaluate the weighing of the animals, cost of inputs and sale prices, this serves to predict profits and solve problems.
9	QP	Qualified personnel	It is essential to have qualified personnel who can provide support in the process of applying the techniques.
10	TL	Type of livestock to be raised	It must be clear if it will be used for cattle, sheep, or pigs

11	LU	Livestock use	It implies being clear about the use that will be given, whether it will be to produce meat, milk or eggs.

Source: Own elaboration

Once the factors have been listed, the GR is applied to the set of specialists to evaluate the dependency and influence relationships of each factor in a square matrix, which concerns stage II of the MICMAC technique. Figure 1 shows the direct influence/dependency matrix filled in by consensus and the GR of the specialists. As can be seen, the first row corresponds to the ICP factor (Investment capacity of the producer) it is distinguished that the relationship between this and the COE factor (Comparison of the observed data against the estimates) is a strong relationship (3), with the CHS factor (Compatibility between hardware-software) the relationship is also strong (3), with the CDCB factor (Clear data on the cost-benefit relationship) it has no relationship (0), with the DO factor (Delimitation of objectives in the short, medium and long term), the relationship is strong (3), with the STP factor (Skill in the use of new technologies by producers) it has a medium relationship (2), with the SED factor (Standardization for the exchange of data between devices) the relationship is strong (3), with the PEPP factor (Periodic evaluation of the production process) there is no affluence/dependency relationship; with the QP factor (Qualified Personnel) the relationship is strong (3); with the TL factor (Type of livestock to be raised) the relationship is strong (3); and finally with the LU factor (Livestock use) the relationship is medium (2); and so on, the relationships of all the factors are detailed.

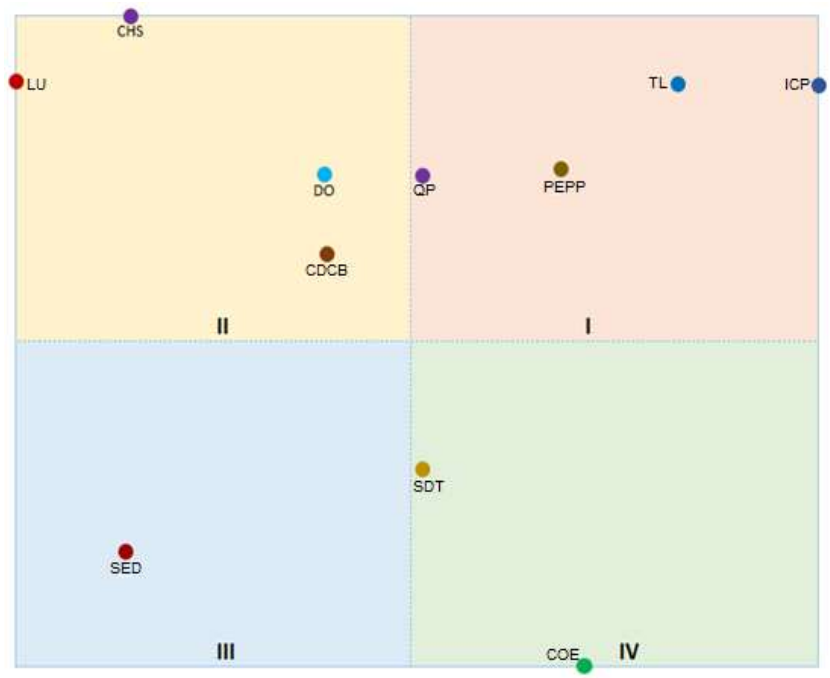
Figure 1. Matrix of influence/direct dependency

	ICP	COE	CHS	CDDB	DO	SDT	SED	PEPP	QP	TL	LU
ICP	0	3	3	0	3	2	3	0	3	3	2
COE	3	0	0	2	1	0	1	2	1	1	1
CHS	3	3	0	2	2	3	0	3	3	3	1
CDDB	2	3	2	0	1	1	2	3	1	2	2
DO	1	2	3	2	0	3	1	2	3	2	1
SDT	3	2	1	0	2	0	0	3	1	3	0
SED	2	1	0	1	1	1	0	2	1	3	1
PEPP	3	3	1	2	3	2	1	0	2	1	2
QP	3	1	3	3	1	1	3	3	0	2	0
TL	2	2	2	3	2	3	1	2	2	0	3
LU	3	2	0	3	2	3	2	2	2	3	0

Source: Own elaboration.

The previous figure, which represents the direct influence/dependence matrix, results in the classification of the factors. This classification is represented in the ID plane that is evidenced in Figure 2. Four (4) factors were located in quadrant I: TL, ICP, PEPP and QP. Four (4) factors were also located in quadrant II: CHS, LU, DO and CDCB. In quadrant III, one (1) factor was located: SED. Finally, in quadrant IV two (2) factors were located: STP and COE.

Figure 2. Classification of variables by direct influences/dependencies



Source: Own elaboration.

According to the results of the ID matrix, the DC was as presented in Table 2.

Among the KV, strategic or challenge, there was TL, which refers to the type of livestock that is going to be raised. This factor is key because each type of livestock has its advantages and disadvantages that must be considered in planning (Ferrán & Castaldo, 2020). Likewise, the investment capacity of the producer is key, because it is the capacity of the producer to meet the commitments. A high investment capacity is key according to the results in Agudelo, Rivera, Tapasco, and Estrada (2003), where it is stated that the producers have a high investment capacity focus on large-scale livestock activity. However, Van, et al.(2021) state that, in most cases, producers face financial limitations in their ability to invest in technological innovations.

Another factor identified as key was the periodic evaluation of the production process. This factor is key, because according to Lei & Simões (2021), the periodic evaluation of body condition and the control of modifiable or non-modifiable risk factors is a valuable tool on farms, with which the effects of some diseases can be mitigated. Likewise, Qualified Personnel was classified as a key factor, which is important, because the correct handling of technological devices guarantees reliable measurements. In this regard, Eastwood, et al. (2013), note that there is a requirement for investment in human capital to support precision technologies, at the same time that knowledge exchange structures are created to link farmers with the lessons learned by others.

Table 2. Classification of variables by indirect influences/dependencies

Factor type	Factor	Code
Key, strategic or challenge factors	Type of livestock to be raised	TL
	Investment capacity of the producer	ICP
	Periodic evaluation of the production process	PEPP
	Qualified personnel	QP
Determant or "influencing" factors	Compatibility between hardware-software	CHS
	Livestock use	LU
	Delimitation of objectives in the short, medium and long term	DO
	Clear data on the cost-benefit relationship	CDCB
Autonomous or excluded factors	Standardization for the exchange of data between devices	SED

Dependent factors or result variables	Skill in the use of new technologies by producers	STP
	Comparison of the observed data against the estimates	COE

Source: Own elaboration

On the other hand, among the determinant or influencing factors, Compatibility between hardware and software stood out, which is of the utmost importance, because this factor is essential for the exchange of information or performance of the functions required when they share the same software or hardware environment (Bhandarkar, 2021). Likewise, the Livestock use factor was classified as determinant, because the techniques that are applied are not the same and are applied according to the purpose of the cattle, that is, either to produce meat, milk, among others. For its part, the factor Delimitation of objectives is determinant, because, having clear the time in which certain objectives are to be achieved, the techniques to be applied can be adequately identified. Another determining factor was Clear data on the cost-benefit relationship because it is important to constantly evaluate the new technologies in the sector, to analyze their cost-benefit and thus achieve an approach towards productive innovation(Lanfranco, Fernández, Soares de Lima, & Ferraro, 2021).

Regarding the autonomous factors, only one was classified as such, and it was the Standardization for the exchange of data between devices. This is because the adoption of common standards for the physical interconnection and the compatibility of data generated by the different equipment constitutes the main space of strategies for the expansion and technological introduction in livestock (Tzounis, et al. 2017).

Aside, the results factor was Skill in the use of new technologies by the producers. This is because, in order to adopt the technology to the livestock sector, it is necessary to have prior technological capabilities and infrastructure (Kumar, et al., 2018). Finally, the factor Comparison of the observed data against the estimates. This factor is important, to a large extent, due to the wide variety of electronic devices at affordable prices with superior computing and data examination capabilities, which facilitate individualized observation of animals within the herd (Bahlo, et al., 2019).

Likewise, it is possible to compare these same data with those initially projected in order to make corrections if necessary.

4. Conclusions

It is important to highlight that the adoption and adaptation of the PLF is a procedure that needs to be developed in stages, beginning with the understanding of the concept itself and slowly oriented towards the implementation of techniques and technologies that favor its use. Likewise, it should be noted that with the use and development of ICT, accurate and real-time information on animal behavior can be obtained automatically.

In this sense, applying PLF techniques allows optimizing and controlling livestock resources in order to maintain the competitiveness of producers in a challenging market. With this study, different factors were acquired that were subjected to a meticulous examination by specialists, who evaluated the relationships between each factor for their classification. The DC according to the results of implementing the MICMAC technique, showed that four (4) of the eleven (11) factors were key and four (4) determinants, which denotes that in the PLF all factors are relevant and must be considered when time to apply PLF techniques. It should be noted that the results of using MICMAC offer an orientation to the reality of the evaluated context, but this does not indicate that it is a permanent reality since it is based on qualitative aspects such as the evaluation of the links between factors and the choice of these.

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