IOSUD - "DUNĂREA DE JOS" UNIVERSITY OF GALATI
Doctoral School of Fundamental Engineering Sciences

DOCTORAL THESIS

RESEARCH ON THE DEVELOPMENT OF PRECISION AGRICULTURAL HOLDINGS FROM THE ROMANIAN PLAIN

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I. Key words

Precision agriculture, traditional agriculture, streamlining, optimization, agricultural drones, measurements, spectral analysis, neural models, lanvandulla augustifolia culture, DJI4 Phantom , food security.

II. Conceptual milestones of the research

The topicality of the research theme . Precision agriculture represents both an opportunity and a challenge for today's farmers because it brings new methods aimed at making information more efficient and valuable in time. Apart from this, an improvement in crop intervention practices is observed by locating them and by locating the factors that affect the crops and the prompt intervention on these factors, thus limiting the damage and locating the influence of the pests on the crops in strictly limited areas. From the point of view of food security, it can be appreciated that precision agriculture contributes to increasing productivity and improving yield to ensure a production that completes the need for food that the growing population around the world requires as a primary need for daily living.

Description of the situation in the research field and identification of research problems. The study carried out in this context through doctoral research, aimed to highlight both at the European and national level the added value elements brought by precision agriculture, this aspect being considered to be one to bring to the attention of users of information the necessity and opportunity of implementing these practices on a large scale in Romania and the beneficial effects that can be obtained by implementing precision agriculture on a large scale.

The purpose of the research The purpose of the paper is to highlight the possibilities of precision agriculture to make agricultural production more efficient, to limit losses and to improve the quality of food production through new and innovative practices in this field .

scientific objectives *were established* ***:***

1. Identifying the main aspects regarding the transition from traditional agriculture to precision agriculture, identifying new possibilities for using precision agriculture based on technological development and the use of information sources;
2. Carrying out an extensive study of the specialized literature on the ability of precision agriculture to meet the needs of farmers, the study at European level of the new directions regarding precision agriculture and the implementation of digital solutions on the European market, the transposition of these directions for the Romanian market as well.
3. Analyzing the stage of development of precision agriculture with the help of drones;
4. Carrying out a SWOT analysis of precision agriculture;
5. Determining the impact of precision agriculture on the productivity of aromatic plant crops in the Romanian Plain;
6. Analysis of the main benefits of precision agriculture on aromatic plant crops;
7. Analysis of state intervention for the implementation of precision agriculture and the correlation of this analysis with efficiency obtained or obtainable in the case of aromatic plant crops.
8. Sequential analysis from the point of view of the climatic impact of the batches of aromatic lavender crops by means of a statistical analysis model to contribute to the staging of the aspects of impact on the development of lavender crops;
9. Realization of neural models through statistical procedures and processes regarding climate impact and timing of climate impact with the help of precision agriculture.

***The research methodology and the theoretical-scientific support of the thesis* .** In order to achieve the objectives, research methods and techniques based on the study of specialized literature will be used in order to analyze the impact of precision agriculture on the entire agricultural productive chain, the methods will be embodied both in the identification of new directions from the specialized literature regarding agriculture precision, as well as in studying the norms and rules at European and national level, regarding various technical and organizational aspects related to the implementation of precision agriculture.

Based on the construction of a realistic picture regarding this new and challenging field, the research proposes the development, based on an experimental study carried out in the field, on a number of 4 plots cultivated with lavender, of a model regarding the impact of the use of precision agriculture on the productivity of plant crops aromatic lavender.

The analytical methods applied consist of the centralization of measurement databases and the collection of information from the field, database consolidation techniques, statistical analysis techniques of the collected data distributions, sequential statistical analysis techniques and last but not least, neural modeling to highlight the impact of specific precision agriculture techniques on the productivity of lavender crops.

Thus, the thesis proposes the creation of a number of eight models for the representation of climatic damage in precision agriculture, based on the effects studied through neural models of the use of practices on the level of climatic damage of lavender crops.

The object of the research is the development of precision agriculture in agricultural holdings in the Romanian Plain.

The novelty and scientific originality of the research consists in carrying out an applied study on the possibilities of optimizing agricultural processes through the implementation of precision agriculture practices and the spectral analysis of captures made with DJI4-Phantom drones to highlight the impact of both vegetation and pests on crops .

The RESOLVED Scientific problem demonstrates that: during the rainy season related to the spring months, crops tend to accumulate higher humidity, which predisposes them to the appearance of mold and fungi; in adverse pedoclimatic conditions, the level of crop damage due to wind intensity increases, the increase being a long-term systemic one; the previous pesticide treatments show resistance over time and protect aromatic lavender crops in the studied area in the SE area of the Romanian Plain; with the help of precision agriculture, the risks of climate damage can be sequenced and subsequently the cost of treatments and interventions carried out on aromatic plant crops, such as lavender, can be reduced.

Theoretical importance and the applied value of the research. It resides in the dissemination of fully implementable practices and procedures especially by farmers with small and medium-sized agricultural plots (up to the level of 100,000 m 2), through the fruition of the use of aerial monitoring specific to precision agriculture and by capitalizing on the results of the 8 neural models of climatic impact of aromatic plant crops. The research can also be successfully used for cereal and leguminous crops.

***The implementation of the scientific results*.** From the presumed results of the research, it is estimated that the analysis will allow highlighting the benefits of precision agriculture, both from a theoretical point of view based on the study of specialized literature, and from a practical, applied perspective, both the intervention methods and the effects will be outlined obtained after applying the methods, through experimental practices, respectively working directly in the field.

Publications on the topic of the thesis. The main results of the research were disseminated at conferences national and international , as follows: An article published in magazines and in the volumes of scientific events indexed ISI WEB OF SCIENCE (Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development ", Vol. 21, Issue 2/2021); 4. articles published in magazines and in the volumes of scientific events indexed in international databases (RePEc , EBSCO, DOAJ, CABELL, J-GATE, ULRICH'S, ERIH PLUS, Index Copernicus , Infobase Index, Scientific Indexing Services, ResearchBib and Directory Research Journals Indexing); 9 papers presented at international/national conferences with international participation (76th International Scientific Conference on Economic and Social Development - "Building Resilient Society" – Zagreb, December 17-18 , 2021; 34 th International Business Information Management Association Conference (IBIMA) 13-14 November 2019 Madrid;

International conference , Agricultural economics and rural development research on the topic "The European green deal challenges to agriculture and rural areas " Bucharest December 7, 2022; 79th International Scientific Conference on Economic and Social Development – Rabat, March 25-26 , 2022; International Conference " Risk in Contemporary Economy ", XXIIth Edition , 2021, Galati , Romania; International Conference IBIMA“Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage ", 2020, April 1-2, Seville, Spain).

The volume and structure of the thesis. The thesis includes the introduction, four chapters, conclusions, personal contributions, limits of the scientific approach and future research directions, bibliography (218 sources), 265 references to bibliographic sources, 1 appendix, 132 pages of basic text, 21 tables and 65 figures .

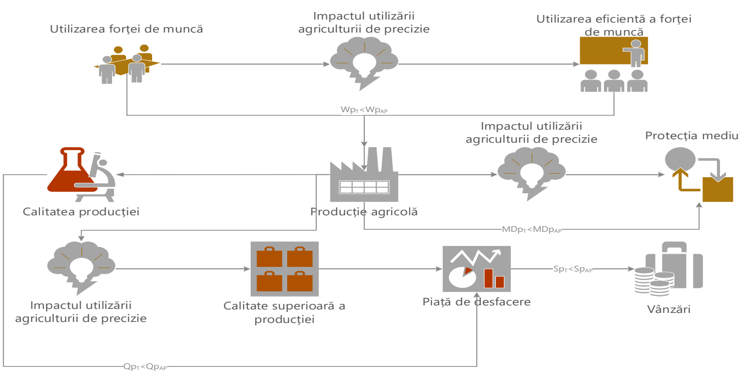
III. The content of the thesis

The doctoral thesis with the theme " **Research on the development of precision agriculture in agricultural holdings from the Romanian Plain** " has an interdisciplinary character, it is structured in four chapters and deals with the concept of precision agriculture from the transformative perspective of technological inputs as a factor of progress compared to traditional agriculture . In the framework of the research, the technical methods of implementing precision agriculture and its top element drones equipped with multispectral cameras are presented, an impact analysis is carried out regarding the results of precision agriculture on the productivity of the aromatic flat crops in the Romanian Plain and 8 models are proposed neural representation of climate impact in precision agriculture.

In **chapter 1,** called **"Approaches regarding the transition from traditional agriculture to precision agriculture"** approaches are presented regarding the transition from traditional agriculture to precision agriculture, it is proposed to highlight these aspects regarding the opportunity to use precision agriculture at a global level and national, at the same time it is proposed to carry out an extensive study of the specialized literature regarding the ability of precision agriculture to satisfy the modern needs of farmers. In chapter 1, the opportunities for the development of precision agriculture are also presented in the context of the decisions taken at the community level, through the common agricultural policy and other current European instruments, the study also aims to create a history of the main developments of sustainable agriculture in Europe. The use of precision agriculture and digital solutions available on the Romanian market are also now presented.

In the current context of challenges regarding food security, precision agriculture represents an alternative with a great potential because it allows the significant elimination of production costs and the streamlining of procedures for monitoring and preventing risks affecting agricultural production as a result of climate changes and the spread of new forms of crop damage.

THE IMPACT OF PRECISION AGRICULTURE ON THE EFFICIENCY OF RESOURCE USE IN THE AGRICULTURAL PRODUCTION PROCESS



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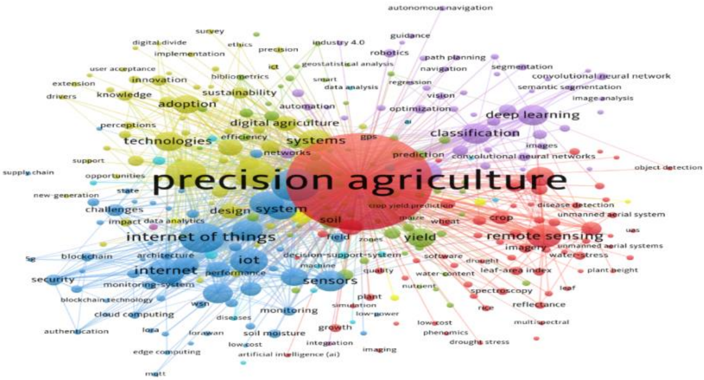
The precision agriculture is a recent agricultural aspiration designed to make agricultural processes cost-effective. This kind of innovative agriculture gives farmers a better oversight of the entire agricultural phenomenon, allowing them to fertilize their crops more precisely, thus optimizing the production of different crops with good results on the efficiency of agricultural processes.

META ANALYSIS OF SPECIALIZED LITERATURE



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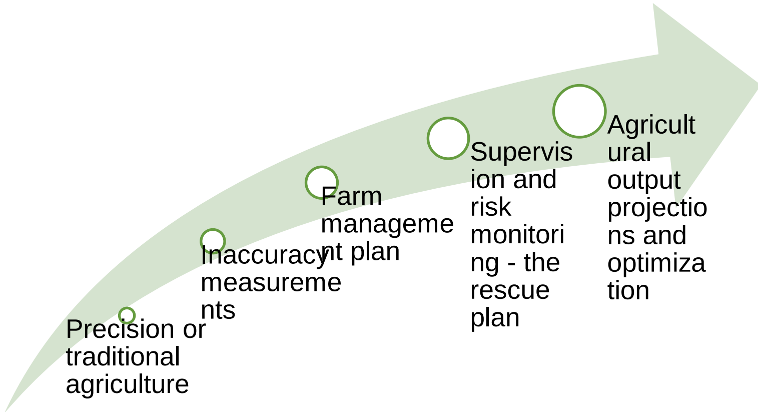
Precision agriculture offers, in addition to traditional agriculture, a high-throughput technology through which farmers can better understand their agricultural plots and determine soil potential, as well as observe signs of disease (pest attack, vegetation). Although precision agriculture has been implemented in the European Union, it still represents a reason for novelty for many Romanian farmers. Its opportunity is beyond doubt, given that Romania is still a European country with a large number of professional agricultural workers. Practicing precision agriculture on the surface prepared for cultivation, or the plot to be cultivated, becomes like a chess board in which the farmer knows how to take advantage of opportunities and optimize his production. The emergence of precision agriculture promotes the collection of real-time information on soil quality and pest presence, allowing farmers to precisely intervene with plant protection substances. In Romania, due to the influence of individual farm traditions or due to lack of education in the field or lack of capital, some farmers prefer to continue working with outdated and inefficient machinery. Currently, precision agriculture practices represent the best progress for agricultural organizations in Romania, so the latest techniques in the field support farmers working in the agricultural sector in achieving performance. For the administration of agricultural production in the decision-making process, against the background of the amplification of information and geospatial technology, precision agriculture is imposed as being necessary step by step. This new approach, specific to exploitation under construction, creates the premise of increasing productivity, on the basis of reducing production costs and reducing negative impacts on the environment. Regarding the technological process, there are still gaps in the system, especially in the case of species adapted to strictly geographically delimited areas for which there are no specific techniques implemented. As farmers adapt, they expand and invest in other technologies. Over time, farmers will adopt alternative ways of working based on new technologies

In the second chapter, called **"The stage of development of precision agriculture with the help of agricultural drones"** , technical methods of implementing precision agriculture and the types of agricultural drones, used to implement these opportunities for improving risk monitoring with the help of precision agriculture, are highlighted . At the same time, the drone with which the applied study was carried out in the field is presented and by correlation, other systems and equipment currently on the market. The characteristics of the exploitation software are described in detail, and at the end of the chapter a SWOT relationship of precision agriculture is made based on the information collected from specialized literature and on the basis of own experiences gained from the application of precision agriculture techniques during the doctoral research period.

From a technological point of view, precision agriculture represents the merging of new technologies with modern surveillance and projection techniques in order to ensure adequate management of external risk factors that affect agricultural productivity. Thus, in the technological equation of precision agriculture, we can affirm without error that the agricultural drone represents a central element, respectively the technological pillar that the branch needs in order to reach the possible optimization solutions offered by the mix between technology and information in the agricultural sector.

TECHNICAL METHODS OF IMPLEMENTING PRECISION AGRICULTURE



Source: Prepared by the author

A SWOT analysis identifies the internal and external factors that favor and disfavor the achievement of the proposed objectives. Precision agriculture consists in a set of means and procedures that allow farmers to maximize the quality and the efficiency of the soil, by integrating firm and well determined actions by the advanced technique, sensor and artificial intelligence. Precision agriculture is highlighted, due to the last generation of systems used, so that we have to find the most suitable product in the right period, in the right area, to meet the specific needs of a crop or a certain region. This is owed to the fact that performing these actions comes along with a high level of precision.

SWOT ANALYSIS OF PRECISION AGRICULTURE

The strengths of precision agriculture	**Weaknesses of precision agriculture**
Although the concept is relatively new in Romania, precision agriculture started with the technology of GPS-equipped machines. Farmers can use GPS coordinates to locate certain points in the analyzed crops. After ensuring the location of the analysis vectors interconnected with the soil sensors, productivity maps can be made. These maps correct areas where treatments are most needed; Urgent agricultural progress, improving the value of products, developing productivity and reducing contact with the environment are the important themes for the assimilation of new competitive agricultural models. Against the background of the development of the global market of digital agriculture, Agriculture 4.0 proposes sufficient connections distinct from those of traditional agriculture. In the next period, the digitization of agriculture can participate with great success in the following determinations: the reduction of hunger, the variation in the classic diet, increased life expectancy; The use of digital technology and the industrialization of agricultural processes open up new possibilities	Low level of basic professional capacity and qualifications of farmers; The technologies used to achieve positive and efficient agriculture (like any new product on the market) can occupy a significant budget, which means high initial costs. Even if the investment diminishes in a certain period, buying new equipment and initiating employees to get all the systems up and running is not affordable for every farmer; In Romania, precision agriculture is at the beginning, so there is a slight accommodation of the form of risk management by farmers; Farmers hesitate to organize themselves in groups and cooperative forms in contrast to the real advantage that they can receive support from the authorities; The degree of technical equipment decreases proportionally with the decrease in the exploitation area; Extremely large number of agricultural holdings with small

for intelligent agriculture. Computerized systems and clever spray mechanisms help farmers anticipate potential problems, proactively find sustainable solutions and mitigate potential damage. Changes in soil climatic conditions, the occurrence of drought or, in extreme cases, heavy rains, pests and plant diseases are just some of the possible scenarios that can lead to the destruction of crops; Fertilizer spreading used in AP (Precision Agriculture) allows farmers to manage the land like a chessboard. In this situation the machine knows exactly where to fertilize and what to do; Drone plant research leads to data collection easily in a short time. Soil data analyzes can be transmitted in about 20-30 minutes; Practicing precision agriculture allows farmers to make the best decisions based on the vacant circumstances and reduce the risk of crop problems. In this way, the value of the harvest is guaranteed, on this occasion farmers have the great advantage of evaluating the harvest at the end of the agricultural year; In addition, automated agricultural work is an environmentally friendly way of doing business, as all the factors involved in the process and	areas (under 5 ha) in contrast to farmers with large holdings;

their impact on nature can be reliably controlled; The new Common Agricultural Policy creates the premise for supporting the environment. In organic farming, the soil is protected from unsuitable crops, fertilizers, herbicides, fungicides and pesticides are applied correctly and only when needed to support the plants without harming the soil. It is recommended the administration with concentration, so that we do not waste water resources; Farmers require, certainly for the continuous and repeatedly inadequate reduction of fertilizers, new techniques and procedures so that the entire agricultural system will be effectively modified; Precision farming is also much easier and can be managed from your smartphone in the best of situations. This means that certain works can be adjusted without the need of the farmer to visit the site and analyze the development of the crop; Agriculture can take advantage of every technological advance. This benefit comes from telecommunications and agriculture companies working together to use as much smart technology as possible. 5G technology can transfer and communicate large amounts of files full of information in a short time;	

A final benefit of precision farming is that it becomes the most convenient and affordable part of the farming process in the long run. If all relevant meta data is in place and each action is well determined, there is no complication of causing ancillary costs. The investment must be evaluated from the beginning, and so must the return.	
Opportunities of precision agriculture Precision agriculture technology amplifies an increased diversity of agricultural operations. For example, agricultural drones were primarily used only to acquire images of the crops under study, but now they can be used for a lot of agricultural work such as; irrigation, spraying with plant treatment substances, fertilizer diffusion, seeding, etc.; The participation of EU member states in establishing a common chronology of agricultural land use, notifies that farmers, depending on the current climatic conditions and the foundation of each country, have the ability to retain, effective decisions to maximize agricultural production; After researching the cultivated area and supporting the promotion of the equipment park, applications about precision agriculture came to light; Funding and use of creations in the	**Threats of precision agriculture** The unhindered circulation as well as the use of agricultural drones in the European Union is restricted by the loaded legislation for the use of aviation safety determinations. All these rules are currently being brought to balance the rights and obligations of drone operators; The hesitancy of farmers to use with great care the techniques developed in precision agriculture; The average age is quite high; Older farmers are less interested in training and education in order to use and specialize in advanced technologies; Renunciation of agricultural activities due to changes in income from the use of precision agriculture; Increasing change in energy and

technical systems characteristic of precision agriculture and by public institutions authorized to manage and support common agricultural policies;	input prices; Increase in size and severity of exceptional climate events;

Source: Prepared by the author

Drones or unmanned aerial vehicles (UAVs) are high-precision technologies used for high-yield agriculture. Drones perform multiple functions in agriculture, but primarily they allow farmers to analyze crops without actually visiting the field:

- field mapping;
- analyzing and observing the state of vegetation of crops on a large scale;
- pest and disease monitoring; precision agriculture has gained a remarkable role to help farmers control crop pests by implementing zoning maps through pesticides, fungicides and treatments, including in affected areas. In the first steps, continuous surveillance and observation of crops allows farmers to perfectly understand the moment of action;
- spraying yield and herbicide use;
- disseminating data in the shortest possible time about crop conditions, potential anomalies and the need for rainfall.

The advantage of the GPS system is that it can be mounted on any agricultural machinery with power steering. This structure usually includes a monitor and a receiver that can be used to control the equipment. With this localization technique as a whole it is achieved:

- Techniques specific to precision agriculture (establishment of crops in soil, administration of chemical fertilizers, etc.); A common occupation in precision agriculture is the use of planting equipment, equipment that reduces the farmer's effort and accumulates valuable time for other occupations. Automated planting involves the use of mini tractors designed for all types of plants.

The technology used is line- by -line. This electronic model permits the supervision and verification of seed dosing at fixed and variable rates on each planting seedling. This new technology, in conclusion, can set the characteristics and volume of planting material equally keeping the same amount of seeds per square meter;

- Precise positioning of soil samples; For large areas of agricultural land, fertilizer equipment makes this deployment extremely efficient, guaranteeing that foliar substances are distributed according to the analysis made in the zoning map, leading to an intensification of the foliar result. This deployment is very beneficial. First, a soil sample is taken to determine the elements that can help crops. Next, using GPS, the machine distributes the amount and type of fertilizer according to the area to be treated given by the crop analysis. The method also allows the analysis of macro and micronutrients and particle size at depths of up to 40 cm. This requires soil productivity mapping carried out using a 1-2 hectare sampling system;
- Capturing and researching crop information. The categorical elimination of pests and weeds will lead to efficient management by farmers of fundamental resources (time, fuel, pesticides), but also to better protect their crops;
- Surveying of agricultural land or culture;
- Sensors and crop monitoring applications provide complete information about the condition of the soil, so farmers know in advance that it is the most suitable. As an example, in a sedimented/compacted soil, water is less permeable and takes the best route to plant roots. This aspect can negatively alter its growth and automatically affect the organization of the harvest carried out by the farmer;
- Harvest supervision and verification;

- Production surveying.

By using GPS, farmers get to exercise their activities in difficult conditions or with limited visibility, which is considered a safe method without high implementation costs. Information technology is common in precision agriculture. Farming systems support farmers to manage their activities with minimal effort. Tracking the applied processes, the amount of treatments used, the soil situation and the climate, among others, are particularly important news acquired when using the applications. in addition, through these applications, GPS-coordinated processes can be controlled, improving service characteristics and increasing planting actions and obtaining appropriate products on the market [192].

The digitization of agriculture in Romania will provide perspectives in the shortest possible time about crops and systematize some aspects related to it. Realistically, it will instill favorable decisions, starting from establishment to harvest. In this way, possible human errors, such as those related to difficult preparation or uncalculated decisions, are neglected. In this way, the efficiency of digital agriculture can be observed:

- The profit can reach up to 50-100%.
- The input cost will be lessened because, according to the current information, the ideal quantity will be used without wastage.
- Using the farmer's card increases profit.
- Pests are much easier to discover and then exterminate.

A not inconsiderable and handy practice would be to order online for the whole range of products (fertilizers, equipment, machines) or other products that are needed, without the need for travel or other effort to get them.

Contact with suppliers, customers or partners is made much more convenient for both parties.

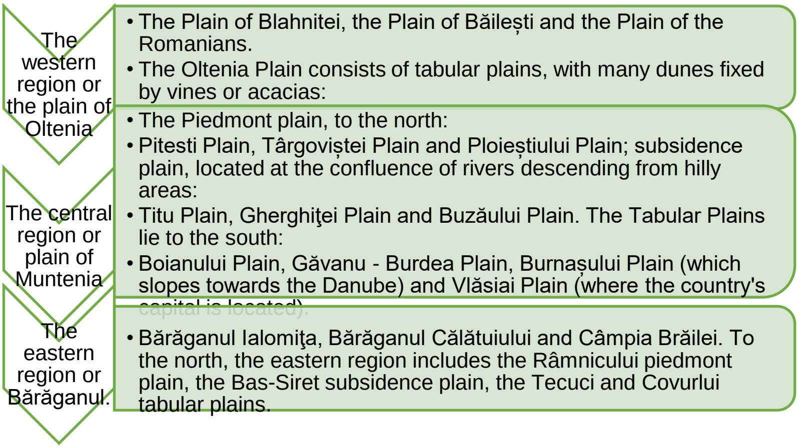
Digitization makes it possible to learn about sustainable development and collective responsibility, but at the same time, to be able to use goods and open systems with the environment, and finally, to obtain healthy products. Progress provides more possibilities for evolution so that we can consider it an interesting long-term investment.

The P4 Multispectral System (or P4 M) is for farmers and agronomists "a tool used to increase production and reduce costs", a tool that will help agricultural specialists, or environmentalists, to "easily monitor vegetation ". To measure crop health, from individual plants to large areas, the P4 Multispectral combines data from six separate sensors. The collection, recording and transmission of the images, which provide the crop information, is carried out by six cameras, one RGB camera (red , green , blue) and five other cameras (multispectral), with narrowband sensors (Blue, Green, Red , Red Edge and Near Infrared), which can capture both visible and invisible light. The gimbal that supports the six-camera device is stabilized on three axes. Combining all the collected data helps to obtain NDVI results (normalized difference vegetation index) precise. In precision agriculture, NDVI is a graphical indicator used to analyze measurements, usually obtained from height, and to evaluate the state of vegetation. The collected data also provides the specialists with information about the composition of the soil and, for example, about the salinity of the water or contamination with various substances.

In chapter 3 called **" The impact of precision agriculture on the productivity of aromatic plant crops in the Romanian Plain",** is delineated both from the researched area and the type of crop selected from the possible aromatic crops, highlighting the main differences between the aromatic plant crops and an analysis of these crops is carried out medicinal and aromatic plants made in the Romanian Plain. Also, this chapter presents the financing instrument, namely state aid and the impact of this instrument on precision agriculture in the area of the Romanian Plain**.**

The impact of precision agriculture on the productivity of aromatic plant crops in the Romanian Plain includes main notions about the shape and content of the study area, about the structural composition of this landform with its subdivisions. As general notions we can also mention the hydrological system used but also the climatic level of this landform so that we can have a complete picture about the application and impact of precision agriculture on the entire area of the Romanian Plain.

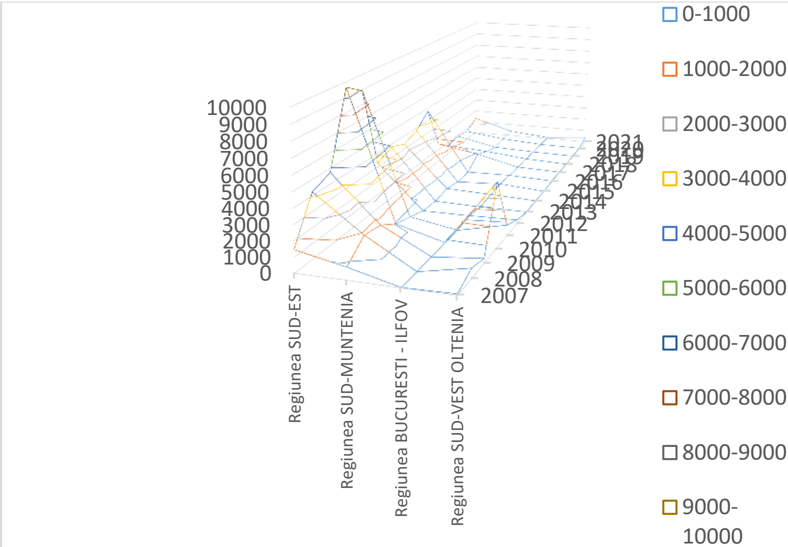
THE ROMANIAN PLAIN AND ITS SUBDIVISIONS



Source: Prepared by the author

Also in the Romanian Plain, both medicinal and aromatic plants are grown in different regions. At the same time for a part of these plants, the farmers were able to have support from the European Union as well as from the state budget, by launching a set of subsidies necessary for farmers for the development of businesses in the agricultural field but also due to the integration of other types of crops, other than usual, according to the diversity of aromatic plants in the Romanian Plain region is analyzed in the figure below:

VEGETABLE AGRICULTURAL PRODUCTION OF AROMATIC AND MEDICINAL CROPS BY REGIONS OF THE ROMANIAN PLAIN



Source: Made by the author after the National Institute of Statistics in Romania, "INS Tempo - Online Database," https://insse.ro/cms/, 2022. http://statistici.insse.ro:8077/tempo- online/ (accessed May 05, 2022)

Aromatic plants are profitable crops, if the agrotechnical techniques specific to the different species are respected, as well as phytosanitary measures to prevent and combat diseases, pests and weeds. Aromatic plants can be used in various ways, either for food or in various industries, such as pharmaceutical or cosmetic, as shown in the table below:

CATALOG OF MEDICINAL AND AROMATIC PLANTS

No. crt.	The name of the variety	Code	Year of registration	Year of re-registration (deletion)	Remarks
1.	ARMORY - Silybum marianum (L.) Caertn . By Prahova	1001	1975	2020	IT
2.	BITTER CUCUMBERS - Biting charantia L. Hof Rodeo 1033 2014	30 1105	2010	deleted 31.12.2019 30.06.2022	-
3.	CUMIN – Carum carvi L. Carol	1033	2020	-	-
4.	CORIANDER - Coriander sativum L. Homage	1001	2000	2016	-
5.	Echinacea - Echinacea angustifolia (DC) Hell . Hof 31.12.2019 30.06.2022 Echinacea - Echinacea pale Nutty . Napoca Echinacea - Echinacea purpurea Moench . Cluj Hof 60	55 1004 1004 1105	1105 2006 2010 2010	2010 deleted 2020 2020 deleted 31.12.2019 30.06.2022	-
6.	PASSION	70 1105	2010	deleted	-

No. crt.	The name of the variety	Code	Year of registration	Year of re-registration (deletion)	Remarks
	FLOWER - Passiflora incarnata L. Hof			31.12.2019 30.06.2022	
7.	CALENDULUS - Calendula officinalis L. Nataly	1136 2018 deleted 31.12.2019 30.06.2022	2018	deleted 31.12.2019 30.06.2022	-
8.	LAVENDER - Lavandula angustifolia Mill . White 7 Emilia 1001 George 90 1135 2017 Moldovan 4 1136 2017 Magic dream 10	1136 1001 1135 1136 1136	2018 2009 2017 2017 2018	deleted 31.12.2019 30.06.2022 deleted 31.12.2019 30.06.2022 deleted 31.12.2019 30.06.2022	-
9.	SWEETWOOD - Glycyrrhiza glabra L. Julide	1081	2003	2018	-
1(	GOOD MINT - Mentha pepperita L.	1001	2009	-	-

No. crt.	The name of the variety	Code	Year of registration	Year of re-registration (deletion)	Remarks
	Coral				
1	TURKEY'S BREAD - Amaranthus caudatus L. Hof 100	1105	2010	deleted 31.12.2018 30.06.2021	-

Source: Made by the author after the National Institute of Statistics in Romania, "INS Tempo - Online Database," https://insse.ro/cms/, 2022. http://statistici.insse.ro:8077/tempo- online/ (accessed May 05, 2022)

In this chapter, data on the surface of the structural land fund were iterated on the macro-regions that make up the whole country, but also on the regions that make up the area of the Romanian Plain, and of course it was supplemented with an analysis of the aromatic and medicinal crops established and developed in the Romanian Plain, making reference to the vegetable agricultural area used, to then move on to the production obtained on these areas starting from 2007, the reference year, when Romania was welcomed into the great family of the European Union, paving the way for support for Romanian farmers for these types of crops and until 2021.

Also in this chapter, reference is made to the analysis of the land fund and implicitly the production obtained in the counties that make up the SOUTH EAST area of the Romanian Plain for aromatic and medicinal plants, the fact that the practical test of this thesis is carried out in Brăila county. Since all the analyzes and sensors used take into account climatic conditions, the analysis of the annual hydrographic and climatic system from the various meteorological stations in the Romanian Plain was also taken into account during the period 2007-2021. For the study of medicinal and aromatic plant crops, it will be possible to emphasize the use and application of natural foliar substances, analyzed by the author, through the prism of the quantities used both within the regions that make up the Romanian Plain, and the amount of foliar substances used in the counties of the SOUTH region EST, namely the counties of Vrancea, Buzău, Galati, Brăila, Constanța.

At the end of this chapter, the help of the Romanian state and precision agriculture in the development of aromatic plant crops was considered. The state is useful through subsidies granted through the Ministry of Agriculture, through the Payments and Intervention Agency for Agriculture (APIA). The grants granted influence the possibility to develop this niche sector, obtaining remarkable productions but also massive economic benefits through the capitalization of production. Subsidized herbs are basil, thyme, coriander, mustard and fennel. Also, organic agriculture was a main target for the common agricultural policy (CAP), so that the foundations were laid for granting the necessary subsidies to promote this sector, also applicable in the Romanian Plain for aromatic plants and not only, the most recent concrete fact was the approval by the European Union of the National Strategic Plan (PNS) in December 2022. Some measures give nuance for the support of young farmers as well as the support of this type of aromatic and medicinal crops.

At the end of this chapter, the categorical contribution of precision agriculture to all crops was emphasized, but in this case the contribution to aromatic and medicinal plant crops by listing some favorable directions that prove the efficiency of precision agriculture. Precision agriculture develops programs for each individual farm to monitor the equipment used as well as the fuels used, for information obtained from precision sensors and through the use of variable application rate (VAR). This is an innovative technology that farmers can use successfully, to obtain information about the crops that they can use with the help of equipment such as agricultural drones, about the soil that can be completed with soil analysis, so that together they can constitute , a detailed map that farmers can access with the full range of works, substances and fertilizers, so that we have a homogenization of agricultural activities and works

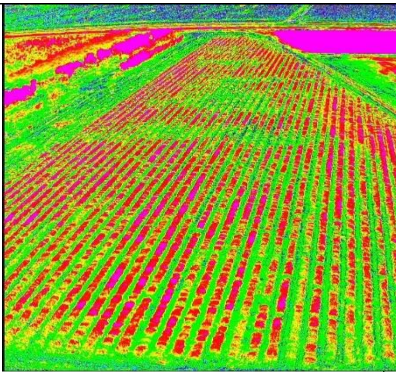
The 4th chapter, named " **Modelling of climate effects in precision agriculture, by means of neural models",** is oriented towards the realization of a sequential statistical analysis of the lots, according to the climate level, field observations and experimental analyzes being discussed, following that the method of statistical dissemination based on the distribution frequency be applied to different parameters and technical characteristics to obtain a complete picture of the efficiency of precision agriculture. The representation of climate effects in precision agriculture by means of neural models constitutes the second applied part of the study and is realized through the design of eight neural models, respectively the seasonal neural model, the pedoclimatic neural model, the neural model of humidity, the neural model of atmospheric circulation, the neural model of the protective treatment, the neural model of resistance to herbicide treatments, the neural model of resistance to previous pesticide treatments, and the neural model of the sustainable effects of precision agriculture. The chapter ends by presenting the main conclusions related to the applied study.

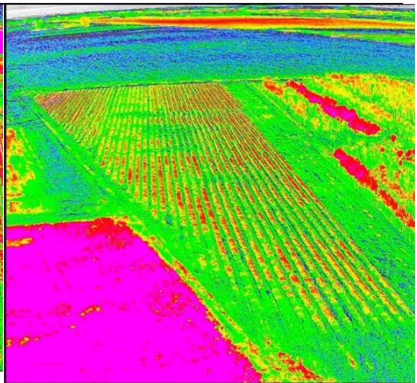
This chapter explores the analysis with the help of neural modeling, the representation of the climate effect in precision agriculture, based on the experimental records made during the period of the doctoral research respectively 25.11.2022 – 10.03.2023 for the four lots of approximately 95000 sq m cultivated with lavender augustifolia in the locations of Urleasca Commune, Brăila County (Lot 1 and Lot 3) and Traian Commune Brăila County (Lot 2 and Lot 4).

The following working hypotheses are established to be demonstrated with the help of research: during the rainy period related to the spring months, crops tend to accumulate higher humidity which predisposes them to the appearance of mold and fungi; which in adverse pedoclimatic conditions, the level of crop damage that as a result of the wind intensity increases, the increase being a long-term systemic one; previous pesticide treatments show resistance over time and protect the aromatic lavender crops in the studied area in the SE area of the Romanian Plain; with the help of precision agriculture, the risks of climate damage can be sequenced and subsequently the cost of treatments and interventions carried out on aromatic plant crops, such as lavender, can be reduced.

In the period 25.11.2022-10.03.2023, 25 there were made spectral determinations with the help of techniques for monitoring the state of the crop vegetation, using the DJI 4 PHANTOM RTK drone with the assimilated multispectral camera practicable precision agriculture . _ These determinations helped the calculation _ SURFACE unaffected by climate as presented in the table below:

SPECTRAL ANALYSIS OF CLIMATICALLY UNAFFECTED LOTS





Color code	Distribution code %	Measurement ID 1040	
#90d818	0.135262	% Affect	11.00 %
#f0a818	0.058788		
#60f018	0.054271		
#18c078	0.052121		
#f0d800	0.026446		
#f000d8	0.024738		
	0.109972		

Color code	Distribution code %	Measurement ID 1150	
#ffffff	0.546667	%Affect	7.25 %
#18f018	0.238133		
#90d818	0.068067		
#d8a818	0.0668		
#18c060	0.031867		
#30c030	0.0206		
#a8a830	0.005667		
#f0fff0	0.004		
#f0f0f0	0.0026		
#d8f0d8	0.002467		

Source: Made by the author

Sequential statistical analysis of the batches allowed the determination of a number of 5 levels of climatic damage from the base level of non-climatic damage to severe climatic damage, levels corresponding to different moments of crop life and different captive characteristics. Thus, during the rainy period related to the spring months, crops tend to accumulate higher humidity, which predisposes them to the appearance of mold and fungi. It is important for the health of the crops as it was also observed in the analysis, the herbicide treatments carried out on the occasion of the previous alfalfa crops that are kept in the soil and protect the lavender crop from the risk of diseases related to pests. From the climatic point of view, it is found that the climatic evolution is seasonal, the climate is specific to the Romanian Plain, a mild climate, the most frequent phenomena being the rains in the spring season and the wind in the autumn season. Spectral analysis led to the conclusion that with the help of precision agriculture, the risks of climate damage can be sequenced and subsequently reduce the cost of treatments and interventions carried out on aromatic plant crops in the case of lavender.

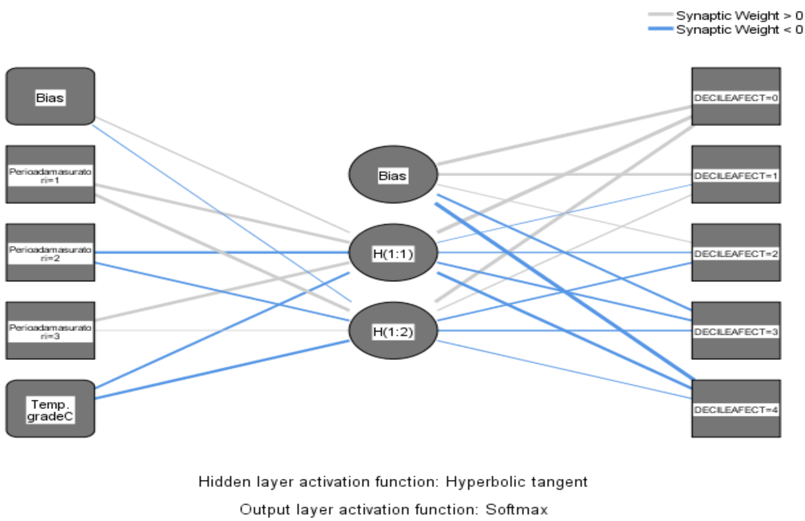
Neural models are layered data processions that highlight the connections between input variables and output variables through neural nodes with the help of connections of different intensity so that through the neural network a prediction of the output variables can be obtained in relation to the instrumented input variables. The neural model is designed in two phases, namely the standard prediction model and the amplified prediction model by means of the boosting aggregation methodology.

Modeling uses weighting based on the projected residual of the lower correlation model to achieve higher prediction quality. It was determined based on the experimental recordings made on the basis of the doctoral research during the period 25.11.2022 - 10.03.2023 the neural models of climatic damage for the four lots of approximately 95000 sq m cultivated with lavandula augustifolia in the location Urleasca Commune, Brăila County (Lot 1 and lot 3) and Traian Commune, Brăila County (Lot 2 and lot 4).

The representation of the climate state in precision agriculture was made on the basis of seasonal neural models in which the level of damage is determined by the observable level through structural analysis from chapter 4.1, respectively no climate damage, minimal climate damage, medium climate damage, high climate damage and severe climate damage .

The main variable of the model is the period of measurements in relation to the climatically affected surface, observing the fact that most of the lots have a minimal climatic effect up to the established safety threshold, i.e. the absence of fungi and molds. Thus, in the initial version, the percentage of no damage is assimilated to risk class 0 in the proportion of 72.2%, with an average damage at the level of 27.8% of the lots analyzed.

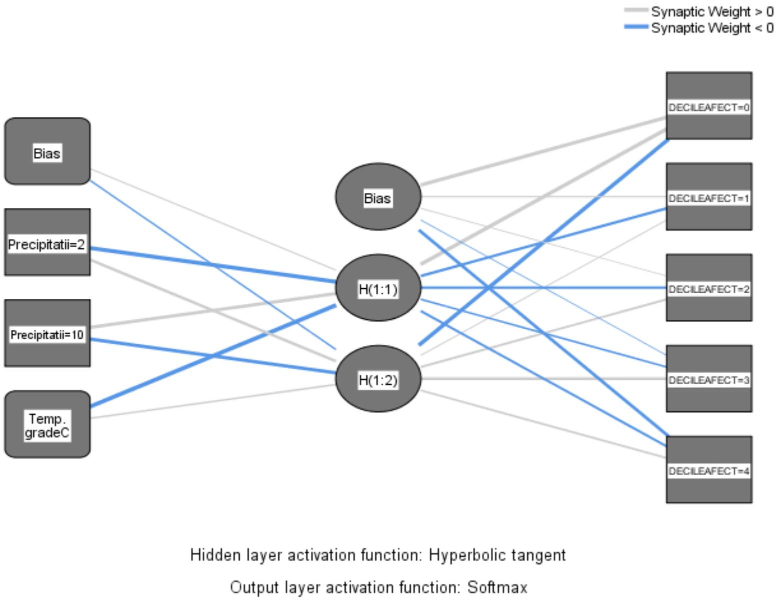
THE STRUCTURE OF THE SEASONAL NEURAL MODEL OF THE CLIMATE IMPACT FUNCTION ON THE 4 LOTS ANALYZED



Source: Made by the author

The pedoclimatic neural model analyzes the influence of temperature and precipitation on climate impact through a tangent hyperbolic function of distribution of climate impact risks on 5 possible levels, 0 meaning level without climate impact to 4, level with severe risk of climate impact. From the point of view of the neural function, it can be observed that in the basic version the hyperbolic function generates a slightly polarized distribution towards the minimum level of climatic damage, respectively 59% of the analyzed surfaces have a risk of no damage with a 0 risk of climatic damage, and 45.5% represents a minimal risk of climatic damage. Aspect that shows that in the Romanian Plain the conditions for the conditions of aromatic plants are almost ideal, both in terms of temperature and precipitation.

THE STRUCTURE OF THE NEURAL MODEL OF THE CLIMATE IMPACT FUNCTION ON THE 4 LOTS ANALYZED



The application study carried out in chapter 4 aimed at the representation of climate impact in precision agriculture by means of neural models. 4 plots cultivated with lavender were used, located in Urleasca Commune and Traian Commune in Brăila County, the observation period being 25.11.2022-10.03.2023.

The 4 lots were approximately equal in area, respectively 95000 square meters, were cultivated with Lavandula Augustifolia. It turned out that there are 5 levels of climatic damage to the lots cultivated with this aromatic plant in the south-east of the Romanian plain, respectively a minimum level with 0 risk of climatic damage, an average level of climatic damage, a level with high climatic damage and a level with severe climate impact.

The distribution of the degree of the climatic damage was presented throughout the research, respectively there being at least 5% of the cultivated area at risk of severe climatic damage, in the absence of precision agriculture practices.

Basically, the observed lands were previously treated both for herbicide resistance and for pesticides on the land, alfalfa being previously cultivated. It was observed from the study that both the treatments with herbicides and the treatments with pesticides applied to the previous crops of alfalfa show a resistance in the field that is beneficial to the lavender crop, following the risk analyzes the decrease in the risk of climate damage as a result of the resistance was observed in the soil of the treatments applied to the previous crop. It was also observed that through precision agriculture, risk sequencing was carried out at the level of crops, making it possible to identify fungi and molds early, this having a beneficial effect on the level of efficiency and effectiveness of agricultural plant production aromatic (lavender).

In addition, the neural models confirmed both the reduction of climate damage risks and the opportunity of precision agriculture on the cultivation of these aromatic plants. In the absence of precision agriculture, the crops have been shown to have an additional risk, both with respect to pseudo-climate conditions, wind and humidity, and with respect to the temperatures that vary in the studied area. Based on the proposed neural models, it has been demonstrated that the effects of precision agriculture are sustainable, being able to reduce to 0 the risk of climatic damage to aromatic lavender crops through the early intervention of treatments on crops identified with potential climatic damage.

In chapter 5, **Conclusions, personal contributions and the limits of the scientific approach,** the general conclusions drawn from the research carried out, original contributions and future research directions will be presented.

IV. Conclusions, personal contributions and the limits of the scientific approach

General conclusions

The work with the title "Research on the development of precision agriculture in agricultural holdings in the Romanian Plain", was a project carried out with empirical methods but also with practical applied methods through direct interventions in the field, proposing to achieve as its goal the demonstration of efficiency and effectiveness of the precision agriculture techniques on increasing the productivity of agricultural holdings.

It was shown during the paper that precision agriculture offers high-quality technologies through which agricultural practices can be better understood and soil potential can be determined more precisely. These aspects contribute directly to the efficiency and effectiveness of agricultural production, the economic efficiency and the efficiency in exploitation of agricultural productions. Also, through precision agriculture, it is possible to observe signs of disease as a result of pest attacks or as a result of the effects of the development of unwanted vegetation, but at the same time interventions can be localized and reduced, so that due to the early detection of these signs of disease, and as a result of the limited extent of the damages. At the European level, precision agriculture has been implemented to a greater extent than at the national level, both on the basis of funding for the development of this sector, and on the basis of the openness of the community farmers to these innovative practices.

In Romania, due to the financial constraints, there are still many farmers who cannot afford to implement their precision agriculture practices, being able to also mention here a deficient education regarding the usefulness and opportunity of using these practices. There is no doubt that the opportunity to use European agriculture is a powerful and beneficial one, practically helping to reduce both costs and the number of labour hours that farmers must pay to cultivate and harvest agricultural crops. Also, as elements in the subsidiary of precision agriculture, we have shown the fact that land parcelling represents a specific condition for the implementation of these practices, parcelled lands being easy to monitor, much easier than those that are not clearly delimited, from this we can conclude that in Romania, the implementation of agricultural cadastre techniques and the completion of agricultural registers in communes and villages in Romania should become a priority for the country's government, so that the implementation of precision agriculture practices can be made easier and thus improve the efficiency agricultural production.

Another aspect related to precision agriculture is the need for additional data processing and the use of data storage systems, which is currently being improved as cloud computing techniques and techniques for storing large databases, but in this context we believe that the improvement or creation of digital platforms for farmers with the involvement of the state for the development of these platforms would be a beneficial tool that would allow the generalization of the use of precision agriculture in Romania. In other words, in the absence of these platforms, companies that will promote precision agriculture in Romania will have to create their own platforms, a costly aspect that will delay the process of large-scale implementation of precision agriculture.

Satellite navigation is also a support for farmers who can better manage the exploitation of their machinery, but it is also useful in precision agriculture because the surveillance technology linked to GPS systems ensures a better coordination of monitoring and provides particular spectral information on the particularity cultures. Also, as technical elements of precision agriculture, data exchange can lead to the optimization of agricultural processes and to higher supplementary productions from a quantitative and qualitative point of view, an aspect widely demonstrated during the research.

In conclusion, we can accept the fact that the large-scale implementation of precision agriculture is based on the pillar of human resources informed and able to use the new technologies on the investment pillar that will allow the creation of a network for widespread use by farmers, networks based on which the data from precision agriculture help in real time from the collection entity to the end users, respectively the farmers, at the same time the third pillar can be the implementation of schemes to support farmers in the use and adaptation of precision techniques, and the fourth pillar would be the conditioning of financing of the results obtained through the implementation of these practices, we can thus say that an ecological culture or a green culture can be financed as a priority over traditional culture if through precision agriculture it can be demonstrated that farmers use environmentally friendly fertilizers, if farmers use resources efficiently materials without additional fuel consumption or if they implement environmentally friendly development projects.

One of the significant pillars of precision agriculture presents drones or unmanned aerial vehicles. They are useful for both crop and disease monitoring, but can also help with cropland mapping, large-scale crop vegetation analysis and observation, pest monitoring, spray yield, herbicide use, and data dissemination in the shortest possible time about crop conditions and other highly beneficial elements regarding the crop surveillance part of the production process.

It was shown in chapter 2 that, by using drones, it is possible to achieve:

- Techniques specific to precision agriculture (establishment of crops in soil, administration of chemical fertilizers, etc.); a common occupation in precision agriculture is the use of planting equipment, equipment that reduces the effort of the farmer and accumulates valuable time for other occupations. Automated planting involves the use of mini tractors designed for all types of plants. The technology used is line- by -line. This electronic model permits the supervision and verification of seed dosing at fixed and variable rates on each planting seedling. This new technology, in conclusion, can set the characteristics and volume of planting material equally keeping the same amount of seeds per square meter;
- Precise positioning of soil samples; For large areas of agricultural land, fertilizer equipment makes this deployment extremely efficient, guaranteeing that foliar substances are distributed according to the analysis made in the zoning map, leading to an intensification of the foliar result. This deployment is very beneficial. First, a soil sample is taken to determine the elements that can help crops. Next, using GPS, the

machine distributes the amount and type of fertilizer according to the area to be treated, given by the crop analysis. The method also allows the analysis of macro and micronutrients and particle size at depths of up to 40 cm. This requires soil productivity mapping carried out using a 1-2 hectare sampling system;

- Capturing and researching crop information. The categorical elimination of pests and weeds will lead to efficient management by farmers of fundamental resources (time, fuel, pesticides), but also to better protect their crops;
- Surveying of agricultural land or culture;
- Sensors and crop monitoring applications provide complete information about the condition of the soil, so farmers know in advance that it is the most suitable. As an example, in a sedimented/compacted soil, water is less permeable and takes the best route to plant roots. This aspect can negatively alter its growth and automatically affect the organization of the harvest carried out by the farmer;
- Harvest supervision and verification;
- Production surveying

The usefulness of drones is not negligible and can be a lever for the rapid amortization of the rather high costs of the equipment, the benefits allow the amortization of the equipment in the first 3 years of use. We have shown during the research that there are several types of drones on the market, classifying them according to the size of the drones according to their content or type of assembly, according to the distances possible to travel with these drones and not in the last line of their price. Thus, it is observed that the market offers multiple possibilities for the application of precision agriculture, however, considering that a vulnerable point is the compatibility of the software on the drone with those of data processing programs or computers, currently there are significant compatibility vulnerabilities as shown in chapter 2 of the thesis.

Regarding the impact of precision agriculture in the area of the Romanian Plain, related to the crops of aromatic plants, the research showed that the impact of precision agriculture is an important one, the Romanian Plain benefiting from a warm climate and in a climate change, some of the areas of the Plain Romanian even being exposed to desertification. The area that I have selected in SE Romanian Plains, respectively Brăila County, still benefits from a climate conducive to the cultivation of aromatic plants, with precipitation, especially in the autumn season, and weather phenomena that favor lavender crops, such as the glow of the sun, the temperature, on the other hand, regarding the wind, is an element that we do not consider favorable for the cultivation of aromatic plants in the Romanian Plain, this being quite strong and constant in the studied area. In this chapter, we made a short history of aromatic plants and compared the crops resulting in the fact that the lavender crop is a perennial crop that has a good productive yield, and its climate impact level is the one that must be monitored because otherwise the crop is exposed to mold and fungi.

The categorical report of precision agriculture on lavender cultivation presented in chapter 3, is a significant one and I presented during the research the fact that it contributes to improving productivity, so that the works and the consumption of substances and fertilizers can be strictly monitored with the help of precision agriculture. In the last chapter of the research, we determined the climatic and biological impact of the aromatic plant crops, which in our opinion represents an essential point of the agricultural management of these crops and allows the early diagnosis of risks, and, through precision agriculture, the reasoning of the risks in relation to cultivated areas, guaranteeing the efficiency and effectiveness of agricultural production, to the extent of ensuring the economic development objectives proposed by the managers of agricultural entities.

With the help of neural modelling, the representation of the climatic impact in precision agriculture was realized based on the experimental recordings made between 25.11.2022-10.03.2023 on 4 lots, cultivated with lavender augustifolia in the locations of Urleasca Commune and Traian Commune, Brăila County. The study carried out in chapter 4 had in mind the representation of the climate impact by means of precision agriculture, using in this sense statistical procedures, namely the neural modelling of the factors and effects of the use of precision agriculture on the cultivation of lavender lots. It has been demonstrated that there are 5 levels of climatic damage to the lots cultivated with lavender in the SE Romanian Plain, from risk 0 or the absence of risk to high climatic damage or even severe climatic damage. The distribution of the degree of climatic damage was presented throughout the research, respectively there being at least 5% of the cultivated area at risk of severe climatic damage, in the absence of precision agriculture practices.

Basically, the observed lands were previously treated, both for herbicide resistance and for pesticides on the land, alfalfa being previously cultivated. It was observed from the study that both the treatments with herbicides and the treatments with pesticides applied to the previous crops of alfalfa show a resistance in the field that is beneficial to the lavender crop, following the risk analysis, a decrease in the risk of climate damage is observed as a result of the resistance in the soil of the treatments applied to the previous crop. It was also observed that through precision agriculture, risk sequencing was carried out at the level of crops, making it possible to identify fungi and molds early, this having a beneficial effect on the level of efficiency and effectiveness of agricultural plant production aromatic (lavender). In addition, the neural models confirmed both the reduction of climate damage risks and the opportunity of precision agriculture on the cultivation of these aromatic plants. In the absence of precision agriculture, the crops have been shown to have an additional risk, both with respect to pedoclimatic conditions, wind and humidity, and regrading the temperatures that vary in the studied area.

Based on the proposed neural models, it has been demonstrated that the effects of precision agriculture are sustainable, being able to reduce to 0 the risk of climatic damage to aromatic lavender crops through the early intervention of treatments on crops identified with potential climatic damage.

The original contributions consist in the identification of the development of precision agriculture in Europe and Romania, the identification of the main factors that influence the acceleration of the development of precision agriculture, but also of some risk factors such as the level of education of the users, access to financing, availability for change, which brake in the Romanian area the implementation of these practices. On the other hand, we have shown that at the European level, through funding programs, significant important steps have been taken in the generalization of the use of precision agriculture practices.

Other important contributions consisted in the presentation of the means of carrying out precision agriculture, in the sense that we did an extensive study on the drones that represent the technology in precision agriculture, together with the data storage systems and together with the ways of processing this data respectively computer programs.

It was highlighted that the main deficiency in the technological equipment, due to the rather early level of development of this sector, consists in the incompatibility of the data transmission and processing programs which the drones are equipped with and which the workstations of the experts are equipped with in the precision agriculture procedures.

A SWOT analysis of precision agriculture was also carried out, analysis during which we showed the fact that precision agriculture is an opportunity for farmers, allows increasing economic efficiency and the effectiveness of work procedures, contributes to increasing food security and contributes to the significant improvement of agricultural management. Among the weaknesses observed during the SWOT analysis, we showed that there is a low level of basic professional capacity and qualification of farmers, the technologies used to achieve a positive and efficient agriculture depend on financing, and financing is in some areas quite difficult to obtain. At the same time, I showed the fact that for Romania, this opportunity is already at the beginning of implementation, with farmers hesitating to organize themselves in groups and cooperative forms that can receive real support from the authorities. As opportunities for precision agriculture, we showed the development of the Internet of Things, we highlighted the fact that community support is pro-precision agriculture, and we also showed that knowledge of the opportunities for this practice of precision agriculture is increasingly favored by the political pro sustainability and pro ecology that the European Union is currently promoting.

As threats, apart from the presence of economic and geopolitical crises, I have shown the fact that there is a reluctance of farmers to use precision agriculture techniques, the fact that the average age of farmers is quite high, which is an impediment to this, and the fact that there is an energy crisis that generates significant agricultural operating costs and prices and which also contributes to limiting the implementation of precision agriculture. According to the analysis carried out for lavender cultivation, precision agriculture, as we have shown, presents an increase in efficiency and effectiveness, contributing to the improvement of the production of aromatic plants, such as lavender augustifolia, and the role of the state in ensuring precision agriculture is a significant one. On the occasion of the applied study, we demonstrated the 4 working hypotheses that are also our own contributions regarding the effects of the use of precision agriculture on lavender crops, the 4 working hypotheses being presented further and being validated on the occasion of the study as follows: in the rainy period related to the months in spring, crops tend to accumulate higher humidity, which predisposes them to the appearance of mold and fungi; in adverse pseudo-climate conditions, the level of crop damage due to wind intensity increases, the increase being a long-term systemic one; the previous pesticide treatments show resistance over time and protect the aromatic lavender crops in the studied area in the SE area of the Romanian Plain; with the help of precision agriculture, the risks of climate damage can be sequenced and subsequently the cost of treatments and interventions carried out on aromatic plant crops, such as lavender, can be reduced.

Research ethics - During the doctoral studies, all academic ethics recommendations were respected. Once the research began, a number of essential ethical steps were taken to convince those involved that they were interested in contributing to the research, to give them confidence that no news of their identity would be divulged, and that they also can withdraw from this research at any time.

The requirement to analyze and discuss the results of the study without commenting on the specific respondents participating in this study was also respected.

Final conclusions and future research directions - The stated purpose of the research was achieved, the fact that precision agriculture is timely and necessary, supplementing agricultural practices with new easy and useful tools for farmers, it was realized that there is the possibility of forecasting through neural models, the levels of climate impact, there are premises for the improvement of some production models based on historical data and on the basis of data collected in real time with the help of precision agriculture.

The following research directions are set to be expanded after this stage of doctoral research: the precision agriculture technique allows the prediction of productive yield models based on the influence of climatic and environmental factors on the crop; the use of precision agriculture can be an element of stopping agricultural losses and improving food security in the new perspectives of multiple crises.

V. List of published works

A. Books/book chapters as author/co-author

1. Ferțu C., Balasan, L.D., Zanet V., Stanciu, S., 2021, Monitorizarea starii de vegetatie a culturii de lavanda cu
ajutorul dronelor, în volumul conferinței *Viabilitatea fermelor si dezvoltarea rurala durabila in contextul actualelor prioritati ale Uniunii Europene privind agricultura si mediul* (Bucuresti, Decembrie 8, 2021), pp. 15-26, Ed. Academiei Romane, ISBN 978-973-27-3645-6.

B. Scientific articles

B1. Articles published in ISI Web of Science/ Clarivate Analytics listed journals

1. Ferțu, C., Dobrota L.M., Balasan D.L., Stanciu, S., 2021, Monitoring the vegetation of agricultural crops using drones and remote sensing - comparative presentation, Scientific Papers Series "Management, Economic Engineering în Agriculture and Rural Development", Vol. 21, Issue 2/2021.; pp 249 – 254, WOS: 000664986400030, ISSN 2284-7995, E-ISSN 2285-3952, https://sci.ldubgd.edu.ua/jspui/bitstream/123456789/8522/1/volume_21_2_2021.pdf
http://www.managementjournal.usamv.ro/pdf/vol.21_2/Art30.pdf. https://www.webofscience.com/wos/woscc/full-record/WOS:000664986400030.

B2. Articles published in volumes of scientific events indexed by ISI Web of Science/ Clarivate Analytics

1. **Fertu, C.,** Dobrota, L.M., Balasan, D.L., Stanciu, S., 2020, Applications of Unmanned Aerial Vehicles in Romanian

Agriculture: Past, Present, And Perspectives, Proceedings of The 35th International-Business-Information-Management-Association Conference (IBIMA): Education Excellence and Innovation Management: A 2025 Vision to Sustain Economic Development During Global Challenges, (Seville, Spain, April 01-02, 2020), pp. 9743-9749, Ed. Soliman, K.S., ISBN: 978-0-9998551-4-0, WOS: 000661489800037, https://www.webofscience.com/wos/woscc/full-record/WOS:000661489800037.

2. Dobrota, L.M., **Fertu, C.,** Turek-Rahoveanu, MM., Simionescu, C.S., 2020, The Importance of Social Farming in the Socio-Economic Development of Romania and of the EU States, Proceedings of The 35th International-Business-Information-Management-Association Conference (IBIMA): Education Excellence and Innovation Management: A 2025 Vision to Sustain Economic Development During Global Challenges, (Seville, Spain, April 01-02, 2020), pp. 9715-9728, Ed. Soliman, K.S., ISBN: 978-0-9998551-4-0, WOS: 000661489800035, https://www.webofscience.com/wos/woscc/full-record/WOS:000661489800035.

3. **Fertu, C.,** Dobrota, L.M, Stanciu, S., 2019, Precision Agriculture in Romania: Facts and Statistics, Proceedings of 34th International-Business-Information-Management-Association (IBIMA) Conference VISION 2025: Education Excellence and Management Of Innovations Through Sustainable Economic Competitive Advantage (Madrid, Spain, Nov 13-14, 2019), Ed. Soliman, K.S., ISBN: 978-0-9998551-3-3, pp. 7366-7375, WOS:000561117200038, https://www.webofscience.com/wos/woscc/full-record/WOS:000561117200038.

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B3. Articles published in journals/volumes of scientific conferences indexed in international databases

1. **Fertu C.**, Balasan, L.D., Zanet V., Stanciu, S**.,** 2022, The future of agriculture drone tehnology. Trends and prospects, Proceedings of 79th International Scientific Conference on Economic and Social Development (March 25-26, 2022, Rabat, Maroc,), pp. 68-76, Ed. Machrafi, M., Uckar, D., Susak., T., ISSN 1849-7535, http://hdl.handle.net/11159/7649.

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3. **Fertu C.**, Balasan, L.D., Zanet V., Stanciu, S., 2021, Monitoring agricultural policy using drones - comparative method: satellites versus agricultural drones, Proceedings of the 76th Economic and Social Development: International Scientific Conference on Economic and Social Development – "Building Resilient Society", (Decembre 17-19, 2022, Zagreb, Croatia,), ISSN 1849-7535, pp. 289-298, https://www.proquest.com/openview/4ae56426aa433af4b9873d7196466b0b/1?pq-origsite=gscholar&cbl=2033472.

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B4. Articles published in volumes of scientific events currently being indexed by ISI Web of Science/ Clarivate Analytics

1. Ferțu,C., Dobrota, L.M., Stanciu, S., 2021, Intelligent Viticulture Tendencies and Perspectives in The Drone Technology, International Conference IBIMA"Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage"), ISBN: 978-0-9998551-7-1, ISSN: 2767-9640, (November 23-24 2021, Seville, Spain), pp. 1091-1091.

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3. Balasan, D.L., Buhociu, D.H. **Ferţu,** C., 2021, The Main Indicators of Rural Development in The South-East Region, Proceedings of the 39th International Business Information Management Association (IBIMA), ISBN: 978-0-9998551-8-8, ISSN: 2767-9640, (May 30-31, 2022, Granada, Spain,) pp. 2281-2288 https://ibima.org/accepted-paper/ The Main Indicators of Rural Development in The South-East Region.

4. **Ferțu,C.,** Bălășan, L.D., Stanciu, S.**,** 2020, "Impact of Satellite Remote Sensing Versus Multispectral Aerial Photography Remote Sensing with Agricultural Drones,", International Conference IBIMA"Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage" ISBN 978-0-9998551-8-8, ISSN: 2767-9640, (May 30-31 2020, Granada, Spain), pp. 391-399.https://ibima.org/accepted-paper/precision-agriculture-versus-digital-agriculture-national-and-european-issues/.

C. Papers presented at international/national conferences with international participation

1. **Ferțu C.,** Balasan, D.L., Zanet, V., Stanciu, S., 2022, The future of agriculture drone tehnology trends and prospects, 79th International Scientific Conference on Economic and Social Development –,March, 25-26 2022 Rabat " Economic and Social Development: Accepted paper; https://www.researchgate.net/profile/Ana-Markuz/publication/367204235_COMPARISON_OF_EMPLOYEE_SALARY_AS_A_MATERIAL_FACTOR_OF_WORKPLACE_SATISFACTION_WITH_OTHER_INTANGIBLE_FACTORS_OF_WORKPLACE_SATISFACTION/links/63c7f503d9fb5967c2e5e1dd/COMPARISON-OF-EMPLOYEE-SALARY-AS-A-MATERIAL-FACTOR-OF-WORKPLACE-SATISFACTION-WITH-OTHER-INTANGIBLE-FACTORS-OF-WORKPLACE-SATISFACTION.pdf#page=74

2. Balasan, D.L., Buhociu, F.M., **Ferțu C.**, 2022, Strategies for the development of south – east region in correlation with the development of the rural labour force, 79th International Scientific Conference on Economic and Social Development – March, 25-26 2022 Rabat " Economic and Social Development: Accepted paper; https://www.researchgate.net/profile/Ana-Markuz/publication/367204235_COMPARISON_OF_EMPLOYEE_SALARY_AS_A_MATERIAL_FACTOR_OF_WORKPLACE_SATISFACTION_WITH_OTHER_INTANGIBLE_FACTORS_OF_WORKPLACE_SATISFACTION/links/63c7f503d9fb5967c2e5e1dd/COMPARISON-OF-EMPLOYEE-SALARY-AS-A-MATERIAL-FACTOR-OF-WORKPLACE-SATISFACTION-WITH-OTHER-INTANGIBLE-FACTORS-OF-WORKPLACE-SATISFACTION.pdf#page=74
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10. **Ferțu,C.,** Dobrota, L.M., Balasan, D.L., Stanciu, S**.,** 2020, Applications of Unmanned Aerial Vehicles în Romanian Agriculture: Past, Present, And Perspectives, International Conference IBIMA“Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage” ISBN 978-0-999-8551-4-0, 35 Edition, 2020,(April, 1-2 Seville, Spain) https://ibima.org/accepted-paper/applications-of-unmanned-aerial-vehicles-in-romanian-agriculture-past-present-and-perspectives.
11. **Ferțu, C.**, Dobrota, M.L., Stanciu, S., 2020, Digitization in

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14. Dobrotă, L.M., **Ferțu C.,** Turek – Rahoveanu, M.M., 2019, Rural Digital Hubs: The "tool" for revitalization of european rural areas through digitization, Proceedings of the 34 th International Business Information Management Association Conference (IBIMA) (November 13-14 2019 Madrid, Spain), Vision 2025: Education Excellence and Management of Innovations, through Sustainable Economic Competitive Advantage, https://bibliotecadigital.ipb.pt/bitstream/10198/21952/1/34th%20IBIMA%20Conference%20Proceedings_2_A%20New%20Approach.pdf
15. **Ferțu,C.,** Dobrota, L.M., Stanciu, S**.,** 2019, Precision Agriculture Versus Digital Agriculture. National and European Issues, International Conference IBIMA"Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage (November13-14 Madrid, Spain, 2019) https://ibima.org/accepted-paper/precision-agriculture-versus-digital-agriculture-national-and-european-issues/
16. **Ferțu,C.,** Dobrota, L.M., Stanciu, S**.,** 2019, Precision Agriculture în Romania: Facts and Statistics, International Conference IBIMA "Vision 2025: Education excellence and management of innovations through sustainable economic competitive advantage", 34 Edition, (November13-14 Madrid, Spain, 2019), https://ibima.org/accepted-paper/precision-agriculture-versus-

digital-agriculture-national-and-european-issues/

D.Awards

1. **Second Prize** Award for Poster Presentation entitled „Drones in agriculture" – Scientific Conference of the Doctoral Schools of „Dunarea de Jos" University held at Galati, between the 18th and 19th of June 2020
2. **Second Prize** Award for oral Presentation entitled " The future of agricultural drone technology in the context of the COVID 19 pandemic", contribution to the 9 th Edition of the Scientific Conference of the Doctoral Schools of "Dunărea de Jos" University held at Galați, between the 10th and 11th of June 2021
3. **Mention Prize** Award for Poster Presentation entitled „The technological future of agriculture- Agricultural drones " – Scientific Conference of the Doctoral Schools of „Dunarea de Jos" University held at Galati, between the 9th and 10th of June 2022

E. Projects

Member in the target group - PROINVENT , Project title: Programme for increasing performance and innovation in doctoral and postdoctoral research of excellence _ PROINVENT / Contract no. 62487/03.06.2022POCU/993/6/13 - SMIS Code: 153299 period 15 July 2022-14 July 2023

Preparation of the scientific report entitled (USE OF AGRICULTURAL DRONES IN PRECISION AGRICULTURE).

F. Postgraduate training and continuing professional development programmes completed during the doctoral traineeship

1.Postgraduate program of training and continuous professional development Educational mentoring in academic environment - October 2019, Galati according to the certificate no.153/23.01.2020.

2.Postgraduate program of training and continuous professional development Management of bibliographic references-November 2019, Galati according to the certificate nr.56/23.01.2020.

VI. Selective Bibliography

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