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ORIGINAL

Big data and artificial intelligence for innovation in management in the agricultural industry in Extremadura

Big data e inteligencia artificial para la innovación en el management en la industria agropecuaria extremeña

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ABSTRACT

Technology behaves in a disruptive way. As the word implies, it abruptly breaks the way in which people's lives unfold, mainly the organizational. Provides unique opportunities, where we can achieve dreams that were only scenes of science fiction movies, but that Today strongly impact in the world of organizations. This can be seen with autonomous vehicles, which transform the way in which transport companies formulate their business models; the holographic communication which provides the possibility of gathering directors of companies in a fraction of a second and decision making; and big data, which implies the reformulation of commercial strategies in relation to real information about consumers offered by bigdata; among others. In order to take advantage of these advances, it is necessary to pay attention to the changes and adapt correctly. The present investigation has the objective to know if agricultural companies in Extremadura, Spain are aware of the need for organizational adaptation to develop successfully in this 4th industrial revolution, mainly by incorporating big data technology. Response that will be sought through a documentary and descriptive investigation about this reality in the companies selected intentionally.

Keywords: 4th Industrial Revolution; Big Data; Organizational Adaptation; Change; Agriculture.

RESUMEN

La tecnología se comporta de manera disruptiva. Como la palabra lo indica, rompe bruscamente la manera en la que se desenvuelve la vida de las personas, principalmente la vida de las organizaciones. Brinda oportunidades únicas, donde podemos alcanzar sueños que solo eran escenas de películas de ciencia ficción, pero que hoy impactan fuertemente en el mundo de las organizaciones. Esto, puede observar con los vehículos autónomos, que transforman la manera en que las empresas formulan sus modelos de negocio; la comunicación holográfica, que brinda la posibilidad de reunir directivos de compañías en una fracción de segundo y acelera la toma de decisiones; y el big data, que implica la reformulación de estrategias comerciales en relación con información real sobre los consumidores; entre otros. Para aprovechar positivamente estos avances, es necesario atender a los cambios y adaptarse correctamente. La presente investigación tiene el objetivo de conocer si las empresas agropecuarias de Extremadura, España son conscientes de la necesidad de adaptación organizacional para desarrollarse exitosamente en esta 4ta revolución industrial, principalmente al incorporar tecnología big data. Respuesta que se buscará a través de una investigación documental y descriptiva sobre esta realidad en las empresas seleccionadas de manera intencional.

Palabras clave: 4ta Revolución Industrial; Big Data; Adaptación Organizacional; Cambio; Agropecuaria.

INTRODUCTION

There are times when technological discoveries underpin changes that, like the effect of a butterfly's flapping wings, transform reality in a very short time and affect humanity in countless aspects. Entrepreneurs take technological advances, apply them creatively, present new businesses, and bring them to the market, where their usefulness and possibilities are enhanced. At the same time, these technological advances adapt to the needs of consumers, become naturalized, and reach the point where it is no longer conceivable to live without this technology. In this way, they transform the way we relate, mobilize, and communicate. In addition, they imply the need for new types of jobs and the expiration of traditional ones.

However, beyond the similarities this industrial revolution shares with previous ones, it is essential to consider that the impact of the present one is so significant and encompassing that, as Schwab[1] points out, in previous revolutions, the changes were mainly social and centered on opportunities. Still, this new revolution is different, especially when considering the speed at which new ideas and technologies spread globally, causing companies across all industries to reconsider their business practices. The implications of this new industrial revolution are so wide-ranging that they affect everything from the simplest things, such as the presentation of highly personalized advertising on Internet search channels, to the way we communicate, to bioscience through biotechnology and artificial intelligence, which aim to solve health problems or enable remote operations on the human body. This is because the 4th Industrial Revolution involves advances such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printers, nanotechnology, biotechnology, and energy storage, among others, that are here to stay.

One of the central issues that concerns large companies is the management of vast volumes of data, known as big data. This is a tool that involves processing a massive flow of information, but with characteristics that differentiate it from standard database systems. The strategy specialist Marr[2] determines 4 "Vs" to understand the operation and importance of the tool: volume, velocity, variety, and veracity. These are the pillars on which this technology is based, which changes the way of planning and managing strategies and business models with information that, when appropriately used, transforms the way of reaching the customer and manages to break, for example, with the coldness and depersonalization that until recently implied dealing with the virtual customer, the way of treating diseases by processing real-time information on each patient, how stock is logistically managed, and many other uses in various industries. Thus, companies across all sectors must reassess their traditional business practices and adapt to the rapid changes in technology and evolving consumer expectations.

Now, what is essential is to understand how this information strategy and value creation impact companies seeking competitiveness, as well-managed technology collaborates with the exponential multiplication of value-generating possibilities and competitive advantages for companies. Porter et al.[3] express that, through the attention to the reformulation of the value chain, the increase of security in the processes, the decision making based on real and updated data at the moment, an advantage related to the personalization of the service is achieved to provide a better quality of experience to consumers.

METHOD

Design

This research will be descriptive in scope and will employ a qualitative approach with a non-experimental, cross-sectional design. It will focus on whether companies in Extremadura recognize the importance of adapting their systems to leverage new technologies and remain competitive. The current level of technology incorporation in Extremadura companies will be taken into account, and the analysis will be divided between companies that have implemented it and those that have not. Previous research explaining the impact of the 4th Industrial Revolution, its components, characteristics, and, primarily, its relationship to big data tools, will also be considered.

The context in which these characteristics are intended to be studied is the Autonomous Community of Extremadura, specifically within organizations of the agricultural industry, although intentionally selected according to the characteristics required by the research objectives.

To fulfill the first objective, we will begin with documentary research on theoretical issues related to the central topics and conduct empirical research using this information. Then, based on the results obtained and through the use of primary sources, the truth about the companies will be revealed, progressing from the general to the particular, to achieve the other specific objectives.

Participants

In the documentary section, the population will consist of management books, and the sample will be a non-probabilistic, intentional sample, with the unit of analysis limited to a book on Principles of Administration. A Global Perspective" Koontz et al.[4], A book on Strategic Management "Strategic Management" by Hill et al.[5] and finally a book on Incorporating Technology for management "Big Data in Practice" by Marr et al.[6].

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For the second section of the research, the population consists of 12 agricultural organizations in Extremadura. The sample is of a non-probabilistic, purposive type, and the participants are composed of general managers from both companies that have the potential to use big data technology and those that have effectively incorporated this Technology. Each of them will answer specially formulated interview questionnaires.

In selecting the companies, organizations of different sizes have been chosen, aiming to maintain a proportionate balance between large and small companies, as indicated by the sector's indicators, according to the National Statistics Institute of Spain.

The interviews were conducted with personnel from 12 companies, seven from the agricultural industry, and five from the livestock industry.

Of the farms, two are large and are managed by personnel with university training. The other 5 are family businesses, managed by their owners, who have been trained on the land itself through courses and cooperatives.

In the case of the five livestock farms, only one is large and managed by trained personnel with a university education.

Table 1. Structure of farms in Extremadura

	Extremadura	Extremadura/Spain % No. of farms with
No. of farms with UAA	61 227	6,6
Usable agricultural land (ha)	2 425 122	10,4
UAA/holding (ha)	39,6	158,0
Owned farm (no.)	52 809	6,4
Leased farm (no.)	14 986	7,0
Other operations (no.)	6104	5,3
AWU	54 657	6,8
Family	30 532	6,5
Salaried	24 125	7,3
Farm manager with agricultural training	12 304	6,0
Farm manager with university education	1400	7,9

Collection instruments

For the documentary part, the collection instruments will be the content cards, bibliographic and hemerographic cards, and the registry of electronic pages.

For the primary source collection part, the collection instrument to be used will be a semi-structured interview, administered through indirect questionnaires by a specialist. This type of interview is ideal for obtaining descriptions and information on ideas, beliefs, and conceptions of the person acting in the reality we want to analyze. In addition, these interviews are characterized by being Part of a script (a tentative list of topics and questions) in which issues related to the subject of the study are highlighted. During the interview development, questions are posed without adhering to the previously established sequence, allowing for unforeseen yet pertinent questions to be asked. The script outlines the necessary information to achieve the stated objectives.[7]

The formulation of the questionnaires should be carried out taking into account the results of the documentary research.

Data analysis

The data to be analyzed will be qualitative in nature. The procedure for data analysis will be as follows: obtaining the information through the documentary research and the questionnaires; capturing, transcribing and ordering the information through the collection of original material and the interviews through the electronic record of the interviews; then it will continue with the codification of the information grouping according to categories, concepts pre-selected by the researcher and culminates with the integration of the information through the analysis and categorization of the information collected about the scope of the proposed objectives.

RESULTS

Interpretation of the results

It is expected that, due to population growth, food demand will increase by at least 60 % above 2006 levels by 2050. This increase, if the way of production does not change, will negatively affect the carbon cycle, since the agricultural industry currently accounts for one-fifth of total emissions.[8]

This problem has led scientists, companies, organizations, governments, etc., around the world to invest in a process of constant innovation in this industry.

The main objective of this work is to find out if the agricultural industry in Extremadura is aware of the advances in the field of artificial intelligence and big data for the sector and if it is aware of the need to implement these new technologies, as well as, if so, if it is prepared to implement the necessary changes in infrastructure and management.

To this end, interviews were conducted with managers of companies of different sizes in the sector, aiming to maintain a ratio between large and small companies based on sector indicators, as reported by the Spanish National Institute of Statistics.[9]

The interviews were conducted with personnel from 12 companies, seven from the agricultural industry and five from the livestock industry.

Of the farms, two are large and are managed by personnel with university training. The other 5 are family businesses managed by their owners, who have been trained on the same land, courses, and cooperatives.

In the case of the five livestock farms, only one is large and is managed by trained personnel with university training.

From the interviews, it is observed that, in general, the agricultural industry in the region is very traditional, and a significant percentage of farm heads are older than 60 years without university training.

Advances are being implemented slowly, much more slowly in the livestock industry than in the agricultural sector, and more by the government, machinery manufacturing companies, etc. than by the initiative of the producers themselves, most of whom do not even understand what artificial intelligence is, nor are they aware of the need to implement it.

Considering that in Extremadura we find more than 10 % of the functional agricultural area (UAA) of Spain and that Spain is among the four countries with the largest UAA in Europe (along with France, Italy and Germany), this data is essential, not only as an indicator of what may be the reality in the rest of Spain and Europe, but also because of the relevance of the region in the industry.[10,11]

It would be essential to extend this study in numbers of companies and even geographically to be able to determine if what is happening in the companies in the sample is truly representative of the sector and, if so, to make producers aware of the need to update the industry to obtain greater production with less environmental impact.

Results

The results are presented below in two categories: the Agricultural Industry and the Livestock Industry, as they have distinct differences.

Results in the agricultural industry

Through the study of bibliography it has been determined what technology is available in the sector and through the interviews, to what extent the available technology is being applied in the industry, if the farms are adapting their infrastructure and management to make the most of this technology and if those companies that are not yet using it are aware of the importance of incorporating it.

1. *Available technology*: has been classified into three main categories: machinery, crop and soil monitoring, and predictive analysis.

This classification comes from one of the first interviews conducted with Jaime Lorenzo. Mr. Lorenzo uses these categories when describing the steps, as he calls them, for incorporating artificial intelligence and Big Data into his farm.

...since my involvement in management, I have started investing in artificial intelligence. We are replacing our current machinery with tractors, brush cutters, and sprayers, all equipped with GPS and sensors that automate these tasks. We obtained a grant shortly after my incorporation, and we invested it completely in modernizing the machines to automate tasks. This makes them more accurate, uses fewer personnel, and generates less product waste.

The next step would be to install sensors in the soil and crops to begin understanding their conditions at any given moment.

Then we would only need to leap, analyzing the information from the sensors to be able to anticipate, not just respond to how things are, but I see that for later.

The classification used by Mr. Lorenzo can be extrapolated to the rest of the organizations to determine where they stand in implementing this technology.

Defined in more detail, as I will use them throughout the paper, the three categories are:

- Machinery/robots: machinery to automate basic agricultural tasks such as planting, harvesting, mix control, and spraying.
- Crop and soil monitoring: using vision by electronic devices and learning algorithms, to process data captured by drones and/or software-based technology, to monitor crop and soil health.

- Predictive analytics: with machine learning models to monitor and predict the impact of environmental conditions on crop performance and yield.

2. *Application in the Extremadura industry of this technology:* 100 % of the farms interviewed (See annexes E1 to E7) use machinery with some form of artificial intelligence (mainly GPS for spraying).

45 % of the farms have actively implemented this technology (E1, E2, E3), while the remaining 55 % (E4, E5, E6, E7) have adapted to this technology by replacing machinery and found these functions to be standard. The managers of these farms confess that they are not sure of using all the functionalities offered.

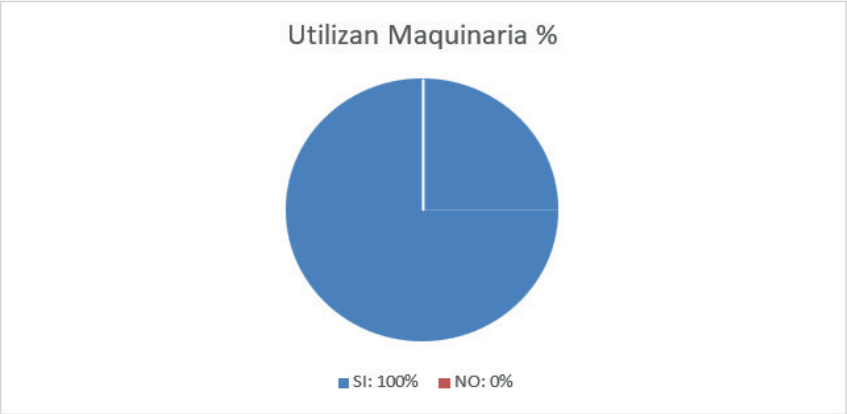

Figure 1. Percentage of farms using some type of machinery with artificial intelligence

Regarding monitoring technology, only the two largest (E1, E2), representing 28,6 % of the sample, have started to use some monitoring tool with artificial intelligence and big data. In another one (E3), the partner has attended some training to learn more about this technology and is considering applying it in the future,

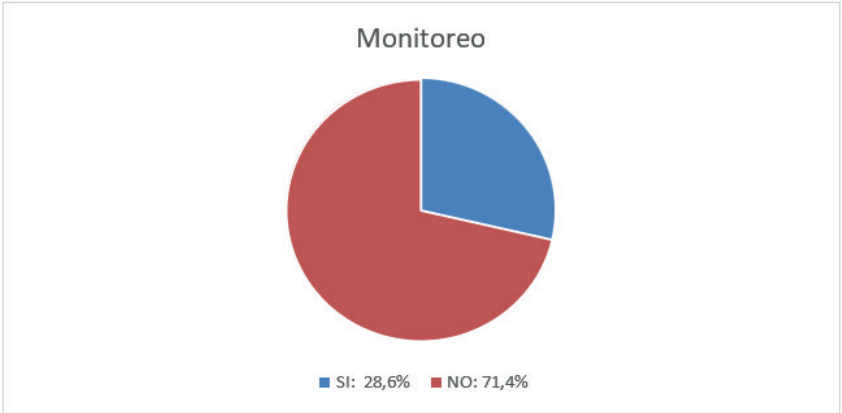

Figure 2. Percentage of farms using sensors for soil and/or crop monitoring

Predictive analysis is not being used in any of the farms interviewed.

Figure 3. Percentage of farms using predictive analytics models

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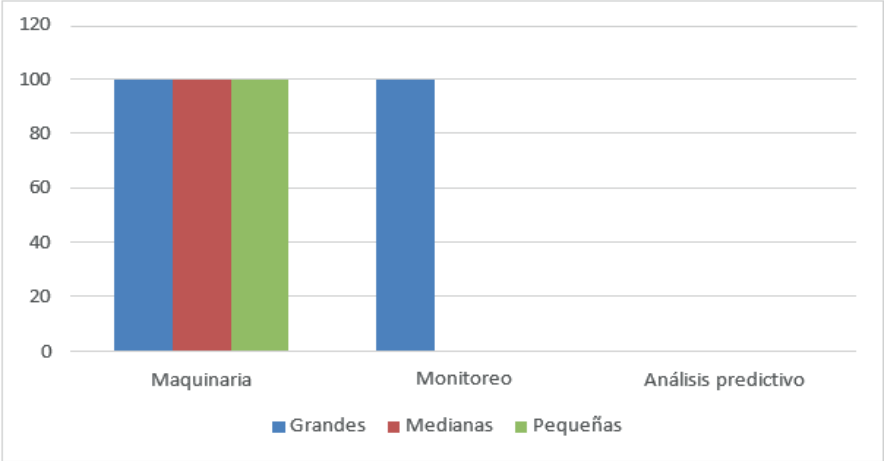

Figure 4. Whether data are presented depending on farm size

3. *Among the companies that do not yet use artificial intelligence:* although all of them apply it to some extent, 55 % of the farms only use it in machinery because this technology comes as standard.

These companies are managed by individuals over 60 years old, the farms are situated on family-owned land, and none of them appear to understand the need or benefits of incorporating this technology. Only one of them (E4) had some knowledge of artificial intelligence and the technology available in the field, and none of them were familiar with the term 'big data'.

4. *Industry adaptation for the implementation of artificial intelligence and big data:* the results will be exposed, taking into account the categories defined for this technology.

- Machinery: all farms claim to have trained their employees to operate machinery with artificial intelligence and are replacing outdated machinery that does not incorporate this technology.
- Monitoring: only the two large companies (E1, E2), which comprise 28,6 % of the sample, already have trained personnel capable of reading and analyzing the data, as well as managers aware of the importance of external consultants and the use of the data obtained to inform management decisions.

The company, planning to incorporate this technology in the future (E3), had not yet considered the need for management restructuring. Unlike what happens in the first two that changed their management structure when they decided to grow and saw the need to adapt to new technologies, in this farm it happened the other way around, when the previous farm manager retired and the interviewee, who was already familiar to some extent with the advances in artificial intelligence and big data, replaced him in the position and began to implement this technology and replace machinery little by little.

Predictive analytics: none of the companies are using this technology, nor have they yet considered the structural or management needs necessary to implement it.

Results in the livestock industry

The results will be presented following the same scheme used for the agricultural industry.

1. Available technology: it will be classified into the same three main categories.

- Machinery / robots: automated milking machinery, feed depositing robots, and grazing drones.
- Livestock monitoring: through sensors in the barn that monitor the location and behavior of livestock, virtual fences (using the same sensors to give small shocks to the cattle when they pass a particular area).
- Predictive analytics: models that analyze animal behavior data obtained by sensors to detect anomalies, measure biometric indicators, and/or are related to energy or feed consumption, predict need, and diseases.

2. Application in the Extremadura industry of this technology: only 1 of the five farms interviewed, 20 % of the sample (E8), uses artificial intelligence and big data. This company, being the largest livestock farm in Extremadura (E8), implements this technology in all three categories, uses machinery for milking, sensors to monitor the animals and their behavior, and analyzes the data obtained by the sensors to decide how much the cattle have to eat or when they have to mate.

In Extremadura, it is mandatory to identify cattle for marketing purposes by assigning a code to an ear tag that contains information on the animal's birth, health, and movement history. Only the largest farm (E8) (which includes this code on an electronic ear tag) has the technology to read and analyze this information. In the

remaining farms, which comprise 71,4 % of the sample, ear tags are placed by veterinarians at the birth of each animal. It is the veterinarians themselves and the cooperatives that update the information as needed.[12,13,14]

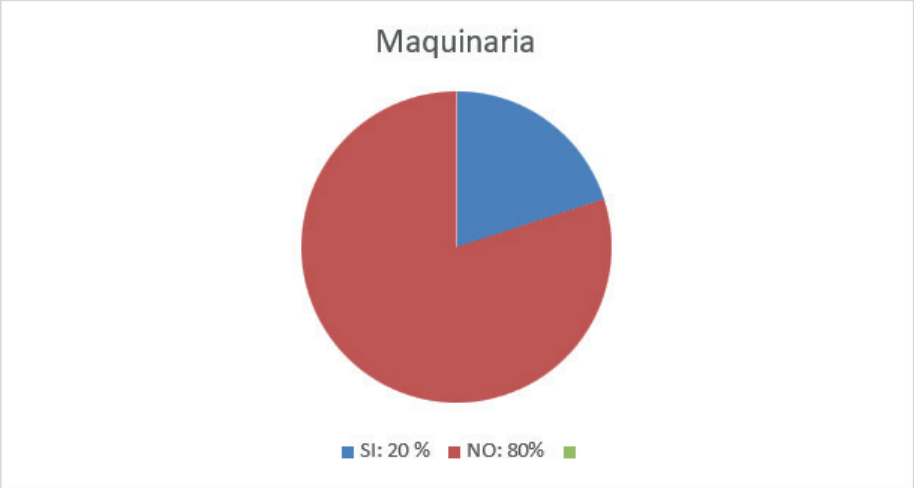

Figure 5. Percentage of livestock farms using some type of machinery with artificial intelligence

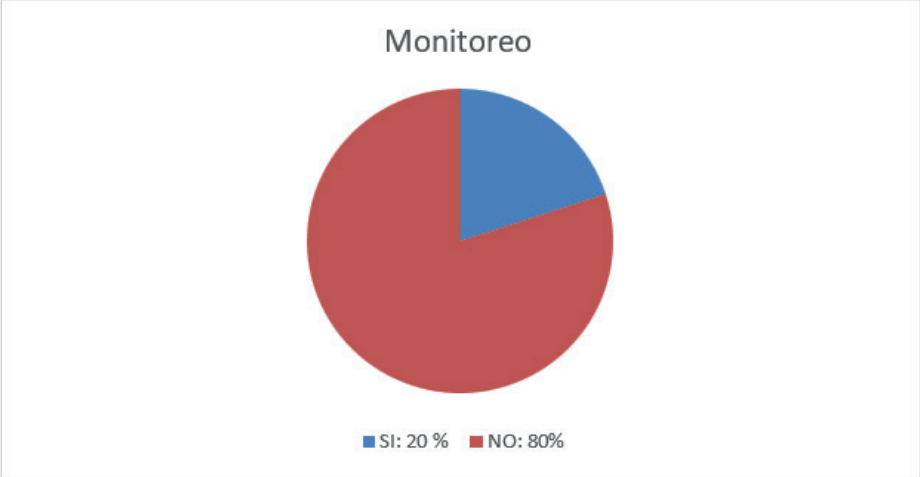

Figure 6. Percentage of livestock farms using sensors for livestock monitoring

Figure 7. Percentage of livestock farms using predictive analysis models

If the data are presented according to farm size, the following figures are presented.

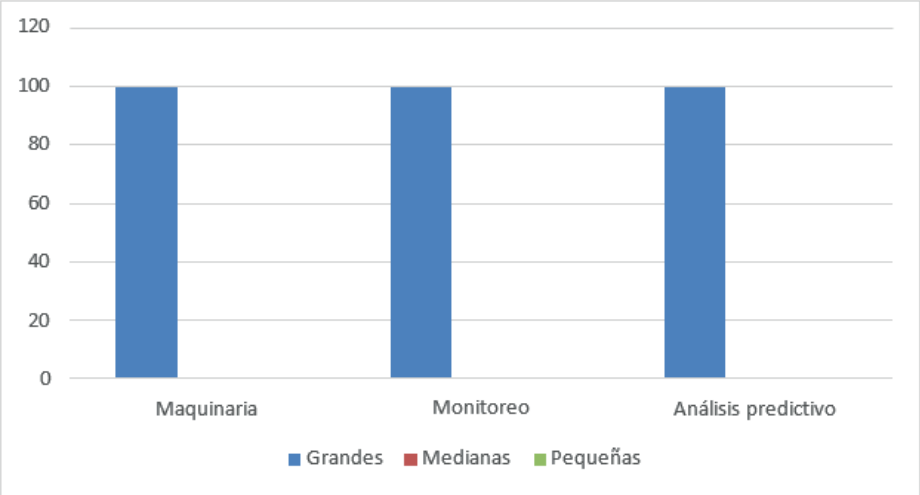

Figure 8. Comparison of results by farm size in the livestock industry

3. Among the companies that do not yet use artificial intelligence: unlike what is observed in the agricultural industry, in the livestock industry, there is much ignorance in the area of artificial intelligence.

None of the interviewees of those who do not yet implement artificial intelligence, which represents 100 % of these farms and 71,4 % of the total sample, plan to implement artificial intelligence in the short or medium term, even two of the interviewees found the idea of applying artificial intelligence in their farms comical, which denotes the little understanding of what artificial intelligence is and its scope.

None of the managers of the farms that do not yet use artificial intelligence, representing 71,4 % of the total sample, are familiar with the term 'big data'.

4. Adaptation for the implementation of artificial intelligence and big data: the company (E8) using artificial intelligence and big data, representing 100 % of the farms that have implemented this technology and 28,6 % of the total sample, has completely restructured the farm and its management team in the last 10 years. It has evolved from being a family business managed solely by its owners to hiring administrators who oversee the farm and provide guidance on decision-making. They have also hired veterinarians who are experts in artificial intelligence and big data, and use consultants to help interpret the information obtained and for decision-making.

Comparative results between farms in the crop and livestock industry

When comparing the results obtained in both industries, it is observed that artificial intelligence is more prevalent in farms within the agricultural sector than in those within the livestock industry.

It is also observed that the livestock farms that do implement it apply more technology than their counterparts in the agricultural industry. In no case, having interviewed large farms, was the application of predictive analysis observed, as it is observed in the farming industry.

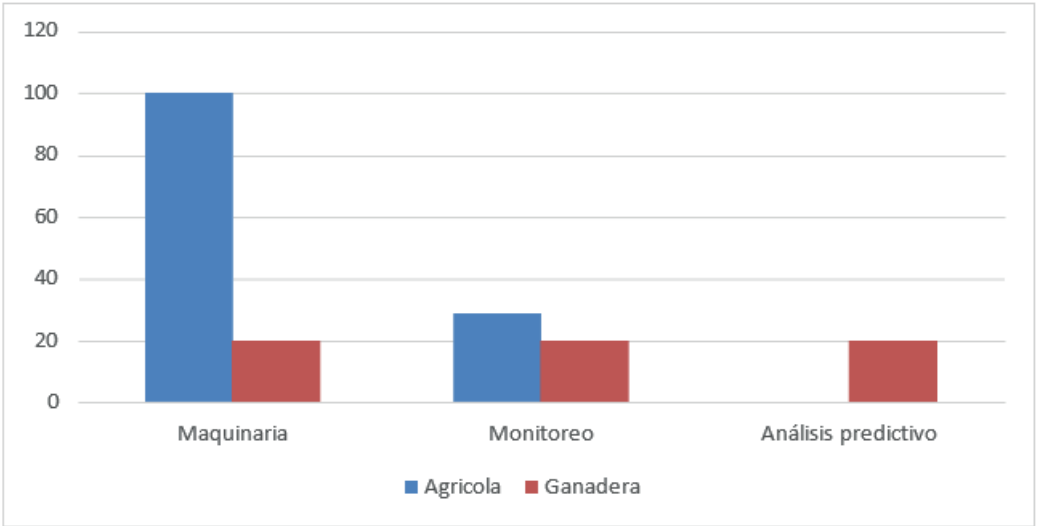

Figure 9. Comparison of results between agricultural and livestock farms

CONCLUSIONS

This study aims to determine whether the majority of managers of agricultural and livestock farms in Extremadura are aware of the advances in the field of artificial intelligence and big data for the sector, whether they are applying these new technologies and, if they are using them, whether they are aware of the structural and management changes needed to take advantage of everything these technologies have to offer.

The relevance of this study lies in the fact that by 2050, global agriculture will need to produce approximately 60 % more food than it did in 2006.

As agricultural production increases to meet demand, so will its emissions. Significant improvements in the management of the carbon and nitrogen cycles in agriculture would be necessary to achieve a reduction in emissions intensity, or emissions per unit of agricultural output, thereby counteracting the tendency of agricultural sectors to emit more when they produce more. Realizing the mitigation potential in the farming sectors will therefore not be easy, not only because of the significant transformations needed in agriculture for more widespread adoption of improved practices, but also because of expected increases in demand for agricultural products.

This increase in production, while improving carbon cycle management, will only be possible with the correct implementation of artificial intelligence and big data. These tools are already available, and data mining techniques have been developed for precision agriculture and intelligent livestock farming, including weather forecasting, disease prediction for plants and animals, and decision support systems for selecting livestock, crops, and soils.

Among the tools mentioned are IoT (Internet of Things) applications for predicting the behavior of livestock, crops, soils, and the occurrence of plant and livestock diseases, to improve sustainability and increase profitability. Precision irrigation, precision horticulture, greenhouse IoT, livestock monitoring, IoT ecosystem for agriculture, mobile robot for precision agriculture, energy monitoring, storage management, and smart farming/livestock.

Researchers, governments, and philanthropists from all over the world have prioritized this industry, and advances are occurring at a breakneck pace in smart agriculture, livestock, and data mining.

In Extremadura, large companies are already using cutting-edge technology available in the region, as demonstrated by Pascualete in the livestock industry. In Pascualete, we use electronic ear tags with sensors to monitor the animals. Additionally, we have recently become one of the few farms in Spain to utilize Alpro. Alpro is a data management program obtained from a chip wrapped in a ruminant bolus. This is ingested by the sheep and is deposited in the second stomach of these animals.

With the information provided by both devices, we know where they are, how much they eat, whether they drink, how much milk they produce, and how many times they have lambed, among other details.

With this information, we can provide the correct feeding to ensure the highest quality milk, know when to advance or delay milking, select the ideal group for each farrowing cow, and more.

In recent years, we have begun to use sensors in the soil to analyze moisture, pH, and other factors, thereby understanding the needs of each sector at all times. We also use machinery with GPS and sensors for harvesting, irrigation, and spraying. Not only this technology is available, also the Junta de Extremadura offers grants and aid co-financed by up to 80 % by the European Regional Development Fund, a way of doing Europe (ERDF), under the Operational Program for the programming period 2014-2020, within the Thematic Objective OT1: “Promote technological development and innovation in the field.”

Lorenzo Paniagua exposes that his farm has accessed one of these grants to support the modernization of the field:

The Junta de Extremadura offers subsidies to modernize the fields. We obtained a subsidy shortly after my incorporation, and we invested it entirely in changing the machines to automate tasks.

Tasks. This way, they are more precise, fewer personnel are used, and there is less waste of product and resources, such as water and energy.

Even so, the interviews reveal that smaller farms are hesitant to adopt artificial intelligence and big data.

In the agricultural sector, although all companies use some artificial intelligence, as irrigation and spraying machines already come with these applications as standard, only the largest (28,6 % of the sample) implement artificial intelligence for soil and crop monitoring, and none use predictive analysis.

In the livestock industry, the incorporation of artificial intelligence and big data is even slower; only the largest company (20 % of the sample) utilizes these technologies, while the rest of the farms claim not to use artificial intelligence. In this case, the company (E8), which employs artificial intelligence and big data, applies these technologies to the three categories described throughout this manuscript: machinery, monitoring sensors, and predictive analytics.

From the interviews, it can be inferred that only large farms, run by personnel with higher training, are making progress in applying these technologies.

Considering that SMEs in Extremadura represent 95 % of the farms in the area and that only 2,3 % of the

farms (1400 out of 60 227 - see table 1) have a farm manager with a university education, and taking into account the need to modernize the industry, this finding is alarming.

Even more alarming if we add to this the aging of the region, studying the demographics of Extremadura we discover that 28 % of the municipalities in the area have among their neighbors a third of the population over 65 years old, specifically 109 localities, according to the Stratego report (2019) on average age and aging in Extremadura municipalities. This report offers an X-ray of the aging of Extremadura, the oldest region in Spain, and the rural exodus it is experiencing, a phenomenon that has become a topic of debate and great concern in the country, in the face of what is being called "empty Spain".

In the interviews, it is observed that none of the farm heads who do not yet use big data are aware of the need to implement it, and they do not see the benefits. Four of the interviewees (E4, E9, E10, and E12) even state that these technologies are beneficial only in "large farms."

With other colleagues from the cooperative, we visited a large pistachio farm in Toledo. They monitored the soil and plants, analyzing the information to determine how much and when to irrigate, among other factors. But in a small business like this, the investment is greater than the benefit.

There is a common misconception that Big Data is something only Silicon Valley companies possess. However, this case (John Deer, "How Big Data Can Be Applied on Farms") shows how any industry can benefit from data, and even more traditional companies.

Until farm managers are made aware of the benefits of applying artificial intelligence and big data regardless of farm size, I find it challenging to think that they will actively pursue these technologies in the near future.

Regarding the next objective, artificial intelligence is not only about automating processes, but it is also about obtaining quality data on a large scale. Once this data is obtained, it is necessary to transform it into high-quality information to make efficient and strategic decisions. In other words, farms will need to have personnel capable of interpreting the data obtained, transforming it into information, and predicting future compartments and needs based on this information, thereby making better decisions according to their objectives and interests.

This information process is essential to take advantage of these technologies. In all the farms of the sample with these characteristics, it is observed that they have an organizational system adapted to their needs.

The major limitation of this work is the small sample size of 12 farms, comprising seven farms from the agricultural industry and five from the livestock industry. Considering the percentage of small and family farms in the area, if the study were to be extended, the rate of farms using artificial intelligence would likely be even lower.

It is also relevant to take into account that, since it is almost exclusively large companies that have incorporated artificial intelligence and big data, the analysis of the last objective (to determine the extent to which companies using artificial intelligence have adapted their management system) will possibly not be extrapolated when family farms with managers without university education are the ones that begin to implement these technologies. It is a reasonable doubt to think that the managers of these farms will not be as aware of the need to not only adapt the infrastructure and machinery, but also their organizational system and to train and/or hire trained personnel (let's remember that all the farms in the sample that implement artificial technology consciously and extensively are large farms and have adapted their management system).

Even taking into account the limitations of the present study, its relevance lies in being the first to investigate the implementation of artificial intelligence and big data in the agricultural sector in Extremadura and possibly in Spain (no works of this nature have been found).

Although it will not be extrapolated as the implementation of artificial intelligence advances in smaller companies, the combination of statistics from the INE of Spain, interviews with farms with different characteristics and the analysis of the implementation taking into account the size of the farms and training of their managers, gives us a broad picture of the current reality and allows us to determine the penetration of these technologies according to the different sizes and structures of the farms.

Increasing production while enhancing food security and reducing energy use and the ecological footprint of farms —i.e., improving the efficiency and competitiveness of the sector —will only be possible with the correct implementation of artificial intelligence and big data. This study enables technology companies and governments to understand the current state of the industry, allowing them to chart the path forward.

A crucial next step is to extend this study to a larger number of farms and expand it nationwide.

I also see a need for work focused on medium, small, and family farms that tracks the difficulties these farms face when implementing artificial intelligence and big data. SMEs represent 95 % of the sector in Extremadura, so any action plan should be very mindful of the difficulties faced by this group.

Once these studies have been carried out, having determined the percentage of farms already implementing artificial intelligence and big data and knowing the interest of the rest in incorporating these technologies shortly, the next step is to promote training and awareness courses.

Researching the website of the Junta de Extremadura, you can find grant schemes, not only for the fields, but

also for research. There are initiatives in conjunction with the most essential cooperative in the area, SCOOP COPRECA, and with technology companies in the sector, such as DUCTOLUX and SET, to promote research; however, no training on artificial intelligence and big data is available.

Given that the heads of small and family farms in the area have commented in the interviews, not seeing the benefits that can be brought by implementing artificial intelligence and not even knowing what big data is, it isn't easy to think that they will actively seek the implementation of these technologies shortly. This is why I consider it fundamental to conduct these trainings, and to do so in collaboration with cooperatives, which is the best channel of communication for small and medium-sized farms.

Only after raising awareness of the importance of modernizing farms with artificial intelligence and big data will research strategies and subsidies be genuinely effective.

At that point, considering that most farms are family-owned and have no employees or just one or two shepherds or farmers, it will be necessary to incentivize the hiring of employees trained in artificial intelligence, as well as to train shepherds and traditional farmers in these technologies.

Roberto Castuera of Pascualete, when asked about the most significant challenge they faced in implementing this technology, responded:

We are a traditional and modern company at the same time. The first thing is the care of the animal; we have to have personnel who are knowledgeable about the sector, who know the animals well, but who are also familiar with this technology. Farm work can be challenging, as we say here in Extremadura, the climate is extreme and harsh. It is hard to get trained personnel willing to work in the field.

Opening up skilled jobs in artificial intelligence and modernizing the countryside could also be a way to retain and attract young and experienced people, a tool to combat Empty Spain.

There is also the issue of reduced employment opportunities in agriculture as a direct result of automation and big data.

This topic falls outside the scope of this manuscript, but I see relevance in mentioning it due to the interest it arouses in the autonomous governments of Spain. It could serve as an incentive to develop a modernization plan for the field.

In conclusion, the need to implement artificial intelligence and big data in the agricultural industry is indisputable, and these technologies are widely available in the region of Extremadura, with the Junta showing interest in encouraging the modernization of the field. However, due to a lack of knowledge, only large companies with university-educated farm managers are using these technologies. In contrast, the rest of the farms do not plan to modernize their facilities with artificial intelligence in the short term. For this reason my recommendation is 1) To deepen this study and extend it, if possible, to the whole country 2) To work together with the cooperatives to inform about what artificial intelligence and big data are and the benefits in terms of production, quality and economics that their incorporation can bring even to small farms 3) Subsidy programs for investment in artificial intelligence and big data, 4) Programs to encourage the hiring of personnel trained in artificial intelligence and big data and 5) Training programs in artificial intelligence and big data for shepherds, farmers and farm managers with traditional training in the field.

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CONFLICT OF INTEREST

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