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Research Results
Резултати от научни изследвания

INTELLIGENT ANIMAL HUSBANDRY: FARMER ATTITUDES AND A ROADMAP FOR IMPLEMENTATION

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Abstract. In order to preserve and develop sheep breeding, it is necessary for traditions to meet with intelligent technologies. This will ensure a better quality of animal products (both dairy and meat), increase the health status of the animals, reduce their stress levels, optimize the costs of the farmers and a number of other benefits. The purpose of this article is to show the possibilities of intelligent technologies in modern sheep farming. In it, one hundred different farms in southern Greece were studied and the attitudes of their owners towards the implementation of intelligent monitoring of sheep flocks were established. Analyzes of farmers' propensity to adopt AI technologies are performed. On this basis, a road map has been proposed, facilitating the process of introducing intelligent sheep farming. It is applicable both to the study area and to other geographical areas with sheep farming traditions.

Keywords: Intelligent Animal Husbandry; Sheep Farming; AI; Opportunities; Road Map

1. Introduction

Agriculture and especially animal husbandry is closely related to human history and development. According to Rojas-Downing, and his team (2017), farmers need to almost double their production in the next few decades to meet the growing global demand for meat and animal products (Rojas-Downing, et al. 2017), i.e. it is necessary to find ways to improve animal husbandry (Neethirajan 2020) and to reach the so-called precision agriculture (Stafford 2000). This requires the application of modern approaches, strategies and technologies through which the most appropriate actions are taken to meet the specific needs of the animals and the interests of the producers. In this way, we can talk about the production of products with certain qualities, with

maximum efficiency, minimal negative impact on animals and the environment, sparing use of natural resources (Valchev et al. 2022).

Modern approaches for monitoring the behavior of animals require monitoring their health status, establishing the moment of breeding, registering the moment of conception (Riaboffa, et al. 2020); behavior, caloric food intake, grazing, active behavior, distance traveled, experience, passive lying down, milk composition, etc. For optimization and more complete tracking and monitoring, the use of sensors for intelligent monitoring of animal's behavior has increased in recent years (Rutten, et al. 2013). It is accompanied by the application of various artificial intelligence tools, on the basis of which an analysis of the behavior and health of each individual animal is carried out. The application of AI and high technology in the agricultural sector is not new. Intelligent animal husbandry aims to improve its efficiency by focusing on animal welfare – health, safety, behavioral and emotional expression (Alves 2021). A number of publications highlights the wide range of use of various sensors, data processing and transmission, AI models, machine learning (ML), deep learning (DL), artificial neural networks (ANN), etc., in condition identification of animals (Daiab et al. 2020), their behavior (Riaboffa et al. 2020), course of diseases (Volkmann et al. 2021) and others. Intelligent animal husbandry is also based on the concepts of Industry 4.0. According to them, the application of intelligent systems for automated management of processes in animal husbandry will significantly increase the quality of production (Ministry of Economy of the Republic of Bulgaria 2017[1]).

The main advantages of intelligent animal husbandry include:

– Animal welfare, including: analysis of animal reproduction and behavior; reduction of animal stress and analysis of breeding conditions, according to the specifics of the breed; analysis of the gene pool of the animal and optimization of selection during crossing; minimizing the likelihood of adverse farm events that may affect productivity and profitability (Shine and Murphy 2022);

– Economic benefits, including: increasing the total profit of livestock breeders; reduction of losses due to disease or premature death of animals; increasing the quality of production; the increase in herd size without additional labor costs; (Shine and Murphy 2022) quantitative and qualitative determination of the milk produced in dairy farms (Slob et al. 2021) and others.

– Environmental protection, including prevention of natural food sources and preservation of natural grasslands.

Along with the advantages, some disadvantages are also identified: technical failures due to methodological and physical and technical reasons; long initial training time (validation of data on specific animals over a period of time); prejudice and lack of trust in technology by farmers (Kling-Eveillard, et al. 2020) (Bartzanas et al. 2017) and others.

Clearly, a sustainable future depends on understanding the diversity and complexity of livestock systems, the uptake of intelligent systems, and the

particular motivations and challenges facing stakeholders in periods of highly dynamic environments (FAO 2019[2]). The timing of farmers' decision to transform will determine their future success. This topic is of global interest, with the largest number of studies conducted in China, followed by the USA, Great Britain and Germany. The application of AI technologies to dairy or beef cattle is often discussed, followed by pigs and poultry (Bao and Xie 2022). Despite the abundance of research on the topic, the literature synthesis shows that AI technologies have not yet entered widespread practice (Benjamin and Yik 2019). This gives us reason to investigate the reasons for this by examining farmers' attitudes and their propensity to use high-potential systems in animal husbandry. The research question we pose is what is the propensity of farmers to use AI technologies in animal husbandry, what would motivate them and what are their inhibitions?

In order to get an answer, in this material we successively reveal: what are the possibilities of AI tools in animal husbandry and in particular in sheep breeding; we conduct research on sheep farmers in a region of the Peloponnese (southern Greece) that is traditional with this activity; we analyse the results and draw conclusions and propose a road map to expand the use of intelligent sheep herd monitoring systems.

2. Opportunities of AI in animal husbandry

To determine the propensity of sheep farmers to switch to intelligent animal husbandry, we look at several main areas where AI technologies are useful:

– Intelligent technologies providing information on the health status of the animals, including changes in the activity and stress level of the individual animal;

– Intelligent technologies providing information on the moment of initiation, fertilization and the course of pregnancy;

– Visualization of the location and exact GPS coordinates of the animal;

– Required daily caloric intake.

Table 1. describes what information farmers would receive in the indicated areas and the way in which it is collected, stored, processed and analysed.

Table 1. Need for data and AI analytics for knowledge mining in intelligent livestock

	Required data	**Method of collection, transmission, storage and processing of data**	**Analysis of the received information using ML and AI**	**Final result**
Health status	Behavioral patterns and data related to the animal's activity (distance traveled,	Collection, through individual sensor groups mounted in smart collars	Using methods and algorithms to detect behavioral patterns;	User visualization of the data, inferences,

Health status	head movement, etc.), according to age, temperament, sex, breed, period of the year, etc.	attached to each animal; Broadcasting, via broadband and broadband radio channels; Storage, through cloud infrastructure with big data; Data processing, through decryption, normalization and parameterization of information; Extracting knowledge from information - applying AI to detect behavioral algorithms and determine real state and generate inferences.	Checking the credibility of the models, through calibration and expert verification; Model bug fixes and tracking their proper work; Introducing principles and self-learning artificial intelligence for continuous model improvement and discovery of new ones (Valchev et al. 2021).	past, current and future events related to the health status of each individual animal.
Reproduction	Behavioral patterns related to the moments of estrus, fertilization and pregnancy			User visualization of timing, fertilization and pregnancy progress data.
Required caloric intake	Behavioral patterns of the animal for movement, distance traveled (for free grazers); time to experience; Parameters from GPS etc.			User visualization of saturation data, type of grass quality (for free grazers), etc.
Location	Locating GPS coordinates, via coordinate system for determining physical location	Collection, through individual sensor groups mounted in smart collars attached to each animal; Broadcasting, via broadband and broadband radio channels; Storage, through cloud infrastructure with big data; Data processing, through decryption, normalization and parameterization of the information.	Here, a separate AI analysis for localization is not necessary; Location data is added to relevant behavioral models and provides insights into other parameters.	User data visualization of exact location of each individual animal.

Smart animal collars measure or detect biological, chemical, physical or mechanical properties or a combination of these properties (Neethirajan 2020). With the help of AI, behavioral patterns of observed animals are detected and analyzed (Valchev et al. 2021), in order to minimize potential risks. AI analyzes provide information on the required caloric intake of each animal and the level to which it has been achieved, so that it produces an optimal quantity and quality of

production (milk). At the same time, the main cost-generating elements – for food and medicine (Neethirajan 2020) are optimized.

In addition to the herd, in animal husbandry, the availability of grazing areas – own or leased pastures and meadows, as well as the method of cultivation – are also important. The effect of the application of AI technologies is significantly greater in freely grazing animals. The main unit of measurement for establishing the quality of the pasture is the grass resistance. Pasture monitoring shows the condition of the grass and when the herd should be moved to another grazing area. Thus, it is possible to restore the grass mass preferred by the animals. The AI analyzes the satiety of the sheep in relation to their movement and behavior on the pasture, and through it the condition and quality of the grass in the area. The effect of smart technologies would be less if the herd is raised in pens with artificial and/or natural food mixtures based on daily rations. In this way, the specific needs of each animal and its individual nutritional needs cannot be precisely determined. All this would be beneficial to the breeders. Most studies related to the use of smart monitoring in dairy animals are conducted on cows (Puupponen et al. 2020) (Jerhamre et al. 2022) whose owners declare a tendency to use. However, sufficient information is lacking for research on sheep. It is known that the principles of the devices and the conclusions they give are similar, but it is not known what their entry into practice is. To fill this gap, we investigate the propensity of sheep farmers to enter into intelligent animal husbandry.

3. Method

3.1. Farms covered by the survey

Greece is an agricultural country with developed animal husbandry (Vlyssides et al. 2015). The Peloponnese peninsula (southern Greece) was chosen for conducting the research. It is characterized by centuries-old traditions in sheep breeding and continuity between generations. Since ancient times, the Greeks have had considerable credit for innovations in animal husbandry. They developed sophisticated animal husbandry techniques (Kron 2012). Moreover, in the area there is a university with a faculty of agricultural technology and agrotechnology (University of Peloponnese[3]), where young farmers are trained. They are actively working on the development of rural regions and public-private partnerships (Manos et al. 2014). This gives reason to define the area as suitable for conducting the research.

There are 100 respondents in the study. owners of flocks of sheep. They were recruited through several approaches: 1. Using the contacts of an expert bureau for consulting services for innovations in livestock breeding; 2. Attracting the customers of one of the main local dairies; 3. Through the Scientific Laboratory of Agrarian Economy, Development and Entrepreneurship of the University of Peloponnese. In order to represent the sample, respondents from different age groups, level of education and size of sheep flocks were sought.

3.2. Methods of conducting the research

The research was conducted using two methods: a survey and in-depth interviews. Survey research, as a form of research, is the primary means of collecting quantitative primary data. It enables the collection of quantitative data in a standardized manner so that the data reveal a consistent and valuable analysis (Roopa and Rani 2012). The method was chosen as the most suitable for data collection, providing guarantees while preserving the anonymity and free will of the respondents. The conducted survey is organized within 14 main questions. Most of the questions were closed-ended with leading answers, providing respondents with a variety of alternatives. There are also issues related to determining the extent to which they would benefit from the use of the above areas of intelligent animal husbandry. The main group of questions in the survey concern the way in which the herds are currently raised, the needs of the farmers in terms of intelligent animal husbandry, what of the AI possibilities on offer they would use.

In-depth interviews were conducted among a narrower range of respondents. Their aim is the unfolding of opinions, experiences, values and various other aspects (Showkat and Parveen 2027) of the studied sheep breeders. The range of respondents here includes various experts with direct observation of farmers' attitudes, as well as a sample of farmers. The questions in the in-depth interview cover both more general topics repeating those of the questionnaire, and those of a more delicate nature, referring to various barriers and inhibitions of farmers regarding the application of AI in their activity.

The period in which the research was conducted is the second quarter of 2022. This period was accompanied by a high degree of economic and geopolitical turmoil, which affected the livestock sector in the Peloponnese.

4. Results and discussion

Analyzing the results requires determining the profile of the respondents and the size of their herds. Summary information about it is given in the Table. 2

Table 2. Basic data on the studied sheep breeders and the size of the flocks

Age (in %)		Education (in %)		Herd size (in %)		Number engaged in the rearing of the herds (in %)	
Up to 25	9	Less than high school	3	Up to 50 sheep	15	Up tp 3	83
26 – 35	20	High school	68	From 50 to 100	35	Up to 10	12
36 – 45	26	Graduate degree	29	From 101 to 200	33	Over 10	5
46 – 55	34			Over 200 sheep	17		
Over 56	11						

The main expenditure elements of animal breeders are for food – 75%; medical care and medicines – 18%; labor costs – 4% and other costs – 3%. Such a structure

of expenses is declared by sheep breeders, not including their personal labor costs in this composition.

Regarding the introduction of new technologies in animal husbandry, 75% of the respondents stated that they use some type of automation in raising sheep and/or processing sheep products. They demonstrate a good attitude towards potentially using the possibilities of technological innovations in animal husbandry, if this would increase the health of the animals, the quality of the production and optimize the costs of their care. 33% of breeders categorically state that they would introduce such innovations, and only 2% categorically state that they are against it. However, the respondents' answers show that high technology is still lacking in their practice. Evidence is that 90% of them rely primarily on human labor for animal grazing. The percentage of those who rely on electronic shepherds for grazing is low, only 10% who use them and 24% who state that they would use them. Directing the questions to the nature of the research, the livestock farmers surveyed were asked if they thought it would be useful to use electronic guidance devices to control the location of the herd instead of shepherds. Here, their answers are diverse – 24% are categorically in favor; another 20% rather support such a decision, but with certain reservations; for 18% it is difficult to give a definite answer to this question; the percentages of respondents who reject this idea are almost the same – 21% would rather not lead to this type of herd management and 17% are categorically against it.

The next group of questions are directly aimed at the aforementioned possibilities of AI, in the studied directions: health status; reproduction; required caloric intake; location. Here, respondents are asked whether it would be useful for them if each animal were fitted with a collar with a sensor to track the indicated directions. Breeders give their rating in numerical form, with possible answers on an ascending scale from 1 to 5. The resulting mean ratings are shown in Figure 1.

From Figure 1, it is clear that the most significant benefit of using AI monitoring on animals for their owners is related to the possibility of obtaining anticipatory information about the health status of the specific animal. Once the understanding of the benefits is clearly realized, it is important to find out if they are willing to take advantage of these innovations. When asked if they are willing to invest in innovations related to the prevention of animal health, 73% of their owners state that they have such a desire and only 5% who categorically refuse, the remaining 22% have various reservations and it is difficult for them to give a definite answer. A specific question was also asked whether they would invest in such software if the investment was recouped within up to 20 months (from fewer animal diseases and drugs, increased and improved production). The answers to this question largely overlap with the previous one. Those who have expressed their readiness confirm it.

Although the demonstrated attitude of the respondents is positive, the research shows that very few of them have a high degree of automation in their production, and the application of AI is not available. This led us to look for the barriers facing

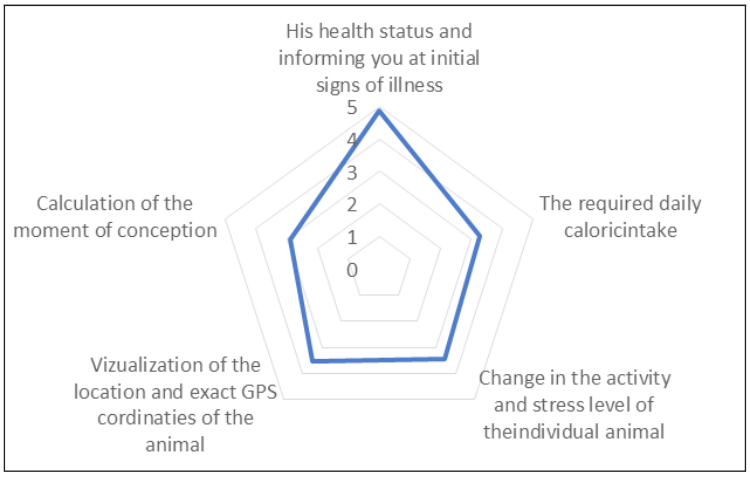

Figure 1. Benefits of using AI monitoring of sheep for their farmers

breeders. Given the delicacy of the subject, the approach here is to establish the barriers through in-depth interviews. The results are presented in the form of conclusions. They can be summarized in several main areas:

– Despite their claim that they are aware of the availability of AI-based animal monitoring systems, they are not sufficiently aware of their real benefits. This is due to the fact that they do not have a visual example from a real application. A potential trial of such a system in several farms would give positive results and gain the confidence of a large proportion of farmers;

– Livestock breeders have concerns when handling high technology. Although they are users and would only receive final conclusions from the results after the analysis of the AI tools.

– The unstable economic environment, i.e. the constant tendency to increase the supply, especially of feed, is driving the breeders away from the relevant investments.

– The lack of a specialized animal husbandry department at the University of the Peloponnese. A relevant department would contribute to the diffusion and adoption of new technologies and mitigate the objections expressed.

– The limited activity of the Directorate of Veterinary Medicine of the Peloponnese region.

– The lack of innovators – innovative breeders to contribute to motivating others.

Table 1 shows the methodology that will be followed for the collection, analysis and dissemination of the information that may be collected by the artificial intelligence systems. This applies mainly to farms based on a system of intensive cultivation and the use of artificial pastures, it will be possible to analyze the data

and create models that accurately describe the functions and needs of the animals. But when the system is used on extensive farms where the animals are not housed in pens and are not systematically given a standard ration, then the data will not be accurate. In order to solve this problem, additional data collection and analysis, such as meteorological data, grazing capacity of the pastures used, nutritional analyzes of the feed received and its quantity, must be simultaneously "launched". By integrating these data, the described system will be able to work in traditional farms, which are the majority in the area of Southern Greece.

5. Road map

The purpose of this roadmap is to facilitate the process of introducing AI in sheep farming. As shown in the results of the study conducted in the area, and according to the observations of the authors in other such, a main reason that slows down the entry of smart technology is not directly related to financing and. The majority of barriers are aimed at a lack of innovation and technological constraints in livestock producers. This is the reason why we propose here a road map to facilitate the process of spreading AI in sheep farming. It was developed for application both to the studied area and to other geographical areas with developed sheep farming.

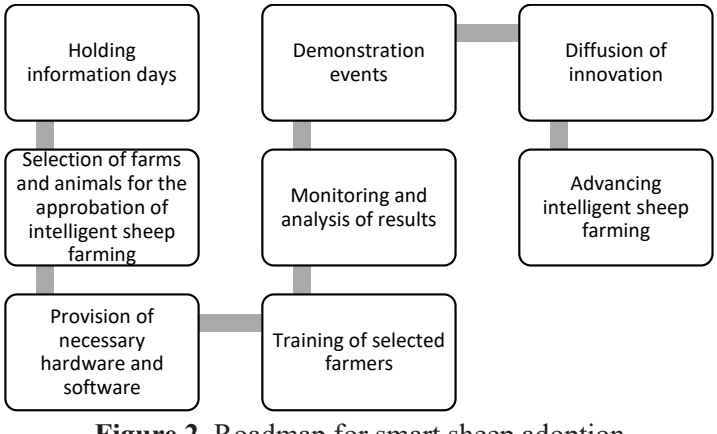

Figure 2. Roadmap for smart sheep adoption

The road map starts with the holding of information days attended by sheep breeders from a given region. In their frames, the benefits of intelligent sheep farming are presented. During this forum, it is important to draw up lists of willing farms on which to test the smart technology. The aim here is to single out the more innovative and brave farmers to set an example for others and thus gain the trust of the whole community. The next step involves selecting one and/or a small number of farms to test the system. At this stage, the participation of the farmer is important to ensure that there is no threat to

the animals and to monitor the whole process. The necessary software and hardware are also provided here. The animals are fitted with leashes with sensor devices that record their behavior. The results serve to train the system and establish the correct signals to the users. The time for testing and training the system is also time for training the farmers themselves. A test period follows to analyze the results, develop self-learning and refine the intelligent system in the test farms. Once the intelligent system has been tested and the farmer's trust has been won, new events are organized aimed at all sheep farmers in the community. They take the form of various forums and other demonstration events. Here the aim is for them to get first-hand information from the test farms. In this way, their confidence in the offered smart product is also increased. Within this step, a list of all farms willing to introduce intelligent sheep farming is drawn up. At the next stage, the diffusion of the innovation takes place, through distribution to the willing farms. The benefits of using intelligent systems in animal husbandry are related to their constant self-learning and improvement over time. This shows that the effect for farmers will increase. This shows that the effect for farmers will increase. In practice, organizations that offer a similar type of service (sigma taurs)[4] are already appearing, which testify that the interest in intelligent animal husbandry will only grow.

Conclusion

This article outlines the future development of the traditional sheep farming industry. To be resistant to the dynamics of the environment, it needs to undergo a change that makes it more flexible. The path to this change is linked to overcoming farmers' inhibitions in the sector and moving them towards the use of intelligent animal monitoring systems. Here, the main advantages of using intelligent animal husbandry, which provide direct data regarding the health status of animals and the detection of early symptoms of its disturbance, were outlined; the reproduction of sheep by establishing the exact moments of dispersal, fertilization and pregnancy; the necessary caloric intake to optimally satisfy the needs of the animal, respectively for the quality and quantity of milk; establishing the exact location of the animal in case of loss from the herd. In this material, one hundred owners of sheep farms were surveyed and their attitudes regarding their need for the use of intelligent flock monitoring systems were analyzed. Based on the results of the study, a road map facilitating the process of their entry into intelligent animal husbandry is also presented.

The analysis of the results of the conducted research shows that a number of recommendations can be given, both to managers of the livestock sector and to farm owners. On the one hand, the governing body should focus its efforts on creating a stimulating environment for the development of intelligent animal husbandry: developing flexible policies, various financial programs and tax incentives, supporting experimental farms, etc. On the other hand, farmers must be more courageous and adaptable to changes in the environment and increase the efficiency of their production through modern innovations.

This gives reason to the research team of this material to continue research in the field of intelligent animal husbandry. He is directing his next research steps in the field to develop a methodology to incentivize sheep farm owners to enter into intelligent animal husbandry.

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NOTES

1. Ministry of Economy of the Republic of Bulgaria, "Concept for digital transformation of the Bulgarian industry (Industry 4.0)", 08 2017. Available at: https://mi.government.bg/bg/themes/koncepciya-zacifrova-transformaciya-na-balgarskata-industriya-industriya-4-0-1862-468.html.
2. FAO, 2019. Five practical actions towards low-carbon livestock., Available at: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1257346/.
3. University of Peloponnese, https://www.uop.gr/en.
4. Sigma taurus, available at: https://sigmataurus.bg/en/.

REFERENCES

ALVES, V., AUERBACH, S., KLEINSTREUER, N., ROONEY, J., MURATOV, E., RUSYN, I., TROPSHA, A., SCHMITT, C., 2021. Curated data in – trustworthy in silico models out: the impact of data quality on the reliability of artificial intelligence models as alternatives to animal testing. *Altern Lab Anim*, vol.49, no. 3, pp. 73 – 82. DOI: 10.1177/02611929211029635.

BAO, J., XIE, Q. 2022. Artificial intelligence in animal farming: A systematic literature review. *Journal of Cleaner Production*, vol. 331, DOI: 10.1016/j.jclepro.2021.129956.

BARTZANAS, T., AMON, B., CALVET, S., MELE, M., MORGAVI, D., NORTON, T., YANEZ-RUIZ, D., VANDONGEN, C., 2017. EIP-AGRI Focus Group Reducing livestock emissions from Cattle farming Mini-paper – Precision Livestock Farming.

BENJAMIN, M., YIK, S., 2019. Precision livestock farming in swine welfare: a review for swine practitioners. *Animals*, vol.9, no.4, DOI:10.3390/ani9040133.

JERHAMRE, E., CARLBERG, C., ZOEST, V. 2022, Exploring the susceptibility of smart farming: Identified opportunities and

challenges*, Smart Agricultural Technology,* vol. 2, DOI: 10.1016/j.atech.2021.100026100026.

HU, H., DAIAB, B., SHENA, W., WEIA, X., SUNA, J., LIA, R., ZHANGC, Y. 2020, Cow identification based on fusion of deep parts features. *Biosystems Engineering*, vol 192, pp. 245 – 256. DOI: 10.1016/j.biosystemseng.2020.02.001.

KLING-EVEILLARD, F., ALLAIN, C., BOIVIN, X., COURBOULAY, V., CR´EACH, P., PHILIBERT, A., RAMONET, Y., HOSTIOU, N., 2020. Farmers' representations of the effects of precision livestock farming on human-animal relationships. *Livestock Science*, vol. 238, DOI: https:10.1016/j.livsci.2020.104057.

KORON, G. 2012, Animal Husbandry, Hunting, Fishing, and Fish Production, *Oxford Academic Books*. Ch.8. pp. 175 – 222. DOI: 10.1093/oxfordhb/9780199734856.013.0009.

NEETHIRAJAN, S., 2020, The role of sensors, big data and machine learning in modern animal farming Suresh. *Sensing and Bio-Sensing Research*, vol.29. DOI: 10.1016/j.sbsr.2020.100367.

MANOS, B., BARTOCCI, P., PARTALIDOU, M., FANTOZZI, F., ARAMPATZIS, S. 2014, Review of public–private partnerships in agro-energy districts in Southern Europe: The cases of Greece and Italy, *Renewable and Sustainable Energy Reviews*. vol. 39, pp. 667 – 678. DOI:10.1016/j.rser.2014.07.031.

PUUPPONEN, A., LONKILA, A., SAVIKURKI, A., KARTTUNEN, K., HUTTUNEN, S., OTT, A. 2020, Finnish dairy farmers' perceptions of justice in the transition to carbon-neutral farming, *Journal of Rural Studies*, vol. 90, pp.104 – 112, DOI: 10.1016/j.jrurstud.2022.01.014.

RIABOFFA, L., POGGIB, S., MADOUASSEE, A., COUVREURC, S., AUBINA, BÉDÈREC, N., GOUMANDD, E., CHAUVINE, A., PLANTIERA, G., 2020, Development of a methodological framework for a robust prediction of the main behaviours of dairy cows using a combination of machine learning algorithms on accelerometer data. *Computers and Electronics in Agriculture*, vol. 169. DOI: 10.1016/j.compag.2019.105179.

ROJAS-DOWNING, M., NEJADHASHEMI, A., HARRIGAN, T., WOZNICKI, A. 2017. Climate change and livestock: impacts, adaptation, and mitigation. *Clim. Risk Manag*., vol. 16, pp.145 – 163. DOI: 10.1016/j.crm.2017.02.001.

RUTTEN, C.J., VELTHUIS, A.G.J., STEENEVELD, W., HOGEVEN, H., 2013. Sensors to support health management on dairy farms. *J. Dairy Sci*., vol. 96, no 4, pp. 1928-1952. DOI: 10.3168/jds.2012-6107.

SLOB, N.; CATAL, C.; KASSAHUN, A., 2021. Application of machine learning to improve dairy farm management: A systematic literature

review. *Preventive Veterinary Medicine,* vol. 187, DOI: 10.1016/j.prevetmed.2020.105237.

STAFFORD, J., 2000. Implementing Precision Agriculture in the 21st Century. *Journal of Agricultural Engineering Research*, vol. 76, no.3, pp.267 – 275. DOI: 10.1006/jaer.2000.0577.

SHINE, F., MURPHY, M., 2022, Over 20 Years of Machine Learning Applications on Dairy Farms: A Comprehensive Mapping Study. *Sensors*, vol. 22, no.1. DOI: 10.3390/s22010052.

VALCHEV, E.; GLUSHKOVA, T.; MILANOV, P. & NIKOLOV, V., 2021, Modeling of a system for intelligent animal husbandry. *2021 Big Data, Knowledge and Control Systems Engineering (BdKCSE),* Sofia, Bulgaria, pp. 1-8. DOI: 10.1109/BdKCSE53180.2021.9627312.

VLYSSIDES, A., MAI, S., BARAMPOUT, E. 2015. Energy Generation Potential in Greece from Agricultural Residues and Livestock Manure by Anaerobic Digestion Technology. *Waste Biomass Valor*, vol. 6, pp.747 – 757. DOI:10.1007/s12649-015-9400-5.

VOLKMANN, N., KULIG, B., HOPPE, S., STRACKE, J., HENSEL, O., KEMPER, N., 2021. On-farm detection of claw lesions in dairy cows based on acoustic analyses and machine learning. *Journal of Dairy Science*, vol.104, no.5, pp. 5921 – 5931. DOI: 10.3168/jds.2020-19206.

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