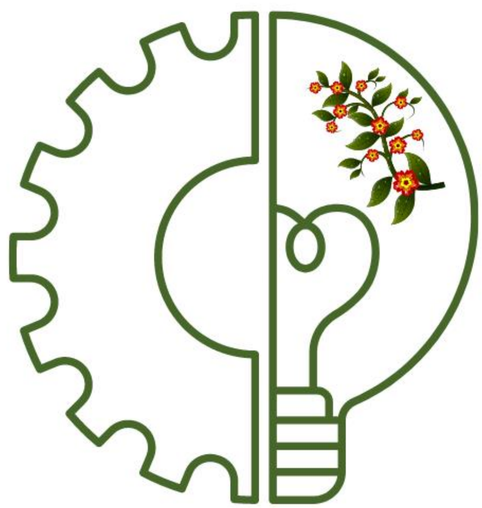
Co-funded by the European Union

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

Module 3

Challenges of today’s agriculture that Agriculture 4.0 solve



Developed by

Cámara Oficial de Comercio de España en Bélgica y Luxemburgo

Disclaimer:

This project is funded with the support of the European Commission.

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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

The food crisis, triggered by the wheat war, is the ghost that nowadays lurks in the Mediterranean and the world, after the UN warned that the nightmare of food shortage could materialize.

We have discovered how fragile the world is during the pandemic and the lockdown, when supply chains have been disrupted. We have experienced firsthand the upheavals during the last torrid seasons, due to climate change.

The food system it became fragile by the pandemic, is now in danger of coming out with broken bones due to the energy shock, the drought caused by climate change and now the war.

The increase in food prices

The price of cereals has risen globally by 53% since the beginning of the war, triggering, among other things, an inflation that has not been seen for decades in the West, where we lived pre-pandemic in the so-called deflationist century. But the price of wheat rose by a further 6% last May 16 when India due to a heat wave, announced that it would block exports, for fear that famine will hit the country, just as an example amongst other cases around the world.

The explosion of poverty

Extreme poverty could therefore quadruple, while people who do not have basic food or enough food to live could reach 250 million and therefore could die of hunger.

The rise in prices and the impact on food shortage

Meanwhile, in this scenario of war of political and social uncertainty, the price of wheat rises, cannibalizing profit margins, due to the increase in the prices of fertilizers and energy. The main costs that weigh on farmers' budgets are rising sharply, due to sanctions. Without fertilizer, field productivity could also collapse vertically. Global yield could drop to its lowest ever levels.

In fact, a fifth of fertilizer exports are restricted, and this will cause a devastating impact on the food crisis: world hunger can only increase.

Introduction to Proposed submodules

To address today's agricultural challenges, technology offers a wide range of possibilities to ensure the food security of countries in the future. Mentioning an interview with Andrea Bacchetti (Smart AgriFood Observatory of the Milan Polytechnic and the University of Brescia): "Agriculture 4.0 cannot provide the definitive solution, however, the Agriculture 4.0 paradigm has characteristics that can help mitigate the effects and bring home the lesson that the pandemic should have already taught us to speed up the transition. In fact, the Agriculture 4.0 market is growing at a significant rate. In the space of three years, we have gone from a turnover of scarce 100 million to 1.5 billion euros. Furthermore, there are more than a thousand agricultural solutions on the market and thousands of companies have already adopted at least one 4.0 technology. "

Produce more with less inputs

Producing more became a necessity as the human population is growing and we must meet people's food needs, in a scenario of strong population growth globally. Furthermore, producing more with fewer resources increases the level of independence regarding supplies coming from abroad and in case of resource scarcity given by climate change and poor management of available resources.

Not in the short, but in the medium-long term, if companies invest in these tools, Agriculture 4.0 represents a paradigm for increasing independence from the supply chain on which it is said that we can no longer count.

Precision Agriculture, aka agriculture 4.0, is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production

Precision Farming can potentially help farmers produce higher yields, less crop damage and fewer inputs such as water, fuel and fertilizer. The European Joint Research Center estimates that PA can make a huge CO_2 saving contribution in European agriculture until 2030. Using fewer inputs means reducing the purchase of products that are in short supply or whose costs have greatly increased, further reducing the margins that companies generally use to invest and trigger the driving force to increase the level of digitization of agricultural production processes".

"Furthermore, the smart parallel drive tractors allow you to work the same field surface, using less diesel, because the parallel drive avoids going over the same spot several times: on large surfaces it significantly reduces fuel consumption.

As mentioned before, agriculture is squarely in the midst of the fourth industrial revolution. Emergent, game-changing technologies are driving economic, environmental, and social change in the global food system. And in the face of rising hunger, populations and a changing climate, everyone from policy-makers to billionaires is paying attention.

The US Association of Equipment Manufacturers published a study in February 2022 investigating how new technologies might help farmers do more with less. On average, new technology trailers achieved a 4 percent increase in crop production, 7 percent reduction in fertilizer use, 9 percent reduction in herbicide use, 6 percent reduction in fossil fuel use, and 4 percent reduction in water use.

Traceability and transparency of goods, food security and Farm to Fork Strategy

Another important issue is that of the discontinuity of supply chains, due to the war on wheat triggered by the conflict. In the livestock sector, companies are struggling to receive feed and grain from the usual suppliers, perhaps involved in the conflict. Companies are forced to suddenly change suppliers, without being able to carry out a preventive assessment of the quality of the feed or grain purchased. It happens that customers are buying blind folded: the verification of the quality, traceability and transparency of where and how the goods were harvested and produced takes place only after the purchase has been made.

However, technology exists to monitor the quality of supplies, traceability and thus evaluate the change of suppliers based on the data.

The Commission will step up its coordination of a common European response to crises affecting food systems in order to ensure food security and safety, reinforce public health and mitigate their socio-economic impact in the EU. Drawing on the lessons learned, the Commission will assess the resilience of the food system 28 Regulation (EU) No 1308/2013 of the European Parliament and of the Council and develop a contingency plan for ensuring food supply and food security to be put in place in times of crisis. The agricultural crisis reserve will be revamped so its full potential can be used upfront in the case of crisis in agricultural markets. In addition to risk assessment and management measures to be activated during crisis, the plan will set up a food crisis response mechanism coordinated by the Commission and involving Member States. It will be comprised of various sectors (agriculture, fisheries, food safety, workforce, health and transport issues) depending on the nature of the crisis.

IoT 8 (The internet of things) devices and Real-time monitoring, early detection (through sensors) or prediction (through models)

Another valuable technology in the current scenario concerns "IoT sensors to assess the level of grain stocks in major warehouses, to answer a crucial question: how long can I tolerate shortages of grain based on the stocks I actually have in the silos? Digital can answer this question, thanks to IoT (Internet of Things) sensors in silos that would be able to monitor the level of stocks in real time. The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing on the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.

How does IoT work?

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data that they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access to the data.

We should at least sensorize large agricultural consortia and collection centers, without expecting a capillary implementation, to provide adequate estimates. Thanks to IoT devices, we would have a situation under control to assess until we are covered, if we have to take countermeasures in case of difficulties related to the actual situation based on the data".

Real -time monitoring is crucial. In fact, Europe must not only feed its population, but it is also an exporter of goods, so it also buys crops to process them and export: our agro-food chain is put to the test. "Instead, no one knew what the level of the silos was at the outbreak of the conflict due to the absence of IoT sensors where they would be needed. We have not yet learned the lesson of the pandemic; we hope that this tragic conflict will leave us as a positive legacy the need to monitor the real situation with IoT sensors "

Farmers are applying Internet of Things (IoT) technology to track crops remotely, using sensors to detect weed growth, water levels and pest invasion. And we're not only seeing this on traditional farmlands. Farm66, located inside a Hong-Kong skyscraper, is using IoT to help manage a 2,000-

square-metre indoor farm. The IoT-enabled agricultural industry is estimated to reach US$4.5 billion by 2025.

In China, drones are being used to survey 20 million hectares of cotton, providing insights into pest protection, fertilizer and herbicide application, irrigation, and harvest timing to drive productivity.

Meanwhile, AI and machine learning are being deployed across Australia's changeable environment to predict weather conditions, temperature, water usage and soil conditions.

Commercial tools and services for smart farming that make extensive use of machine learning are currently available to farmers. A few examples are as follows. Plantix, created by the German startup Progressive Environmental and Agricultural Technologies (PETA), is an android-based farming assistant tool that provides crop health information, helping with identification of plant diseases using computer vision and deep learning techniques. Other examples of similar applications are Agrio and CropDiagnosis. Gamaya is a startup company based on Switzerland that offers a wide variety of smart farming services based on the analysis of images acquired by drones connected to IoT systems. The Asian iFarmer is another company that offers IoT-based soil analysis and satellite imaging-based crop monitoring solutions. See & Spray, developed by California-based Blue River Technology, is a large tow-behind herbicide sprayer, that uses computer vision and deep learning-based algorithms to automatically locate and identify weeds (in real time), applying herbicides to the specific locations found rather than to the entire field. Some related surveys can be found in the literature, but most of them are focused on traditional ML techniques: a comparison of ML algorithms for predicting the yield of soybean crops is presented; the possibility of using different ML techniques in agriculture are discussed, but most of the present work is about statistical forecasting methods from weather data for predicting wheat yield. Since the mentioned surveys do not simultaneously cover forecasting, detection, and classification of diseases and pests, and do not fully explore recent deep learning-based techniques, the review performed in this paper aims to fill the gaps on these subjects. The literature review presented in this module aims to provide an early guidance on the development of such ML-based tools, in order to provide farmers with data-driven decision-making assistance systems. In this way, farmers can be assisted with lowering the need for pesticide application and the harm that comes with it, while also preserving and enhancing crop quality and yield. This contributes to the continued availability of food to meet global population demands while doing less damage to the planet.

The application of ML-based techniques has promoted the emergence of projects that have enriched the development and the evolution of smart farming. Literature Review Data gathering, data pre-processing (i.e., data preparation that includes feature extraction), and ML classification models are the three basic steps of ML applications, represented in *Figure 1.*

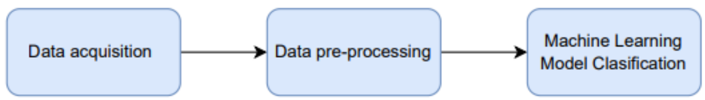

Figure 1. Simplification of the ML pipeline.

The following sections present and discuss different approaches used in these three stages. Data acquisition Data pre-processing Machine Learning Model Classification Figure 1. Simplification of the ML pipeline.

Big data in the field

Big data will play an increasing role in agriculture. “But currently we would be satisfied with seeing small data managed, the very normal data in the hands of farms and contractors: the latter, due to the nature of their work (cooperating with multiple farms and multiple stages), have a mine of data. They could also develop a business: alongside the activity in the field, the contractor could act as a consultant, collecting data, processing it and making it available to customers. However, currently contractors fill up on GBytes of data in order to bill and then overwrite, as sadly there is, any market yet is using this mine of data to improve productivity.

In many EU rural areas, Internet access is limited, and this holds back the use of big data.

Big Data has enormous potential to radicalize the industry by reducing future variables and uncertainty. Relying on cloud computing to analyses massive data sets, farmers can closely monitor environmental conditions in real-time.

Data acquisition is the process of gathering data from various sources systems. Previous studies gather their data various sources to be used for ML techniques. Some of them produce their own images by taking pictures of plants in greenhouses, such as in the studies from Gutierrez et al. and Raza et al. However, image data acquisition using manual processes, as done by many, generally results in small image data-sets, which can compromise the development of effective ML-based models. Weather data collection is also proposed in the literature using for instance sensors in greenhouses, as done by Rustia and Lin Meteorological data can also be obtained from weather stations of regional areas, which typically store records for a longer period of time. Images can be collected using search engines on their own [This approach can get a large number of images, but ground truth must be checked by domain experts, and data cleaning is frequently used to filter out images that do not meet the requirements. Remote sensing images from satellites and drones have the advantage of being able to retrieve image data for large agricultural areas. Remote sensing data from satellites typically consists of multi-temporal and hyper-spectral imagery data, which can be used to assess the development of the crops. This task can be performed by monitoring the evolution of vegetation indices which provide important information about the development status of the crop fields. Spectral imagery can be used for computing different vegetation indexes, such as those proposed in which are robust to variations on the sun illumination, an important advantage when compared to visible light spectrum imagery. Images retrieved from drones can also be used but have additional needs: to define the path of the device; to coordinate the drone position with the camera for image acquisition; and to correct geometric distortions on each acquired image in order to merge the different acquired images in order to reconstruct a larger image of the whole field. Therefore, it can be stated that data consists of different modalities and variables. With ML-based and data analysis techniques it can be possible to understand their interaction and how they relate to a studied outcome. In the context of the cultivation fields, the questions are usually: which disease is affecting crops? What pest is causing damage? What is the relation between weather data and disease and pest occurrence? Freely available data-sets can also be utilised for the development of ML-based applications. This enables researchers to directly compare the performance of different ML techniques and approaches. The data conditions a significant impact on the performance of ML models. Data-sets should be representative and include enough records for the model to perform an effective generalization.

By 2025, the agricultural Big Data market alone is estimated to hit US$1.4 billion.

The promise of enhanced profitability is causing quite a stir in the private sector. Agritech startups have grown by more than 80 percent since 2012. Amazon's Jeff Bezos and tech billionaire Eric Schmidt are getting on board. Along with the world's largest technology-focused investment fund, they're injecting around US$200 million into vertical indoor farming startup 'Plenty'. Bill Gates and Richard Branson, along with food conglomerate Cargill, are also making a play.

The EU is pushing for a digital revolution within the agricultural sector by supporting specific schemes and offering financial incentives to farms.

But industry believes that costly compliance with EU legislation will hamper future innovation. According to industry, nearly one third of the price increase of a tractor in the last 15 years can be attributed to comply with new EU legislation.

Promotes a system of jobs creation and equalities

Industry 4.0 has been creating new jobs for several years, and people are already being employed in work positions that did not exist ten years ago. Due to the speed and complexity of the changes brought about by the Fourth Industrial Revolution, it will be necessary to respond adequately and flexibly to this challenge. This research paper is devoted to the issue of Industry 4.0 outbreak into industrial enterprises, while the issue of job structure will become an increasingly urgent one.

First and foremost, must be said that increases cannot be gained at the cost of livelihoods or adverse environmental impacts. Technologies can assist in balancing productivity, employment, and sustainability (Figure 1). They offer affordable and innovative solutions to improve productivity while mitigating economic and environmental risks.

The Fourth Industrial Revolution is a concept based on the German concept of Industry 4.0, nevertheless experts still do not completely agree on what the result from the introduction of this concept would be (Hnat and Stuchlikova 2014; Zemanova and Drulakova 2016). Krnacova and Drabik (2018) argue that industrial companies in Slovakia, represented by their management, have not taken Industry 4.0 challenges into account for a long time. So far it has been seen something like as a Western fashion trend, and the implementation of platforms such as the

Internet of Things, Big Data, cloud computing operations, virtual reality, and 3D printing were not deployed in almost any domestic industrial enterprise. Jirankova et al. (2015) and Krajnakova et al. (2018a) reason that it was different story when it comes to foreign investors, especially in automotive industry and in the network of their suppliers. Recently, however, the situation has changed, and companies have become more involved in the Industry 4.0 platform. According to Mura (2019) and Dudáš and Grančay (2019) the problem remains the uncertainty as the Industry 4.0 with all its components to be gradually and successfully implemented within not only the large companies but also small and medium sized enterprises.

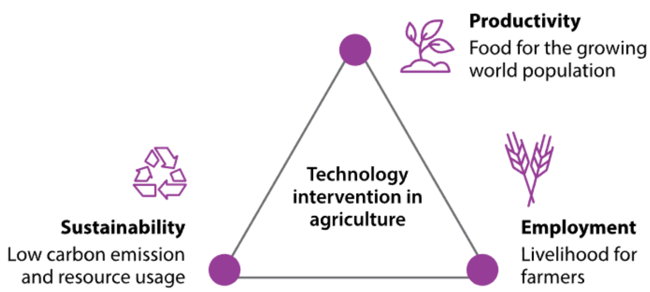

Figure 1. Technologies balance productivity, employment, and sustainability

Source: Infosys

While several industries have identified technologies for sustainability and climate resilience, agriculture has not yet done so at scale. More than 25% of the global population will need to adopt green farming practices for a sustainable future, given the fragmented nature of the sector and therefore invests in new professionals for the sector. Technological intervention in agriculture is broadly happening through physical paths, by automating tasks using machinery, and digital paths, by providing information flows that assist timely and key decision-making. Soil parameters, weather patterns, and commodity prices are examples of data that help farmers take actions that translate into efficiency and yield improvements and for this transition a trained working force is needed.

The history of agricultural modernisation strongly suggests that increased productivity carries potential risks, including intensifying social inequality and ecological degradation. Either way, a pursuit of high-tech farming futures will lead to a unique set of both positive and negative consequences.

Challenges include rising digital inequality, access to energy and other resources, varying laws and regulations, data interoperability and security concerns - smart farms are hackable farms. And with big corporations collecting and selling data from farmers, escalating tensions over data misuse is a considerable threat.

Agriculture globally faces a “perfect storm” of a rapidly growing population demanding more kilojoules per day, amid considerable environmental challenges, whilst needing to maintain livelihoods on 570 million farms worldwide, the bulk of them family enterprises.

If integrated correctly, new technologies can enhance crop yields, reduce production costs, improve the traceability of food, eliminate unnecessary waste and detect diseases in advance. But harnessing Agriculture 4.0’s full value won’t be easy. Industry, research, government and commercial groups must work together to remove legal barriers, improve digital literacy and access, and enable platforms to better exchange secure data. Agriculture may have been some of human’s earliest technological steps, but it will take the full suite of human ingenuity to ensure they continue.

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