PRISM

A VET Toolkit Promoting Digitization in the Agriculture Industry for Sustainable Farming

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01 INTRODUCTION

TO THE PROBLEM BACKGROUND

The chapter outlines the challenges the farming and agriculture sector are currently facing including increased demographics, food waste, intense use of natural resources, climate change, poverty, and hunger.

It also provides a brief history to how farming approaches have changed over time, leading to increased digitization and hence the era of Industry 4.0 and Agriculture 4.0.

01 Introduction

Challenges in farming and the agriculture sector

Agriculture is one of the first and most important activities people developed over time. Starting with Adam and Eve and ending in the 4th Industrial Revolution. Although it's such a fundamental task of such importance, it confronts a set of very serious challenges and problems.

The most problems are globally difficult, like the growing population, the urbanization, climate change, food waste or the use of natural resources. All those are connected to each other and all together they have a big influence on the development of agriculture and are being influenced by agriculture as well.

Increased demographics and urbanization

The assumed number of people on earth is probably around 9.73 billion by the year 2050 and 11.2 billion by 2100. This extreme growth of population will result in a strong need for much more food than we are producing at the moment to feed the world's population. Farmers will have to produce 70% more food by 2050. Another problem connected to this change is the changing demands of the population.

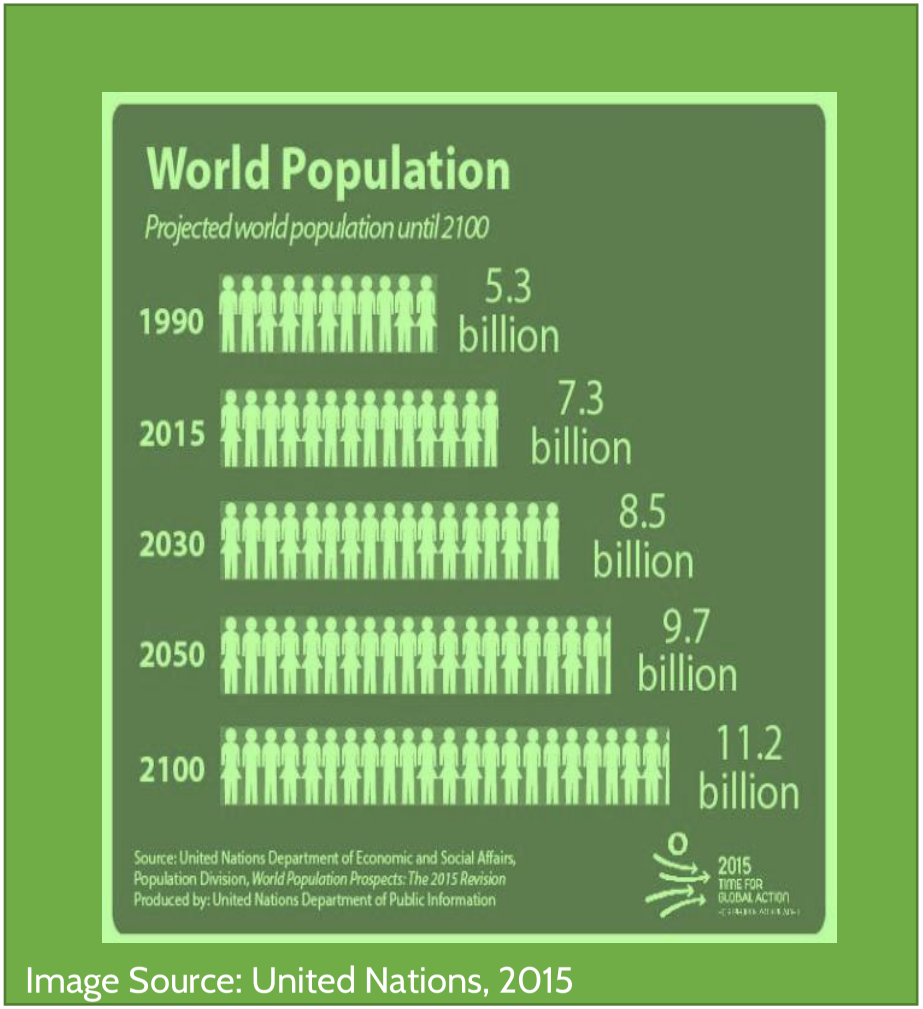

Image Source: United Nations, 2015

More and more people consider only healthy foods of high value. This changes the whole approach of today's agriculture. The focus has to be put on value and not only on quantity. This is very difficult regarding the need of feeding a fast growing population.

Considering the growth of the world's population, an increasing urbanization is more and more visible. Millions of people will supposedly move to towns and cities in the next 50 years. A growing urban population means automatically a decreasing rural population, which will age with the time.

In a few years there will be an enormous shortage of the workforce and the development of rural areas will be shrinking.

This will raise the incomes and the demand for processed and animal-source foods. The growing demand of meat-based food leads to a bigger consumption of fast food, which therefore leads to chronic diseases and childhood obesity. All this has not only an influence on health but also on the environment.

Food Waste

Farming and agriculture are currently facing a big problem of food waste regarding that between 33 and 50% of all produced food is being wasted on different levels – farm level, packaging, labour, manufacturing and so on. It is a big threat for the environment. This inefficiency is especially hard to accept since there is so much poverty in the world where around 800 million people don't have anything to eat.

The problem is in the food supply system where crops and food are being poorly placed or exported to other countries while there is not enough food to feed their own population. Food waste is a threat also for the environment. A massive part of land has to be degraded and deforested in order to grow food that is being ultimately wasted. Not only has it impacted on the land but also on freshwater. Up to 25% of freshwater is used and in consequence wasted in the food growing process. In addition, the uneaten food decomposes creating methane and contributing to climate change.


Image Source: Wikipedia, 2021

Climate change

The main and growing challenge is obviously climate change. Mainly induced by human activity it is a global problem causing a series of other problems. Over the last years, agriculture has been influenced by the changes in climate and weather enormously as climate and agriculture are two very correlated areas and have mutual effect. Agriculture is responsible for the largest share of methane and nitrous oxide emissions in the world.

On the other side climate change affects agriculture causing floods and droughts which results in weaker crop yields. Climate change is among other reasons a consequence of overpopulation and therefore the reason for the declining process of food production and rising food prices. There must be something to be done in order to stop that change and prevent even bigger problems.


Image Source: EU Political Report, 2020

INTENSE USE OF NATURAL RESOURCES


Image Source: European Commission, 2018

The degradation of natural resources, caused mainly by climate change is a big problem since the farmland becomes progressively unsuitable for the needed production. Already 25% of farmland, that is a finite source, is highly degraded. 44% is rated as slightly degraded. This kind of land cannot be replaced anymore which results in lower production per person. The reason for this degradation is mainly intense agriculture including crop rotations, unbalanced fertilizers, livestock overgrazing or wrong orchestration of fallow periods. Clearing vegetation results unfortunately in eroding water resources. Because of poor planning and foresight

which leads to unsustainable land management, around €135 billion will be needed for soil conservation.

Poverty and hunger

As mentioned earlier, 800 million people in the world have to deal with the problem of chronic hunger and poverty as an outcome of the previously described global trends and dangers. A big percentage of this number lives in rural areas of third world countries and in countries with strong political conflicts which result in lack of safety and insurance. In order to end poverty and hunger in the world, global trends like climate change, overpopulation or income inequality must be stopped.

Image Source: Borgen Magazine, 2014

Brief history to how farming approaches have changed over time, leading to increased digitization and hence the era of Industry 4.0

Facing challenges and trends like climate change, food waste, scarcity of natural resources and fast population growth, farming and agriculture had to take on new approaches to deal with those current problems. Since the first technology revolution in agriculture in 1961 a lot has already changed in terms of modern farming practices. It develops to be more and more productive and innovative. Therefore, Agriculture 4.0 as the new agricultural revolution has to be as technological and green as possible. It has to satisfy both the demand of quantity and value of food as the growing population will demand 70% more food by the year 2050 and is concentrated on healthy meat-based food. That's

why innovation and technology is not only important for agriculture's development itself but for fulfilling the needs of the world in the next few decades.

New innovative technologies such as robots, sensors, machines and GPS devices have to be implemented for the businesses to be more efficient and safe. In order to delay the process of climate change, the new approach has to be as environmentally friendly as possible. Agriculture won't be dependent on constant supply of freshwater, fertilizers, pesticides or even much human workforce, which is lacking in many rural areas since young people are not eager to work physically and older workers are ageing and won't be able to fulfil all the duties in a few years. New approaches will be able to use mainly resources such as the sun or seawater.

Three main new approaches can change the agriculture and farming sector towards stronger digitalization: Different production using new techniques, new technologies to bring food production to consumers, increasing efficiencies in the food chain and incorporation of cross-industry technologies and applications.

In addition, the most important change of thought in the agricultural sector is precision farming, which is finally leading to the 4th agricultural revolution. The idea is to implement intentional action while planning the food growing process. The goal is to prevent food waste and therefore delay climate change and face the problem of overpopulation and urbanization. That is possible by implementing new treatments at the right time and in those places where it is needed. For example, by scanning and analysing soil farmers can precisely decide which crops will be most suitable for that time in that place. Therefore, the production of the land is maximised and used as efficiently as possible without wasting or losing neither land nor food. The concept of precision farming makes agriculture more appropriate in areas like seeding, fertilisation, tillage, herbicide or pesticide application and so on. Agriculture 4.0 which is based on precision farming can therefore foresee problems by monitoring yields and quality and collecting data with sensors, GPS signals and many other new technologies and solving those in a very conscious and environmentally friendly way. It reduces costs and input and protects the environment.

In order to implement precision farming and the concepts of agriculture 4.0 there is a strong need for training for farmers. Of course it is not enough to give farmers devices and machinery which collects data without explaining what to do after receiving said data. Nevertheless, this step towards digitalisation of agriculture and the transformation of methods will be crucial for farmers to maintain an ecological and efficient outcome. The goal is for farmers to understand and interact with nature and as a result increase efficiency and productivity of land and animals. There is a series of new technologies that are already highly developed such as for example Internet of Things, automation of workforce, data-driven farming or drone technologies and are being used to improve the precision of agricultural processes.

Image Source: ETAuto, 2020

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DIGITISATION

IN THE AGRICULTURAL SECTOR

A brief introduction to terminologies, and the range of digital (hardware and software) technologies being increasingly used in modern Farming and Agricultural activities.

02 DIGITISATION

DIGITISATION

Digitisation is a process that has already covered most sectors of the agriculture economy. In recent years, agriculture has also increasingly benefited from the advantages of this process. The introduction of digital management in a farm allows it to work more efficiently while saving their resources.

Modern agriculture is driven by continuous improvements in digital tools and data as well as collaborations among farmers and researchers across the public and private sectors.

ADVANTAGES OF DIGITISING AGRICULTURE

Digitalisation in Agriculture Sector is a response to the frontier of agricultural production by the size and efficiency of agricultural machinery, which has already reached the maximum value that can be achieved. However, production efficiency can also be increased by optimizing work management processes. Such possibilities are provided, among others, by the wide use of computers, which not only support the management of agricultural equipment, but also allow the collection and processing of large amounts of data from sensors installed both on machines and in farm buildings or in the field.

Another source of data improving work on the farm are those from outside the farm. This can be both public information, such as data from weather satellites, and information collected on behalf of the host and performed by external entities, such as information on soil fertility. It is also possible to use a smartphone as the centre of the warning system against weather phenomena, such as hail or torrential rains, threats related to the appearance of diseases or pests, as well as monitoring the amount of rainfall and estimating the irrigation needs of the plantation. The use of remote sensing systems in the farmer's work makes it easier to make decisions related to the fertilization needs of individual crops or the need to perform plant protection treatments.

Benefits of Digital Farming:

- Higher crop productivity
- Decreased use of water, fertilizer, and pesticides, which in turn keeps food prices down
- Reduced impact on natural ecosystem
- Less runoff of chemicals into rivers and groundwater
- Increased worker safety

INCREASED INTEREST IN AGRICULTURE DIGITISATION

Digital Farming is a response to the challenges faced by mankind - first of all it is about the growth of the human population and the demand for food on the one hand, and on the other - the decline in the area of cultivated soil. In addition, the situation is complicated by the emerging extreme weather conditions, such as droughts, unusual temperatures, or floods. Therefore, agriculture requires a change in approach to the subject of food production. Digital Farming is one of those

innovations that will allow for higher yields despite growing problems. Thanks to it, it is possible to optimize the use of seeds that can be sown in the right amount, fertilizers and pesticides in amounts that are best for specific growing conditions.

Digital Farming also allows for the protection of the natural environment and its resources, as the most advanced digital systems are used as foundations for implementing precision farming. The means of production are applied in the necessary doses, thanks to which there is no loss resulting from excessive use.

DIGITAL AGRICULTURE TECHNOLOGIES

In recent years, the adoption of digital technologies in precision agriculture has been adjusting the ways that farmers treat crops and manage fields. One doesn't have to be an expert to see how the technology has changed the concept of farming making it more profitable, efficient, safer, and simple.

The growing number of connected devices represents a big opportunity for food producers, it also adds complexity. The solution lies in making use of cognitive technologies that help understand, learn, reason, interact, and increase efficiency. Some technologies are further along than others. But the innovations hold great promise.

Here are some key game changers:

- **Internet of Things (IoT):** Digital transformation is disrupting the agricultural world. IoT technologies allow correlations of structured and unstructured data to provide insights into food production. IoT platforms such as IBM's Watson are applying machine learning to sensor or drone data, transforming management systems into real AI systems.
- **Automation of skills and workforce:** By the 2050, the UN projects8 that two-thirds of the world's population will live in urban areas, reducing the rural workforce. New technologies will be needed to ease the workload on farmers: Operations will be done remotely, processes will be automated, risks will be identified, and issues solved. In the future, a farmer's skills will

increasingly be a mix of technology and biology skills rather than pure agricultural.

- **Data-driven farming:** By analysing and correlating information about weather, types of seeds, soil quality, probability of diseases, historical data, marketplace trends, and prices, farmers will make more informed decisions.
- **Chatbots:** Currently, AI-powered chatbots (virtual assistants) are used in retail, travel, media, and insurance sectors. But agriculture could also leverage this technology by assisting farmers with answers and recommendations on specific problems.

Among other technologies, the following are deemed to be the best:

GIS software and GPS agriculture

A Geographic Information System (GIS) is a tool that creates visual representations of data and performs spatial analyses in order to make informed decisions. It is a technology that combines hardware, software, and data. The data can represent almost anything imaginable so long as it has a geographic component. The hardware can be anything from a desktop computer or laptop to satellites, drones, and handheld GPS units. However, GIS' true strength resides in its capacity to examine numerous data layers or variables. A map represents the number of farm injuries by county, or the quantity of crop acres lost to flood by tax map area, are simple examples of this in agriculture. The changing colour ramp is the most typical approach for the polygons representing different ownership or municipality to convey the change in values.

Satellite imagery

Space-based technology is of value to farmers, agronomists, food manufacturers and agricultural policymakers who wish to simultaneously enhance production and profitability. Remote sensing satellites provide key data for monitoring soil, snow cover, drought, and crop development. Rainfall assessments from satellites, for example, help farmers plan the timing and amount of irrigation they will need for their crops.

Drone and other aerial imagery

Farmers may define crop biomass, plant height, weed presence, and water saturation on specific field regions with great precision with the use of drones. In comparison to satellites, they provide better, more accurate, and higher-resolution data.

Farming software and online data

Farm management software centralizes, manages optimizes the production activities and operations of farms. With farm management software, farmers can become strategic and efficient in their daily farm-related tasks and responsibilities. Farm management software automates the recording and storage of farm data, monitors and analyses farm activities and consumption, and tracks business expenses and farm budgets. To get meaningful interpretations in one's field, one should occasionally combine data from different sources. Additionally, the software can support farm financial management with accounting programs, farm planning and procurement functionality, and marketing and budgeting tools. During crop monitoring, combining datasets is beneficial.

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GUIDE TO HARDWARE

Technologies in Agri 4.0

A guide to a range of hardware technologies used in Agricultural & Farming sectors. These include Drones, 3D Printing, Robots, Autonomous Pickers and Sensors.

Each technology includes general background / information, diagrams/images and an indication to how and where they are used in Agriculture / farming, highlighting the benefits it brings.

03 HARDWARE TECHNOLOGIES

DRONES

Agriculture 4.0 with drones is innovation and research which, together with other new technologies such as precision farming or robots, are very important issues for agricultural producers, as they offer them significant opportunities to increase profitability going towards ecological conversion and result in greater sustainability of the agricultural sector.

Thanks to drones, agrotechnicians and farmers can analyse the situation of the crop in a simple and fast way, so as to be able to take any corrective actions in a timely manner or evaluate anomalies that, if observed from the ground or by traditional means, are not always so obvious. This turns into a more profitable management of the land, aimed at increasing the profitability of the crop, both in terms of production and turnover.

By using, for example, drones with multispectral technologies, crops can be monitored more precisely and, with special cameras, nanometer frequencies (specific colours) can be seen. This allows farmers to understand if there are anomalies and possibly locate them more precisely, as it is the case for some parasites that, with their own shade of

pigment, change the colour of the leaf. Thanks to this technology it is possible to see its specific colour and immediately operate with a precise and targeted disinfestation in the affected area.

Another example where drones can be applied is the one used by wine producers in order to monitor the degree of ripeness of the grapes. In fact, multispectral cameras have the ability to be able to view with great precision some specific pre-set colours. This technology aims at optimizing harvest times. The same criterion can be used for apples or wheat. Drones with the carrying capacity of up to 10 Kg of liquids can distribute them, at high speed, over an area of 4,000-6,000 m^2 in just 10 minutes, tens of times faster than a manual distribution. The automatic distribution system is variable, depending on the flight conditions and the amount of liquid distributed is regulated with great precision.

Drones equipped with high-resolution cameras, thermal infrared sensors and multispectral cameras, acquire data which, processed quickly, generate maps of vegetative vigour essential for locating areas of water stress, areas with poor fertilization, useful for differentiated treatments. Whereas the data acquired by the satellite does not guarantee the right resolution and the right acquisition frequency, the drone is the best tool for Precision Agriculture.

Benefits of drones in Agriculture

- **Promptness and ease of intervention:** A drone ensures a great speed of intervention, giving in some cases the possibility of reaching parts of land that are more difficult to reach by other means.
- **Great precision:** Using a drone ensures high standards in the quality of the surveys.
- **Variety of use:** A drone allows various types of analysis and intervention, even paired with high-tech tools such as multispectral cameras.

- **Time saving:** The drone is within everyone's reach and, as in many other sectors, it guarantees a great reduction in costs. A survey carried out with the drone can also serve to avoid an economic loss due to a badly set strategy.
- **Preventive analysis and corrective actions:** Thanks to drones you can set the best strategy to make your land perform at its best, but you can also quickly correct your strategy to stem any problems that may arise during operations.
- **Environment and Sustainability:** Drones go hand in hand with precision agriculture. The use of a tool that does not release pollutants and avoids waste of resources is a winning choice, not only on a commercial level, but also on an ethical one.

3D Printing

Three Dimensional (3D) printing, also known as additive manufacturing, is a method of creating a 3D object layer-by-layer using a computer created design. As opposed to a subtractive manufacturing process where a final design is cut from a larger piece of material, 3D printing is an additive process where an object is created through the building of layers on top of each other. This enables less material waste.

3D Printing Technologies

There are three broad types of 3D printing technology; sintering, melting, and stereolithography.

- **Sintering** is a technology where the material is heated, but not to the point of melting, to create high resolution items. Metal powder is used for direct metal laser sintering while thermoplastic powders are used for selective laser sintering.

- **Melting** methods of 3D printing include powder bed fusion, electron beam melting and direct energy deposition, these use lasers, electric arcs or electron beams to print objects by melting the materials together.
- **Stereolithography** utilises photopolymerization to create parts. This technology uses the correct light source to interact with the material in a selective manner to cure and solidify a cross section of the object in thin layers.

Additionally, there are a variety of 3D printing materials, including thermoplastics, metals (including powders), resins and ceramics. 3D printing can be used to create simple things but it can also be used to create complex, high quality and durable personalised items, making it ideal for rapid prototyping.

Uses in Agriculture

The application of 3D Printing / Additive manufacturing is proving to be a valuable asset for many industries including agriculture with applications ranging from urban gardens to 3D printed tools.

Common uses of 3D printing in Agriculture includes but not limited to:

- **Custom tools:** Farmers are utilising additive manufacturing and 3D printers to print their own custom tools. Having the ability to manufacture custom tools gives remarkable flexibility to farmers.
- **Urban farming:** 3D Printing can be widely utilized for Urban farming. A typical example is the development of custom light fixtures, mounting brackets, sorting rails, and anything else needed for in-door plants growth.
- **Replacement parts:** Replacing a damaged or missing part of agricultural equipment can be very expensive both in terms of the part itself and the downtime it causes especially if the part is difficult to find. Through 3D printing, and as long as one uses material that is fit for purpose, spare parts that are typically needed can be easily produced on demand. That is as long as a material that's fit for the purpose is used.

- **Prototyping parts:** Through additive manufacturing, farmers and indoor gardeners can test out a part before they place a large order to a manufacturer. This can be easily done using a 3D printer for such prototyping purposes.
- **Scale farm models:** Printing to-scale 3D models can extensively help farm planners and engineers in their evaluation tasks by identifying problems and even minor issues before the plan is realized, consequently leading to great cost-savings in the long run.

Benefits of 3D Printing in Agriculture

Additive manufacturing is helping the development of agriculture. Benefits include:

- **Mass Customisation:** The creation of custom made objects such as 3D printed tools adapted to their specific use is giving farmers a competitive advantage. Using 3D printing, tools are adapted to specific uses and applications.
- **Flexible design useful for both Production and Prototype:** 3D printing allows for the design and fast print of more complex designs than traditional manufacturing processing as well as enabling small in-house batches production as well as prototyping. With the advent of new resistant 3D printing materials on the market, more farmers are finding ways to use 3D printing for prototyping (testing) and production. Furthermore, 3D Printing enables the printing of certain parts on-demand, especially useful in remote areas.
- **Printing on Demand:** 3D files can be stored in electronic format in a library and part/tools can be printed when required. This saves space and costs as there is no need to print in bulk unless required. This reduced costs in terms of unnecessary wastage of out of date inventory and investing in tools.

- **Affordable:** No moulds are required and associated printing costs are relatively low compared to procuring new tools and/or parts.

Things to be aware of (Disadvantages)

- **Limited Materials:** Although a selection of plastics and metals are available for 3D printing, the list is not exhaustive as not all metals or plastics can be temperature controlled enough to allow 3D printing, Additionally, many of these printable materials cannot be recycled and very few are food safe.
- **Restricted Build size:** Currently the printing size is restricted and the larger the required print, the cost of the printer rises considerably.
- **Post Processing**: 3D Printers require some dedicated time to be cleaned. The amount of post processing required depends on factors including the size of the part being produced, the intended application and the type of 3D printing technology used for production. So, while 3D printing allows for the fast production of parts, the speed of manufacture can be slowed by post processing.
- **Limitation of Large Volumes:** As opposed to injection moulding, where large volumes may be more cost effective to produce, once scaled up to produce large volumes for mass production, the cost per unit in 3D printers does not reduce as it would with injection moulding.
- **Printed Structure:** It is always important to choose the right material for the right purpose. Although the printed layers adhere together, they can delaminate under certain stresses or orientations

- **Copyright Issues:** As 3D printing is becoming more popular and accessible there is a greater possibility for people to create fake and counterfeit products and it will almost be impossible to tell the difference. This has evident issues around copyright as well as for quality control.

ROBOTS

An agricultural robot, also called an agribot or agbot is a robot which is autonomous and is helpful in farming as It helps the farmer to raise efficiency by reducing the need for manual labour. Agricultural robots are equipped with arms which are specialised, end effectors and many other tools in order to work on several tasks related to agriculture. The agricultural robots can also get connected to the wireless sensor networks and by using the drones, these robots will collect a huge amount of information or data.

Agricultural robots are specialized articles of technology that are capable of assisting farmers with a wide range of operations. They automate tasks for farmers, boosting the efficiency of production and reducing the industry's reliance on manual labour.

They have the capability to analyse, contemplate, and carry out a multitude of functions, and they can be programmed to grow and evolve to match the needs of various tasks.

Applications in Agriculture

As the human population grows, farmers are having to use new technologies to keep up with growing demand. By 2050, there are expected to be about 9 billion people in the world. According to the IEEE Robotics and Automation Society (n.d.) "agricultural production must double if it is to meet the increasing demands for food and bioenergy."

In order to meet the 9 billion people's demand for food, robotics and automation are expected to play a major role in society. Agricultural Robots are used for an incredible number of tasks to ease the burden on the farmers. Their primary role is to tackle labour-intensive, repetitive, and physically demanding tasks. Recently however, robots are being used for various specialised chores as well that were previously only tackled by experienced farmers such as the picking of sensitive fruits and vegetables such as lettuce and strawberries.

Some of the main and emerging applications of agricultural robots include:

- **Automated smart harvesting and picking of crops:** Robot harvesters and pickers are more precise and faster than any human farmer can and so improve yield sizes while reducing crop wastage.
- **Robotic planting and seeding:** These robots assist farmers in automatically planting and seeding crops
- **Autonomous mowing, spraying for weed control, pruning and thinning:** Some robots are multifunctional targeting the assurance of healthy crop growth after seeding but before harvesting.
- **Sorting and packing:** Robots that prepare harvests for distribution and order fulfilment
- **Phenotyping for crop improvement:** These robots analyse plants' genetic makeup along with environmental changes, which are vital to improving crops.

Benefits of Agricultural Robots

- **Speed and Efficiency**

  Agricultural robots are much faster and more accurate than humans in carrying out certain tasks. They make fewer mistakes and save time. Consequently, they increase production and profit margin. Additionally, some of them are equipped with sophisticated technologies such as specially designed vision system that enable

robots to accomplish tasks that would be impossible or too demanding for the humans to perform rapidly. For example, in sorting fruit harvests, agribots are able to quickly and easily sort the defective products from the consumable ones much faster than humans. are faster, more precise (high quality) and consistent than people.

- **Steady and continuous Work Flow**

  Unlike human employees, agricultural robots can work 24 hours a day since they do not need holidays, sick days, time off or breaks. Additionally, agribots operate in full capacity all around with high accuracy and quality compared to humans. They can also work under any weather conditions with the same consistency. These factors lead to a stabilised food production process. In sorting fruits of a certain colour, for example, a robot can be able to single-handedly complete the task which would require an entire day for the human employees.

- **Protection of Human Workers**

  An agricultural robot can either be designed to complete spraying tasks from an elevated point or closer to the target using a specially designed industrial robot arm. Thus, robots eliminate work that is dangerous to humans and protect them from potential harm that may be caused by inhaling or handling farm chemicals by hand by performing tasks such as herbicide and pesticide spraying.

- **Reduced Wastage**

  Robots are able to deliver error-free outcome within a shorter work-time compared to human workers. In the case of spraying chemicals, for instance, agricultural robots can be able to focus on the exact part that ought to be sprayed. Like there are some herbicides that must be sprayed on the roots, some on the leaves and so on.

The same case applies to other activities like sowing. Because the robot is able to focus on the target better than a human being, there's reduced wastage of farm inputs.

- **Reduced Cost of Farming**

  Farming is a labour intensive activity. In crop farming for example, there is a need for labour to prepare the land, sow the seeds, water, prune, weed, and to harvest among other activities. Maintaining a sufficient human workforce to do all the necessary activities can be very expensive. In other cases, some tasks may not even attract human employees. With collaborative robots, all the above activities are quick and easy.

Other benefits associated with the use of robots in agriculture include the following:

- Robots **automate** slow, repetitive and dull tasks for farmers, allowing them to focus more on improving overall production yields.
- Robots have the **flexibility** to perform a variety of tasks and applications in any environment
- Robots can **reduce** the use of pesticides by up to 80% of the farm
- Robots can have **multi functions** at the same time
- Robots provide an **opportunity to replace human operators** with a good return on investment by providing effective solutions.

Considerations when dealing with Robots in Agriculture (Disadvantages)

- Robots are expensive to make or buy
- Robot maintenance can be very high

- Farmers can lose their jobs with the introduction of robots
- Robots can change the culture / the emotional appeal of agriculture.
- Robots can produce a higher carbon footprint than people
- There is a high cost of R&D associated with robots in agriculture
- Poor farmers might be disadvantaged due to lack of access to robots

Autonomous Pickers

Image Source: Fruit Growers News, 2021

The goal of Agriculture 4.0 is to make work easier and more efficient. Obviously picking fruit is a very hard physical job to do for men and women. It requires a lot of standing and crouching during long working hours and lifting heavy weights, which makes the job less and less attractive for young people and more and more difficult for older people to fulfil. Furthermore, it is a fact that other crops are better paid than fruit picking and maintaining a seasonal worker is not easy for employers. That's why young people are more likely to search for an urban job rather than to work physically. In addition to that, the pandemic of COVID-19 has increased the problem for seasonal workers who couldn't cross borders. This situation opens a strong need for a solution.

One solution is therefore more and more attractive, which doesn't require as many human workers to pick fruits: Autonomous fruit pickers. It is a cheaper and more precise realisation of the fruit picking process and easier to manage.

This kind of robot is a relatively new technology, which uses artificial intelligence in order to recognize ripe fruits and pick them when it's the right time. Thanks to perception algorithms it locates trees and detects the fruit among the foliage. The pickers are equipped with flying devices – a drone – which make the precise picking even easier. Therefore, the vision algorithms make it possible for the robot to pick the fruit in the most suitable time. Timing is in the fruit picking process of fundamental importance for the fruit to have the exact right amount of value classified by size and ripeness. Using a robotic arm, the autonomous picker grasps the fruit and puts it into a basket.

The advantage of this robotic device is the possibility of picking day and night, which increases the outcome even more. Unlike human workers, the robot never gets tired and can pick thousands of raspberries, apples, oranges and other types of fruit on a daily basis. According to the observations of the University of Plymouth an autonomous picker can collect around 25,000 raspberries a day whereas a human manual worker is only able to pick around 15.000 berries. Furthermore, thanks to connected software the work of the robots can be precisely controlled. The device is able to recognize different kinds of fruit which results in a wider range of implementing the technology.

Due to the mentioned algorithms the robot is able to decide about the ripeness better than the human eye. This allows the fruit picking process to be more precise and therefore more efficient. Before this technology was implemented there was an enormous lack of manual workers which had as a result that a big amount of fruit was left to rot. Following this problem there was a big waste of fruit and as a consequence of course waste of money for many farmers. This solution can therefore solve the problem of inevitable food waste and help farmers to save money.

To answer concerns, that robots would someday replace human manual workers, it is important to emphasise, that the autonomous pickers are at the moment only a complementing device to human work, which is supposed to fill the gap, which is caused by the constant lack of people eager to work that hard in the fruit picking seasons.

Sensors

Sensors are devices that can measure physical characteristics and transform them into signals for the observer to see. The main goal of the sensors is to determine the physical properties of soil and surroundings. Key uses of sensors are- monitoring and control, security and warning & diagnosis and analysis (Wadhwa and Singh, 2020). Sensors make modern farming more efficient and hassle-free. It is one step closer to making agriculture self-dependent and free from human interaction. The irrigation process will essentially speed up and production will exponentially rise (Kidwai et al., 2020). Because of technological advancements, sensors are becoming more widely used in nearly every sector of life and of course in agriculture.

There are many types of agricultural sensors. Following are the types that are most common (Ratnaparkhi et al., 2020):

Optical sensors

Optical sensors make use of light to measure properties of soil. They can determine moisture content, organic matter, and clay in the soil. This type of sensor is installed in drones, robots, and satellites.

Electromagnetic sensors

Electromagnetic sensors implement electrical components to capture data on a variety of factors such as soil texture, water drainage, salinity, level organic matter, cation exchange capacity, and soil pH. The potential of charge to transfer through or build in the soil is measured using electric circuits. Electromagnetic sensors can be installed directly in touch with the soil, for example installed on tractors and other vehicles that can be tracked using GPS

(Contact-Method) or entirely outside of it using electromagnetic induction (EMI) technique (Non-Contact-Method). Most electromechanical sensors are used for the purposes like mapping of electrical conductivity, mapping of temporary EM response or a real-time application of various rates.

Electrochemical sensors

Some of the most important soil properties required for analysis are the pH levels and nutrient content in the soil.. The electrode employed in these sorts of sensors must be in touch with the soil sample for this method to work.

Location sensors

Location or position sensors are used to map farms accurately using GPS. These tracking devices are used by farmers to understand how and where to use pesticides, fertilizers and in what quantity. This can be used to detect irregular landscapes, uneven land, levelling problem which causes water logging etc.

Airflow sensors

The use of airflow sensors is to measure the air permeability in the soil. The air permeability of soil is the measure of how the soil resists the flow of air through it. This factor is important to measure the type of soil, structure and moisture/ humidity content of the soil.

Acoustic sensors

These sensors are frequently used in the field to identify pests. They have stations which are to be placed at strategic positions on the field so that if a pest passes by and its sound will be easily detected and transmitted to the linked device, along with the insect's locations.

04

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FONDACIJA AGRO CENTAR ZA EDUKACIJA FACE

GUIDE TO SOFTWARE

Technologies in Agri 4.0

A guide to a range of software technologies used in Agricultural & Farming sectors. These include Geographical Information Systems (GIS), Farming Software, Satellite Imagery and Big Data Analytics.

04 SOFTWARE TECHNOLOGIES

INTRODUCTION

Software is a set of instructions, data or programs used to operate computers and execute specific tasks. It is the opposite of hardware, which describes the physical aspects of a computer. Software is a generic term used to refer to applications, scripts and programs that run on a device. In order to use software applications, the precondition is to have a computer or computer-like devices (smartphones, tablets and so on). Computers are one of the electronic devices which have simplified the world by its usefulness to the people. As a modern electronic device computer has not only made changes in modern occupation but it has also made changes in traditional occupation sectors like Agriculture. Computer help Agriculture through Computer software, computer internet etc.

Use of computers in the agriculture field through software/application nowadays is very common. For example, through computer applications animals are individually tracked so, no mistakes will take place but if it is done by a person sometimes mistakenly error can happen. Information such as the health of the animal, milk production, reproductive information. These types of information are known as herd recording. This herd recording is stored on the computer.

Computer convenience in the agriculture field through internet applications. Through forum and social networking sites farmers can get connected with other experts and exchange their views and other details. Farmers can get a lot of information on a variety of agriculture topics by surfing. Farmers can connect foreign customers which can help to improve their product and increase their production capacity. Farmers can get information regarding price, weather, temperature etc.

Other uses of computers in the agriculture field using software are for example keeping financial records, production records, online banking, buying required resources through the internet etc. The amount of water sprinkled in a balanced quantity can also be computerized. The production capacity in farming and animal husbandry has increased due to use of computers in agriculture. There are less losses due to work being monitored by computers.

By using computers in traditional fields like agriculture, we can increase productivity and minimize errors.

By using the computer, you need to have software. Software is a set of programs, which teaches computers what to do. Software is divided into two types: system software and application software. System software manages the basic process of the computer (E.g.: MS Windows). Application software is used according to the need of the people to perform various tasks such as documents, spreadsheet, databases etc.

Below you can find some modern software applications that can help farmers in their work and business.

Geographical Information Systems (GIS)

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information.

Though the underlying systems may perform some quite complicated analytical functions, **GIS** can present results that can be visually evaluated in form of simple maps, tables or graphs - allowing the farmer to virtually see and predict issues based on the underlying information. Ready visualization supports accurate decision-making and other courses of action.

Use of **GIS** in agriculture has advanced significantly since it was first used in the mid- 1990s, with quite widespread use now (Corwin and Lesch, 2003). **GIS** in farming has become essential for precision agriculture, where issues such as soil sampling have become an evolving management practice (Flowers et al., 2005, Van Schilfgaarde, 1999). **GIS** is now an integral component in the delivery and further refinement of novel techniques in soil sampling and other processes (Knowles and Dawson, 2018).

GIS captures, stores, manipulates, analyses, manages, and presents all types of geographical data. Though often used as a term for the academic discipline, or career, of working with geographic information systems, **GIS** is really a fusion of cartography, statistical analysis, and database technology – all applied to sectors such as agriculture. Making farming decisions are based on geography and spatial phenomena. By understanding the geography and the location, overall ideas of environmental, administrative and social needs can be established.

By helping farmers to increase their production, but reduce the costs of managing the land in an efficient way, **GIS** plays a major role in today's agriculture production. It has a fundamental influence in the success and profitability of a farming business by offering a balancing between the inputs and outputs of the farm.

GIS outputs are generally portrayed through three principal views:

1. Database View. A **GIS** is a unique kind of database of the world - a geographic or geo referenced database. All data are expressed with longitude and latitude coordinates, with the objective of creating digitized maps.
2. Map View. **GIS** output can be represented as a set of intelligent and interactive maps, with views showing features and feature relationships on the earth's surface. These maps are used like 'windows into the database' to support queries, analysis, and editing of the information.
3. Model View. **GIS** also provides a set of information transformation tools that derive new geographic datasets from existing data sets. These geo-processing functions take information from existing data sets; apply analytic functions, and record results into new, derived datasets for various potential uses (Parthasarathy, 2010).

FARMING SOFTWARE

There are generally 4 types of software used in Agriculture.

- Farm Management Software
- Crop Management software
- Livestock Management Software
- Precision Agriculture Software

While farm management software, crop management software, livestock management software and precision agriculture software all solve overlapping production and yield concerns, the scope of the farmer is larger and more comprehensive. Furthermore, specialized farm management solutions exist, tailoring the record-keeping and farm production monitoring functionalities to the specific business needs of dairy or cattle farms, grain farms, cannabis farms, and other types of agribusinesses. However, vendors do offer more generalized, sector-agnostic farm management solutions, benefiting farmers, ranchers, growers, and other agribusiness employees who manage and oversee operations that are multi-sectorial.

Farm Management Software

Farm management software is useful for a variety of reasons in the farming industry and has proven essential to farmers, growers, and agronomists alike.

- Resource Accountability — Farm management software keeps track of agricultural resources, including chemicals, livestock feed, and machinery. Not only do farmers have the ability to monitor resources, but they also have the ability to maintain a resource budget and ensure resources are being used efficiently and properly.
- Reporting — Farm management solutions offer useful analytics involving a farm's ecosystem. For example, the ability to anticipate and prevent risks associated with adverse weather or an influx of pests, as well as the ability to measure soil quality, helps farmers stay ahead of the game when it comes to maintaining the best possible crop production.
- Labor Cost Savings — with streamlined and automated processes, farm management software is cost-effective in terms of labor savings. Basic crop monitoring tasks are easily handled by farm management software.

Crop Management Software

Crop management software, also known as crop planning software, monitors and optimizes the crop production of a farm. With crop management software, farmers, growers, and agronomists can better understand the costs and variables that impact and affect overall crop profitability. Crop management software helps farms maintain clean, accurate, and up-to-date field and crop records. Beyond that, crop management software enables more accurate and precise food tracking and traceability.

A farming business can comprise hundreds or even thousands of crops across acres of land, at one or multiple locations. These crops (e.g. grains, legumes, fruit, vegetables, etc.) are cultivated at different rates, with unique challenges and demands in route to their final delivery. Rather than scribble down farm data and planning details in paper notebooks, farmers can leverage these software solutions for record keeping and other tasks related to their diverse portfolio of crops. These applications are also capable of providing advanced insights and real-time data that yesterday's farms simply could not access. All in all, crop management products allow farms to move into the future while retaining their general practices and philosophies.

Livestock Management Software

Livestock management software helps farmers record and track livestock, from birth to sale and everything in between. While livestock most often refers to cattle, it can also refer to other animals such as chickens, pigs, goats, and even rabbits. Livestock management products offer animal inventory management, from number of livestock to height, weight, health, and fertility. Livestock management may provide feed costing and performance metrics. Often, livestock management systems may provide reporting capabilities to better inform users. They may also offer financial tracking to record profits from livestock sales. These products may coexist with crop management products or be a part of larger farm management systems.

Precision Agriculture Software

These tools are designed to maximize yield and revenue related to crops using data-driven insights. This software assists with information such as ideal planting schedule, maintenance instructions, and environmental factors that could impact a given crop. Precision agriculture software often offers predictive analytics features such as expected waste, yield size, and profitability in relation to market values, allowing farmers and growers to make optimal production decisions throughout each growth cycle. Precision farming software is a powerful type of agriculture technology that includes diverse applications for farm operators and workers. In a number of cases, these solutions will integrate with or be sold alongside sensors or other modern farm equipment to collect real-time data, offer detailed analytics, and provide intelligent recommendations. Precision farming is only going to become more prevalent as standards continue to rise among consumers and farming operations realize the benefits. The solutions in this category are one of the foundations on which the future of farming is being built.

Key Benefits of Precision Agriculture Software are:

- Gain a deeper understanding of land health and farming conditions
- Learn the ideal time, location, and process for growing different crops
- Schedule and execute farming-related activities for optimal results
- Maintain the well-being of crops and fields

Some Farming Software are: Agrivi, Granular, Trimble, FarmERP, FarmLogs, Agworld, AgriWebb, Conservis, etc.

Satellite Imagery

The number of surveillance satellites is expanding the quantity and quality of the data that is available to growers and consultants. Satellite views help them quickly detect seasonal problems regarding nutrient deficiencies, pests, and disease. This information gives them the best chance to correct issues that would constrain crop performance.

Geospatial technologies are used to map three-dimensional disparities in crop and soil conditions so that growers will know what to add, such as water, seed, and fertilizer. Zone maps show the discrepancy between healthy and stressed plants by denoting the amount of light that they are reflecting in different bands of the electromagnetic range; while prescription maps tell the growers how much water, seed, and fertilizer to apply to each of smaller areas known as management zones.

Satellites are used to portray a grower's fields in detail. When used in combination with geographical information systems (GIS), satellites help with more concentrated and efficient crop growing practices. As an example, different crops might be suggested for different fields while the use of fertilizer can be adjusted in a cost-effective and environmentally friendly manner.

Reconnaissance satellites orbit the Earth at a relatively low altitude and take sharp images of the Earth. The majority of today's satellites are custom made and adapted to the particular needs of the user. A reconnaissance satellite is equipped with high resolution CCD (Charge-Coupled Device) cameras. These are coupled large lenses that are able to take high resolution pictures of the ground below them. Image quality is this satellite's key feature. Generally, the bigger the lens, the better the picture quality with greater detail.

DigitalGlobe's GeoEye-1 satellite was launched on September 6, 2008. The GeoEye-1 satellite has a high-resolution imaging system with ground resolution images of 16 inches in the panchromatic mode. And 64 inches in the multispectral or colour imagery mode.

Up until now, satellite imagery was simply not frequent enough to react to crop stress in a timely manner. Now, daily imagery is a game changer for agriculture. Growers can recognize changes in vegetation from preseason to harvest, which helps them farm more efficiently, and profitably with constant field coverage.

Frequent imagery allows for crop health monitoring because of continuous field coverage over wide and distributed areas. Easy access imagery along with historical archiving of images can improve productivity within dynamic management zones.

Advancements in artificial intelligence (AI) have made autonomous, large scale analysis of photographic imagery possible. AI has demonstrated that it can manage satellite imagery with very little error; and AI can differentiate between different forest types, as well as certain soil and vegetation varieties. Researchers use AI to monitor satellite imagery for vineyard and grape health as well as estimate wheat harvest size.

GOES-8 is a United States weather satellite that is chiefly used to observe the weather and climate of the Earth. For growers, weather is very serious business, as just the right amount of water and the right temperature is needed for their crops to grow well. A team of satellites, called the Joint Polar Satellite System (JPSS) is assisting to monitor and forecast severe weather conditions. The more information that growers have about weather conditions, the better they can react to potential disasters.

Information from visible and infrared light can be used to determine the health of plants in a certain region. For example, a weather satellite can determine how much stress plants are under in a region of extreme drought, such as California's central valley, which is an important farming region, during its severe drought season.

Big Data Analytics

Nowadays people not only want to collect the data, but also they need to understand them and need to identify the importance of the data set in order to make better decisions. Big data is considered as a large collection of dataset, which has high velocity, volume, and varieties that make it difficult to process and manage by using traditional techniques and tools. It can be either structured, unstructured or semi-structured. An advanced analytic technique which can be used for analysing big data to reveal unknown, hidden and useful patterns is identified big data analytics (Elgendy and Elragal, 2014). Hence big data plays a major part in the decision making process.

According to the available research and studies, big data analytics in agriculture have been adopted to various applications and use cases.

Big data analysis in agriculture applications advance the productivity, weather decisions and increase the cost efficiency related to the fertilizers, pesticides and harvesting (Kumari, Bargavi and Subhashini, 2016). Also, big data analytics applications on agriculture maximize the resulting benefits than the cost of operations (Sonka, 2016). It is needed to identify the right inputs at the right time. Since most of the countries in the world survive in agriculture, implementing applications which aid to bring the agriculture towards profits is highly needed.

Some applications are focused on collecting real time data. Using smart phones' applications and give the knowledge to the farmers to how to use it, is one of the method used for gathering data from the farmers (Athmaja and Hanumanthappa, 2016). Apart from this, applications are implemented which have the capability of collecting data and transmitting them to a centralized database. Also, mentioned that visualization, data acquisition and management applications can be found in Hadoop. Hadoop is an open source, Java based framework used for storing and processing big data. The data is stored on inexpensive commodity servers that run as clusters. Its distributed file system enables

concurrent processing and fault tolerance. Further mentioned that, using 64-bit computers for big data analysis is the best practice.

Currently, big data has become more powerful with the development of the technology. Many industries have already used the analysis of big data with the aid of technology. As big data analytics is vastly adopted by many industries especially in agriculture, it has to face many challenges. As a result of these challenges, directions for the future are revealed for further improvement.

Most of the applications are implemented focusing on the characterized 4Vs in big data. The table on the following page outlines the 'V' characteristic and the particular applications on that area (Kamilaris, Kartakoullis, and Prenafeta-Bold, 2017).

Reliability is highly important when implementing applications on big data analysis regarding agriculture. Furthermore, applications can be found for understanding the impact on climate change, irrigation and water distribution, agriculture finance, crop insurance and marketing (Shah, Hiremath, and Chaudhary, 2016). Several android based mobile applications have been implemented in India such as CropInfo, KisanYojana, mKisan, and m-Krishi is one of the android based agro advisory systems

THE AGRICULTURAL APPLICATIONS BASED ON BIG DATA 'V' aspect	'V' Explanation	Applications on Agriculture
V1	High volume	Weather forecasting, farmers financing, crop identification, data sharing for earth observations, food security estimations
V2	High velocity	Weather forecasting, safety and quality of animal products, farmers' productivity improvement, weed discrimination
V3	High variety	Small farmers' insurance and protection, crops' drought tolerance, management zones identifications, wildlife population evaluation
V4	High veracity	Dairy herd culling, animals' disease recognition, food availability estimation, farmers' productivity improvement,

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05

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EMERGING TRENDS

IN AGRI 4.0

Information about a number of emerging trends within the Agricultural & Farming sectors. These include Artificial Intelligence (AI) and Machine Learning, Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR) and Driverless Machinery.

05 EMERGING TRENDS

INTRODUCTION

Emerging technological trends are paving the way for increased prospects in farming and agriculture by assisting modern farmers in making better, faster and more informed decisions. In order to thrive, the agriculture industry must embrace a digital transformation facilitated by connectivity. Likely, the current emerging technologies will be used by more farmers in the coming years to better manage their crops, resources and regenerate agriculture. This chapter aims to provide general information about five emerging technologies that target to achieve from soil health, to farm profitability and environmental sustainability. While technology makes it easier to monitor soil conditions, weather and water usage, Artificial Intelligence (AI) makes it easier to make decisions based on those data. Machine Learning (ML) as a subset of AI offers the potential of dealing with many challenges in the establishment of a knowledge-based system.

The Internet of Things (IoT) has revolutionized many aspects of our modern world. Precision agriculture is acknowledged as a sustainable, environmentally beneficial, and profitable method of increasing agricultural yields and quality, and it is becoming a reality as IoT methods are progressively implemented in agriculture.

Moreover, technologies such as Augmented Reality and Virtual Reality are changing the landscape of planning and training in the field of agriculture, by revolutionising what is possible with everyday equipment available to most people, such as smartphones.

Lastly, Driverless Machinery is another form of new technology that should have a major impact in Agriculture, as these machines will be able to both work more but also more efficiently than humans ever could. This means better yields for farmers, with fewer costs.

Artificial Intelligence (AI) and Machine Learning (ML)

Artificial intelligence and machine learning are technologies following under computer science and correlated with each other. These two technologies are considered to be currently the most "trendy" technologies used for the creation of intelligent systems.

Artificial Intelligence

Artificial intelligence (AI) as defined by Lakshanagv (2021):

> "*Is all about training machines to mimic human behaviour, specifically, the human brain and its thinking abilities. Similar to the human brain, AI systems develop the ability to rationalize and perform actions that have the best chance of achieving a specific goal*".

The technology's focus is on three cognitive skills: i.e. learning, reasoning and self-correction. AI can be classified into three types (Jachja, 2021; JavaT Point, 2021):

- **Narrow or Week AI:** is the type of AI that is currently most commonly utilized. Narrow AI is usually designed and programmed to perform one specific task. It simulates human behaviour based on a set of parameters and input

data. Narrow or week AI depends at a level by human intervention in terms of setting parameters for learning algorithms, feeding training data and ensuring accuracy of prediction.

- **General AI:** is a theoretical type of AI that is not currently in use. This type of technology could perform equally with a human. This means the machine would be able to interpret and understand human tone, emotions and act accordingly.
- **Super or Strong AI:** is not currently being used either as still a lot of research needs to be performed. Super AI will allow the machine to be become self-aware and surpass human's intelligence and ability.

Watch a video about Artificial Intelligence and what the technology is by clicking here.

Machine Learning

Machine Learning (ML) is a subset of AI that uses data to complete tasks. Lakshanagv (2021) describes ML as a:

"Provider of statistical methods and algorithms and enables the machines/computers to learn automatically from their previous experiences and data and allows the program to change its behaviour accordingly".

It provides many different techniques and algorithms to make the computer learn. ML performance is well under the condition of reasonably good input data. ML is classified into three types:

- Supervised ML working with known data and problem,
- Unsupervised ML working with unlabelled,
- Reinforcement ML is learning models over time.

Watch a video about Machine Learning and what the technology is by clicking here.

Uses of Artificial Intelligence and Machine Learning in Agriculture

Artificial Intelligence (AI) and Machine Learning (ML) are ideal applications in the agriculture industry. AI and ML have the potential to be implemented and improve agriculture in a variety of ways that fall under the five categories below:

- Internet of Things (IoT) powered data analytics
- Predictive analytics and precision farming
- Risk management
- Pest control
- Agricultural robotics and digital workforce

Some applications AI and ML are currently being utilised are (Columbous, 2021):

- Collection and provision of real-time data from sensors and visual analytics from drones aiming to improve the crop yield prediction,
- Improvement of the track-and-traceability of agriculture supply chain for a more effective process of trading achieving to provide the market with fresher and safe products,
- Livestock's health monitoring to ensure healthier animals,

- Optimisation of irrigation systems, identification of possible leaks in the system and plan the frequency of irrigation,
- Mapping of yield that relies on supervised ML algorithms to identify patterns in large-scale data sets and understand the orthogolality of the yield in real-time,
- Solving the issues of lacking personnel through smart tractors, agribots and robotics.

Watch a video about applications of Artificial Intelligence in Agriculture by clicking here.

Watch a video with examples AI application in Agriculture by clicking here.

Benefits

Artificial intelligence and machine learning have numerous benefits in improving the agriculture sector (Young, 2020; Schmelzer, 2020).

- Improve forecasting and planning,
- Impact positively the reduction of deforestation by enabling food production in urban areas,
- Increase productivity and yield,
- Improve safety of food storage,
- Protect carbon sinks, i.e. forest areas,
- Effective utilisation of resources such as water and energy

- Limit the use of pesticides and limiting pollution of the surrounding ecosystem.

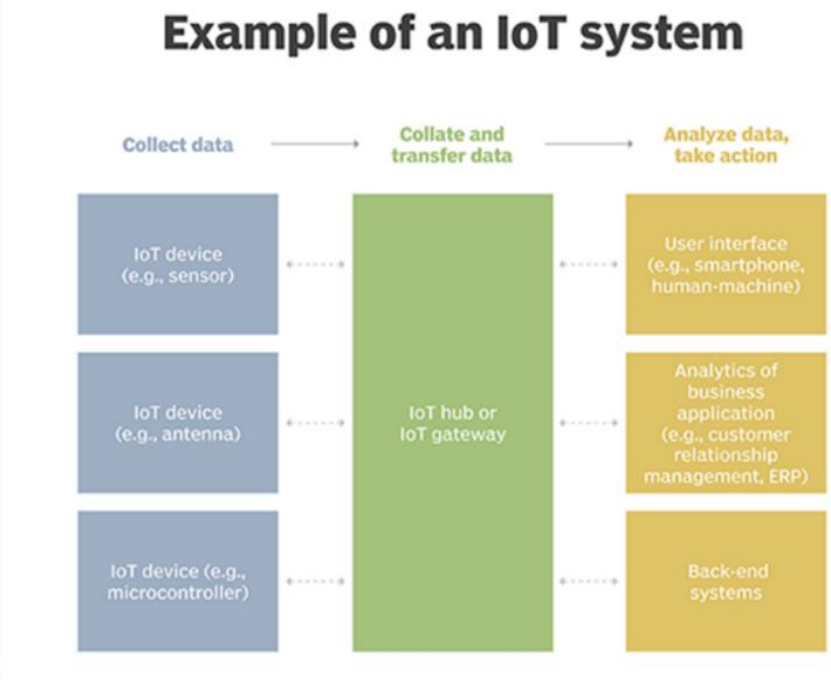
INTERNET OF THINGS (IOT)

Gillis (2021) describes Internet of Things (IoT) as:

"*A system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to computer interaction*".

The "Thing" in the term, i.e. IoT, can refer to a person with a heart monitor implant, a farm animal with a bi-chip transponder and other natural or man-made object that can transfer data to the network when an Internet Protocol (IP) is assigned to them. This enables different objects to communicate with real-data and without involving a human being in the collection of the data. Artificial intelligence (AI) and machine learning can also be used by IoT to assist into the data collection process making it more easy and dynamic.

Watch a video about the Internet of Things and what the technology is by clicking here.



Agricultural IoT systems collect millions of data points to utilize in end-stage analysis (Walch, 2020).

Uses of IoT in Agriculture

It was estimated that data collection from technologies used an average farm, i.e. farm machinery, drones and crop analytics, will grow drastically from today until 2050 (Walch, 2020). The combination of IoT and Artificial Intelligence (AI) will serve farmers and agriculture technology workers highly for data analysis of value to their business. IoT and AI can provide support to farmers on analysing different conditions essential for the crops yield, i.e. weather conditions,

water usage, soil conditions, temperature. In this way farmers are able to make informed decisions, such as which crops to grow that year, the amount of fertiliser they need to use etc. IoT have the potential to transform agriculture in aspects like (IOT Solutions World Congress, 2021; Vincent et.al, 2017):

- Data collected by smart agriculture sensors
- Agricultural drones
- Livestock tracking and geo-fencing
- Smart greenhouses
- Predictive analytics for smart farming.

Some practical examples where IoT is being implemented are described below:

- Watering crops control system with wireless sensor network development. A network is being developed between node sensors and the data collection and management with an application available on smartphones and the web (Jirapond et.al. 2019).
- Combination of farm sensors acting as weather stations. The sensors install in the field for the collection of various data and send to the cloud resulting in mapping the climate conditions (Chalimov, 2020)
- Utilization of wireless IoT applications to follow the livestock health, well-being and/or location (Pathak, 2020).

- Utilization of smart self-driving farming vehicles for precision farming capabilities. The vehicles are equipped with sensors, computer vision, GPS and machine learning that require an operator whom is not highly qualified in driver of agriculture vehicles (Digiteum, 2021).

Watch a video about applications of Internet of Things in Agriculture by clicking here.

Benefits of IoT in Agriculture

IoT can have a positive impact in agriculture in various ways link to the protection of the environment as well as economic efficiency for the farmers. More specifically IoT technologies can (IOT Solutions World Congress, 2021; Vincent et.al, 2017):

- Enable farmers to manage efficiently and effectively resources such as water, electricity etc.
- Reduction of operational costs through precision in agriculture;
- Enhance the productivity of high quality crop yields through the monitoring of crops and livestock; the quality of fertilizer used to the number of journeys a smart vehicle performs;
- Optimised farmer's business model based on transparency of production, sharing of knowledge to improve farming and minimizing or preventing maintenance.

Augmented Reality (AR)

Put in simple terms, Augmented Reality (AR) is the ability to place a digital image on top of a real-world environment. Thanks to Agriculture 4.0, AR can have a lot of direct applications in farming, regardless of whether the people using it are familiar with this new technology or not.

AR training will help farmers by giving them an interactive and safe form of training, and all they need is a smartphone or a tablet. Through an Augmented Reality application for farming, they will be able to capture and share information on their machinery, their crops, and their livestock in an efficient manner.

Furthermore, AR can be used to gather weather forecasts and show how the upcoming weather will affect their farm. This can help them in making decisions about their crops and crop selection, and mitigate any risks associated with bad weather.

Another implementation of Augmented Reality that could be very useful for farmers is the ability to identify pests in their fields. Instead of manually checking their entire field, which could take many hours, they can use an AR system to check their fields for the presence of pests and insects much faster. There are even AR systems that are sophisticated enough that can tell which insects are beneficial and which are pests, so the farmer may not have to use pesticides to get rid of them.

There is also one more implementation of AR for farming that could be very beneficial to farmers. These applications collect satellite data with information about the farmer's lands and then use artificial intelligence and deep learning to find which parts of the farmlands need urgent attention and then present this information to the farmers.

Through all this, farmers will be able to use Augmented Reality to potentially minimize crop losses and ensure healthy harvests of high quality.

Example 1: https://www.queppelin.com/augmented-reality-in-agriculture/

Example 2: https://www.vsight.io/augmented-reality-revolutionizing-agriculture-industry/

Virtual Reality (VR)

When it comes to agriculture, new technology can be expensive and difficult to swap if damaged. Worse yet, an inexperienced worker may even injure themselves or others when operating machinery. Luckily, technology has the right tools to help with us with this.

Virtual Reality (VR) is easily described as the use of computer technology to create a simulated environment, usually through a Head-Mounted-Display, a sort of helmet that is attached to a person's head, through which they view this simulated environment.

This technology is expected to be a big part of Agriculture 4.0, and it will help with such issues. Before going out to use new equipment in the field, workers can try it first in VR, train their muscle memory and get ready for the real thing, stress-free. Working on muscle memory can turn handling machinery into a second nature, resulting in a significant increase in job efficiency.

Specific training scenarios can be created, too, to better prepare the workers for situations or even emergencies that may occur out in the field. The workers, already having trained the necessary muscle memory to react to the situation in VR, will potentially be able to avoid a bad situation.

An added value of being able to train in Virtual Reality is the fact that it is more engaging than video training, which can be passive and dull. Through VR training, workers will have a hands-on experience that is more interesting and

fun. It is also much easier than having one-person train many workers, as the same VR training course can be used for all of them.

Aside from aiding the workers, VR can also be used to visualize the growth of their crops through a virtual farmland. This will allow them to predict future status changes, making them better able to manage their land and their crops.

Virtual Reality, as part of Agriculture 4.0, has the ability to be of great help to farmers because it allows farmers to see their crops 'live' in real time. This allows them to identify problems in the fields and crops before they occur.

Example 1: https://www.agritechtomorrow.com/article/2020/11/smart-farming-is-ready-for-augmented-and-virtual-reality/12516

Example 2: https://www.visartech.com/blog/how-virtual-and-augmented-realities-help-agriculture/

Driverless Machinery

Driverless machinery is going to change the way agriculture works. A driverless tractor is an agricultural vehicle that is capable of operating without a human driver – it can drive into the field on its own by using a GPS to navigate the field and avoid obstacles.

This technology is designed to be available to you 24/7, and it never gets tired, unlike a human. This means that farmers can use it whenever they need it, for as long as they need it, and they can even use it alongside traditional farming machines.

The use of driverless machinery will enable inexperienced or new farmers to produce more goods faster than they would otherwise be able to. It will also allow more experienced farmers to complete their work more quickly and use this extra time for other farm tasks.

Driverless machinery has the added benefit of working with data not only for the farm it is working on but also for the current and near-future weather, which means it will work within the constraints of its farm and make adjustments based on the weather conditions.

This is accomplished by employing high-quality sensors and cameras, which allow them to collect data about the farm's soil as well as its plants.

Even better, their cameras will be able to determine whether the plants encountered by the machinery are crops or weeds.

Farmers can use more precise amounts of fertilizer and pesticides as a result of this, making their farms more sustainable and cost-effective.

As a result, both the soil and the crops are better protected than if only traditional methods were used, and the end product is of higher quality, making them more competitive in the market.

This type of change not only improves the efficiency of any farm, but also helps to protect the environment.

Example 1: https://www.foodandfarmingtechnology.com/news/autonomous-vehicles/monarch-launches-worlds-first-fully-electric-self-driving-tractor.html

Example 2: https://www.yanmar.com/global/about/technology/vision2/robotics.html

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INSTITUTO SUPERIORE MINUTOLI

06

ROLE OF GOVERNMENTS

TO FOSTERING AGRI 4.0

Information about a number of EU Policies and initiatives, UN initiatives, International Conferences and Summits aimed at promoting the concepts and benefits of Agri 4.0 and fostering support in implementing Agri 4.0.

06 ROLE OF GOVERNMENTS

INTRODUCTION

Agriculture is a sector which is supported almost exclusively at European level, unlike most other economic sectors, for which the responsibility lies with national governments. It is important to have a public policy for a sector which is responsible for guaranteeing our food security and which plays a key role in the use of natural resources and the development of rural areas. There is a single, large European market for agricultural products, in which a common approach to support for agriculture guarantees fair conditions for farmers competing on the internal market of the EU and worldwide.

In the absence of a common policy, each state member would adopt different national policies and with varying degrees of public intervention. A Europe-wide strategy ensures common standards in a single market; it safeguards progress carried out with the recent reforms aimed at increasing the competitiveness of European agriculture, and offers a common commercial policy, allowing the EU to speak with one voice in negotiations with its own business partners worldwide.

EU Policies and Initiatives

The protection and development of the primary sector has always played a fundamental role in European policies and it is also a priority for national and regional policies.

Over 44% of the entire EU budget is used to support the Common Agricultural Policy (CAP) and rural development, and another 11% is aimed at supporting the research and innovation that have such a part in the agricultural and agri-food sectors.

The **Common Agricultural Policy** (CAP) accounts for around a third of the EU budget.

Its main goal is:

- Providing EU citizens with safe food at affordable prices
- Ensuring a fair standard of living for farmers
- Protecting natural resources and respecting the environment

The European Union's rural development policy was established as the second pillar of the Common Agricultural Policy promoting sustainable rural development with the so-called 'Agenda 2000' reform. It is co-financed by the European Agricultural Fund for Rural Development (EAFRD) and regional or national funds.

Its main goals are the following:

- Promoting agricultural and forestry competitiveness;
- Ensuring the sustainable management of natural resources and climate action;
- Obtaining balanced territorial development of rural economies and communities, including the creation and maintenance of jobs.

In step with the Union's commitment to execute the Paris Agreement and the United Nations Sustainable Development Goals, actions under the CAP are expected to contribute 40 per cent of the overall CAP budget to climate action. The CAP's contribution to the EU's rural development objectives is supported by the European agricultural fund for rural development (EAFRD). The EAFRD budget for 2021-27 amounts to €95.5 billion, which includes an injection of €8.1 billion from the next generation EU recovery instrument to help address the challenges provoked by the COVID-19 pandemic.

The future CAP will foster better investment in knowledge and innovation, and enable farmers and agricultural communities to benefit from it. The main tool supporting innovation under the new CAP will continue to be the European Innovation Partnership (EIP-AGRI), especially by means of the support of strategic innovation projects carried out by operational groups. The EIP-AGRI innovation approach pays exclusive attention to knowledge exchange, in which all actors are interactively involved in the process.

Technological innovation is the only way to achieve sustainable competitiveness. Therefore, tools such as *Assisted Evolution Technologies* (TEA) or *precision farming* can undoubtedly make a valid contribution in this direction, always bearing in mind that there is no single solution to this joint challenge among sustainability, scarcity of resources, increased food demand and contextual competitiveness of companies.

Agriculture 4.0, in this regard, allows not only to recover efficiency thanks to savings in production costs that, for extensive crops such as common wheat, reach up to 15% per hectare, but also a greater productivity that can reach a + 10%. This results not only in an increase in profitability for the farmer (economic sustainability) but also in a lower environmental impact, thanks to the use of agro-pharmaceuticals, fertilizers and water according to the real needs of the cultivated plants (environmental sustainability).

Thanks to the strategy called the **European Green Deal**, the European Union aims at achieving climate neutrality by 2050, that is, net-zero greenhouse gas emissions. Achieving this goal will require a transformation of Europe's society and economy, which must be cost-effective, fair and socially balanced. This is certainly an ambitious goal that, in order to be achieved, requires significant interventions attributable to an action plan that affects all economic and productive sectors, primarily agriculture. For this sector, indeed, two strategies have been defined (*Farm to Fork* and *Biodiversity*) declined on a series of objectives implying, in general, "sustainable" production approaches, that is to say, approaches able to protect natural resources to avoid their degradation.

Called upon to make a decisive contribution to the implementation of the new Green Deal, European agriculture will have to comply with a series of new rules, which translate into environmentally friendly agricultural practices to which a quarter of European aid will be tied. Green practices will be chosen within a menu set at EU level and that individual Member States will then have to decline in national strategic plans, the heart and real challenge of the reform, to ensure governance to the 350 billion allocated to the sector by the EU budget.

According to the Commission's proposals for the future of the common agricultural policy, rural development actions will be included within the framework of national CAP strategic plans from 2023 on.

Within this framework, the European Commission aims at making rural development actions more efficient and reactive to present and future challenges such as climate change and generational innovation, while continuing to support European farmers for a sustainable and competitive agricultural sector. Agricultural development actions will also strongly contribute to the Commission's major priorities and strategies, such as the European Green Deal and the long-term vision for stronger, connected and prosperous rural areas. The aim is to better identify and take into consideration the potential impact and implication of European policy initiatives on rural jobs, growth and sustainable development.

UN Initiatives, Conferences, Summits

Three important Summits aimed at promoting Sustainable Agriculture were held in September and October 2021 in the UN and Europe.

The FAO Food Systems Summit, held during the UN General Assembly in New York on **23 September 2021** was aimed at promoting concrete actions to achieve the zero hunger goal and set the stage for global food systems transformation to achieve the Sustainable Development Goals (SDGs) by 2030. For this reason, five action areas were developed to observe good practices around the world and promote them: feeding all people, promoting nature-based solutions for production, building resilience against vulnerability, shocks and stresses, promoting conditions fair work for workers and give communities a voice. The action areas recognize that efforts must respond to country priorities, while facilitating the impact of large-scale systems, including through multi-stakeholder initiatives, locally, nationally and globally. At the same time, taken together, these action areas can demonstrate what a systemic and integrated action looks like, as foreseen in the 2030 Agenda. To be effective, the priority action should be anchored to the science, evidence and knowledge that emerged during the Summit.

The Summit, which saw nearly 300 commitments from hundreds of thousands of people from around the world and across all constituencies, aimed at motivating accelerated action to achieve the Sustainable Development Goals, promoting an inclusive recovery from *Covid-19* through the power of food and transforming food systems. It gave rise to several multi-stakeholders' initiatives led by civil society, farmers, women, youth and indigenous groups to bring about tangible, positive changes to the world's food systems. As a people's summit and a solutions summit, it recognized that everyone, everywhere must take action and work together to transform the way the world produces, consumes, and thinks about food.

It also aimed to provide a platform for ambitious new actions, innovative solutions, and plans to transform food systems in order to deliver progress across all of the SDGs. Its objectives and outcomes included the following:

- Raise awareness of food systems' centrality to the entire sustainable development agenda, and the urgency of transforming food systems, particularly following a global pandemic;
- Join stakeholders together around a common understanding of a food system framework as a foundation for a combined action, making food and food systems a more widespread issue for promotion and achievement of effective sustainable development action to be reached by the 2030 Agenda;
- Recognize the need for inclusivity and innovation in food systems governance and action;
- Motivate and encourage stakeholders who support food systems transformation through the development of improved tools, measurement, and analysis;
- Encourage, expedite, and expand bold action for the transformation of food systems by all communities, including countries, cities, companies, civil society, citizens, and food producers.

By fulfilling all these objectives, the 2021 Food Systems Summit aims to transform global food systems and put the world on a new trajectory within a generation.

Sustainability of agricultural and food systems was also the central theme of **the G20 on Agriculture 4.0** which was held under the Italian Presidency in Florence on **17 and 18 September 2021** and it ended with the adoption of a Joint Declaration reaffirming the commitment to achieve food security in the framework of the three dimensions of sustainability: economic, social and environmental.

To achieve food security and nutrition for all, ensuring sustainable and resilient food systems leaving no one behind, the G20 Ministers reaffirmed their intention to reach the goal of zero hunger, which is also threatened by the consequences of Covid-19. They recognized that sustainable and resilient food systems are fundamental for food security and nutrition, contributing to healthy and balanced diets, poverty eradication, sustainable management of natural resources, conservation and protection of ecosystems and climate change mitigation and adaptation.

For G20 Ministers, climate change, extreme weather events, parasites, animal and plant pests and diseases and distressing events such as the Covid-19 pandemic require coordinated actions able to produce effective results. They recognized that, despite global efforts, hunger is rising and the multilateral effects of the COVID-19 pandemic are increasing food insecurity and malnutrition. This is the reason why they underlined the importance of strengthening the cooperation between G20 members and developing countries on food and agriculture in order to share knowledge and help developing the internal production capacities best suited to local needs, thus contributing to the resilience and recovery of agriculture and rural communities.

By signing the "Food System Sustainability Charter" they all agreed to adopt no unreasonable restrictive measures that could result in extreme instability of food prices in international markets, thus threatening food security. They underlined the importance of an open, crystalline, predictable, and non-discriminatory multilateral trading system in accord with World Trade Organization (WTO) rules, to improve market predictability, increase business confidence, let agri-food trade move with no obstacles so as to contribute to food security and nutrition and promote effective actions in sustainable agriculture and food systems to ensure measurable progress towards the 2030 Agenda for Sustainable Development.

The seventh Agrievolution World Summit was held in Madrid on **1 and 2 October 2021** with the participation of 120 delegates from 15 countries. The meeting, which saw the participation of 18 "key speakers", was dedicated precisely to the topic of specialized crops, as well as to education and vocational training in the mechanical-agricultural field. A wide-ranging meeting, that of Madrid, since Agrievolution is the international body that brings together the manufacturers of agricultural machinery (15 associations representing six thousand manufacturers) and which thus confirms itself as a reference point for knowledge and the development of agricultural mechanics worldwide. At the centre of the summit were the new eating styles and the growth of specialized crops.

The world demand for fruit and vegetables is constantly growing, and this has consequences on the destination of agricultural land and on the market for specialized crop machinery. For farmers, the boom in specialized crops opens up new opportunities in terms of higher added value productions; and for the agricultural mechanization sector, this growth represents an important challenge, which is played out not only on the level of productivity, but above all on that of sustainability. In short, the phenomenon of crop diversification must become salient for the agricultural mechanical industry, which must deal with it effectively. Along with agricultural diversification, specialized crops can be one of the answers to the challenges of food self-sufficiency and climate change.

The containment of greenhouse gases, the shortage of water resources, the impact of chemical products on the environment and of processing on the quality of the soils, are salient issues builders must pay great attention to and which can be effectively addressed precisely with design and construction of innovative machines. If agriculture 4.0 is already a reality, if the "electrification" of mechanical means will be more and more effective in the years to come, the next step in technological innovation is linked to the transition from automation to autonomy, in particular to the large-scale use of artificial intelligence. The work on the field will be enhanced thanks to the sensors installed on the agriculture equipment, like tractors, which, by promptly monitoring conditions and operating parameters, will be able to obtain all the information necessary to optimally manage the tractor-implement combination.

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