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The international education program in the field of precision farming as an opportunity to raise the efficiency of agricultural farms manage by young agro-technicians

"PRECISION FARMING"

LESSON PLANS

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LESSON PLANS

Number of lesson	Subject of the lesson	Program of the lesson	Methods and tools	Credit, learning, outcomes, qualification	Unit of learning outcomes	Assessment
1.	Soil nutrients	Divide the class into 10 groups Have each group send a representative to get a carnation and a cup of water with food colouring. Explain that the lesson is on soil nutrients and each colour represents a different nutrient. Have the students put the carnation in the water and then set it aside until the end of class. To start the class, the teacher will show the students how to set up the carnation in the food colouring and water. The teacher will use the PowerPoint and lecture to provide the students with the information.	PowerPoint presentation Handout of slides Hands on experiment Lecture Food colouring White carnations Paper cups Water	Know the definition of deficiency, nutrient, toxicity macronutrients, micronutrients, identify the plant deficiencies from pictures Evaluate a plant to identify the nutrient absorption rate	The monitoring of soil quality indicators	The teacher first covers the results of the carnation experiment. Showing how the different nutrients have different absorption rates. Each group shows their flower to the rest of the class. Then the teacher hands out envelopes containing a short memory game. The students identify and match the nutrient deficiency symptom to the nutrient. They will do it in the same groups as before.

2.	Microbiota	The teacher explain relations of organism in the life of soil from the kingdom of flora and fauna. The importance of organisms in soil formation The teacher and students will interact through questions about the life of the soil, creatures, the trophic relationships and the trophic network of soil organisms The fauna in the soil is extremely rich (millions of individuals per square metre), but most species are extremely small in size. Soil protozoa can be observed under a microscope	Observation, worksheets, brainstorming, pictures Methods of ecological research of zoonoses: - qualitative/quantitative study: terrestrial invertebrates -soil fauna- soil samples in the laboratory -fauna from soil level and from litter- barber traps, processed litter samples -fauna from soil level and the grass layer: the square method and the fascia method, invertebrates from various activity centres: brash, forceps, jar with preservative fluid and exhaust.	The student will be able to define; identify the organisms in the soil Trophic relationships	The monitoring of soil quality indicators	Definition applied discussion Identification of organisms of soil and trophic relationships. Practical evaluation sheet
3.	Compost	Definition of compost, importance, composition, role. The teacher uses a school composting DVD, telling a story related to the	Stellar explosion, brainstorming, practical activity, minicompost	The students will be able to identify the natural materials for making a compost cell.	Compost	Definition applied discussion Identification of natural materials from the school yard Composting

		composting process. The teacher explains and teaches about composting, talks about compost. With a power point presentation also explaining those educational activities. Lesson consists of technical aspects and information to improve composting practical advise, applications of biowaste compost, description and results of a compost experiment				Posters of different sizes and contents Campaign of home composting Tips for reducing waste in several aspects of our daily life
4.	Sustainable development and organic farming	This lesson allows the students to explore the many concepts of Sustainable development and to develop in their own mind a definition of organic farming . Lesson consists of the lecture ”Importance of mapping in organic farming for the decision making”. The instructor and students will interact to answer questions about what is Sustainable	lecture - case study - brainstorming	We are talking about sustainability in the social sense This is also what defines our key values: sustainability, continuity We considers it a fundamental strategy objective formation and maintenance of a sustainable development system of the agriculture sector Upon completion of this unit, the student will be able to:	The monitoring of soil quality indicators	Formative, discussion questions: - Define “Sustainable development” - What is the difference between Sustainable development and Organic Farming? - How has Sustainability made Organic Farming Possible? - Discuss applications of Sustainability in Organic Farming - Define Geographic Information Systems

		development and organic farming and the uses of it		- define organic farming, - explain the importance of maps in Organic Farming - define Sustainability - define Organic Farming - analyse a diagram of the relationship between Sustainability and Organic Farming		- Explain the relationship between Sustainability and Organic Farming - Provide examples of Sustainability/Organic Farming usage in other branches of industry
5.	Determining soil pH and its importance for plant growth and development	This lesson will take the form of a practical work in nature and in the biology laboratory and will allow students to understand the importance of soil pH for the growth and development of crop plants. Students will take soil samples; with the help of the laboratory kit, they will determine the soil pH and will be able to make decisions about planting some species of agricultural importance according to their preferences for this abiotic factor, pH.	Learning through discovery Heuristic conversation Problem Remark Demonstration	At the end of the activity, the students will be able to: - define the pH of the soil; -classify soils according to pH; -describe the characteristics of strongly acidic soils; -characterize strongly alkaline soils; -determine the pH of the soil; -interpret the result of the determination in correlation with the growth and development process of the culture plants.	Soil and crop management to increase productivity in agriculture.	1. Define the pH of the soil. 2. Classify soils according to pH. 3. Describe the characteristics of strongly acidic soils. 4. Characterize strongly alkaline soils. 5. Determine the pH of the soil samples collected. 6. Explain how the pH of the soil influences the growth and development of crop plants.

6.	Determining the texture of the soil and its importance for the growth and development of crop plants	This lesson will take the form of a practical work, in nature and in the biology laboratory and will allow students to understand the importance of soil texture for the growth and development of crop plants. Students will take soil samples; with the help of the laboratory kit, they will determine the soil texture and will be able to make decisions about planting species of agricultural importance depending on their preferences for this abiotic factor, soil texture.	Learning through discovery Heuristic conversation Problem Remark Demonstration	At the end of the activity, the students will be able to: - define the soil texture; -classify soils by texture; -describe the characteristics of soils with a coarse texture; - characterize soils with a medium texture; - describe soils with a fine texture; -determine the texture of the soil; - interpret the result of the determination in correlation with the growth and development process of the culture plants.	Soil and crop management to increase productivity in agriculture.	1. Define the soil texture. 2. Classify the soils by texture. 3. Describe the characteristics of coarsely textured soils. 4. Characterize the soils with a medium texture; 5. Describe the characteristics of fine-textured soils. 6. Determine the texture of the collected soil samples. 7. Explain how the texture of the soil influences the growth and development of crop plants.
7.	Interpretation of soil characteristics	This lesson can be carried out in a specialized laboratory and includes the following activities: Interpretation of the phenomenon of formation of the mineral part of the soil Interpretation of the phenomenon of	Learning through discovery Heuristic conversation Problem Remark	a. Interpretation of the phenomenon of formation of the mineral part of the soil - processes of disaggregation and alteration, mineralogical composition, magmatic, metamorphic, sedimentary rocks;	Soil surveillance and control	1.Determine the mineral part of the soil. 2.Interpret the phenomenon of formation of the organic part of the soil. 3.Identify the main soil types.

		formation of the organic part of the soil. Identification of the main soil types Correlation between living organisms in the soil and its properties		b. Interpretation of the phenomenon of formation of the organic part of the soil - decomposition of organic residues by hydrolysis, oxidation-reduction and total mineralization and humus formation c. Identification of the main types of soil: chernozem, reddish brown, brown, podzol, solonetz, solonchak, alluvial soil, peat soil; d. Correlation between soil organisms and their properties: frame-fertility		
8.	Determine the physical characteristics of the soil	This lesson can be carried out in a specialized laboratory and includes the following activities: Determination of soil moisture Determination of particle size composition and soil texture Determination of soil capillarity Determination of soil density and bulk density	Learning by doing Learning through discovery Heuristic conversation Problem Remark	At the end of the class, the students will be able: -to determine the soil moisture, according to the performance criterion - to determine the particle size composition and soil texture - to determine the capillarity of the soil, according to the performance criterion	Soil surveillance and control	1.What is the sample's humidity? 2. Describe the soil capillarity 3.Identify soil density and bulk density

				- to determine the density and the apparent density of the soil		
9.	Determine the chemical indicators of soil quality	The lesson takes place in a specialized laboratory and involves completing the following activities: Collection of soil samples with specific tools Preparation of the sample collection form Determination of soil reaction Determination of soil saturation with chemical fertilizers Determining the degree of soil infestation with pesticides Quantitative determination of microelements and secondary elements in the soil Interpretation of the results	Learning by doing Learning through discovery Heuristic conversation Problem Remark	At the end of the class, the student will be able: - to collect soil samples, according to the performance criterion - to draw up the sample collection form - to determine the reaction of the soil - to determine the degree of soil saturation with chemical fertilizers - to determine the degree of infestation of the soil with pesticides - to determine quantitatively the microelements and the secondary elements in the soil - to interpret the results of the determinations	Soil surveillance and control	Determination of chemical soil quality indicators: Soil samples: simple, medium, deep, surface Collection form: name and surname of the person collecting the samples, date and time of sampling, place of collection of samples, type of sample, weather conditions at the time of collection, the purpose of collection Instruments: agrochemical probe Soil reaction: pH, alkalinity, acidity Chemical fertilizers: nitrogen, total phosphorus, potassium Microelements: Mn Secondary elements: Ca, Mg, Fe Interpretation: quality indicators
10.	Determine the microbiological indicators of the soil	The lesson will take place in a specialized laboratory and includes the following stages:	Learning by doing Learning through discovery	At the end of the class, the students will be able: - to prepare specific instruments and	Soil surveillance and control	Work tasks: Determination of soil microbiological indicators

		Preparation of specific instruments and equipment for sampling and the microbiological analysis Collection of soil samples with specific tools Preparation of the sample collection sheet Determination of microorganisms Interpretation of the results	Heuristic conversation Problem Remark	equipment for the collection of samples and the microbiological analysis - to collect soil samples, according to the performance criterion - to draw up the soil samples collection form - to determine the microorganisms in the soil, according to the performance criteria - to interpret the results of the microbiological analysis		-Prepares: sterilization with solutions, by buckling, heating to red, in autoclave - Samples: simple, medium, surface, deep - Instruments: agrochemical probe - Collection form: name and surname of the person collecting the sample, date and time of collection, place of collection, type of sample, weather conditions at the time of collection, the purpose of collection -Microorganisms: bacteria, fungi - Interpretation: soil quality indicators
11.	Determine the radioactivity of the soil	This lesson will take place outdoors, in nature, on different plots that we want to analyse: Collect soil samples Measures soil radioactivity with special devices Monitor and interpret the results of determinations	Learning by doing Learning through discovery Heuristic conversation Problem Remark	At the end of the class, the students will be able: - to collect soil samples, according to the performance criterion - to measure the radioactivity of the soil, according to the performance criterion - to monitor and interpret the results of the determinations	Soil surveillance and control	What is the harvest depth? What is used to collect soil samples? Describe the Scintillation Detector.

12.	Segmentation algorithm	In light of the increasing demand for food production, climate change challenges for agriculture, and the economic pressure, precision farming is an ever-growing market. For the automatic delineation of MZ, a segmentation algorithm was developed based on RapidEye satellite images. The workflow was divided into three steps: (a) automatic selection of suitable satellite images which reflect crop patterns, (b) combining the NIR bands of all selected images to one averaged raster and dividing the result into five classes, (c) conversion into vector data and assignment to areas of relative yield expectation (corresponding to MZ). Detailed information on these steps is provided below.	Lecture Description Learning through discovery Heuristic conversation Problem Remark	At the end of this lesson, the students will: - be aware of the segmentation algorithm; - know the steps of the workflow ; - be able to overcome the difficulties of using vegetation indices for segmentation	Management of zones	Students will be segmenting different plots of land

		Before the selection process, every image was clipped to the extent of the field 100-01, including a negative buffer of 18 m to exclude margin artefacts, especially in the area of headland. The algorithm was programmed in R (R Core Team 2012) with the use of the packages 'raster', 'maptools', 'stringr', 'rgeos', 'diptest' and 'moments'.				
13.	Improving water use efficiency (WUE), Nitrogen use efficiency (NUE), and Radiation use efficiency (RUE) in field crops	The lesson teaches students how precision agriculture uses geographic information systems (GIS) to help farmers and manufacturers make smart, efficient, and responsible decisions about how and when they plant, grow, irrigate, harvest, and transport crops. The lesson consists of the lecture "Improving Water Use Efficiency, Nitrogen	lecture case study brainstorming GIS GPS	Upon completion of this unit, the student will be able to: -Explain the definitions of water and nitrogen, and radiation use efficiencies -Find the interactions between water and nitrogen in crop production -Describe the importance of improving water and nitrogen use	Exploring options for improving water, nitrogen and radiation use efficiency in crop production system	Formative, discussion questions: - What are the options for increasing yield, WUE and NUE in a rainfed dryland system? - What are the effects of long-term applications of soil organic amendments and mineral fertilizers on crop yields, WUE and NUE in a rainfed dryland system? - What are the potentials of increasing WUE and NUE in orange production?

		Use Efficiency, And Radiation Use Efficiency In Field Crops"		efficiency in crop production -Calculate water use efficiency (WUE), Nitrogen use efficiency (NUE), and Radiation use efficiency (RUE) -Name water and nitrogen saving techniques -Explain the role of long-term field monitoring studies -define GIS -explain the role of soil-crop modelling		- What are the possible fertigation strategies for improving WUE and NUE in orange production?

14.	Improving water use efficiency (WUE) in climate changing conditions	The teacher starts the lesson with a short presentation which contains many photos which illustrate the consequence of climate change. The teacher also prepares a lecture "Water use efficiency in response to climate change" in which he or she explains that water use efficiency (WUE) is the most important characteristic of ecosystem productivity, which links carbon (C) and water cycling. The last part of the lesson is work in groups: each group will receive a problem related to the lesson's topic.	Lecture Presentation Work in groups	The student will be able to: - define water use efficiency - calculate water use efficiency (WUE) - name four factors changing in the climate that will affect water use by plants - explain the consequence of climate change. - find links between climate change and water use efficiency	To increase awareness about climate change	Formative, discussion questions: -Why is water use efficiency important? - How water use efficiency can be improved in the climate change conditions? What are the main problems in the process of improving water use efficiency? - Which crop has the highest water use efficiency?
15.	Improving water use efficiency: Agronomic perspective. Irrigation management practices	The lesson consists of a lecture about the agronomic perspective and irrigation management practices of improving water use efficiency. Also the teacher and the students create a tree of terms	Lecture Tree of terms Debates	The students will be able to: - explain the importance of water use efficiency. - calculate water use efficiency (WUE) in agriculture -define the irrigation system	To increase awareness about water use efficiency in agriculture	Formative, discussion questions: - What is water use efficiency in agriculture? -Which crop has the lowest water use efficiency? - Explain the role of the irrigation system in

		which they will use during the lesson. In fact, agriculture is the largest consumer of water. The last part of the lesson are debates on the suggested topic about the pros and the cons of irrigation management practices		-make examples of irrigation management in different countries -explain the differences between drip irrigation and raised bed irrigation - explain which of the types of irrigation practices are the more effective		improving water use efficiency - what are the pros and the cons of irrigation management practices -what is the best implementing practice of irrigation management? Why?
16.	Agronomic and soil management practices	This lesson allows the students to explore many agronomic and soil management practices. The lesson consists of a lecture, practical tasks and a presentation about soil erosion, loss of soil fertility, and land degradation due to climate change as the major environmental problem, video materials about Ethiopian experience with soil management practice. At the end of the lesson, there will be brainstorming.	lecture case study presentation video materials brainstorming	Upon completion of this unit, the student will be able to: - define soil erosion, soil fertility, climate change. -name the major environmental problem -explain the term 'sustainable development' -make examples which illustrate the results of successful implementation of the practices.	Soil and crop management to increase productivity in agriculture	Formative, discussion questions: - What is sustainable development? - What is the difference between sustainable development and organic farming? -what are the ways of solving soil erosion, loss of soil fertility, and land degradation. - analyse partner countries' experience with soil management practice
17.	Biochemical alterations and	The teacher starts the lesson with the heuristic	Learning through discovery	The students will be able to:	Exploring options for	Question for discussion:

	stomatal physiology. Alteration of cropping environment, root architecture, and improved harvest index	conversation with which students will be able to find right answers that the lead to topic of the lesson. Next, the teacher explains the lecture about alteration of cropping environment, root architecture, and improved harvest index. After that, the students are provided with a problem related to the topic. They should solve it with their acquired skills and knowledge from the lesson.	Heuristic conversation Problem solving Practical task	-define the terms biochemical alteration, stomatal physiology, harvest index -calculate the harvest index -explain the physiological basis of stomatal response - understand three functions of stomata - know the Father of Plant Physiology - explain crop modelling - define root system architecture and know all types of it	biochemical alterations and stomatal physiology	-What are biochemical alterations? - What is the physiology of a plant? - What is the role of plant physiology in agriculture? - analyse one of the crop management techniques to enhance the harvest index - How are crops affected by climate change? -How can we adapt crops and cropping systems to climate change?
18.	The importance of improving nitrogen use efficiency in crop plants	This lessons provides information about the significant role of Nitrogen in farming. In fact, Nitrogen (N) is the most critical externally added input for any crop production system. The lesson consists of tree parts. The first one is a lecture ”The importance of improving nitrogen use efficiency in crop plants”. The second one are the	Lecture with slides Cooperative learning Brainstorming	Students will be able: - to explain the importance of Nitrogen in farming; - to discuss examples of improving nitrogen use efficiency in crop plants in different countries; - to know different strategies for nitrogen use efficiency.	The increase of the use of Nitrogen fertilizers in agriculture has a crucial impact on the diversity and functioning of the non-agricultural neighbouring bacterial, animal, plant ecosystems.	Questions for a discussion: - What is Nitrogen? - What is the role of Nitrogen in farming? - Describe the Nitrogen cycling in nature. - Which factors influence nitrogen use efficiency? - How many strategies for nitrogen use efficiency do you know? Describe one of them. - Which country has the best experience of improving

		practical exercises related to the following topic in groups of 3-5 students. And, finally, the last one is brainstorming: the teacher introduces an issue and asks the students to reach a conclusion on their own. The teacher, of course, moderates the whole process.			The use of Nitrogen has also increased the quantity of agricultural food production.	nitrogen use efficiency in crop plants? Explain your opinion.
19.	Improving nitrogen use efficiency: Agronomic perspective (Rotation, Irrigation management)	This lesson can be carried out in a specialized laboratory and includes the following activities: Interpretation of the phenomenon of formation of the mineral part of the soil Interpretation of the phenomenon of formation of the organic part of the soil. Identification of the main soil types Correlation between living organisms in the soil and its properties	Learning through discovery Heuristic conversation Problem Remark	a. Interpretation of the phenomenon of formation of the mineral part of the soil - processes of disaggregation and alteration, mineralogical composition, magmatic, metamorphic, sedimentary rocks; b. Interpretation of the phenomenon of formation of the organic part of the soil - decomposition of organic residues by hydrolysis, oxidation-reduction and total mineralization and humus formation	Soil surveillance and control	1.Determine the mineral part of the soil. 2.Interpret the phenomenon of formation of the organic part of the soil. 3.Identify the main soil types.

				c. Identification of the main types of soil: chernozem, reddish brown, brown, podzol, solonetz, solonchak, alluvial soil, peat soil; d. Correlation between soil organisms and their properties: frame-fertility		
20.	Nitrogen source and placement method. Precision agriculture and management practices	This lesson can be carried out in a specialized laboratory and includes the following activities: Determination of soil moisture Determination of particle size composition and soil texture Determination of soil capillarity Determination of soil density and bulk density	Learning by doing Learning through discovery Heuristic conversation Problem Remark	At the end of the class, the students will be able: - to determine the soil moisture, according to the performance criterion - to determine the particle size composition and soil texture - to determine the capillarity of the soil, according to the performance criterion - to determine the density and the apparent density of the soil	Soil surveillance and control	1.What is the sample's humidity? 2. Describe the soil capillarity 3.Identify soil density and bulk density
21.	Improving nitrogen use efficiency: Physiological perspective	The lesson takes place in a specialized laboratory and involves completing the following activities: Collection of soil samples with specific tools	Learning by doing Learning through discovery Heuristic conversation	At the end of this lesson, the students will be able: - to collect soil samples, according to the performance criterion	Soil surveillance and control	Determination of chemical soil quality indicators: Soil samples: simple, medium, deep, surface Collection form: name and surname of the person

		Preparation of the sample collection form Determination of soil reaction Determination of soil saturation with chemical fertilizers Determining the degree of soil infestation with pesticides Quantitative determination of microelements and secondary elements in the soil Interpretation of the results	Problem Remark	- to draw up the sample collection form - determine the reaction of the soil - to determine the degree of soil saturation with chemical fertilizers - to determine the degree of infestation of the soil with pesticides - to determine quantitatively the microelements and the secondary elements in the soil - to interpret the results of the determinations		collecting the samples, date and time of sampling, place of collection of samples, type of sample, weather conditions at the time of collection, the purpose of collection Instruments: agrochemical probe Soil reaction: pH, alkalinity, acidity Chemical fertilizers: nitrogen, total phosphorus, potassium Microelements: Mn Secondary elements: Ca, Mg, Fe Interpretation: quality indicators
22.	Definition of Radiation use efficiency (RUE)	The lesson will take place in a specialized laboratory and includes the following stages: Preparation of specific instruments and equipment for sampling and microbiological analysis Collection of soil samples with specific tools Preparation of the sample collection sheet	Learning by doing Learning through discovery Heuristic conversation	At the end of the class, the students will be able: - to prepare specific instruments and equipment for the collection of samples and the microbiological analysis - to collect soil samples, according to the performance criterion - to draw up the soil samples collection form	Soil surveillance and control	Work tasks: Determination of soil microbiological indicators -Prepares: sterilization with solutions, by buckling, heating to red, in autoclave - Samples: simple, medium, surface, deep - Instruments: agrochemical probe - Collection form: name and surname of the person

		Determination of microorganisms Interpretation of the results		- to determine the microorganisms in the soil, according to the performance criteria - to interpret the results of the microbiological analysis		collecting the sample, date and time of collection, place of collection, type of sample, weather conditions at the time of collection, the purpose of collection -Microorganisms: bacteria, fungi - Interpretation: soil quality indicators
23.	Improving radiation use efficiency: agronomic perspective	This lesson will take place outdoors, in nature, on different plots that we want to analyse: Collect soil samples Measure soil radioactivity with special devices Monitor and interpret the results of determinations	Learning by doing Learning through discovery Heuristic conversation Problem Remark	At the end of the class, the students will be able: - to collect soil samples, according to the performance criterion - to measure the radioactivity of the soil, according to the performance criterion - to monitor and interpret the results of the determinations	Soil surveillance and control	Formative, discussion questions: What is the harvest depth? What is used to collect soil samples? Describe the Scintillation Detector.
24.	Relationship between water use efficiency, nitrogen use efficiency, and radiation use efficiency under water-deficit conditions	The lesson teaches students how precision agriculture uses geographic information systems (GIS) to help farmers and manufacturers make smart, efficient, and responsible decisions about how and when	- lecture - case study - brainstorming -GIS -GPS	Upon completion of this unit, the student will be able to: - Define water and N use efficiencies - define Radiation Use Efficiency - Explain the interactions between water and	Exploring options for improving water, radiation and nitrogen use efficiency in crop production system	Formative, discussion questions: - What career could you choose that uses these skills to develop instruments used in precision agriculture? - Why is precision agriculture important?

		they plant, grow, irrigate, harvest, and transport crops The lesson consists of a lecture “Improving Water Use Efficiency, Nitrogen Use Efficiency, And Radiation Use Efficiency In Field Crops Under Drought Stress”		nitrogen in crop production - Explain water and nitrogen use efficiency in crop production - List water and nitrogen saving techniques - Understand the role of long-term field monitoring studies - define GIS - Understand the role of soil-crop modelling		- What are the effects of soil mulching on yields, WUE and NUE? - What are the options for increasing yield, WUE and NUE in a rainfed dryland system? - What are the effects of long-term applications of soil organic amendments and mineral fertilizers on crop yields, WUE and NUE in a rainfed dryland system?
25. 26.	PRECISION AGRICULTURE Definition of Precision Agriculture The Importance of Maps in Precision Agriculture The Importance of Mapping in Data Acquisition in Precision Agricultural Technology	This course enables students to explore many concepts of precision agriculture and develop a definition of Precision Farming on their own. The course consists of "Precision Agriculture and the Importance of Mapping in Decision Making in Agriculture".	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart Board, Educational CDs, Simulations, Auxiliary Resources	Define precision agriculture. Explain the importance of maps in precision agriculture.	Soil and crop management to conserve food and increase food security	Define "Precision Farming". What is the difference between precision agriculture and traditional agriculture?

27. 28.	Using GPS in Precision Agriculture Use of GIS in Precision Agriculture	Instructors and students will interact to answer questions about precision agriculture and what traditional farming is and its uses.	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart Board, Educational CDs, Simulations, Auxiliary Resources	The use of GPS in precision agriculture. The use of GIS in precision agriculture.	Soil and crop management to conserve food and increase food security	How is Precision Farming Possible with GPS? Define Geographic Information Systems?
29. 30.	The Relationship Between GPS and GIS Methods in Precision Agriculture The Use of GPS / GIS in Other Industries	Instructors and students will interact to answer questions about the relationship between GPS-GIS Methods in Precision Farming and its use in other industries.	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart Board, Educational CDs, Simulations, Auxiliary Resources	Explain the relationship between GPS and GIS methods in precision agriculture. Explain the use of GPS/GIS in other branches of industry. Draw a relationship diagram between GIS and GPS	Soil and crop management to conserve food and increase food security	Explain the relationship between GPS and GIS. Provide examples of the use of GPS GIS in other industries.
31. 32.	SOIL AND PLANT MANAGEMENT TO SAVE FOOD AND INCREASE FOOD SAFETY Sustainable Soil and Plant Management Technological Advances in Agriculture	This course enables students to explore concepts in technological advances in sustainable soil and plant management and agriculture and to follow technological developments on their own.	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart Board, Educational CDs, Simulations, Auxiliary Resources	Explain sustainable soil and plant management. Understand the importance of following technological developments in agriculture.	Soil and plant management to increase food conservation and food security	What is Sustainable Soil and Plant Management? What are Technological Advances in Agriculture?
33. 34.	The Use of Technology in the Animal Husbandry Sector	This course enables students to explore the concepts of Technology Usage in the Livestock	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart	Understand the importance of following technological	Soil and plant management to increase food	How is the Technology used in the Animal Husbandry Sector? How is the Technology used in Water

	Water Resources Management and The Use of Technology in Fisheries Water Resources Management	Sector, Water Resources Management and The Use of Technology in Fisheries and Water Resources Management.	Board, Educational CDs, Simulations, Auxiliary Resources	developments in agriculture.	conservation and food security	Resources Management and Fisheries? How should Water Resources Management be done?
35. 36.	Use of Technology in Fishing Use of Technology in the Food Industry	The instructors and students will interact to answer questions about the Use of Technology in Fishing and Food Industry.	Lecture, Practice, Brainstorming, Group Work, Textbook, Computer, Smart Board, Educational CDs, Simulations, Auxiliary Resources	Understand the importance of following technological developments in agriculture.	Soil and plant management to increase food conservation and food security	How to use Technology in Fishing? What are the developments in Technology Usage in the Food Industry?
37.	Wireless Sensor Networks and their Applications	This lesson allows the students to understand the essence of the structure of WSNs, their main types, the fields and areas of their application, as well as what are the limitations of these applications. The lesson consists of a lecture ”Wireless Sensor Networks and their Applications - Introduction”. The instructor and students will interact to answer	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - define Wireless Sensor Networks; - explain the various topologies of WSNs; - define the classification of WSNs, depending on the environment; - explain and understand the limitations of WSNs; - define and explain the various applications of WSNs.	- WSNs topologies; - classification of WSNs topologies (depending on the environment); - limitations of WSNs; - WSNs applications.	Formative, discussion questions: - What sort of device is WSN? Why has this technical tool acquired such a popularity recently? What needs does it meet in the modern society? - Describe the main constituting parts of a WSN and say what their functions are. - What are the main types of WSNs deployed, depending on the environment? Which

		questions about what are Wireless Sensor Networks and where and how they are used.				one is the most popular according to you and why? - Which of all limitations of WSNs is, in your opinion, the most difficult to overcome? Why? - In your opinion, which of all applications of WSNs is the most important and why?
38.	Main groups of sensors in accordance with their operational disposition; Wireless Sensors application in Precision Agriculture	This lesson allows the students to realize the important role, allotted to sensors in precision agriculture and to get acquainted with their functions and types. The lesson consists of a lecture ”Wireless Sensors Open a Gateway to Smart Farming”. The instructor and students will interact to answer questions about the three main functions of sensors within a system: 1.monitoring and control, 2. security and warning, and 3. diagnosis and analysis.	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - define the main types of sensors; - explain their functions; - describe their specific applications; - explain the principles of their operation; - present their classification in the form of a flow chart or a block scheme.	- Types of sensors; - Principles of their operation; - Classification of sensors; - Practical benefits as a result of the application of wireless sensors in agriculture; - Specific areas of application of wireless sensors.	Formative, discussion questions: - What sort of a device is a sensor? - What is the function of the wireless sensor nod? - What physical properties of the soil can sensors in WSNs measure? - What are the three main functions of a sensor in WSNs? - How many groups of wireless sensors are there according to their general functions? - What is the operation principle of a wireless sensor nod? - How can sensors, including the wireless ones, help the farmers in their work?

						- How do you understand the phrase at the end of the text that “prevention is better than cure” and what is the role of wireless sensors in this strategy?
39.	Wireless Sensor Network (WSN) and Internet of Things (IoT) in Precision Agriculture; The characteristics, the architecture and application of WSN and IoT.	This lesson allows the students to understand how the concepts ‘Wireless Sensor Network’(WSN) and ‘Internet of Things’(IoT) can support the contemporary agriculture. To explain, how these technologies can be applied in practice, a ‘Proposed System’ architecture is introduced. The lesson consists of a lecture: ”Wireless Sensor Network and Internet of Things in Precision Agriculture”. The instructor and students will interact to answer questions about the structure of WSNs and how IoT is designed. Also, the students will be able to provide examples	- lecture - case study - brainstorming	Upon completion of this unit, the students will be able to: - describe the WSN and IoT technologies - explain the work of the of multiple Sensor Nodes in a wireless communication-based environment - state the components and characteristics of wireless Sensor Nodes - give examples of WSNs application areas in relation to agriculture - define the structure of IoT -explain how IoT increase productivity and reduce costs	The Role of WSN and IoT in relation to Precision Agriculture; The Structure and application of WSNs; The way of working of the Sensor Nodes; IoT practical application in Agriculture	Formative, discussion questions: - How do WSNs collect information? - What is the IoT environment composed of? - Which part of Wireless Sensor Networks enables detecting of physical phenomena such as temperature, humidity, and moisture with limited energy and memory? - What are the application areas of WSNs? Provide examples. - Which are the main components of a Sensor Node? - How can farmers collect such data as: temperature, air humidity, soil humidity, volumetric water content unit (VWC) and gravimetric water content (GWC)?

		of agriculture applications based on IoT and how its objects communicate together.				- Which technology uses communication standards such as Wi-Fi, low-power Bluetooth, NFC, RFID? - In which areas can IoT be applied?
40.	Field information collection; mUAV-based WSNs (micro Unmanned Aerial Vehicle - based of Wireless Sensor Networks); mUAV-based RS (micro Unmanned Aerial Vehicle - based Remote Sensing); Multi-sensor monitoring system.	This lesson allows the students to explore various technologies and applications that improve the field information collection method. The lesson consists of a lecture "Field information collection: An air-ground multi-sensor monitoring system". The instructor and students will interact to answer questions about The existing benefits and limitations of WSNs, RS, mUAV-based WSNs and mUAV-based RS.	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - describe **WSNs** in terms of real-time agricultural environment monitoring, - explain **mUAV-based WSNs** systems in agricultural applications, their benefits and limitations; - define **mUAV-based RS** systems and state their benefits and limitations - define an **air-ground multi-sensor monitoring system**	Various techniques and applications to obtain field information, increase the production and optimize the overall farming practices	Formative, discussion questions: - What are the limitations and benefits of classic WSNs? - What is the communication workflow in mUAV-based WSNs architecture? - What are the limitations and benefits of mUAV-based WSNs? - What are mUAV-based RS systems? - What are the limitations and benefits of mUAV-based RS? - What systems does an air-ground multi-sensor monitoring system combine?
41.	Crop Monitoring System based on Wireless Sensors Network	This lesson allows the students to explore the structure of Crop Monitoring System,	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to:	- The main elements of the monitoring system, based on	Formative, discussion questions: - In what respect is IOT of crucial significance to

		which applies Wireless Sensors Network and to acquire understanding of its constituting elements, their roles and functions. The lesson consists of a lecture ”Crop Monitoring System based on Wireless Sensors Network”. The instructor and students will interact to answer questions about the essence of the system in question, its practical significance and application.		- define the constituting elements of the Crop Monitoring System; - explain their function; - describe the architecture of the hardware platform; - explain the circuit of sensor control matrix; - describe the architecture of operating system; - explain the operation of applied types of nodes.	Wireless Sensors Network; - the function of the various types of sensors and principles of their work. - The application of Internet of Things (IOT) in precision agriculture.	precision agriculture nowadays? - What are the main elements of the crop monitoring hardware platform? - What parameters does the environmental parameter acquisition platform collect? - What are the requirements to the design of the hardware platform? - How many parts are there in the crop monitoring network system? - What does the system kernel provide? - What tasks does the system software include? - How many types of nodes are implemented in the system? How do they function?
42.	Wireless Sensor Networks for Greenhouse (Parameter Control) - Part I	This lesson allows the students to learn about the use of Wireless Sensor Networks in green house technology as part of Precision Agriculture. The lesson consists of a lecture ”Wireless Sensor Networks	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - define Remote Application Server (RAS); -explain the Wireless sensors and smart transducers;	The outside sensor - designed for collecting information about the outside climate of the green house, such as	Task 1. Answer the questions to the text of the lesson. 1. What sort of devices are Wireless sensor nodes? What is their function? 3. What levels of networking are used when a large number of sensors are

		for greenhouse parameter control". The instructor and students will interact to answer questions about what GREEN HOUSE is – an upcoming technology in precision agriculture, which helps farmers to grow a high-quality crop. Special attention is paid to the application of Wireless Sensor Networks, which play a vital role in this technology.		- define Wireless communication protocols, such as 802.11, 802.15.4 and 802.15.5 - define Sensors based on time-domain reflectometer (TDR)	Temperature, Pressure, Light, Humidity, CO_2, Wind speed and wind direction. All these parameters provide information about the climate of the outside world.	connected wirelessly for greenhouse control? 4. When is a ZigBee sensor network used? And when a Remote Application Server (RAS)? 5. What systems of wireless sensors are used in a typical Precision Agriculture model of a green house? What is the function of each one? 6. How are the sensor nodes classified? Explain the characteristics of each class. 7. What is the main objective of a WSN system in Precision Agriculture? 8. What sort of information does an outside sensor collect? 9. Why is it necessary to monitor outside wind direction and wind flow in a typical green house control system? 10. How are soil sensors placed in respect to their density? What sort of information are they expected to collect? Task 2. Questions for discussion.

						1. Compare the green house method of growing crops with the traditional ones. What are the advantages and disadvantages according to you. 2. In what way the application of WSNs for green-house growing of crops reflects the digital reality nowadays? 3. What, according to you, is the economic and social effect of the application of WSNs for the green house method of growing crops? 4. What do you think, which of all types of sensors, listed in the text, are the most important? Why?
43.	Wireless Sensor Networks for Greenhouse (Types of Sensors and Controlling Parameters) - Part II	This lesson allows the students to become acquainted with three types of sensors: Sensor node 'A' which is an outside climate sensor, Sensor node 'B', which is an inside climate sensor, Soil sensor node type 'C' to monitor the soil conditions.	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - define Air Temperature Control; -explain the Humidity Control - define Soil Condition Control.	The greenhouse control is an event-based control system with a level crossing sampling technique. In this system, control is executed in an	Formative, discussion questions: - What is the function of each of the three types of sensors, applied in a green house? - What are the requirements about the minimum size of each parameter value? - What is necessary to be done to the temperature

		The lesson consists of a lecture ”Types of Sensors and Controlling Parameters in a Green House”. The instructor and students will interact to answer questions about WSNs to analyse the diurnal and nocturnal parameter control with natural ventilation, heating systems, screen control and sprinkler control as a primary control objective.			asynchronous way through the use of three types of sensors.	rate in both the diurnal and nocturnal state? - Temperature and humidity are controlled by the same actuators. Which of the two factors is given priority and why? - Why is the monitoring and control of soil condition of specific interest? What are the key parameters in this respect? - How many parts are there in an event-based controller? What are their functions? - How can economical wireless sensor nodes be developed for some parameters of the green house?
44.	Hog Farm Control System Using Wireless Sensor Networks for Environmental Monitoring and Facilities Control	This lesson allows the students to understand that monitoring and control of the quality of an indoor environment is of crucial importance for animal health and welfare and directly impacts productivity and quality. One of the ways to accomplish evaluation	- lecture - case study - brainstorming	Upon completion of this unit, the students will be able to: - define the environmental factors, considered by the systematic management of a hog farm; - explain the importance of environmental sensors;	Hog farm system structure and evaluation of animal welfare by wireless monitoring; Management of a hog farm indoor environment; the specific	Formative, discussion questions: - What sort of information should an ubiquitous hog farm system collect and monitor? - In respect to the system architecture, how many stages shall be there in the proposed ubiquitous hog farm system?

		of animal welfare is by wireless monitoring . The lesson consists of a lecture ”Hog Farm System Using Wireless Sensor Networks for Environmental Monitoring and Facilities Control”. The instructor and students will interact to answer questions about what is Environmental Monitoring and Facilities Control in relation to a hog farm and the uses of Wireless Sensor Networks to achieve it.		- define the various layers of a hog farm control system and the correspondent types of sensors; - describe diagrams about the hog farm system architecture. - describe a hardware scheme of data acquisition and facilities control.	application of wireless sensor networks for this purpose.	- How many layers is each stage/class composed of? What are they? What is the function of each layer? - What are the main elements of each layer? What is their function? - What sort of devices does the hog farm control facility consist of? - What are the main functions of the Application layer? - How many sub-layers are there in the middle layer? - Which layer provides users with the hog farm monitoring service, the hog farm facility control service, pig history management service and situation notice services, etc.?
45.	Implementation of Wireless Sensor Networks with a herd management system	This lesson allows the students to explore the phases of functioning of WSNs with herd management and to understand the mechanism of work of	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - explain the use of WSNs in herd management for data collecting; - understand, explain and describe flow charts	Application of Wireless Sensor Networks in the cattle monitoring system for: - wireless communications;	Formative, discussion questions: - What sort of challenges could arise in the application of Wireless Sensor nodes in the cattle monitoring system?

		sensor nodes in this specific application. The lesson consists of a lecture ”Implementation of Wireless Sensor Networks with a herd management system”. The instructor and students will interact to answer questions about what is cattle monitoring and how and why are WSNs recommended to be used in this field.		diagrams in relation to data collecting; - analyse diagrams about sensor node operational protocols; - define the phases of the proposed Implicit Routing Protocol (IRP).	- receiving data about cattle mobility; - creating a dynamic routing scheme.	- What are the advantages in attaching two antennas to the collar of the animal? - What question does the breaking up of a herd rise in relation to the function of WSNs? - Why does the behaviour of a herd need to be modelled in order to obtain a better function of WSNs? - What elements determine the radio connectivity range? - How does the open environment affect the received signal? - What problems can appear in the case of low power WSN? - Why is the connectivity between each animals’ collar often sporadic? - What is the function of the Implicit Routing Protocol in respect to the cattle monitoring system? - What is the characteristic of the data configuration phase and the data forwarding phase?

46.	Applications of Wireless Sensor Networks in the Food Industry (A General Overview) – Part I	This lesson allows the students to understand the importance of the application of WSNs in the Food Industry and to gain better knowledge on all factors that could potentially have a significant impact on the supply chain. The lesson consists of lecture ”Applications of Wireless Sensor Networks in Food Industry”. The instructor and students will discuss the perishable food products supply chain management with a special focus on the use of wireless sensors in refrigerated vehicles, containers, storage places, wineries, etc.	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - define WSN -based system for monitoring; -explain the applications of Wireless Sensor Networks in the Food Industry; - explain the information gathered by the WSN; - define Cold Chain Monitoring and Traceability	Successful supply chain logistics calls for an automated and efficient monitoring and control of all operations. The monitoring should allow establishing a better knowledge, detecting weaknesses, and optimizing the whole process, all things that potentially could have a significant impact on the supply chain.	Formative, discussion questions: - How can WSN-based systems for monitoring the productive cycle of wine in wineries be implemented and used successfully? - Why is temperature the most important factor in prolonging the practical shelf life of perishable food products? - What sort of sensors can refrigerated vehicles host? - Are the sensors, controlling the cooling used for other purposes as well? - Around what is the application for monitoring the fresh fish logistic chain built? - Why is sensor fusion proposed for the development of smart containers? - What are the positive features of the systems for intelligent containers, combining wireless sensor networks and RFID?

47.	Wireless Sensor Networks and the Food Industry (in a food factory, Environmental monitoring, Sustainable food production) – Part II	This lesson allows the students to understand that Environmental monitoring is a key aspect in food production. In this respect, WSNs are a convenient solution for the food industry, where production processes cannot be interfered for health reasons. The lesson consists of a lecture: ”Wireless Sensor Network Solution for Sustainable Food Production”. The instructor and students will interact to answer questions about WSN practical application in a food factory, discuss various parameters and sensors of WSNs in relation to the food industry. They will also discuss the challenges, related to the sensors selection and their integration with the WSN platform.	- lecture - case study - brainstorming	Upon completion of this unit, the students will be able to: - explain the importance of WSNs’ application in environmental monitoring in the food factories; - define measurable parameters, important for the food production industry; - describe sensors that measure those parameters - describe the WSN platform from both hardware and software points of view; - explain tests, conducted in meat factory facilities - analyse diagrams and flow charts about the WSNs in the Food Industry.	Environmental monitoring in Food Production; WSN setup - parameters and sensors, hardware-software design and deployment in food factory.	Formative, discussion questions: - Why is environmental monitoring , such as water and air quality monitoring, essential in food production processes? - Compared to the wired systems, what more functions can WSNs offer? - What are WSNs limitations? - What parameters can be measured in the meat production factory? - How can controlling the pH level help to avoid toxic effects? Provide examples. - Which sensors are used to measure the relative humidity and air temperature? - Which are the four capabilities required by WSN nodes?

48.	Wireless Sensor Networks and the Food Industry (Food Processing Companies, the Chill Chain and the Wine Industry) – Part III	This lesson allows the students to explore the various applications of Wireless Sensor Networks in the Food Industry. The lesson consists of a lecture ”Wireless Sensor Networks and the Food Industry”. The instructor and students will interact to answer questions about the specific applications of WSNs, their characteristics and requirements they have to meet.	- lecture - case study - brainstorming	Upon completion of this unit, the student will be able to: - understand the reasons for WSNs usage in specific areas of the Food Industry; - explain the mechanism of WSNs functioning; - define the stages of Chill Chain; - explain some issues connected with the application of WSNs in the Food Industry; - analyse diagrams and flow charts about the WSNs in the Food Industry.	Various Applications of Wireless Sensor Networks in Food Industry to prevent perishable types of food from spoiling and to enhance food security	Formative, discussion questions: - What parameters can be measured with the help of WSNs in the wine industry? - In which other segments of the Food Industry could WSNs be used aside from the wine industry? - How are sensors used with the fermentation process of wine? - What is the function of the WSNs in the process of wine storage? - What are the main steps in the Chill Chain? - Define ‘primary chilling’ and ’secondary chilling’. - How are WSNs used in the stages of the Chill Chain? - Whose responsibility is the primary and secondary chilling? - Why is the role of WSNs so crucial during the transportation of food goods? - What issues could sometimes preclude the implementation of WSNs in the food industry?