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Agriculture 4.0: Equipping young NEETs with basic & advanced digital and green skills

Module 5

Technologies used in Agriculture 4.0

Developed by

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Contents

1. Introduction

Following the analysis of the findings from the literature review and field research activities there is a strong need to train and upgrade rural young people to become attractive, employable and to take up central positions in the circular and regenerative economy.

Adapted training material will be further described and developed for practical implementation within our project. The training material will provide young / women NEETs with a package of digital learning resources designed based on the concept of micro-learning: short and coherent learning nuggets delivered in multimedia formats aiming to promote blended learning methodologies. The digital learning nuggets will include a variety of resources such as interactive games, podcasts, e-learning videos, interactive case studies, infographic resources, etc.

2. Content

Main objectives

Learn about the newest technologies used in agriculture: Agricultural Drones, Irrigation Controllers, Aeronautical Meteorology, Agricultural Sensors,

- Understand how and when to use new technologies
- Know the basic controls and specific areas of activity the new technologies can be used in
- Understand the basic EU regulations on the new technologies

Learning outcomes

By the end of this module learners will be able to:

1. Understand and determine the differences between different types of UAS, and UAS trends, will be able to determine which type of UAS is suitable for specific tasks, they will familiarize themselves with the regulation of UAS flights and therefore how to safely operate UAS when someone is familiar with them.

2. Learners will be able to define basic maneuvering, classify drone controls, explain basic navigation in drone operation and compare different navigation sensing in the drone. They will also be able to understand the general aspects of Human Limitations and the way they are related to various aspects of drone operations

3. Learners will be able to define basic irrigation methods meaning and significance, classify different types of automated irrigation, explain basic areas of activity in automatic irrigation and compare different pros and cons of the use of each one of them.

4. Learners will be able to identify weather conditions, how they affect drone flight and assess what to do. They will receive information on relevant facilities that produce aviation-specific weather forecasts for the purpose of flying as safely as possible in certain weather conditions.

5. Learners will be able to define the agricultural sensors' meaning and significance, classify different types of sensors and GPRS tracking devices, explain basic areas of use of the sensors, compare and select the appropriate one.

Learning contents

Modern farms and agricultural facilities operate quite differently than those a few decades ago. Advancements in technology helped tremendously to accelerate crop productivity, and decrease the amount of resources used like water, fertilizer, and pesticides, and the amount of chemicals that go into the natural ecosystem. These technologies help agricultural businesses be more profitable and sustainable while ensuring safer growing conditions and safer foods.

Agricultural Drones

The word "drone" is an everyday term for unmanned aircraft vehicle (UAV) or unmanned aircraft system (UAS) a pilotless aircraft that is controlled either by a remote pilot or flies automatically.

Drones in agriculture have several advantages and are one of the main tools that advance Precision Farming and Agriculture. Precision Farming and Agriculture is the science of using technology to increase efficiency, productivity, crop output, and profitability. Through drone photogrammetry, drones can assist farmers in building extremely precise maps and 3D models of their farm. Through the usage of drone mapping software, images taken by drones are stitched together to create a topographical map of the area. Drones can work with a variety of cameras depending on the kind of data that the farmer needs – for example, multispectral cameras, thermal cameras, etc.

Drone Types Used in the Agricultural Sector

There are mainly two types of drones that are widely used in the agricultural sector: Fixed-wing and Multi-rotor. Fixed-wing characteristics:

- Fixed-wing looks more like an airplane than a helicopter.

- Fixed-wing drones are more durable than Multi-rotor drones, they can resist extreme weather conditions and often have longer flight times.

- They also require bigger landing and takeoff space due to their design and are usually more expensive. In essence, they require a runway to fly.

- Fixed-wing drones (as opposed to 'rotary wing', i.e. helicopters) use a wing like a normal aeroplane to provide the lift rather than vertical lift rotors.

Multirotor drones can have several propellers, which, combined with the varying speeds of the motors, create lifting power and movement. A quadrocopter drone has four arms and four propellers: two propellers spin clockwise (CW) and two propellers spin counter clockwise(CCW). In this way, the total rotational force becomes neutral.

Multi-rotor drones are far more adaptable than fixed-wing drones. They are simpler to fly and considerably less expensive. Apart from photogrammetry, they can be utilized for precision spraying of seeds, fertilizers and pesticides. Multirotor basic characteristics:

- Multi-rotor drones are easy control and maneuver
- They have the ability to hover
- They can take off and land vertically
- They have a limited flying time (pending on layout between 15-30 minutes).
- They only have small payload capabilities.
- Most of the drone's energy is spent on fighting gravity and stabilizing in the air.

What kind of drone is suitable for your tasks?

Depending on what kind of task you want the drone to do you should choose between a fixed wing and a multi-motor. Large drones will lift heavy loads while small ones are easier to navigate and perform photogrammetry. When you make your decision assessing flight time and payload is important.

Maximum Take-Off Mass (MTOM)

MTOM is the maximum mass defined by the manufacturer. It included all the elements onboard the drone: structural elements, motors, propellers, electronic equipment, antennas, batteries and

maximum capacity of fuel, oil and other fluids. It's essentially the heaviest payload allowed by the manufacturer including sensors and equipment.

UAS Regulation

The new EU regulations establish three (3) categories of drone operations with different safety requirements, proportionate to the risk involved:

Open Category

Low risk operations that do not require prior authorizations. It can be as simple as 'Buy & Fly'. However, they are limited to operations:

- in visual line of sight (VLOS)
- below 120 m altitude
- below 25kg MTOM (Maximum Take Off Mass)
- minimum age for remote pilots is 16 years old
- no flying over assemblies of people
- no dropping off goods
- no carriage of dangerous goods
- no autonomous flights (uploading waypoints is allowed)
- performed with a drone compliant with the technical requirements defined in the regulation.

To demonstrate this compliance drones that can be operated in the Open category will bear a class identification label, called 'C Class'. Additional operational restrictions apply to each class of drone, in particular with regard to the distance that must be maintained between the drone and uninvolved persons.

Specific Category

Medium-risk operations that exceed the restrictions of the "open" category. Operations involving drones of more than 25kg MTOM and/or operated beyond visual line of sight (BVLOS) will typically fall under the "specific" category. In such a case, operators must either (a) perform a risk assessment using a standardized method called the 'SORA' (Specific Operations Risk Assessment) and define mitigation measures or (b) verify that they comply with a specific scenario defined by EASA (or the national aviation authority). On that basis, they will be able to obtain authorization from the national aviation authority (in some cases a simple declaration may be enough). The authorization or the specific scenario will define the authorized operation and the applicable mitigation measures (drone technical requirements, pilot competence, etc.)

Certified Category

This category includes high-risk operations involving large drones in controlled airspaces. Rules applicable to the "certified" category will be the same as for manned aviation: drones must be certified for their airworthiness, pilots shall be licensed, and safety oversight will be performed by the relevant National Aviation Authorities and EASA.

➢ **Subcategories of UAS operations**

The 'Open' category of operations is divided into three Subcategories: A1, A2, A3, on the basis of operational limitations, requirements for the remote pilot and technical drone requirements. In other words, each Subcategory specifies where you can fly, what type of drone to use and what type of certificate(s) the remote pilot must have in order to comply with the regulations.

Subcategory A1: Use of small drones with Maximum Takeoff Mass (MTOM) up to 900g, can fly over people but never fly over assemblies of people, be familiarized with the drone manual and pass an online theoretical examination. Privately built drones can be used in this subcategory but they must have an MTOM < 250g and comply with the requirements of this category. Drones with C0 or C1 class mark can operate in this subcategory.

Subcategory A2: Use medium size drones with MTOM up to 4kgs, can fly close to people by keeping a horizontal distance of 30m from uninvolved persons or 5m when the drone is equipped with a low speed mode, never over assemblies of people, be familiarized with the drone manual, pass an online theoretical examination and pass an additional knowledge examination at an

approved organization. Only drones with C2 class mark can operate in this subcategory. The minimum horizontal distance of the UA from uninvolved persons should be defined as the distance between the points where the UA would hit the ground in the event of a vertical fall and the position of the uninvolved persons. As a reference, when the UA is operating in close proximity to people, the remote pilot should keep the UA at a lateral distance from any uninvolved person that is not shorter than the height ('1:1 rule', i.e. if the UA is flying at a height of 30 m, the distance from any uninvolved person should be at least 30 m). In any case, the distance from uninvolved persons should always be greater than: (1) 5 m, when the lowspeed mode function on the UA is activated and set to 3 m per second; (2) 5 m, when operating a UAS balloon or airship; or (3) 30 m in all other cases.

Subcategory A3: Use of larger drones with MTOM up to 25kgs, must fly far from people, keep a horizontal distance of 150m from residential, commercial, industrial or recreational areas, be familiarized with the drone manual and pass an online theoretical examination. Privately built drones can be used in this subcategory but they must have an MTOM < 25kg and comply with the requirements of this category. Drones with C2, C3 or C4 class mark can operate in this subcategory.

Basic Agricultural Drone Navigation

How to fly UAS in the open category

In order to fly UAS in the open category it is mandatory to pass theoretical exams with a minimum grade of 75%. For the A1 or A3 subcategories knowledge in the following fields is needed:

- Air safety
- Airspace restrictions
- Aviation regulations
- Human performance limitations and operational procedures
- Privacy and data protection
- Insurance and aviation security

- General knowledge of UAS.

Additionally for A2 subcategory knowledge in the following is needed:

• Familiarity with meteorology

• How to manage risks by flying close to the ground and near people

➢ **Pilot certificate, UAS class and CE Marking Pilot Certificate**

All remote pilot certificates are recognized and accepted in all EU members. Furthermore, the remote pilot can choose in which EU member state to conduct the training/exam. CE Marking Indicating that the product has been tested and meets the specific requirements, shall also be visibly affixed to the frame of the UAS. UAS class UAS authorized to fly in the open category are divided in 5 classes from C0-C4. It is based on:

• MTOM

• Technical specifications

• Automatic functions

• Performance of the aircraft

➢ **UAS operator and Remote Pilot**

UAS operator: A UAS Operator is a physical person or organization responsible for one or more UASs and is responsible for the entire operation.

Remote Pilot: A remote pilot is a person operating the UAS flight controls manually or when the UAS flies automatically by monitoring its course and remaining able to intervene at any time. Notice: The operator is usually the same natural person as the remote pilot when it comes to private use. But if a company is responsible for the UAS, the operator is usually a legal and not a natural person.

➢ **Registration of UAS operator**

Remember that it is mandatory to register as a drone operator. To do so, register on the relevant national website, display the registration number on the drone, and upload it on the remote identification system.

➢ **Responsibilities of the Operator**

Some of the main responsibilities of the operator goes as followed. An operator must:

• Develop operational procedures adapted to the type of operation and the risk involved.

• Ensure that all operations effectively use and support the efficient use of radio spectrum in order to avoid harmful interference.

• Designate a remote pilot for each UAS operation

• Ensure that the remote pilots and all other personnel performing a task in support of the operations are familiar with the user's manual provided by the manufacturer of the UAS

• In the case of an operation with a UAS of one of the classes C0, C1, C2, C3, C4, ensure that the drone is complying with the legislation and the rules.

➢ **Responsibilities of Remote Pilot**

In order to read the responsibilities of a remote pilot please follow the link below: https://www.easa.europa.eu/document-library/easy-access-rules/onlinepublications/easy-access-rules-unmanned-aircraft-systems?page=5#_Toc256000070

➢**Discontinuation of flight and reporting procedures**

Discontinuation of flight It is important to know that the remote pilot should discontinue the flight if the operation poses a risk to other aircraft and that he/she must maintain a thorough visual scan of the airspace to avoid any risk or a collision with manned aircraft.

Reporting procedures

If an accident or incident occurs while you are flying, you must report it to the Department of Civil Aviation. It is mandatory to report an accident under the following circumstances:

1) When someone is seriously injured.

2) When there has been an accident with fatal outcome

3) When the occurrence involves manned aircraft (airplanes, helicopters etc.)

Basic Navigation in Drone Operation: Specifics of Delivery

There are four main drone controls:

- Roll: Done by pushing the right stick to the left or right. Literally rolls the drone, which maneuvers the drone left or right.
- Pitch: Done by pushing the right stick forwards or backward. Tilts the drone, which maneuvers the drone forwards or backward.
- Yaw: Done by pushing the left stick to the left or to the right. Rotates the drone left or right. Points the front of the copter in different directions and helps with changing directions while flying.
- Throttle: To increase, push the left stick forwards. To decrease, pull the left stick backward. This adjusts the altitude, or height, of the drone.

Human Limitations and how they relate to various aspects of drone operations

One of the most decisive factors in terms of the successful implementation of a drone's flight is the state in which the operator is, in what is generally called the human performance factor and its limitations. Each human being is unique and different situations may affect people in a variety of ways. But in the quest for responsible decisions and reliable, safe outcomes, a set of rules has been established. Factors that may influence a pilot's performance:

1. Stress
2. Psychoactive Substances or Alcohol
3. Medication
4. Fatigue

5. Accuracy of senses (sight, hearing, smelling, touching)

6. Peer Pressure

7. Automation

Aeronautical Meteorology in Agriculture (Agricultural Meteorology)

Agricultural meteorology draws on basic physical and biological sciences to discover, define, and apply knowledge of weather and climate to the production of food-, feed-, fiber-, and bio-based products. Agricultural meteorology is based on fundamental principles of radiation and surface aerodynamics and thermodynamics.

For any farmer or professional working in agriculture, the benefits afforded by digital technology can be of huge advantage to crop management. Monitoring local and global weather patterns is critical to helping farmers to prepare for the worst when extreme weather is likely to hit.

Apps that could be useful to farmers:

- Strawberry Advisory System: this highly useful free app allows strawberry producers to keep their crops free of devastating fruit rot like Botrytis and Anthracnose.
- AgroForecast
- Weather Impact
- AccuWeather

Aeronautical Meteorology and Drone Flights

A special branch of meteorology that supplies drone owners and operators with weather forecast is called Aeronautical meteorology. Weather conditions affect almost every aspect of our lives. Until the development of computers and smartphones, hydrometeorological institutions informed general public about the weather forecast through available media. Today, weather forecast is available through apps that can be easily downloaded to the smartphones. This fact

facilitates the work of a drone operator who can easily obtain information about weather conditions in real time. A drone operator poses an increased risk to people and objects on the ground and therefore he/she must have extra knowledge about how the weather and meteorological conditions affect drone and flight. The flight can be affected by different meteorological factors:

• Windy weather: Both the drone's ability to move through the air and its balance can be disturbed by strong winds. It is important to make sure that the payload is properly secured and attached; The wind can blow the drone off its desired route or make it difficult to control.

• Humid weather: Many drones are sensitive to rain, fog and snow. Drones can also attract lightning and, in addition, some of the drone's sensors can be adversely affected during rainfall or fog.

• Cold temperatures: The risk of ice build-up on the propellers and batteries getting cold at freezing temperatures must be considered.

• Air density: The propellers has less air resistance, the thinner the air is. The air gets thinner at higher altitude.

• Turbulence: Mechanical turbulence may affect your drone if you fly between buildings, mountains or other high objects that interfere with the even flow of the air. Regardless of the subcategory drone operator fly in, before each flight one must check the weather forecast for the period when he/she plans to fly and to always be aware of drone's limitations.

Irrigation controller

An adequate water supply is important for plant growth. When rainfall is not sufficient, the plants must receive additional water from irrigation. Various methods can be used to supply irrigation water to plants. Each method has its advantages and disadvantages. These should be taken into account when choosing the method which is best suited to the local circumstances. Sophisticated methods of water application are used when larger areas require irrigation. There are three commonly used methods: surface irrigation, sprinkler irrigation and drip irrigation.

- Surface Irrigation: Surface irrigation is the application of water by gravity flow to the surface of the field. Either the entire field is flooded (basin irrigation) or the water is fed into small channels (furrows) or strips of land (borders).

- Sprinkler Irrigation: Sprinkler irrigation is similar to natural rainfall. Water is pumped through a pipe system and then sprayed onto the crops through rotating sprinkler heads.

- Drip Irrigation: With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Only the immediate root zone of each plant is wetted. Therefore this can be a very efficient method of irrigation (Figure 6). Drip irrigation is sometimes called trickle irrigation.

Automatic Irrigation

Automatic irrigation is the use of a device to operate irrigation structures so the change of flow of water from bays can occur in the absence of the irrigator.

Automation can be used in a number of ways:

- to start and stop irrigation through supply channel outlets
- to start and stop pumps
- to cut off the flow of water from one irrigation area — either a bay or a section of channel and directing the water to another area.

These changes occur automatically without any direct manual effort, but you may need to spend time preparing the system at the start of the irrigation and maintaining the components so it works properly.

Benefits of automatic irrigation

The benefits of automatic irrigation are:

- reduced labour
- timely irrigation — plants being watered when needed

- management of higher flow rates
- accurate cut-off of water compared to manual checking
- reduced runoff of water and nutrients
- reduced costs for vehicles used to check irrigation.

Disadvantages of automatic irrigation

The disadvantages of automatic irrigation are:

- costs for purchasing, installing and maintaining the equipment
- reliability of irrigation system (due to human error when setting up)
- increased maintenance of channels and equipment to ensure it is working properly.

Developing an Automatic Irrigation System

Before installing automatic irrigation develop a whole farm plan for your property.

During the development of the farm plan, consider automatic irrigation in the planning process so you can incorporate some of the features required for automation from the start. This might involve design of the channels for channel automation if possible — or it might be the use of bay outlets and other channel structures that will suit automation at a later stage.

Installing the automatic irrigation

When it comes to installing the irrigation there are a number of ways of getting started.

1. Automate the areas chosen for irrigation at night time — so appropriate irrigation flow rates can be achieved.

2. Automate those areas that are difficult to irrigate — areas of short steep bays that require the irrigator to be present more often or require frequent changes.

Things to be aware of

Automation is not only suited to areas of the farm that have been laser-graded. Non-lasered areas can also be automated. This can include automation of the channel structures to irrigate sections of the non-lasered areas.

Using the information from a whole farm plan— channel structures that will be used when the development works are carried out — can be purchased and used to automate these non-lasered areas. This can be done with the knowledge that the structures will be suitable for use after the development work is carried out.

Choosing the best-automated irrigation

All systems of automation have advantages and disadvantages that need to be considered when deciding which system will suit the irrigation layout for a particular property. There is no system that will be the best system for all properties. If a system that can be moved around the property, and perhaps used on other properties, is required then you need to consider systems that are portable.

If you want a system where the components are fixed and can follow the same irrigation sequence each irrigation — a fixed system would be more appropriate.

In determining the best system for a property, you will need to consider:

- the cost of the system
- back up servicing of the system
- which system will best suit your property and irrigation layout.

Types of automatic irrigation systems

Pneumatic system:

A pneumatic system is a permanent system activated by a bay sensor located at the cut-off point. When water enters the sensor, it pressurizes the air, which is piped to a mechanism that activates the opening and closing of irrigation structures.

Portable timer system:

A portable timer system is a temporary system which uses electronic clocks to activate the opening and closing of the irrigation structures. Because of its portable nature, 4 or 5 units are usually purchased to move around the whole property.

Timer or sensor hybrid:

As the name suggests, this system is a hybrid of portable timer and sensor systems.

Like a portable timer, it uses an electronic device to activate the opening and closing of the irrigation structures.

This system has an additional feature of the irrigator being able to place a moveable sensor down the bay. When it comes in contact with water, transmits radio signals to the timer devices at the outlets to open or close the structures. It then sends a radio message to a receiver to let the landowner know water has reached the cut-off points down the bay.

Supervisory Control and Data Acquisition (SCADA)

Automation systems that use SCADA consist of a personal computer and software package to schedule and control irrigation via a radio link. Signals are sent from the computer to control modules in the paddock to open and close irrigation structures with linear actuators. Bays are opened and closed on a time basis. Some systems have the capacity to automatically alter the time a bay outlet is open, if the channel supply is inconsistent. SCADA based systems have the additional benefit of being able to start and stop irrigation pumps and motors.

Automating an irrigation layout

An irrigation layout can be automated at one of two places — in sections of channel or at individual bay outlets.

Automation of channel sections

In this system, the channel structures are automated allowing the channel level to be changed. The bay outlets do not have opening or closing structures rather each set of outlets is set at a specific level (such as a set of sills). This method of automation requires a larger amount of fall to be available in the channel system to allow for a change in water level between different areas.

This change in water level is required to prevent water flowing onto bays previously irrigated, when another section is to be irrigated. On many farms, this fall is not available, so this method of automation in many cases is not suitable.

Automation of individual bay outlets

This method of automation involves control of the bay outlets to change the flow of water onto the areas being irrigated. This system of automation is the most frequently used in areas where there is insufficient fall to automate channel sections. The same type of automatic devices available can be set up to operate either automation of channel sections or automation of bay outlets.

Agricultural Sensors and GPS tracking devices

Precision agriculture sensors are very efficient in agriculture because they transmit data that helps farmers not only to monitor but also to improve their products and keep abreast of changes in the field and ecosystem. Intelligent agricultural sensors help to easily identify animals, detect heat and monitor their health, thus facilitating the isolation and healing of sick cows by identifying, detecting, and following herds. Using smart sensors in agriculture, farmers can now record their crops and keep an eye on their effectiveness remotely, address crop pests and take swift action to protect their crops from any risk to the environment.

What type of sensors are used in Agriculture?

A sensor is a gadget that perceives and responds to certain inputs which could be illumination, locomotion, pressure, heat, or moisture, and transforms it into a representation or signals that can be read by humans for further reading and processing. There are various types of sensors used in agriculture that enable the need for smart agriculture incorporation.

Optical Sensors In Agriculture

This is the use of light to evaluate soil materials and track countless light prevalence. These sensors can be positioned on automobiles, satellites, drones, or robots thereby enabling the soil

to reflect and the gather and processing of plant color data. Optical sensors also have the ability and capacity to condition the clay, natural matter, and humidity properties of the soil.

Electrochemical Sensors For Soil Nutrient Detection

The electrochemical sensors aid in the collection, processing, and mapping of the chemical data of the soil. They are usually mounted on specially designed sleds. They supply accurate details required for agriculture. This includes the nutrient of the soil levels and pH. The soil samples are then sent out to a soil testing lab and standard procedures are carried out. Error-free measurements especially in the area of determining pH are carried out with the use of an ion-selective electrode. These electrodes notice the pursuit of specified ions, such as hydrogen, nitrate, and potassium.

Mechanical Soil Sensors For Agriculture

These sensors are used to measure soil compression or mechanical opposition. This sensor uses an application that passes through the soil. This sensor then records the force calculated by pressure scales or load cells. When a sensor passes through the soil, it documents the holding forces that result from the cutting, smashing, and displacing of soil. Soil mechanical resistance is recorded in a unit of pressure and points out the ratio of the force necessary to go into the soil channel to the frontal area of the tool engaged with the soil.

Dielectric Soil Moisture Sensors

This sensor calculates the moisture levels in the soil with the assistance of a dielectric constant. This is an electrical property that substitutes depending on the moisture content in the soil. The moisture sensors are used in association with precipitation check locations all around the farm. This allows for the scrutiny of soil moisture positioning when vegetation level is low.

Location Sensors In Agriculture

They are also known as agricultural weather stations. They are positioned at different places throughout the fields. These precision agriculture sensors are used to determine the variety, distance, and height of any position within the required area. They take the help of GPS satellites for this purpose.

Electronic Sensors

They are installed on tractors and other field equipment to check equipment operations. Data are transmitted via cellular and satellite communication systems to computers or mailed to individuals directly. The supervisor in charge can now have access to the information either on their office computer or their personal cell phones.

Airflow Sensors

Its measurements can be made at particular locations while on the move. They measure soil air penetration. The expected result is the pressure needed to push a decided amount of air into the ground at a prescribed depth. There are various soil properties, including moisture levels, soil type compaction, and structure, which produce a different identifying signature.

Agriculture Sensors IoT

With the increase in adoption of the Internet of Things (IoT) the ability to connect various devices have being implemented in virtually every aspect of our life. It only makes great sense that automation also finds its own application in agriculture as it will have a great impact on it.

This sensor provides real-time information on what is happening on the field such information including air temperature, soil temperature at various depths, rainfall, leaf wetness, chlorophyll, wind speed, dew point temperature, wind direction, relative humidity, solar radiation, and atmospheric pressure.

This indicates that farmers are in the know-how of when their crops are due for harvest, the quantity of water being used, the soil health, and if there's a need for any additional input. This is measured and recorded at scheduled intervals. There is a big list of sensors used in agriculture IOT sensors which means (Solutions for Smart Farming). Making use of precision agriculture sensors will definitely transform the agricultural industry by increasing crop production, adopting a pest-free high-yield variety in crops, and keeping up with the increasing demand for food.