'IN_AGRICULTURE'
INNOVATION IN AGRICULTURE

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ERASMUS+ PROGRAMME KEY ACTION 2: SMALL-SCALE PARTNERSHIPS
IN
VOCATIONAL EDUCATION AND TRAINING

INNOVATION IN AGRICULTURE

Çukurova District Directorate
of
Agriculture and Forestry

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Mustafa Kemal Ataturk (1937)

"The Foundation of the National Economy is Farming"

Introduction

Many years ago, Mustafa Kemal Ataturk emphatically stressed that the foundation of any country's national economy must be agriculture and that a nation that does not produce cannot survive and develop.
Ataturk's statement is confirmed today in various ways, even though societies have diversified greatly, conditions and terms of development have changed, and globalization has altered the conditions for local development.

Specifically:

- Agriculture continues to be the basis of economic development.
- Without a strong Agricultural Policy, there can be no sustainable industry.
- Rural development is a prerequisite for social stability and national independence.

In conclusion, the progress of a country cannot be based solely on developed cities, industry, Tourism, and the Service Sector, but special emphasis must be placed on Agricultural Production and the Primary Sector, which feeds all the others.

Chapter 1

1.1 Modern Technology in Human Activities

The evolution of humankind from ancient times to the present day has been characterized by our efforts to become more creative and productive, with the aim of achieving better living conditions.

The further back we go in human history, the more we discover "steps of evolution" such as the use of stone tools, later the use of metal tools, or the use of fire, the discovery of the wheel and its use in various applications of everyday life, etc. But even in more recent history, the use of scientific achievements and their application in everyday life have brought about major changes in the functioning of human communities, improving living conditions and greatly increasing life expectancy.

In the last century, the discovery and use of computers has brought about tremendous changes, from the simplest human actions to the most complex actions and applications, in a period of just over 75 years. The latest development is Artificial Intelligence (AI).

Artificial intelligence is now applied to almost every human activity. From the simplest everyday human actions, to the most complex scientific activities. Of course, agriculture could not be an exception. In the following chapters, you will often see references to applications that use (AI). For this reason, we thought it appropriate to begin the book you hold in your hands by introducing readers who are unfamiliar with technology to the most well-known tools used to leverage modern technology.

1.2 What is Artificial Intelligence (AI)?

According to the OECD (2019), (AI) is a machine-based system that can, for human-defined objectives, make predictions, recommendations, or take decisions that affect real or virtual environments. It uses mechanical and human-centric inputs to perceive the environment, abstract, unified, and specific perceptions in models in an automated or manual way, and to use the conclusions of the models to form options for information or actions. (AI) systems are designed to operate with different levels of autonomy.

Artificial Intelligence is an advanced technology, which is usually performed by a series of algorithms, computers, or robots. It also uses real-time data to simulate human intelligence.

It can reproduce human thought and make decisions. In other words, it is programmed to think, act, and respond just like a living human being.

However, it should not be confused with automation. Automation, like (AI), uses real-time data to perform a function. However, the mechanisms and the result are very different.

For example, automation requires manual data entry to perform a task. The task will be repeated regardless of what the data says or whether there is an error. In contrast, artificial intelligence is machine learning. This means that it requires data input, but as it processes the data, it can recognize errors. It can then adjust its functions and algorithms as needed, thus avoiding potential errors.

Artificial Intelligence (AI) can help humans in many areas because:

1. It reduces human error

Let's face it, sometimes people make mistakes. The good thing about making mistakes is that we usually learn from them.

(AI) works in the same way. While acting and performing like a human, it can greatly reduce errors. This helps us understand all possible outcomes and choose the most appropriate one.

By using data and predictions, we can better understand our options, the outcomes, and the implications of those outcomes. This is particularly useful for businesses. Decision-makers can consider all the possibilities before taking action.

2. It helps with research and data analysis

Another advantage is the use of technology for research and data analysis. (AI) technologies are intelligent and can collect the necessary information and make predictions in a matter of minutes.

What would normally take a person months of research can now be done in significantly less time. The data collected by (AI) and the analysis performed are invaluable. You can use this information in collaboration with data analysts.

3. It can make unbiased, intelligent decisions

With the right data, artificial intelligence removes bias from decision-making. You can achieve the best results by using it. However, you must ensure that specific information and the most accurate data set are entered.

When it has and processes the best data, it can accurately predict results, solve problems, and perform functions correctly. However, if the data you feed into the programs is problematic, you will likely get a questionable result.

4. Performs repetitive tasks

Automation and (AI) are different technologies. However, artificial intelligence can function as an advanced version of automation. It can be used to perform repetitive tasks and suggest alternative results. Most importantly, users gain more free time to deal with other more complex issues.

1.3 Ethical Issues Arising from the Use of AI

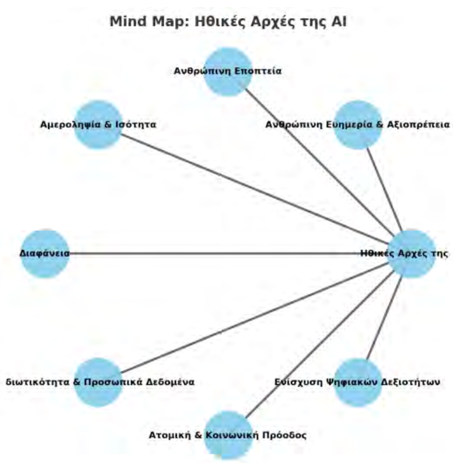
The ethics of artificial intelligence is a set of rules that ensure that AI is developed and used in ways that are beneficial to society and includes, among other areas, justice, security, particularly of personal data, transparency in actions affecting society as a whole, prevention of actions that could have a social impact, etc.

(AI) ethics, with the above conditions, is a positive force that helps to limit injustice and enhance creativity. The more natural or legal persons rely on (AI) the more likely they are to experience the positive or negative effects of its use.

While the technology on which (AI) is based can be designed to prioritize ethical issues, it is the human factor that ensures its operation in accordance with ethical rules.

To date, there is no **"Universally Agreed System of Ethical Principles for (AI)"**. Many organizations are working toward creating guidelines on **"Ethical Principles"** for AI law.

These principles mainly concern



● **Human welfare and dignity.**

AI systems must prioritize and ensure the well-being, safety, and dignity of individuals and not aim to replace them.

● **Human oversight.**

To ensure that ultimate responsibility lies with humans, (AI) requires human oversight and monitoring at every stage of monitoring and use.

● **Impartiality and Equality.**

AI design processes must prioritize fairness, impartiality, and the absence of any form of discrimination based on gender, race, religion, etc.

● **Transparency.**

AI models must propose solutions and recommendations using completely transparent processes and in a completely clear manner.

- **Support for privacy and personal data protection**. AI models must follow standards that ensure **"Avoidance of Personal Data Breaches"** and protect **"Privacy"** in all its forms.

- **Individual and social progress**.

AI must contribute to **"Individual and Social Progress"** in all areas of social life, preventing practices of inequality and unfair competition.

- **Strengthening digital skills**.

AI must be understandable to everyone, and services must be provided that are accessible to all and contribute to upgrading their digital skills.
The application of "Ethical Principles in AI" is up to all of us, those who are more or less involved, directly or indirectly, in the design of AI models, as well as the use of these models. The groups involved include natural persons and legal entities with different roles, such as:

- **Developers and Researchers.**

They play a key role in the creation of AI systems, giving priority to humans, dealing positively with all forms of prejudice (religious, racial, etc.) and aiming for transparency and the avoidance of all forms of discrimination.

- **Policy makers.**

They must enact laws and regulations that promote the use of AI with respect for its ethical principles.

- **Academic teachers.**

With their authority as individuals and scientists, as well as the authority of the institutions they represent, they contribute to the development of ethical guidelines for the use of AI.

- **End users of AI**

End consumers and citizens have an interest and a duty to ensure, through their behavior towards AI products, that the AI systems they use are reliable, transparent, and beneficial to society, while contributing to social development alongside the development of AI.

1.4 Personal Data Protection and (AI)

AI technologies create a wide range of opportunities in many social activities. AI systems include, among other things, the processing of personal data. This raises the need to establish rules governing issues between (AI) and "citizens' personal data," such as rights relating to

- individuals' freedom of thought,

- freedom of expression,
- freedom of access to information,
- the right to conduct business by legal means,
- the right to education.

For the specialized training of individuals involved in personal data protection, the Personal Data Protection Authority has developed Special Study Programs for

- Data protection officers (DPOs) and privacy professionals,
- Cyber security program managers and system development program managers (AI).

A basic prerequisite for the protection of personal data is the methodology that must be followed, which concerns the "Security of Personal Data Processing" and includes:

✔ **Confidentiality.**
Information/data must not be disclosed to unauthorized persons.

✔ **Integrity.**
Information/data must be accurate and authentic, not incorrect, altered, or out of date.

✔ **Availability.**
Information/data must be available to Users whenever requested.
The "Data Controller" is obliged to comply with the above conditions. At the same time, they are obliged to manage incidents of non-compliance, which requires the existence of mechanisms and procedures for identification, recording, notification to the competent authority, and communication to the persons affected.

1.5 Popular Artificial Intelligence tools for general use.

Modern technology constantly surprises us, providing us with new Artificial Intelligence Tools at such a pace and with such new capabilities that the information below may soon be considered outdated. Another feature of advanced new technologies is that they are easier to access and more user-friendly, allowing users to take advantage of their capabilities.
Below you will find a list of the most popular Artificial Intelligence websites. Each website provides information about its specific features and how you can use each of them.

Indicative list of websites (AI).

- Chat GPT - https://chatgpt.com/
- Perplexity - https://perplexity.AI/
- Claude - https://claude.AI/login;returnTo=%2f3F

- Napkin - https://napkin.AI/
- Microsoft Designer - https://designer.microsoftcom/
- Google Gemini https://gemini.google.com/

1.6 Popular Artificial Intelligence Tools for Agriculture

Agricultural applications and software are transforming the way modern farms and agricultural businesses operate. Whether you manage a livestock farm, a small vegetable farm, or a **CSA (Community Supported Agriculture)** model, the right digital tools can reduce paperwork, improve decision-making, and increase profitability. From crop planning and field monitoring to customer orders and financial reporting, software now plays a central role in everyday agricultural activity.

These platforms are not only aimed at high-tech agricultural businesses. Many tools are designed specifically for small and medium-sized farms, with features that simplify subscriptions, automate order packaging, and manage retail and wholesale pricing. Others focus on data-driven agriculture, using field maps, soil data, and yield tracking to improve production. Whatever your focus, there is software that can help you save time, reduce costs, and grow your business with greater reliability.

1.7 What are Agricultural applications (AI)?

Agricultural applications are digital tools designed to help farmers manage specific parts of their operations via mobile devices, tablets, or computers. These tools range from simple data recording applications to complete platforms that integrate production, sales, inventory, and finance.

Some apps focus on specific functions, such as soil monitoring, crop planning, or equipment tracking. Others provide broader management systems that cover everything from customer communication to order fulfillment. Many are cloud-

based, enabling real-time updates and data sharing between farm workers, managers, and outside consultants.
The goal of agricultural apps is to simplify workflows, reduce paperwork, and support better decisions through accurate and reliable information. Whether you manage farm work or sell products online, these tools are designed to meet the daily demands of modern agriculture.
For example, there are apps that inform farmers when to water their crops based on prevailing weather conditions, recorded humidity, and the volume of water used during recent water-ings. Of course, it is not enough to simply download the application on your mobile phone; but also sensors must also be placed in the ground and connected to a meteorological network so that the system is constantly updated. Nevertheless, the accuracy provided is very useful.

Other apps help to better organize the business's production. All expenses are recorded, as the app is connected to all the businesses the farmer buys from, whether services or equipment, and provides real-time updates on the financial status of the business. Let's not forget that a farmer is also an entrepreneur.
Other applications inform farmers about which plant protection products and in what quantities they can use depending on the crop and the type of infestation, such as https://plantpro.gr/
Recently, technological advances have been made in the agricultural sector with the help of drones—those small flying devices that are widely used to take photos and videos from the sky. By providing images from above, drones make it possible to identify any problems in the crop related to fungal, bacterial, and insect infestations, such as the olive fruit fly.
How useful any of the above applications are, depends on the needs of the individual and their crops. In any case, the technology exists and can be used to the benefit of anyone who uses it.

1.8 Useful Websites for Managing Agricultural Issues. Agricultural Applications & Apps

International mobile applications

1. **Plantix** – for diagnosing crop problems (diseases, pests, nutrients) from photos
https://play.google.com/store/apps/details?id=com.peat.GartenBank&hl=en
2. **FarmLogs** – monitoring and recording tasks, weather forecasts, soil data
https://play.google.com/store/apps/details?id=com.farm.logapp&hl=en
3. **Granular** – integrated farm operations and cost management
https://play.google.com/store/apps/details?id=ag.granular.insights&hl=en
4. **Trimble Ag Software** – precision farming, mapping, and analytics.
https://ww2.agriculture.trimble.com/software/prior-farm-works-desktop-versions/
5. **Agri360** – cloud-based platform with dashboard and alerts Visual alarm on control panel. https://marketplace.microsoft.com/en-us/product/web-apps/agrivi.agrivi_fms_insight?tab=overview

6. **SmartFarm** – real-time monitoring with sensors & alerts.
   https://play.google.com/store/apps/details?id=com.appsforagri.smartfarm&hl=en
7. **FJD Farm Management System (FMS)** – task planning, GPS & data.
   https://fj-dynamics.co.uk/autosteer/software/fjd-farm-management-system/
8. **ifarma by Agrostis** – farm and producer group management software.
   https://ifarma.agrostis.gr/index_en.php
9. **Solvi** – drone data analysis tools for smart input use.
   https://solvi.ag/
10. **John Deere Operations Center** – platform that connects machine and application data.
    https://operationscenter.deere.com/

1.9 Mobile phone applications for Agricultural Management

The following websites provide interested parties with applications that can be used on their mobile phones (Android, iOS) and focus on areas such as environmental footprint, recycling, sustainable markets, reducing water waste, crop monitoring, production control, etc.

Like any successful mobile application, the best "green" applications are also easy to use. There are already several applications on the market that successfully focus on environmental principles.

As mobile apps continue to dominate the digital age and show unprecedented growth rates, their influence is likely to continue to grow. Mobile apps have a significant advantage in terms of influence, as research shows that most smart phone owners spend 60% of their time on mobile apps. For apps that seek to bring about change, focusing on "green" values is an excellent way to achieve this goal.

Some of the most frequently used apps are:

- **Earth Hero**

  Earth Hero promotes positive environmental habits through its platform, connecting you with an eco-friendly community and allowing you to share your actions and thoughts with others! This app has everything you need to make a positive impact on the climate crisis. It is easy to use and has an excellent design, which gives it a strong foundation to positively influence society. Track your progress, find new "green" goals, and spread the word with Earth Hero.
  https://www.earthhero.org/

- **Joro**

  Joro analyzes your spending habits and provides action steps to help you adopt a more sustainable lifestyle. Joro helps users make small changes to their spending that have a big impact on the environment. The app looks at the emissions associated with your purchases and provides easy-to-understand reports so you can see where you are leaving the largest carbon footprint. It is an easily integrated mobile app, ideal for anyone who wants to make small but meaningful changes.

https://play.google.com/store/apps/details?id=com.monbuilding.app.joro&hl=en

Many apps encourage their users to make better environmental choices, even if the app itself is not exclusively focused on climate. There are many ways apps can promote social change, such as planting trees as a reward, highlighting sustainable products, and sending climate-related alerts. There are currently several mobile apps available that successfully incorporate green features.

- **Flora**

Flora is an environmentally-focused habit-tracking app that helps you manage your daily tasks. Although you can track any activity you want, the app promotes environmentally friendly choices and actually plants trees as a reward for achieving your goals within the app. It is an excellent example of integrating green features into a more general app. The app is free, but there is also a paid option that allows you to fund the planting of more trees if you want to help the planet even more.
https://play.google.com/store/apps/details?id=com.appfinca.flora.android&hl=en

- **Thrive Market**
  Thrive Market is a successful online food marketplace that aims to help people live a healthy lifestyle at an affordable price. Although its vision goes beyond narrow environmental impact, it does an excellent job of highlighting sustainable products so that users know when they are making "green" choices. This brand regularly promotes information, tips, and practical steps related to the climate. Users who interact frequently with Thrive Market can easily reduce their carbon footprint and waste. If reducing your carbon footprint is a key goal, you can even sort products based on sustainability. This is an excellent app that combines green features with a multifunctional platform.
  https://play.google.com/store/apps/details?id=com.thrivemarket.app&hl=en

- **Plantix** – Crop Doctor (diagnostic app) on Android

Official website with download instructions: **Plantix** Agricultural app for crop diagnosis and care. It recognizes crop diseases and pests from photos and provides treatment recommendations.
https://plantix.net/en/

- **Bushel Farm**

For monitoring and recording crops and financial data related to crops (works on iOS)

https://play.google.com/store/apps/details?id=io.trigger.forge633ed212c46d11e185cd12313d1adcbe&hl=en

- **AgriWeb –** Farm & Livestock Management

Official page with information and mobile installation instructions.
Farm data management with offline mode.

Chapter 2

The European Green Deal and Sustainable Agriculture.

2.1 European Green Deal

It is an agreement between the countries of the European Union with the aim of making Europe the first climate-neutral continent and sets out a plan for the transformation of Europe's economy, energy, transport, agriculture, and industry in Europe with the goal of a more sustainable future. The Green Deal invests in innovation, clean technology, and green infrastructure, ensuring a fair upgrade for the societies most affected.

In this way, Europeans will rely more on renewable energy sources for their daily needs, enjoy cleaner air and better quality products.
The Green Deal supports the transformation of the European Union into a fair and prosperous society with a modern and competitive economy, with human activities that will limit the rise in global temperatures and extreme social phenomena that have devastating consequences for our lives.
The vision of the European Green Deal is to restore a healthy balance in nature and ecosystems by 2050 and to achieve

- Climate neutrality, by reducing greenhouse gas emissions.
- A circular economy, by reusing repair materials and reusing devices, resulting in reduced waste.

- Clean Industry, by promoting sustainable and energy-efficient industries.
- A healthier environment, with respect for nature and efforts to minimize environmental pollution.
- Sustainable Agriculture, with ecological farming practices that protect the environment while providing healthy and affordable food.

2.2. Sustainable Agriculture

Sustainable agriculture is a combination of philosophy and Innovative Practices that meets the following conditions:

- Protection of the environment and natural resources
- Ensuring adequate income for Farmers
- Ensuring the professional sustainability of future generations in agricultural occupations.

In other words, Sustainable Agriculture ensures

- Satisfactory returns for farmers.
- Protecting the environment (water, soil, air) from pollution.
- Recycling of all types of waste.
- Ensuring the balance of the ecosystem and biodiversity.
- Rational use of water resources.

Example to avoid - Alternative solution

Spraying an area with broad-spectrum herbicides irreparably damages plants and insects, many of which pose no threat to the crop in question, may even help it, and generally harm the ecosystem.

An alternative solution could be crop rotation on each farm, which has been shown to improve soil quality and reduce the population and species of weeds.

The biggest obstacle to the establishment of sustainable agriculture is the general lack of education in society and the lack of training and lifelong learning for those involved in agriculture, so that the rules of sustainable agriculture can be adopted. In order to properly implement the rules of Sustainable Agriculture, at least three years of preparation are required for farmers to reap the benefits.

On the other hand, farmers rely almost exclusively on and look forward to their income each season. For the project to succeed, a basic prerequisite is for governments to draw up a realistic plan that includes

- Training farmers in sustainable agriculture.
- Subsidies for farmers for a specific period of time.
- Informing society about the benefits of sustainable agriculture for everyone.

In the European Union, agriculture occupies a unique position and is at the heart of the European Union's society, environment, and economy. For this reason, it established the Common Agricultural Policy (CAP), which applies to all European Union countries and is based on three pillars/objectives.

- Economic sustainability.
- Environmental sustainability.
- Social sustainability of farms.

To achieve these objectives, each country draws up its own plan of targeted actions aimed at meeting the specific needs of each country and achieving the common objectives of the European Union, which are:
See:
https://agriculture.eu.europa.eu/cap-my-country/sustainability/environmental-sustainability/biodiversity

2.2.1. Enhancing Agricultural Biodiversity

Enhancing Agricultural Biodiversity in the European Union.
The Common Agricultural Policy aims to enhance the diversity of species, natural habitats where organisms (animals and plants) live and grow, pollinators, and landscape features that are necessary in the agricultural ecosystems of the European Union.
Agricultural biodiversity encompasses all wild and domesticated life forms found on farms, from plant varieties and animal breeds to soil organisms, harmful insects, and pollinators.
The Common Agricultural Policy aims to safeguard biodiversity within sustainable farming systems, ensuring that farmers can produce food and earn an income while protecting agricultural ecosystems.

2.2.2 Protection of natural resources

The protection of natural resources (soil, water, air) in the European Union is of paramount importance for the functioning of agriculture and ensures the responsible management of these resources.

- **Protection of soil health.**

The Common Agricultural Policy ensures compliance with rules for soil protection and encourages farmers to take additional measures to I mprove soil management.
Soil is an essential, non-renewable resource for agriculture, as it provides the basis for the production of food, fiber, and other resources for a modern bioeconomy.
Soil also supports biodiversity, plays a central role in carbon sequestration and storage, and provides a range of ecosystem services, such as water regulation and nutrient cycling.

To protect these vital functions and ecosystem services, the Common Agricultural Policy supports sustainable soil and land management.

- **Water protection. (Safe Water)**

The Common Agricultural Policy (CAP) protects water by ensuring compliance with European Union rules and encourages sustainable management practices, thereby helping to protect the essential role that water plays in food, agriculture, and the environment.
Clean and sufficient water is a key natural resource for society and the basis of human health and quality of life. To protect this resource, the Common Agricultural Policy encourages farmers to use their water resources in a safe and sustainable way.
Agriculture is highly dependent on water, as it requires a stable and secure supply to ensure the health and prosperity of crops, livestock, and all forms of life within an agricultural ecosystem. However, water is vulnerable to a range of challenges often linked to unsustainable management practices.

Climate change poses additional challenges to agricultural water use, with an increased risk of drought and greater water scarcity in some areas, while others are experiencing increased flooding. In some areas, both droughts and floods may occur.
Through the Common Agricultural Policy, the European Commission aims to ensure that agriculture contributes effectively to European Union policies.
Water protection is also a key pillar of the European Green Deal, particularly In relation to the ambition of zero pollution by 2030 and the achievement of a sustainable food production system.

- **Air protection. (Safe Air)**

The Common Agricultural Policy supports farmers in reducing emissions that can cause air pollution and in controlling emissions of harmful substances into the atmosphere.
Fresh, clean air is essential for human, plant, and animal health and is an important element of quality of life in the European Union.

The CAP supports farmers who protect air quality as part of a sustainable agricultural system. Along with soil and water, clean air is an essential natural resource for agriculture. However, agriculture is a significant source of air pollution because:

- ✔ Agriculture is responsible for approximately 93% of final ammonia emissions in the EU, which are linked to poor manure management in agricultural activities and the use of synthetic nitrogenous ammonium fertilizers (especially urea). Emissions from this process can lead to excessive nutrient enrichment of water and soil acidification.
- ✔ Methane, a by-product of animal intestinal fermentation, is a pollutant of the terrestrial environment that can cause damage to crops.
- ✔ Specific substances, such as PM10, come from pollutants emitted by industries, factories, and cars, as well as from biomass burning and forest fires.

The CAP ensures that agriculture can have a strong impact on the EU's intention to achieve a clean environment.

2.2.3 A long-term vision for rural areas

This vision sets out three actions to make the EU's rural areas stronger, connected, resilient, and prosperous.

To ensure that rural areas can contribute to the key roles of the plan, a European Commission communication sets out a long-term vision for the EU's rural areas up to 2040.

It identifies areas for action with the aim of stronger, connected, resilient, and prosperous rural areas and communities. An EU Rural Pact and Action Plan, with concrete flagship actions and new tools, will help achieve the goals of this vision.

For more information, ideas that can be applied in any rural area, examples of good practices from different countries, contact details and feedback, and anything else that might interest you, please visit the following websites.

1. https://rural-vision.europa.eu/action-plan_en
2. https://ruralpact.rural-vision.europa.eu/index_en

2.2.4 Ecological Programs

About half of Europe's land area is cultivated. Farmers cultivate it as stewards and produce goods that we all need through their work.

Agricultural activities are affected by many factors, such as climate change and weather events, as well as the quantity and quality of water available for agriculture.

Eco-schemes aim to contribute to the priorities of the green transition.

Eco-schemes are a new feature of the (CAP) 2023-2027 and support farmers in adopting practices that minimize the negative impact of agriculture on the environment and climate and help them evolve and implement more sustainable agricultural models.

Ecological programs support farmers who implement agricultural practices that contribute to achieving the EU's environmental protection goals and create conditions to combat climate change.
Through eco-schemes, the EU rewards farmers who strive to conserve natural resources and provide agricultural products for the benefit of all.
Eco-schemes support practices that:

- Cover activities related to climate and the environment
- Are defined by the European and National Strategic Plan for the Common Agricultural Policy
- Are in line with the objectives of the EU Green Deal.

2.2.5 Organic Farming - Organic Crops.

Organic farming promotes environmentally friendly practices that minimize the use of fertilizers and pesticides, improve soil health, and enhance biodiversity.
The EU's goal is for organic farming to account for 25% of European agriculture by 2030.
The European Regulation on Organic Farming and Cultivation sets clear and strict standards for organic production and certification to ensure consumer confidence in organic products.
Organic farming in the European Union covers a wide variety of products, including all production processes from seeds to final edible products.
Specifically, it covers:

- Seeds and propagating material, such as cuttings, rootstocks, etc., from which plants or crops are produced.
- Agricultural processed or unprocessed products used as food.
- Animal feed.
- New products, such as products, cork stoppers, essential oils, raw cotton, beeswax, wild plants when they come from natural habitats, etc.

The production of organic products must comply with the rules of organic farming, which are designed on the basis of the principles of environmental protection, biodiversity conservation, and the creation of consumer confidence in organic products.

The basic principles of organic production are:

1. Sowing.
2. Prohibition of the use of genetically modified organisms.
3. Prohibition of the use of radiation.
4. Restriction on the use of chemical fertilizers, herbicides, and pesticides.
5. Prohibition of the use of hormones, restriction on the use of antibiotics, and prohibition of nitrogenous chemical fertilizers.
6. Implementation of methods and crops that bind nitrogen or others that contribute to the restoration of soil fertility.
7. Reduction of the impact of weeds by selecting resistant varieties and developing techniques that promote natural pest control mechanisms.

The rules cover all stages of production and distribution, from primary production, storage, processing, and transport to the final consumer. In other words, strict rules must be followed from the farm to the consumer's plate.
The European Union promotes sustainable and environmentally friendly practices in food production, with the aim of protecting the environment, human health, and improving food quality.
Measures relating to organic farming envisage its development to 25% of the total by 2050, and all products marketed as organic must be derived from plant reproductive material that complies with organic production standards.
European Union countries maintain a database of organic plant reproductive material to assist producers who have difficulty finding suitable sources.

2.3 General Conclusion - Innovation Goals in Agriculture

Innovative farming methods focus on maximizing yield in a limited space, improving efficiency through technology, and enhancing environmental sustainability, thereby reducing the environmental footprint of each crop.
Innovative farming methods achieve :

- A significant reduction in the amount of water required for innovative crops compared to the amount of water used in conventional crops.
- Minimization or even zero use of insecticides, herbicides, and all kinds of chemical additives, the use of which in crops degrades the quality of the final product.
- Utilization of alternative forms of energy production (wind turbines, photovoltaic systems) in order to use this energy in the cultivation process, instead of using other polluting energy sources.

- Utilization of technological applications and artificial intelligence in order to

determine with great accuracy and in a timely manner the actual requirements of each specific crop and thus achieve the highest possible crop efficiency.

- Making the best possible use of the human resources employed in farming and shifting human activities from manual labor to the use and exploitation of technological applications.

- The utilization of even small arable areas, which in fact multiply if exploited in the form of vertical crops.

- The creation of jobs for young people, mainly farmers, which diversify employment with innovative crops, compared to the traditional image of farmers and agricultural occupations.

- The production of specific agricultural products that are considered seasonal, throughout the year, satisfying the professional aspirations of producers and, at the same time, the desires of consumers.

- Innovative crops, even on small areas of land, can produce products close to where they are consumed, meaning they reach consumers fresh and with lower transport costs.

The conclusion that each of us can draw from the above is that achieving the goals of innovative crops will have the following results.

- Increased productivity per unit of cultivated area.
- Improved quality of products.
- Savings in energy and water resources.
- Reduction to zero of environmental pollution from agricultural waste.

- Use of alternative forms of energy.
- Upgrading the employment status of those engaged in agriculture.
- Creation of new professional standards and new jobs.
- Upgrading of rural areas and the countryside in general.

In order to achieve these objectives and results, appropriate **"initial and Lifelong Education"** is required for those who intend to engage in innovative farming. This role belongs to public or private educational institutions and is supported by European educational programs
Adapted to the local needs and local, regional, and climatic characteristics of each country.

Chapter 3.

Innovative methods of Agricultural Land Use.

3.1 Introduction.

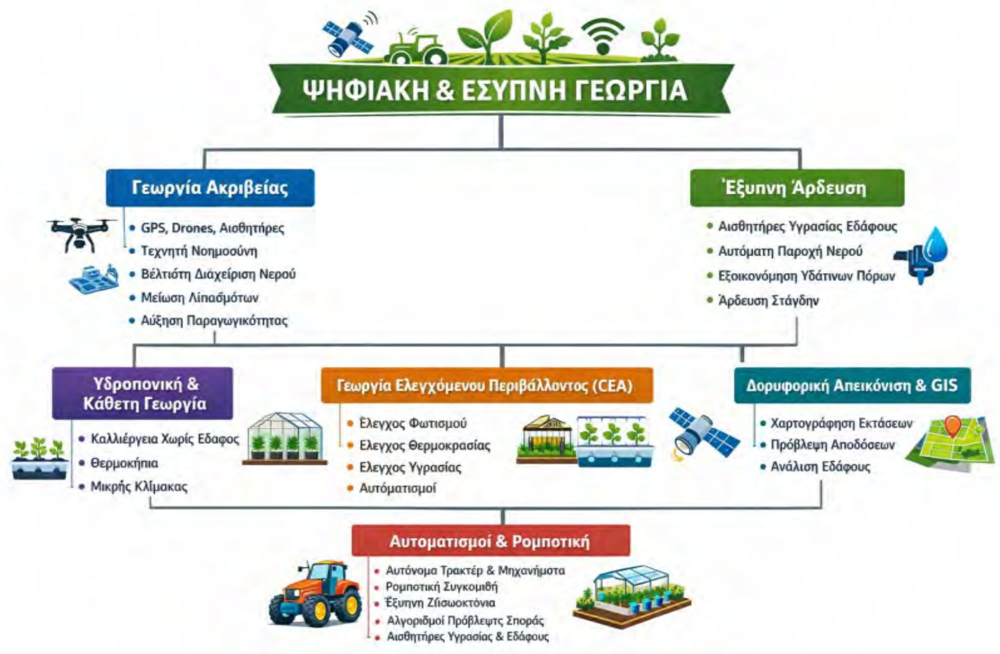
Innovative methods of agricultural land use focus on maximising the yield and efficiency of each crop through the use of modern technology applications while protecting the environment.
Some innovative methods of agricultural land use that combine sustainability with productivity and technological progress are as follows:

- **Precision Agriculture**

It relies on the use of GPS, drones, sensors, and artificial intelligence, and aims to optimize water management, minimize the use of chemical fertilizers, increase plant protection, and increase efficiency per unit of cultivated area.

- **Smart irrigation Systems – Precision irrigation – Drip Irrigation**

Aim to eliminate water waste in crops with the help of special sensors that monitor soil moisture, determine the necessary amounts of water for irrigation, and provide



automated irrigation.

- **Controlled Environment Agriculture**.

- **Hydroponic Agriculture - Vertical Farming**.

This involves small-scale crops, particularly greenhouse crops
and uses technology applications to control lighting, temperature, humidity, and other environmental factors.

- **Satellite Imaging and Mapping, GIS.**

This mainly concerns large-scale crops and aims to plan and allocate the use of arable land, predict yields, detect specific soil conditions, etc.

- **Artificial Intelligence Automation - Robotics**.

These applications mainly concern large-scale crops and use technological applications for the autonomous operation of tractors and other agricultural machinery, the robotic operation of weed control machines and harvesting tools, the use of algorithms to predict ideal periods for sowing, the use of moisture sensors, etc.
The list of innovative methods and ideas is not limited to the above examples but can include a number of other applications depending on the category to which the crops belong.
In this essay, we will refer to innovative cultivation methods that fall into the following three categories.

a. Small-scale farming.
b. Large-scale farming.
c. Smart "Cultivation Villages."

3.2 Small-Scale Producers and crops

Small-scale producers and small-scale farming play an important role in local communities because they are family-based and constitute a significant part of local employment.

Small-scale producers are often the driving force behind agri-food systems, particularly in marginalized and threatened environments, mainly in low- and middle-income countries, where climate change —along with other disruptive forces—has a disproportionate impact.

Small-scale producers make a significant contribution to many national economies and include many groups, such as women, young people, and indigenous peoples, whose existence and contribution are systematically undervalued.

Despite their importance, they often fail to compete successfully with well-equipped large-scale producers. This ultimately leads to social, environmental, and economic inequalities.

Focusing on small-scale production can help the transition to agri-food systems that are more in tune with ecosystems and human needs, and that can better respond to disruptions and changes. Small-scale producers will be key to the sustainable transformation of agri-food systems and to achieving the goals of the 2030 Agenda.

Small-scale producers participate in agri-food systems that may be less productive than large-scale systems, but are often more resilient to climate change and environmental pressures. The nature of small-scale production often allows for the adoption of ecologically restorative practices, and such systems can be important sources of agrobiodiversity and diverse knowledge systems.

Efforts are being made at national and European level to maximise their contribution to improving prosperity and quality of life worldwide. Recommendations and proposals are being formulated to exploit the largely untapped potential of small-scale producers and their contribution to the transformation of sustainable agri-food systems.

The benefits of moving small-scale production from the margins to the center are clearly presented, showing how small-scale producers can play a decisive role in the transition from the dominant industrial agricultural model to a system that ensures food security and nutrition for all.

Small-scale production is often not adequately supported by advisory services, agricultural research, or formal education programs. There is a need to democratize power imbalances in knowledge provision and recognize the diverse forms of local knowledge of small-scale producers.

3.2.1 Low-Cost Solutions to increase productivity.

There are many low-cost and easy-to-implement solutions that small-scale agricultural producers can adopt to increase efficiency, improve yields, and manage resources in a sustainable manner. These solutions are often based on smart management practices, organic methods, and simple equipment.

a. Crop and Soil Management

The implementation of simple but effective agricultural practices can dramatically improve farm health and productivity at minimal cost:

- Crop Rotation:
  Rotating crops in a specific area each growing season interrupts insect and disease cycles and prevents the depletion of specific soil nutrients. This is a basic, zero-cost technique.
- Companion Planting:
  Strategically planting different crops together can repel pests and attract beneficial insects. For example, planting basil with tomatoes can repel tomato greenworms.
- Composting and Green Manure:
  Using agricultural waste (crop residues, manure) to produce compost and growing cover crops (green manure such as clover or rye) that are incorporated into the soil are low-cost ways to increase organic matter, fertility, and water retention.
- Mulching:
  Covering the soil with organic materials such as straw, wood chips, or plastic sheeting helps to conserve moisture, suppress weeds, and regulate soil temperature. Simple organic materials are often free or very low cost.

b. Irrigation Management

Water management is critical, and there are several economical systems that are more efficient than traditional irrigation:

- Drip Irrigation Systems:
  These deliver water slowly and directly to the roots, significantly reducing losses from evaporation and runoff. Low-cost kits or improvised constructions, often using gravity from an elevated tank, are particularly efficient and affordable for small areas.
- Rainwater Harvesting:
  Collecting and storing rainwater in simple tanks, barrels, or small ponds can provide a critical, free source of water during dry periods. The basic components are usually gutters and downspouts.

●

●

● Manual/Portable Sprinklers:
For very small plots, a few portable sprinklers connected to a small water source (e.g., a household well) can provide irrigation by moving from zone to zone.

c. Weed and Disease Management

Organic and non-chemical methods are often the cheapest and safest for small farms:

● Attracting Beneficial Insects:
Planting insect-attracting plants (such as yarrow, clover, or dill) in flower

strips provides nectar and pollen to natural enemies of pests, such as ladybugs and parasitic wasps.

- Homemade Natural Preparations:
  Homemade solutions with ingredients such as garlic, hot peppers, or neem oil can repel or kill many common insects without the cost or toxicity of chemical pesticides.
- Physical Barriers:
  The use of crop covers or insect nets can physically prevent access by insects such as fleas or squash bugs. Yellow sticky traps are also a low-cost tool for monitoring and reducing flying pests.
- Manual Removal and Trapping:
  For larger insects, manual collection or makeshift traps can be particularly effective and cost-free, although labor-intensive.

3.2.2 Digital Technologies

Digital technologies have shown that they can help address some of these challenges. However, digital divides remain, along with concerns about the distribution of costs and benefits to small-scale producers in agri-food systems promoted through digital innovations.

The following pages provide ideas for innovative initiatives involving small-scale farming using smart farming systems on small plots of land and leveraging technology applications.

Expanding the potential of small-scale producers to transform sustainable agri-food systems requires policies, institutions, legislation, and investments that maximize the synergies of small-scale production and minimize conflicts between the social, economic, and environmental dimensions of agri-food systems.

Support is needed for the creation and exchange of knowledge and innovation for sustainable small-scale production in order to have a real impact, as Mona Chaya, special advisor to the FAO Office, points out.

The increasing specialization and simplification of agri-food systems, as well as the concentration of decision-making, are unlikely to contribute to solving today's challenges. Addressing them requires persistent,

small-scale producers around the world.

Even basic technology can increase efficiency and market access:

- Mobile Phone Advisory Services:
  Simple mobile phones allow farmers to receive local advice on planting times, weather forecasts, and warnings about diseases or insects from agricultural services.
- Digital Market Platforms:
  Using apps or social networks to connect directly with consumers or traders can improve market access and secure better prices.

The study "Small-scale production in the transformation of sustainable agri-food systems" is an attempt to highlight their importance and potential in the transformation of agri-food systems.

3.3 Controlled Environment Agriculture-Aquaculture- -Hydroponics

Aquaculture is an innovative method of cultivation without soil, using nutrient-rich aqueous solutions that are continuously recycled, thereby saving 70% - 80% of the water used in traditional agriculture. For this reason, hydroponics is particularly useful in areas facing water shortages.

Small-scale hydroponic systems can be adapted to any indoor or outdoor space and have the following characteristics.

- They are simple and easy to use.
- They are inexpensive to install.
- They are easily expandable.
- They do not require specialized knowledge to install and operate.
- They are easy to install.
- They can be monitored electronically and automated.
- Prefabricated hydroponic systems are readily available on the market and are guaranteed
- Systems constructed by the grower according to their needs, combining a range of components purchased from the market, have selected the appropriate system and techniques for their case, such as
    - substrate cultivation.
    - substrate-free cultivation.
    - Preparation of seedlings.

All techniques are equally valid and all start from the seedling or cutting stage, continue through the plant's growth period, and end with the fruiting period.

Everything takes place in a suitable **"Grow Room,"** which can be a building or a greenhouse, as long as the plant's growth parameters are systematically monitored.

3.3.1 The Future Potential of Hydroponics and Integration into Existing Food Systems

Aquaculture has enormous potential to complement traditional agriculture. You can integrate it into existing systems to enhance productivity and sustainability. By adopting aquaculture, you diversify your farming methods. This diversification allows you to produce a wider variety of crops such as leafy vegetables, tomatoes, cucumbers, strawberries, herbs, and even fruits in controlled environments. This approach ensures a steady supply of fresh produce, regardless of external conditions. You can use hydroponics to support traditional farming practices. It provides an alternative method for crop species that may not thrive in soil-based systems. By combining both methods, you optimize land use and increase overall yield. The synergy between hydroponics and traditional agriculture enhances food security and ensures that consumers have access to diverse and nutritious product options.

Aquaculture is poised to play an important role in food production in the future. As the global population grows and demand for food increases. You can leverage aquaculture to meet demand in a sustainable way. By producing food locally, you reduce the need for long-distance transportation. Local adaptation minimizes carbon emissions and enhances food security.

You can use aquaculture to meet the challenge of meeting food demand locally. Its ability to produce high yields in limited spaces makes it an ideal solution for farming in peri-urban and urban areas.

Hydroponics complements traditional agriculture rather than replacing it.

Hydroponics offers enormous potential because it can meet food demand in a sustainable way, producing high yields in limited spaces.

Hydroponics offers many environmental benefits, such as reduced water consumption, minimized use of pesticides, support for sustainable agriculture, and a lower carbon footprint.

3.3.2 Hydroponics System Equipment.

With the various equipment systems that every hydroponics unit must have, we aim to achieve the following:

- Nutrient uptake by the roots.
- Oxygenation of the root system.
- Selection of a suitable substrate for hydroponic cultivation.
- Selection of suitable nutrient material.
- Selection of the desired hydroponic system from among
    - Systems in which the root grows in a substrate and the nutrient material is supplied by surface or underground irrigation.
    - Systems where the root grows in the nutrient solution.
    - Systems where the root grows in the air (aeroponics) and is sprayed with the nutrient solution.

The various equipment systems consist of

a) Materials for providing artificial lighting, such as full or double spectrum lamps, lamp hangers, lamps, and mirrors. Their prices range from €10 to €40.

b) - Growing chambers measuring 1.2m x 0.6m x 1.9m to 2.97m x 2.97m x 2.17m. Their prices range from €280 to €1,100.

- Cultivation space heaters. Prices range from €35 to €55

c) Ready-made hydroponic systems

- Liquid solution, pH adjustment.
- Oxygenation system.
- Coco peat substrate.
- Self-watering plant systems. Prices range from €200 and up, depending on the size of the installation.

d) Climate control.

- Air purity control device.
- Cultivation area heater.
- In-line box with filter.
- Thermometer - Hygrometer

Prices range from €10 to €60.

e) Nutrients.

_ Organic flowering stimulant.
_ Plant fertility booster.
- Liquid fertilizer.
- Mineral fertilizer compatible with all substrates.
- Organic micronutrient supplement

and prices ranging from €24 to €90, depending on the ingredient and the ml of the package.

f) Cultivation supplies.

- Coconut substrate.
- Perforated pot to increase plant mass.
- Soil improvers.
- Clay gravel.

- Hand tools. (gloves, pruning shears, saw, hoe, etc.) Prices range from €8 to €40.

e) Tools for processing fruit to produce oils

from aromatic herbs, extraction bags, moisture retention bags, freeze-drying and sublimation machines, etc.
Prices range from €1.80 for 10 airtight bags to €5,500 for a professional dehydration, freezing, and sublimation machine.
For more information, visit https://www.miilkiiagrow.com/

3.3.3 Technological Applications in Aquaculture

Technology plays a critical role in aquaculture. You can use automation and artificial intelligence to monitor and manage your systems. Smart farming technologies provide real-time data on environmental conditions and plant health. These developments enhance efficiency and productivity.
The integration of technology, AI, and automation enhances the effectiveness of aquaculture because it enables continuous, accurate monitoring and management of crops.
The initial investment for the aquaculture unit may be high, depending on the management and operating systems chosen. The medium- and long-term multiple benefits from the exploitation of aquaculture products can quickly offset the initial investment.

3.4 Vertical Farming

Vertical farming is a modern method of growing plants in layers stacked on top of each other.
It is an ideal solution for growing crops in small spaces, especially in greenhouses, and uses hydroponics (roots in an aqueous solution) or aeroponics (roots suspended in air with a nutrient mist), combining space savings of up to 90% with increased production 12 months a year.

The idea of vertical farming was born in 2011 in a classroom at Columbia University (N.Y.C.). During a class, Professor Dickson Despommier challenged his students to find a way to produce food within the perimeter of Manhattan Island. The students initially suggested growing plants on top of skyscrapers, but even if they used all the roofs on the island, they would only cover 4% of the population's food needs. So, a new idea was born: "Let's grow crops inside buildings, taking advantage of vertical space." At that time, all the technology we needed to make this vision a reality already existed.

We are already using soil-free cultivation (e.g., hydroponics) at an ever-increasing rate to produce vegetables or small fruits in greenhouses. We can also modify and control the internal temperature and humidity, and there are heating and lighting lamps suitable for use in greenhouses. All that is needed is to combine these technologies. Since then, the number of so-called "vertical farms" has increased worldwide. In recent years, expertise in this technology has grown rapidly. New technologies have made this type of production increasingly efficient, and many different crops have been successfully grown in such systems. Let's try to understand how these farms work by analyzing the various elements of vertical farming.

Cultivation methods on a vertical farm

The two main methods of soil-less cultivation in vertical farming are hydroponics and aeroponics.

Hydroponic cultivation is the most common.

The history of hydroponics dates back to the ancient gardens of Babylon and has been applied in various parts of the world. Even today, for example, in Myanmar, the local population cultivates crops on rafts floating on Lake Inle.

On an industrial level, Dutch farmers have developed hydroponic methods for production in greenhouses, and even NASA has developed some prototypes for food production in space.

The idea is simple: plants are suspended above ground level thanks to various supports, allowing water and nutrients to flow through the roots, creating a closed irrigation circuit. Plants receive the exact amount of nutrients they need and there is no waste of water.

The aeroponics system is relatively newer. It is based on the same principles, but water and nutrients are sprayed directly onto the roots of plants suspended in the air. This method is sometimes preferred to avoid water stagnation and increase root oxygenation.

3.4.1 How a Vertical Farming unit works – Equipment

The following conditions are required for a vertical farming unit to operate

a. Insulation

For vertical farming to work, it is necessary to create a separate environment to maintain the desired conditions, such as temperature, humidity, and ventilation. This closed environment should prevent the entry of pests and diseases.

It should also consist of multi-story vertical surfaces or towers. These surfaces can be installed practically anywhere, such as in buildings, boats, warehouses, homes, for educational purposes, in outdoor restaurants, but mainly in greenhouses

b. Ventilation System (Humidity Ventilation and Air Control)

After insulation, the ventilation and humidity control system (HVAC) is the most critical "tool" in vertical farming. This system must filter the incoming and outgoing air, creating the best possible environment for crops.
When setting up a vertical farm, it is essential to design the HVAC system with great care in relation to the space. The success of the crop, the productivity of the plants, and the operating costs related to energy consumption depend on this.

Cultivation system
Regardless of whether a hydroponic or aeroponic system is chosen for cultivation, Skygreen (one of the first vertical farming companies) mobile platforms (panels) can be used for vertical farming. Nutrient film technique (NFT) cultivation, towers or tubes, and shelves/tables are the most commonly used systems.

Lights
Since we are talking about indoor cultivation, you will need the right lighting to replace direct sunlight. Specifically, the wavelength of red and blue (which appears pink or purple to us) must be reproduced.
The lighting systems used today are very energy efficient and can be used to grow a variety of plant species . Some LED lamps are so efficient that they allow the spectrum and intensity of light to be modified when it is necessary to switch crops or even simulate, for example, sunset and sunrise , replicating natural conditions and photoperiods as closely as possible.

Crop software
These systems have a different type of software for controlling and managing climatic conditions, irrigation flows, and lighting. Software, artificial intelligence, and the Internet of Things (I.o.T.) are constantly evolving, increasing the level of automation in all crops.

Seeds and Substrates
Growing from seeds is less expensive and is preferred over transplanting seedlings. It also makes it easier to control the production process, from sowing to harvesting.
The plants generally grown in vertical farming are leafy vegetables, microgreens, small fruits (such as strawberries), hemp, herbs, and flowers.
There is a wide variety of substrates used for cultivation, both in terms of shape and material (e.g., peat, rockwool). The substrate must be carefully selected according to the system chosen, the crop, and the irrigation method. Usually, organic substrates are chosen, which can be composted and do not produce harmful waste.

3.4.2 Advantages and Disadvantages of Vertical Farming

a. Advantages

It is clear that vertical farming has many advantages:

- Land conservation: in vertical farming, space is used efficiently, which is essential for food production due to the growing global population without the exploitation of additional agricultural land. It also avoids problems such as over-fertilization, which causes water pollution (especially in monocultures).
- Water conservation: vertical farming is particularly water-efficient. It has been proven to use 90% less water than conventional farming.

With some systems, water can be recovered and moisture from transpiration can be reused to irrigate plants.

- From farm to fork: The ability to grow crops in a fully controlled environment allows production in any location or facility, from warehouses to schools, ships, or even space stations. Growing plants in or near large cities is an effective way to avoid significant carbon dioxide emissions and transportation costs. Reducing the time from harvest to consumption is a good way to keep crops fresh, tasty, and nutritious.

Twelve-month continuous production: The ability to produce year-round regardless of external climatic conditions allows crops to be grown anywhere in the world continuously and safely.

Crop production and preservation: Monoculture, pesticides, and climate change are responsible for the decline in the number of species and varieties grown around the world. The ability to control climatic conditions allows you to maintain varieties that are being abandoned because they are less productive or less tolerant to new, more intense environmental stresses.

- Clean nutrition: Indoor cultivation allows for pest- and disease-free growing, eliminating the need for herbicides or pesticides.
- Attractiveness of the practice and attraction of new professionals: The loss of interest in agricultural practices is a phenomenon observed worldwide. However, the technology and modern features of vertical farming are attracting new people, reversing the trend of recent years.

b. Disadvantages

- Energy consumption: The energy required for the HVAC system (which operates 24 hours a day) and lighting must be taken into account. However, photovoltaics and batteries can reduce costs and energy consumption.
- Crop selection: Although you can grow almost any crop, only certain species and varieties are suitable and profitable.

3.4.3 Before starting a Vertical Farming Business

If you want to start a new business in this field, you need to be passionate and motivated, as developing such a business requires time and research. It requires constant updating, a strong ability to overcome obstacles and bureaucracy, and an understanding of regulations. However, sustainable production of high-quality food is an exciting and creative endeavor.

a. Bureaucracy

To start vertical farming, you must follow all the steps required by bureaucratic procedures.

Specifically, you need to learn:

- How can I start a vertical farm in my country?
- What costs will I incur to get started?
- What are the food regulations and legislation in my country?
- Are there incentives/subsidies for innovative (or start-up) agricultural businesses?

b. The market for Vertically Farmed products – Market Research

Although many vertical farms are created worldwide every year and it is a rapidly growing sector, many of them close in their first years of operation. One of the reasons may be a lack of knowledge or market research prior to setting up a vertical farm.

Although food is essential and food needs are increasing year by year, every agricultural product market is different.

Therefore, it is necessary to conduct extensive market research to understand which crops could be attractive to potential buyers/stakeholders. Restaurants, private consumers, wholesalers, supermarkets, farmers' markets, and food stores are all options (solutions) that should be considered. You need to know which crops might be of interest and what price interested parties are willing to pay.

c. Equipment supply and cost

Each crop consists of different elements. You can buy each accessory/part/piece of equipment separately or you can buy a ready-made solution. There are providers of different technologies worldwide, and each claims that their solution is the best. You can request various quotes or hire a consultant to help you. The second approach may be smarter and faster, although more expensive, especially if the consultant works with different partners who can provide you with the best solution.

The cost of equipment is generally similar to the cost of installing a hydroponics unit (see section 3.3.2) and depends mainly on the size of the installation.

d. Degree of Activity Development

Once you have gathered all the above information, you should make a forecast of annual operating expenses (such as labor, consumables, energy, etc.), the revenue that will be generated, and the profit.

Developing a business plan is fundamental and necessary to see how profitable your business will be. It is also useful for submitting funding applications or participating in public or private tenders.

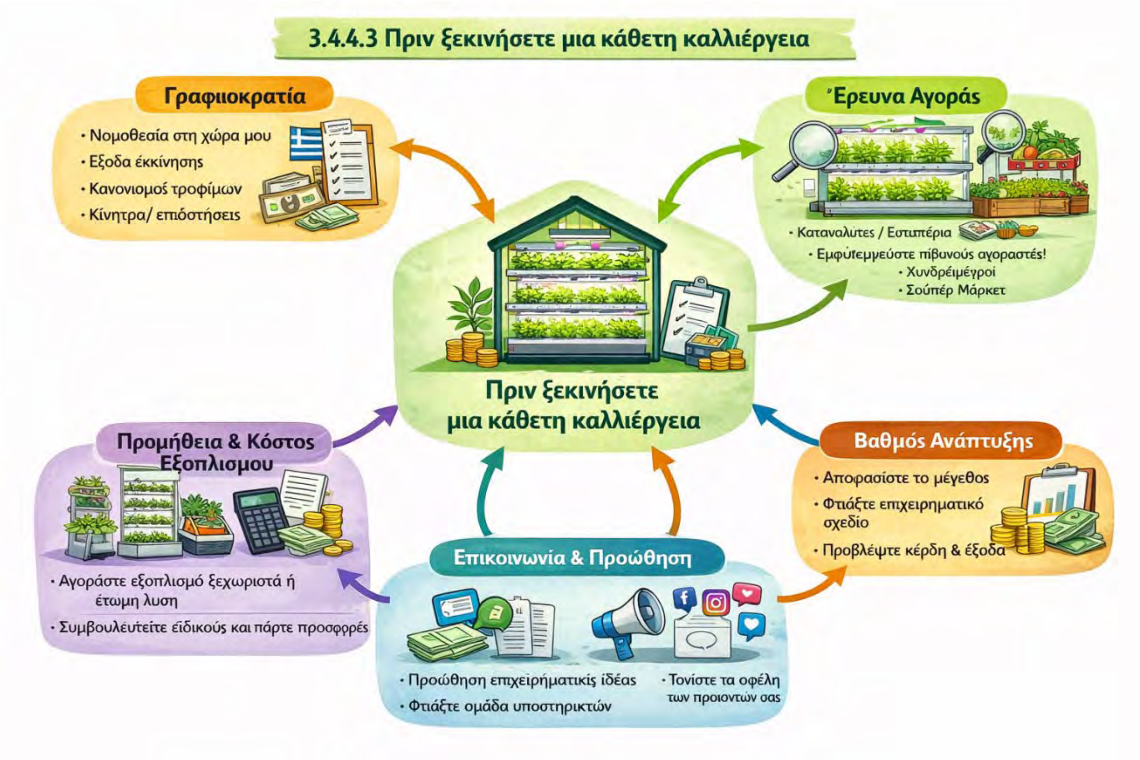
To reduce risk, it would be a good idea to start with a small-scale crop and then expand the scale once the business is up and running. However, starting with a small-scale crop can have certain limitations, such as a lack of automation, which increases labor costs, and the fact that some markets require high production volumes.

It is very important to carefully consider each variable before you start.

e. Communication and promotion

Inform stakeholders about your work

Investing in information and communication is a good strategy to increase your bargaining power and the final selling price. Especially in a new sector such as this, it is very important to inform people about the health and environmental benefits of using your products, thus creating a sense of transparency. In addition, creating a group of supporters is an excellent starting point for your survival in the complex and competitive food market.



3.5 Smart Irrigation Systems – Precision Irrigation – Drip Irrigation

Smart irrigation systems are a modern tool that helps producers use only as much water as their crops need, at the right time, reducing costs and environmental impact.

Water is the most important chemical compound on the planet, essential for every living being. Although 70% of the earth is covered by water, only 3% is suitable for consumption, and most of that is locked up in glaciers, making available freshwater resources extremely limited.

Water demand is constantly increasing and is expected to rise by 50% by 2050, while 70% of available water is already used in agriculture (FAO, 2017), which also pollutes the water with fertilizers and plant protection products.

The need to protect limited water resources and increase water use efficiency makes it necessary to adopt innovative and sustainable solutions such as precision irrigation to ensure food production without excessive water consumption.

3.5.1 Precision Irrigation

Precision irrigation is a technology that provides the exact amount of water a crop needs at the right time to meet its evapotranspiration and metabolic needs, with the aim of maximizing yield with the least possible amount of water.

Precision irrigation uses soil sensors, weather stations, and AI systems to collect data on moisture, temperature, and rainfall data so that irrigation only happens when it's really needed, instead of the traditional practice of irrigating at set times.

The main differences between Traditional Irrigation and Precision Irrigation are as follows:

Traditional irrigation:

It is carried out at fixed intervals without taking weather conditions into account.

Over- or under-irrigation is often observed.

Requires manual opening/closing of valves.

It has higher cultivation costs and energy consumption.

Precision irrigation:

Irrigation is determined by the required soil moisture.

Rainfall and temperature are taken into account.

Water consumption and costs are reduced.

The energy and labor required are reduced.

Remote control and automation are possible.

What are the benefits of precision irrigation?

Water and cost savings.

Reduced energy consumption and labor requirements.

Improved crop yield.

Immediate alerts in case of malfunction.

Maintenance of optimal crop conditions throughout the growing season.

growing season.

Better understanding of crop needs through the collection of data from sensors and satellites.

Precision irrigation helps modern farmers manage water efficiently, reduce their environmental footprint, save energy, and increase production, contributing to sustainable agriculture that responds to growing food needs and the challenges of climate change.

1. Obaideen, K., Yousef, B. A. A., AlMallahi, M. N., Tan, Y. C., Mahmoud, M., Jaber, H., & Ramadan, M. (2022). An overview of smart irrigation systems using IoT. Energy Nexus, 7, 100124. https://doi.org/10.1016/j.nexus.2022.100124
2. Pothula, S., & Singh, A. K. (2022). Precision Irrigation Water Management—Current Status, Scope and Challenges. 18, 372–380.
3. Souza, S. A., & Rodrigues, L. N. (2022). Increased profitability and energy savings potential with the use of precision irrigation. Agricultural Water Management, 270, 107730. https://doi.org/10.1016/j.agwat.2022.107730
4. Water Scarcity | Threats | WWF. (n.d.). World Wildlife Fund. Retrieved September 28, 2022, from https://www.worldwildlife.org/threats/water-scarcity
5. FAO, 2017. The future of food and agriculture: trends and challenges. Rome, Italy. https://www.fao.org/3/i6583e/i6583e.pdf Precision Farming Precision Irrigation

3.5.2 Drip irrigation

In this method, water is distributed throughout the field using a system of closed pipes through which water flows under pressure. In drip irrigation, with the help of drippers, water is supplied to part of the soil, more specifically to the root zone. The flow rate of the drippers is very low, around 2–3 liters/hour, while the corresponding hourly flow rate in artificial rain reaches up to 40 liters/hour. This low flow rate of the drippers means that all the water supplied is absorbed into the soil and there is no surface runoff. Furthermore, because irrigation is often applied, depending on the crop, to replace the water that has evaporated, there is no loss of water and nutrients in the deeper layers. This irrigation method is considered ideal for areas that are particularly sensitive to nitrate leaching, as well as for areas with limited water availability. Drip irrigation was initially used in greenhouses and for particularly efficient crops. Today, it is used for various crops such as vines, citrus fruits, olives, and others.

The basis of the drip irrigation system is the drippers. Water appears at the outlet of the drippers in the form of drops at regular intervals, so that a few liters per hour are infiltrated into the soil at each location. In order to perform its task properly, a dripper must ensure a small and uniform supply that is not affected by limited pressure changes in the application pipe, have a relatively large flow cross-section so that it does not clog easily, be made of a material that is not significantly affected by and does not suffer permanent damage from intense temperature changes when exposed to the field, be easy to use and have a low cost. Based on these criteria, a wide variety of drippers has been designed which, depending on their specific characteristics, are divided into certain categories.

Thus, depending on the type of water flow, they are classified as drippers with laminar, partially turbulent, and turbulent flow. Depending on the method of pressure dissipation or throttling, they are classified as drippers with a long flow path and with a nozzle or hole. This category also includes self-regulating drippers, which maintain a constant load and supply with an automatic adjustment mechanism. Depending on their self-cleaning ability, they are classified as self-cleaning and non-self-cleaning. Self-regulating drippers are usually self-cleaning.

The proper operation of a drip irrigation network requires certain operations related to the start and stop of the network, the sequential water supply to its various units, and the adjustment of the required flow and pressure at the beginning of the transport and supply pipes. Start-up and shutdown can be performed using manual switches (valves) or volumetric valves. These valves close automatically when a certain amount of water, for which they have been set, has passed through. Such valves can be installed at the beginning of the network and at the beginning of its units, as appropriate. In the case of a network consisting of more than one unit, sequential water supply can be achieved automatically with diaphragm valves. The operation of a network can be automated using a programmer, which regulates, according to the desired irrigation program, the sequential operation of the electric diaphragm valves installed at the beginning of each unit.

In some cases of networks with more than one unit, it is possible that, when calculating the network, loads on the transfer pipe at the water intake points of the supply pipes may be greater than those required for their proper operation. In this case, pressure regulators are used to adjust the pressure to the desired levels.

The design of drip irrigation systems is based on the desired moisture content of the field and a clear understanding of the distribution of moisture in the soil after the

water leaves the dripper, especially the lateral movement. This movement has been found to be a function of soil characteristics and dripper flow rate. In an irrigation system, adjacent wetting zones may be adjacent to each other, in which case the entire soil is moistened, or they may not be adjacent when this is not required, in which case only part of the soil is moistened.
The advantages of drip irrigation compared to other methods are therefore:

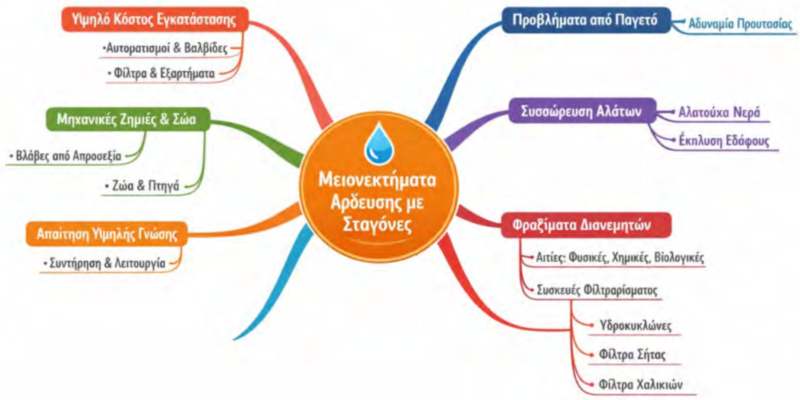
- Water savings: This is due to the low water losses during application through the closed pipe network and the limited volume and surface area of soil that is moistened.
- Labor savings: The pipe networks are permanent and are usually combined with automation systems.
- Reduction of weeds due to the limited wetted surface area of the field. ll

cultivation work can be carried out during irrigation.

- Can be used on highly permeable and steeply sloping land without prior leveling.
- Better uniformity in water distribution, even at the boundaries of the field.
- Better control of water quantities, especially when using automated systems.
- Utilization of small supplies. Related to water economy and the possibility of utilizing the network during the night.
- Easy and effective fertilization, as fertilizers are distributed in the desired quantities directly to the root zone through the irrigation water.
- Irrigation is not affected by wind when water is applied through drippers.
- Low operating costs. Drip irrigation systems usually operate at low pressures that require less energy consumption than sprinkler irrigation systems.

- Control of certain diseases and insects because irrigation does not wet the foliage of crops.
- Favorable conditions for plant growth and yield, because irrigation is frequent and thus the soil water in the root zone is close to field capacity.
- Possibility of utilizing saline water. This is due to the fact that there is no wetting of the crop foliage and that frequent irrigation creates conditions of high soil water content.

The disadvantages of this method include the following:



- High initial installation cost. This is because the installations are permanent and usually require a lot of automation and other accessories (e.g., filters, valves, taps).
- Mechanical damage from careless use of machinery; damage caused by various animals and birds.
- Inability to protect against frost, because water flows under the canopy of trees.
- Salt accumulation in the soil is observed due to the use of saline water at the boundary between wet and dry soil, and soil flushing is required when rainfall is insufficient.
- High level of knowledge required for network maintenance and operation.
- Clogging. Clogging of distributors is a major problem when using such systems and requires the installation of special devices (e.g., filters). The causes of clogging can be physical, chemical, or biological. Clogging of drippers is the most serious problem in drip irrigation systems. Clogging inevitably leads to reduced production and therefore reduces the efficiency of the system. To combat clogging, settling tanks, hydrocyclones, and filters (sieve, gravel) are used. Settling tanks are used when the water contains large amounts of sand or clay. Hydrocyclones mainly remove sand, while filters remove finer materials.

In screen filters, the water is filtered through a fine mesh made of metal (stainless steel) or plastic threads. A characteristic of the meshes is the mesh number, which refers to the number of threads per inch (25.4 mm). Depending on how they work (clean), screen filters are classified as simple, semi-automatic, and automatic. Gravel or sand filters use gravel graded from various aggregates or quartz sand as a filter medium and are suitable for retaining mainly organic materials (algae) but also very fine-grained inorganic materials (clay). Their operation is based on the large surface area of the filter medium (gravel, sand) on which the fine-grained materials are retained. They are cleaned by reverse water flow using the special valves of the filter system.

Chapter 4

Large-scale farming

4.1 The Future of Agriculture

The agricultural technology of the future is being tested in laboratories, piloted in practice, and is expected to change the face of agriculture by reducing the use of water, energy, and fertilizer and making agriculture an attractive profession accessible to all for the benefit of all.

4.2 Technological Applications in Large-Scale Farming

A new era is dawning in agriculture with the use of technology that is not limited to smart machines, but extends to other categories such as:

a) Robotic Swarms:

Robotic swarms are drones that are connected to each other online, as well as to ground robots and agricultural machinery, with the aim of intervening in crops with precision, reducing resource use and increasing crop efficiency. For example, a drone with a hyperspectral camera can monitor plant health in real time, provide information on necessary fertilization, collaborate with irrigation robots, and coordinate the use of agricultural machinery.

b) Digital Twins:

These are revolutionary applications. They operate with the help of sensors, systems (IoT), and 5G networks and create digital copies of farms, allowing producers to simulate strategies and interventions before implementing them on the actual farm.

c) Soil Monitoring with (IoT) – Smart Agriculture

Soil monitoring with (IoT) uses technology to empower farmers and producers to maximize yields, reduce disease, and optimize resources. IoT sensors can measure, among other things, soil temperature, volumetric water content, photosynthetically active radiation, soil water potential, and soil oxygen levels. Data from the sensors (IoT) is then transmitted to a central location (or to the cloud) for analysis, visualization, and trend analysis.

The data generated can be used to optimize agricultural operations, identify trends, and make small adjustments to conditions to maximize crop yield and quality. The use of IoT in agriculture is known as Smart Agriculture or Smart Farming, and IoT is a key component of Precision Farming. See previous chapters

Smart Agriculture focuses on soil, weather, and crop conditions. Given the importance of weather and irrigation, many Smart Farming solutions are combined with Smart

Environment (Air Quality) and Smart Water (Pollution, Turbidity, Nutrients) for a comprehensive solution. The most common sensors (IoT) are listed below:

- **Soil Temperature Sensors**

Soil temperature is a key factor in plant activity below the surface, affecting root growth, respiration, decomposition, and nitrogen mineralization. IoT sensors can estimate soil temperature by measuring air temperature and other factors. However, the most accurate measurement is achieved by using a probe buried in the soil.
Depending on the structure of the plant's root system, multiple probes can be installed at different depths. The temperature of the soil surface can be monitored with a different type of sensor (IoT) that uses infrared (IR) technology.

- **Soil Moisture Sensors**

Soil moisture content can be monitored using buried probes with electrodes. In hydrology, soil science, and agriculture, soil moisture plays a vital role in soil chemistry, plant growth, and groundwater recharge. Soil moisture is critical for many reasons:

- Water in the soil is an essential nutrient for all crops and plants.
- Water is an essential component of photosynthesis.
- Crop yields are greatly affected by the availability of water in the soil.
- Soil water is an important carrier of soluble nutrients for plant growth.
- Soil water helps regulate soil temperature.

Libelium's IoT and Smart Farming technologies can measure the following:

- Soil moisture (at 3 depths).
- Conductivity.
- Volumetric water content.
- Soil water potential.

- **Solar radiation sensors**

Sensors (IoT) can measure different types of solar radiation that play a decisive role in photosynthesis. Beyond basic light levels (Lux), the (IoT) can measure:
Solar, photosynthetically active radiation
Solar, Ultraviolet (UV)
Solar, Shortwave
Solar radiation can have a significant impact on plant growth, and IoT allows you to monitor solar radiation levels to understand correlations and trends.

- **Weather Stations**

Weather stations provide rich data on weather conditions, which is important for correlating patterns and related data.
Rainfall/precipitation, wind, humidity, and atmospheric pressure play a decisive role in plant growth. Smart Farming systems support many advanced weather stations. Weather stations and soil sensors offer a panoramic (360°) view of your agricultural activity.
Meteorological stations (IoT) can measure:

- Precipitation (visual and tipping bucket measurements).
- Temperature.
- Humidity.
- Atmospheric pressure.
- Wind speed.

- Wind direction.

- **Soil Nutrient Measurement Sensors (NPK)**

Nitrogen, phosphorus, and potassium (potash) sensors are relatively new to the market, but they provide a way to measure these key soil nutrients via sensors (IoT). NPK sensors use various technologies, with TDR being a common method. NPK sensors support RS485 for integration into (IoT) solutions, including LoRaWAN and data loggers.

Combined NPK sensors can measure:

- Nitrogen
- Phosphorus
- Potassium
- pH
- EC
- Temperature
- Humidity

- **Wireless Communications for (IoT) and Smart Agriculture (Libelium Smart Agriculture Pro)**

A key advantage of IoT solutions is the wide range of wireless communication options available. IoT is not limited to urban areas with extensive mobile coverage; support for LoRaWAN, 4G, Zigbee, Sigfox, WiFi, and satellite communications means that Smart Farming solutions work perfectly in urban, rural, or very remote environments. The low energy consumption of IoT systems allows nodes and sensors to be powered by batteries, solar energy, or other renewable sources.

You can have a local sensor network via LoRaWAN (e.g. up to 15 km), before the data is transmitted to the cloud via satellite communications.
This transmission can be in real time or periodically in packets. The use of IoT, satellites, and agriculture is particularly important for remote rural communities and facilities spread over large areas—especially where mobile phone or traditional broadband coverage is limited or non-existent.
The first stage of any precision farming or automation system is measurement. IoT and Smart Farming solutions collect thousands of data points every day. Once this data is analyzed, formatted, and correlated, systems can use it to trigger smart responses or automate other infrastructure.
For example, when soil moisture falls below a certain level, the software can activate the irrigation system. If moisture levels rise to suboptimal levels, the system can generate alerts to operational or agricultural staff. With IoT and agriculture, the possibilities are endless.
The effective use of data and information depends largely on your environment and application.
Web-based dashboards can visualize data.
Mobile apps and mobile-optimized websites can display data on mobile devices.
Data can be imported or analyzed with tools such as Excel, PowerBI, or Tableau.
Monitoring systems can generate alerts when thresholds are exceeded (e.g., NPK levels, soil moisture, etc.).

The field of soil science is extensive, and the characteristics and important properties of soil vary significantly depending on the crop or specific soil conditions. If you would like to discuss how the Internet of Things (IoT) can help your business or contribute to optimizing yield, reducing disease, and improving quality, please contact the problem-solving team at sales@mtg.im

For more information, visit https://www.ypaithros.gr/agrotechnologia-tou-mellontos-metaschimatismos-tis-georgias-me-robot-techniti-noimosyni-kai-psifiaka-didyma/

Large-scale farming (intensive farming) mainly involves annual crops (cereals, cotton, corn, etc.) grown on large areas of land using mechanical means to achieve higher yields. They are usually based on intensive methods such as the use of fertilizers and soil improvers (e.g., zeolite) with the aim of maximizing production.

4.2.1 Precision Agriculture

Introduction

It is an agricultural method based on measurements of plant and soil data, with the aim of recording the exact needs of each field, evaluating and implementing the results with great accuracy. The result of this method is a reduction in expenses such as pesticides and fertilizers, while the ultimate goal is to optimize the quality and quantity of the harvest, while producing an ecological product.

The process begins with mapping the fields, where we get a picture of the arable land, then we collect information about the quality and structure of the soil, deficiencies and surpluses in trace elements, so that we can add or remove elements such as fertilizer, pesticides, etc., as needed. Finally, during harvesting, we check the yield of the plot per meter, which allows us to monitor the effectiveness of our annual actions, evaluate them, and make the appropriate decisions for the next year's cultivation plan.

Precision agriculture began to develop in the 1990s with the use of satellite technology, such as the first GPS systems and yield maps. Since then, the possibilities have evolved with the integration of sensors, drones, data analysis software, artificial intelligence (AI), the Internet of Things (IoT), and Earth observation data, mainly through the European **Copernicus** program and **Sentinel** satellites.

At the beginning of the 20th century, agriculture was the main source of livelihood for most of the population, and the techniques used were mainly manual and physically demanding.

In 1950, industrial agriculture emerged. Steady economic and demographic growth required more and more food, and so industrial agriculture was born. Thanks to mechanization and the use of fertilizers and pesticides, crop yields increased at low cost.

In 1990, precision farming made its appearance. Satellite technology was used in agriculture with the first GPS guidance systems, yield maps, and variable rate applications. Precision farming allows farmers to manage variability in the field and distribute what they need where it is needed without wasting resources. Today, we have smart farming. The introduction of IoT enables digitization and interconnection, while predictive models and DSS help farmers take action at the right time, saving resources and protecting the environment.

With the integration of sensors, drones, data analysis software, artificial intelligence (AI),the Internet of Things (IoT), and observation data through the European Copernicus Program and Sentinel satellites, the possibilities of Precision Agriculture have evolved significantly.

The concept of precision agriculture is based on the observation that the specific characteristics of each field can be measured and managed using techniques that meet the needs of the crop. These needs vary in space and time, as is only natural. Information can be gathered and used appropriately. We live in an era of technological development, and agriculture is undoubtedly influenced by it, so much so that we have all certainly heard the term "precision farming." In order to take practical advantage of the modern technologies offered by the market, farmers and professionals in the sector must be familiar with them, master them, and utilize them to the fullest extent possible. Before we begin, it is interesting to note that precision agriculture falls under the umbrella of smart farming.

a. Advantages

The main advantages of precision farming are as follows:

- Reduction in the number of passes (routes taken by the farmer with an agricultural machine) when tilling the soil. As a result, the producer's time (or that of the human resources employed) is used more efficiently, while at the same time a significant amount of fuel (diesel) and other inputs are saved. All of the above leads to the preservation of the structure of the cultivated soil.
- Ability to operate in low visibility conditions or even at night night,
- Significant improvement in the farmer's standard of living and reduction of stress
- Targeted application and efficient use of farm inputs agricultural inputs, such as seeds, fertilizers, and pesticides, through the use of different quantities in each case, adapted to the needs and requirements of each field or part where the application is made (segmental control).

- Timely and accurate intervention with the help of special software which provides advice to the farmer
- Traceability of operations and products that were produced and used, from the field to the table (i.e., the consumer),

Mitigation of environmental impacts related to agricultural activities,

- Savings (fertilizers, pesticides)
- Predictive crop yield results for crop quantity.
- Production of healthier products
- Reduction in working time
- Increased profits
- Reduced use of chemicals
- Field uniformity

b. Disadvantages - Challenges

The adoption of precision agriculture faces challenges such as:

- Lack of training and technological familiarity among producers
- High initial equipment costs
- Limited internet access in some rural areas
- Difficulty in processing and utilizing large volumes of data

4.2.2 Technologies and Equipment

Precision agriculture takes data collected by satellites and converts it into useful information for decision-making. The European Copernicus program uses a set of satellites called Sentinels. These satellites have instruments that use light radiation in the spectrum visible to the human eye (red, green, blue) as well as infrared light that cannot be perceived by humans.

Sentinel images can be verified using data from drones and ground sensors for calibration and validation. This data allows agronomists to accurately monitor soil properties and crop conditions, evapotranspiration, water requirements, and soil nitrogen content. Sentinel images and data can be rendered as maps that can help farmers make decisions about water and nutrient conservation measures.

Advances in artificial intelligence (AI) and big data have also been an important step forward. Research shows that the more decision-making in agriculture is based on data, the more the value of the final product increases.

The technologies necessary for Precision Agriculture include, among others

- Global Positioning Systems (GPS).
- Satellite remote sensing and multispectral maps.
- Drones with thermal and spectral cameras.
- Soil and weather sensors.
- Variable rate application (VRT) systems.
- Decision support software (DSS).

- Big data analysis and AI.
- Remote crop monitoring and control platforms

The above list presents a comprehensive system for the optimal monitoring of Precision Agriculture implemented by each farmer. Even the use of individual technological systems, such as navigation systems, precision fertilization, and precision irrigation and spraying, offers significant benefits.

Precision agriculture offers multiple advantages at the local, regional, and global levels, such as:

- Optimization of input use (water, fertilizers, pesticides).
- Reduced production and fuel costs.
- Increased yields and product quality.
- Enhanced traceability and food safety.
- Environmental protection and reduction of emissions.
- Support for informed decision-making

The benefits come from the fact that it offers:

- Precision irrigation through collective or point systems.
- Fertilization and plant protection with variable doses.
- Integrated insect and disease management with drones, sensors, and tools (AI).
- Crop monitoring and harvest forecasting through remote sensing.
- Precision hydroponics with automated feeding and environmental control systems.

Especially in terms of irrigation, Precision Agriculture can help improve water use efficiency, reducing the footprint of irrigated crops. The information obtained from remote sensing makes it possible to identify the plots and wells that need to be inspected using objective selection criteria, saving labor and resources.

4.2.3 Useful applications of technology in the management issues and problems in crops

Smart Agriculture represents the application of modern Information and Communication Technologies (ICT) in agriculture, leading to what can be called the third Green Revolution. Following the plant breeding and genetic revolutions, this third Green Revolution is beginning to take hold in the agricultural world based on the combined application of ICT solutions such as precision farming equipment, the Internet of Things (IoT), sensors and actuators, geolocation systems (GPS), Big Data, Unmanned Aerial Vehicles (UAVs), robotics, etc. Smart Agriculture has the real potential to deliver more productive and sustainable agricultural production, based on a more accurate and efficient use of resources.

Some of the most useful applications are:

4.2.3.1 Agro-Meteorological Station Systems

Meteorological data, combined with monitoring of climatic and soil conditions, help to increase production regardless of inputs. At the same time, the integration of real-time data into the supply chain helps to plan the transport of sensitive products more effectively worldwide, preventing adverse conditions and greatly reducing the risk of disasters.

The optimal allocation of the company's machinery and vehicles (tractors, trucks, threshing machines, etc.), especially during the busy farming season, greatly determines the company's performance. GPS and IoT technologies can provide important real-time information for making key decisions for the smooth daily operation of the fleet.

- Monitoring the geographical location and status of vehicles throughout the day
- Early warning of necessary equipment repairs
- Automatic notifications regarding compliance or non-compliance with rules set by the user
- Improved planning and scheduling of tasks for each machine
- Reduction of fleet transportation and maintenance costs

4.2.3.2 Insect and weed management and control systems in Crops

Traditional pest control methods sometimes require horizontal interventions with pesticides, which can lead to misuse, low effectiveness, and environmental pollution. Precision application techniques supported by technology provide a more targeted and effective approach to managing insect pests in crops.

Variable rate technology (VRT) modifies pesticide application rates based on real-time data. The VRT system uses a comprehensive approach, taking into account various factors such as insect density, crop health status, and prevailing environmental conditions. By analyzing this diverse set of criteria, VRT technology can accurately estimate the most appropriate and effective amount of pesticide required for application and ensures targeted and precise pesticide use, enhancing insect control while minimizing environmental impact and optimizing crop health.

4.2.3.3 Sensor-based traps for attracting and trapping insects

Monitoring pest populations is essential for their integrated management, and sensor-based traps have proven useful in this effort. These devices use pheromones or other attractants to attract male or female adult insects. An infrared (IR) sensor helps detect insects, making it easier to monitor and assess pest populations.

Technology has transformed Integrated Pest Management by introducing new tools and ideas that improve the effectiveness, efficiency, and long-term sustainability of pest management systems.

The integration of remote sensing and GIS, data analysis, artificial intelligence, and biotechnology has paved the way for improved approaches to crop insect management. Farmers and pest management specialists can make data-driven decisions, target interventions accurately, and reduce dependence on chemical pesticides by harnessing the power of technology. This technique promotes sustainable agriculture, protects biodiversity, and ensures the long-term sustainability of our ecosystems. Continued investment in research and development will be critical in the future to improve and refine technical solutions for integrated pest and plant disease management.

GPS and Geographic Information System (GIS) technologies have significantly improved the accuracy and effectiveness of integrated management. By combining GPS and GIS, accurate spatial maps can be created that show in detail the distribution and intensity of insect infestations.

Farmers can use this spatial data to develop appropriately tailored pest control methods, minimizing the application of insecticides. Unnecessary use of chemicals is reduced by applying control measures only where necessary, reducing the cost and environmental impact of their use.

Data analysis and artificial intelligence (AI) are vital for leveraging the vast amounts of data generated in modern crop management. Artificial intelligence algorithms can analyze large amounts of data to find patterns and correlations. This analytical capability helps predict pest outbreaks, understand insect behavior, and forecast crop diseases. All of this allows for timely intervention and preventive control measures.

The integration of remote sensing and GIS, data analysis, artificial intelligence, and biotechnology has paved the way for improved crop insect management approaches. Farmers and pest management specialists can make data-driven decisions, target interventions accurately, and reduce dependence on chemical pesticides by harnessing the power of technology. This technique promotes sustainable agriculture, protects biodiversity, and ensures the long-term sustainability of our ecosystems. Continued investment in research and development will be critical in the future to improve and refine technical solutions for integrated pest and plant disease management.

4.2.3.4 Machinery and Vehicle Management Systems

The optimal allocation of farm vehicles (tractors, trucks, threshing machines, etc.), especially during peak periods of the growing season, greatly determines the performance of the farm. GPS and IoT technologies can provide important real-time information for making key decisions for the smooth daily operation of the fleet.

- Monitoring the geographical location and status of vehicles at all hours of the day
- Early warning of necessary equipment repairs.
- Automatic notifications regarding compliance or non-compliance with certain rules by the user.
- Improved design and scheduling of tasks for each machine.
- Reduction of fleet transportation and maintenance costs.

4.2.3.5 How to get started

The steps you need to follow to acquire the necessary technical equipment to implement Precision Farming are as follows:

1. The first step is to purchase a GPS navigation system. With this device, you will map your fields and know exactly where you are spraying, avoid double applications, and significantly reduce your raw material costs
2. Next, you need to purchase or convert your sprayer and fertilizer spreader so that it can automatically adjust the quantity (VRC) and sections (Section control).
3. Finally, there are the steps of mapping efficiency and measuring trace elements, plants, etc.

Information on precision farming technology equipment such as sprayers, drones, and unmanned vehicles that manage all agricultural tasks can be obtained from many sources and companies that supply such machinery, such as https://tractorgps.gr/

4.2.3.6 Bibliography and Useful Links

1. "What is Precision Farming and how can farmers benefit from it?" *Wikifarmer*. Retrieved on July 14, 2025.
2. "Precision Farming – Benefits and Challenges." *Wikifarmer*. Retrieved on July 14, 2025.
3. "Precision farming: an ally of integrated pest management in crops." *Wikifarmer*. Accessed July 14, 2025.
4. "Collective Precision Irrigation Systems – Irrigation Water Management." *Wikifarmer*. Retrieved July 14, 2025.
5. "What is Precision Agriculture and how can farmers benefit from it?" Wikifarmer. Retrieved on July 14, 2025.
6. "Precision Farming - Benefits and Challenges." Wikifarmer. Accessed July 14, 2025.
7. "Precision agriculture: an ally of integrated pest management in crops." Wikifarmer. Accessed July 14, 2025.
8. "Collective Precision Irrigation Systems – Irrigation Water Management." Wikifarmer. Retrieved July 14, 2025.
9. *Obaideen, K., Yousef, B. A. A., AlMallahi, M. N., Tan, Y. C., Mahmoud, M., Jaber, H., & Ramadan, M. (2022). An overview of smart irrigation systems using IoT. Energy Nexus, 7, 100124. https://doi.org/10.1016/j.nexus.2022.100124*
10. *Pothula, S., & Singh, A. K. (2022). Precision Irrigation Water Management—Current Status, Scope and Challenges. 18, 372–380.*
11. *Souza, S. A., & Rodrigues, L. N. (2022). Increased profitability and energy savings potential with the use of precision irrigation. Agricultural Water Management, 270, 107730. https://doi.org/10.1016/j.agwat.2022.107730*
12. *Water Scarcity | Threats | WWF. (n.d.). World Wildlife Fund. Retrieved September 28, 2022, from https://www.worldwildlife.org/threats/water-scarcity*
13. *FAO, 2017. The future of food and agriculture: trends and challenges. Rome, Italy. https://www.fao.org/3/i6583e/i6583e.pdf Precision Agriculture Precision Irrigation*
14. *Campos, J., Gallart, M., Llop, J., Ortega, P., Salcedo, R., & Gil, E. (2020). On-Farm Evaluation of Prescription Map-Based Variable Rate Application of*

Pesticides in Vineyards. Agronomy, 10(1), Article 1 *https://doi.org/10.3390/agronomy10010102*
15. *Filho, F. H. I., Heldens, W. B., Kong, Z., & Lange, E. S. de. (2019). Drones: Innovative Technology for Use in Precision Pest Management. Journal of Economic Entomology, 113(1), 1–25. https://doi.org/10.1093/jee/toz268*
16. *Flórián, N., Jósvai, J. K., Tóth, Z., Gergócs, V., Sipőcz, L., Tóth, M., & Dombos,* M3.6

4.3 Energy crops.

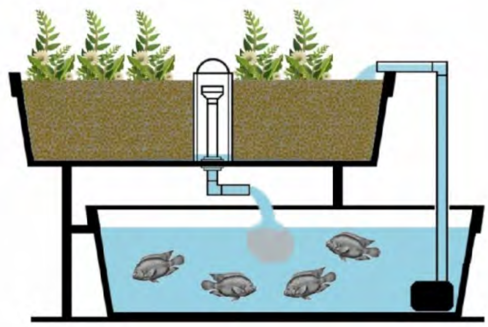
In recent years, there has been growth in the cultivation of plants from which biofuels can be produced (energy crops). Such plants include sugar cane and corn, from which bioethanol is produced, and sunflowers, from which biodiesel is produced.

The advantages of these crops are that they provide farmers with significantly higher yields, while reducing cultivation costs, transport costs, and the environmental footprint.
Another positive aspect is that they can be grown in less fertile soils, while lower quality water can be used for irrigation.
Finally, perennial energy crops can address the issue of soil erosion because they develop an extensive root system. For more information, visit https://jmce.gr/pcontent/uploads/2017/04/Panagiotopoulos-Energeiakes-kalliergeies-sthn-ellada.pdf.

4.3.1 Hydroponics.

Aquaponics, a symbiotic ecosystem.

Aquaponics combines fish farming (aquaculture) with hydroponic plant cultivation in a mutually beneficial cycle. Fish waste provides nutrients to plants, which in turn purify the water before it returns to the fish tanks. Beneficial bacteria play a vital role by converting ammonia into nitrates that can be absorbed by plants.
This closed-loop system is a prime example of circular economy principles—effectively recycling water and nutrients while eliminating the use of chemical fertilizers. Aquaponics uses up to 90% less water than conventional agriculture and produces both protein and



vegetables in compact systems suitable for urban or desert environments. (Aquaponics 2). Despite these advantages, maintaining the balance of the system requires technical expertise in both aquaculture and plant biology.

Essential Equipment for Aquaponics Operation.

Main Components of an Aquaponics System
A typical aquaponics system consists of the following components:
Fish Tank:
A container for raising aquatic organisms.
Growing beds:
The space where plants are cultivated, using one of several methods. **Biofilter:**
A critical component where beneficial bacteria grow to convert ammonia into nitrates. In some cases, this function is incorporated into the growing beds themselves.
Water Pump:
Circulates water between the fish tank and the growing beds.
Aeration system:
Provides oxygen to both fish and beneficial bacteria.

Advantages of Aquaponics
Aquaponics offers several environmental and practical advantages over conventional agriculture
Efficient Water Use:
Uses up to 90% less water than conventional agriculture, as water is continuously recycled within the closed system.
Natural Fertilization:
Waste is converted into natural, organic fertilizer, eliminating the need for synthetic chemical fertilizers [1].
Reduced Waste Disposal:
The system minimizes environmental pollution by reusing waste as valuable nutrients for plants.
No Pesticides:
The use of chemical pesticides or herbicides is generally incompatible with fish health, resulting in clean and safe products [1].
High Yields in Small Spaces:
Aquaponics allows for intensive food production in urban environments or in areas with limited space.

Disadvantages of Aquaponics
Despite its advantages, there are also disadvantages, such as
Initial Installation Cost:
Building a reliable system can be expensive.
Technical Knowledge:
An understanding of the balance between fish biology, plant nutrition, and microbiology is required.

System Vulnerability:
A pump failure or power outage can quickly cause damage to the fish population.
Ecosystem Balance:
Maintaining the right balance between fish density, plant uptake, and nutrient levels is critical to the success of the system.

4.3.2 Controlled Environment Agriculture (CEA).

At the heart of many innovative farming systems is **Controlled Environment Agriculture (CEA)** – a high-tech approach that regulates temperature, humidity, lighting, and CO2 levels to optimize plant growth. (Controlled Environment Agriculture (1). CEA uses automation, sensors, and artificial intelligence to precisely manage the environment and achieve consistent yields.

The benefits of CEA include year-round production, minimal use of pesticides, and significant resource efficiency, using up to 95% less water and land. Furthermore, its adaptability allows food production in urban, desert, or even polar regions, enhancing global food security (Controlled Environment Agriculture 2). The main challenges include high energy costs and limited crop variety, although ongoing developments in renewable energy and biotechnology are constantly improving its potential.

4.3.3 Conclusion.

The evolution of agricultural land use is shaped by innovation, technology, and ecological awareness. High-density agriculture and urban agriculture strategies make efficient use of limited land, vertical farming and CEA use advanced technology to optimize productivity, hydroponics, aeroponics, and aquaponics are transforming food production through efficient, soil-less, water-saving systems. Collectively, these methods signal a shift toward regenerative, climate-resilient agriculture—an agriculture that balances food security with environmental responsibility. As the global population continues to grow, these innovations will be crucial to transforming agriculture into a system that is sustainable for both people and the planet.

4.4 Urban Agriculture

When asked to imagine a farmer, most people will picture someone working in a field, tending to large or small plots of arable land. But what is urban agriculture? Let's take a closer look at this practice that is critical to modern sustainability efforts.

It is no secret that concerns about climate change are prompting all industries to rethink how they operate, and agriculture is no exception. As global transportation and supply chains contribute significantly to the overall carbon footprint of the food we consume, it makes sense to seek innovative ways to produce more food closer to urban centers. This may sound

easier than it is in practice, but this challenge lies at the heart of the growing practice of urban agriculture.

What is Urban Agriculture?

Urban agriculture is defined as the practice of growing plants, raising animals, or producing food in an urban environment.

Although farming in areas outside of traditional agricultural land may seem like a modern practice, urban agriculture has a long history. The inhabitants of ancient Mesopotamia devoted land to cultivation, while in more recent times, "victory gardens" were a feature of cities during World War II. In recent years, urban agriculture has been the focus of attention for advocates of agricultural sustainability and social justice, as it can offer avenues for positive change.

But how does urban agriculture work? It is reasonable to wonder how agriculture can thrive in areas full of concrete and steel. Although there are practical challenges, examples of urban agriculture can be found in spaces with untapped potential. For example, more and more buildings are being designed with infrastructure for community gardens on their rooftops. Other practices, such as vertical farming, can transform existing urban spaces into dense centers of agricultural production.

4.4.1 Benefits of Urban Agriculture

There are several practical benefits of urban agriculture. Let's look at some of the most common ones.

- Transporting food on a global scale requires a lot of energy. Urban agriculture can offer more local sourcing options.
- Practices such as vertical farming allow for greater production per square meter.
- Urban farming activities can make use of inactive spaces, such as warehouses, for the benefit of both residents and urban planners.

4.4.2 Community Gardens – Abandoned Lots

Community gardens are usually what most people think of when they think of urban agriculture. They are an excellent opportunity for urban communities to beautify and enrich their neighborhoods. They are usually no larger than an urban plot (often abandoned or underutilized spaces) and are managed by local volunteers. Some municipalities may have funding programs, but in general, farming is not a paid activity.

Although the benefits of converting an inactive plot into a vibrant community garden are obvious, there are also challenges. Depending on the space, there may be issues of zoning or land use. In addition, infrastructure such as access to water may not be readily available. Soil quality is also an issue, as urban pollutants can seep into groundwater and negatively affect crop sustainability.

- **Community Farms**

Similar in many ways to community gardens, community farms differ in that they are run by non-profit organizations. This means that they are often managed by both volunteers and paid staff.

These socially oriented organizations often aim to cultivate a love of nature and provide educational programs for young people. As with community gardens, they may face challenges related to infrastructure, land use, pollution, and maintaining a stable volunteer base.

- **Commercial Farms**

As for-profit businesses, commercial farms seek maximum efficiency and cost reduction wherever possible. Commercial urban farms are more often located indoors and use vertical farming techniques to make the best use of available space. With profitability as their primary goal, they often focus on producing specialized and relatively expensive products that are in demand by businesses such as local restaurants.
Commercial viability is a major challenge for these units, and careful planning and marketing are required to ensure that the products produced meet specific market needs or are sold at competitive prices.

- **Smart Villages.**

Smart villages are communities or settlements in rural areas that use innovative solutions to develop local agricultural production and improve the economic, social, and cultural level of their inhabitants.
Smart villages benefit from partnerships and alliances with other communities and organizations, other rural areas, or neighboring urban areas to take advantage of funding tools available from national or European programs, which aim to provide ongoing training in:

- Digital and technological applications that are useful for innovative agricultural uses.
- Utilization of the Internet of Things (IoT) and the Internet.
- Improving the quality of life of residents.
- Planning short-term, medium-term, and long-term actions aimed at developing Smart Villages through the utilization of natural resources, environmental protection, and the utilization of their cultural heritage.

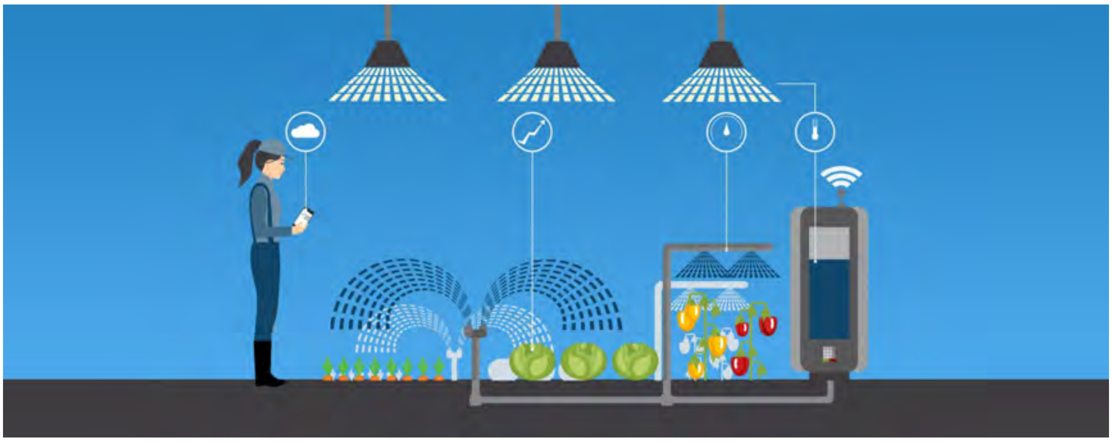
Chapter 5

Ways to Utilize Innovation in Agriculture

When used correctly, innovative applications of technology can bring innovative ideas that will create new conditions and a kind of "revolution" in crops and agriculture.
Below are some innovative ideas that are already being implemented by farmers in various countries.

5.1 Smart greenhouses

Smart greenhouses are technologically advanced facilities that combine traditional agricultural practices with cutting-edge technology, creating an environment where crops can thrive with the highest possible yield.
Smart greenhouses are equipped with sensors, automated climate control systems,



and advanced irrigation methods, allowing farmers to monitor and adjust growing conditions in real time, ensuring that plants receive what they need at all times.
The significance of this innovation goes beyond simple crop yields and represents a shift towards sustainable agriculture that addresses the challenges of climate change, water scarcity, food security, and labor shortages.

But let's take a look at what the Smart Greenhouse actually is.
Imagine a space where temperature, humidity, light levels, and soil moisture are constantly monitored and adjusted in real time. This is achieved through an interconnected network of sensors that collect data and feed it into sophisticated algorithms. These algorithms analyze the conditions and make precise adjustments, such as activating irrigation systems, adjusting shading, or regulating ventilation.

In addition, smart greenhouses often incorporate hydroponics or aeroponics, enabling soil-less cultivation methods that conserve water and maximize space. With the integration of artificial intelligence, these systems can learn from historical data, predict the best conditions for crop yields, make informed decisions that enhance productivity, and minimize waste.

Smart greenhouses can be managed remotely via mobile apps, allowing farmers to oversee operations from anywhere in the world. This combination of technology not only leads to greater efficiency and sustainability, but also addresses the pressing challenges of climate change and resource scarcity.

Smart greenhouses facilitate year-round cultivation, allowing farmers to grow crops regardless of seasonal changes. By controlling the environment inside the greenhouse, farmers can produce fruits and vegetables out of season, tapping into lucrative markets and meeting consumer demand when fresh produce is in short supply. This ability is increasingly positioning Greek farmers as key players in the European agricultural market, strengthening their competitiveness.

Insights based on data provided by smart greenhouse technologies enable farmers to make informed decisions. Through analytics and real-time monitoring, farmers can identify potential issues before they escalate, such as pest infestations or nutrient deficiencies. This proactive approach not only reduces crop losses but also minimizes the need for chemical interventions, promoting sustainable agricultural practices.

In terms of labor efficiency, smart greenhouses can significantly reduce the need for manual labor through automation. Tasks such as watering, harvesting, and climate control can be handled with minimal human intervention, allowing farmers to reallocate their workforce to other key areas of their operations. This shift not only boosts productivity, but also addresses labor shortages, a common concern in the agricultural sector.

5.1.1 The Technology Behind Smart Greenhouses and the Role of Education

At the time of writing, the main sources of technological support for smart greenhouses are as follows:

a. The Internet of Things (IoT) plays a central role in smart greenhouses by connecting various sensors and devices that monitor environmental conditions in real time. These sensors monitor vital parameters such as temperature, humidity, soil moisture, and light levels, providing farmers with accurate data for informed decision-making. Using IoT technology, farmers can optimize resource use, reducing water and energy consumption while ensuring that crops receive ideal growing conditions. This not only minimizes waste but also contributes to the overall sustainability of agricultural practices in the region.

b. Artificial Intelligence (AI) further enhances the effectiveness of smart greenhouses by analyzing data collected from devices (IoT). Artificial intelligence algorithms can predict crop yields, identify potential diseases, and recommend interventions based on historical data and real-time observations. This predictive capability allows farmers to take preventive action, mitigating risks that could lead to crop loss. In addition, artificial intelligence can help plan planting schedules and maximize yield potential, ultimately boosting economic growth in the agricultural sector.

c. Automation connects these technologies together, enhancing operational efficiency in smart greenhouses. Automated systems can control irrigation, ventilation, and climate settings with minimal human intervention, allowing farmers to focus on higher-level management and innovation. For example, automated irrigation systems can deliver precise amounts of water based on soil moisture measurements, ensuring that plants receive exactly what they need without overwatering. This level of precision not only improves crop health but also conserves valuable water resources, a critical factor in the Mediterranean climate.

Smart greenhouses, with the integration of devices (IoT), climate control systems, and data analysis, require a new level of expertise. Farmers must not only understand how to operate these technologies, but also how to interpret the data they generate in order to make informed decisions. This is where educational initiatives come into play. Local agricultural schools, universities, and government programs must provide targeted training that focuses on the practical application of these modern tools. Workshops that combine theoretical knowledge with practical experience allow farmers to experiment with smart technologies in real-world conditions, fostering a culture of innovation and adaptability.

In addition, collaboration with technology companies is becoming increasingly common as agtech solutions emerge. Training programs often include input from industry experts, providing farmers with a comprehensive understanding of both the agricultural and technological aspects of smart greenhouse management. By embracing continuous learning, farmers not only enhance their operational efficiency but also contribute to the broader goal of sustainable agriculture.

By inviting local farmers to participate in workshops and demonstrations, smart greenhouse developers can showcase the benefits of advanced cultivation techniques, such as automated irrigation systems, climate control, and data analysis. These educational opportunities enable farmers to understand how technology can improve yields, reduce resource consumption, and ultimately increase profitability. In addition, local farmers can share their traditional knowledge and practices, creating a rich exchange of ideas that enriches the community.

Stakeholders, including agricultural organizations, government agencies, and local businesses, also play a central role in this ecosystem. Collaborations can lead to the development of tailored programs that address specific regional challenges, such as water management or pest control. With the active participation of these stakeholders, smart greenhouse projects can be aligned with broader economic goals and sustainability initiatives, ensuring that the benefits of innovation are felt throughout the community.

The impact of this commitment is profound. Not only does it empower individual farmers, but it also strengthens the local economy by creating jobs and fostering entrepreneurship. Successful smart greenhouse initiatives can inspire new business ventures, from tech startups focused on agricultural solutions to local markets offering fresh produce.

5.1.2 Future Trends

One of the most anticipated trends is the integration of artificial intelligence (AI) and machine learning. These technologies will enable smart greenhouses to analyze vast amounts of data collected from sensors embedded throughout the growing environment. By evaluating factors such as temperature, humidity, soil moisture, and light levels, AI algorithms can optimize growing conditions in real time, ensuring that crops receive exactly what they need for maximum yield and quality. This level of precision agriculture not only boosts productivity but also minimizes resource waste, aligning perfectly with every society's goals for sustainable development.

Furthermore, the integration of advanced climate control systems will be a game changer. Using Internet of Things (IoT) devices, growers will be able to monitor and adjust environmental conditions remotely via smartphone apps. Imagine a farmer adjusting the climate of his greenhouse from a seaside café, ensuring the optimal temperature and humidity for his crops without being physically present. This flexibility will not only enhance productivity, but also attract a younger generation of tech-savvy farmers to the industry.

Vertical farming techniques and hydroponic systems are also set to win over farmers to smart greenhouses. By stacking plants vertically and using soilless cultivation methods, these innovations will allow for greater crop density, reduced land use, and accelerated growth cycles. As urban areas continue to expand, these systems can be particularly beneficial for supplying fresh produce to densely populated cities while reducing emissions from transportation.

The next generation of smart greenhouses will likely incorporate blockchain technology to track products from seed to table. This level of transparency will not only boost consumer confidence but also empower farmers by providing them with valuable insights into market trends and consumer preferences.

In conclusion, the future of smart greenhouses holds enormous potential for agricultural innovation and economic growth. By embracing these emerging technologies, farmers can look forward to a new era of efficiency, sustainability, and profitability.

By applying data analytics, farmers can make informed decisions that maximize production while reducing waste, ultimately leading to greater profitability. Furthermore, the ability to grow a variety of crops throughout the year not only enhances food security but also opens up new markets, both domestically and internationally.

However, the journey to a modern agricultural landscape requires a collective effort. Policymakers, agricultural organizations, and technology providers must work together to ensure that these innovations are accessible to all farmers. Training programs and financial incentives can play a critical role in facilitating this transition, allowing even the smallest businesses to benefit from smart greenhouse technologies.

As we look to the future, the promise of agriculture lies in its ability to combine timeless practices with innovative solutions. By embracing smart greenhouses, farmers can cultivate a resilient agricultural sector that thrives amid challenges, fuels economic growth, and delivers fresh, sustainable produce to both local and global markets. In this way, each country not only secures its agricultural heritage, but also plants the seeds for a sustainable future.

Imagine a model of agriculture that harmonizes cutting-edge technology with old practices. By incorporating sensors (IoT), climate control systems ( ), and data analysis, smart greenhouses allow farmers to monitor and manage their crops with unprecedented precision. This proactive approach minimizes waste, optimizes resource use, and ultimately leads to healthier yields. It's a win-win situation for both the economy and the environment.

But this transformation requires more than individual initiatives. It requires collective action and a commitment to innovation at all levels. Farmers must be encouraged to adopt these modern methods through accessible training programs and government incentives. Policymakers should prioritize investment in research and development, ensuring that the Greek agricultural sector remains competitive on a global scale. Furthermore, collaboration between technology companies and agricultural experts can facilitate the development of customized solutions that address the unique challenges faced by farmers.

5.2 Agro-photovoltaic energy production systems for Open Crops and Greenhouses

When we talk about agrivoltaics, we mean installations where crops remain active and photovoltaics are designed to coexist with production. This way, you protect the crop and at the same time produce energy that is useful for the crop.

Producers are not looking for technology for its own sake. They are looking for results. A properly designed solution can provide practical benefits such as

- a more stable microclimate, meaning fewer sudden changes that stress the crops
- better light management during periods of intense radiation
- energy production on the same land with the potential to meet the unit's needs where this is technically and regulatory feasible
- reduced income risk, because you are not dependent on a single source of income.

Most importantly, we are not talking about yet another cost. We are talking about an option that can act as a "safety net" against volatility when that volatility begins to affect yields.

a. Agro-photovoltaics, for open crops

These are elevated photovoltaic panels under which there are rows of agricultural crops. They are usually placed at a height of up to 5 meters, with various crops growing underneath. The distance between the photovoltaic panels is usually 4 meters, so that agricultural machinery can pass between them.

- In open crops, the value of agrophotovoltaics is that they act as a tool for stabilizing the microclimate.
- They can reduce the intensity of radiation during peak hours in summer, thus limiting heat stress.
- They can help maintain more stable conditions near the ground, which is important when the weather becomes more extreme and unpredictable.
- At the same time, the producer gains energy production on the same land, which enhances the resilience of agricultural income.

The important thing here is how much shade and how much permeability is right. There is no one-size-fits-all solution. The right choice is made based on the crop and the climate of the area. See https://wattcrop.com/

Combining renewable energy sources with agriculture on the same arable land has significant benefits. Photovoltaic panels protect crops from extreme weather conditions, excessive heat, frost, hail, etc., and help maintain soil moisture.

Agri-photovoltaics (Agri PV or agrivoltaics) offer a practical solution because they combine crop cultivation and solar energy production on the same land. By integrating photovoltaic structures above crops, the system influences the microclimate around the plants, helping to "mitigate" extreme temperature fluctuations.

Agro-photovoltaics help reduce the risk of frost through different mechanisms. The elevated surfaces act as a "thermal shield," limiting nighttime heat loss. At the same time, the system can influence exposure to wind, which often accelerates the drop in temperature near crop level. In addition, the changing microclimate helps reduce sudden thermal shocks, giving the plant more time to adapt.
Unlike temporary frost control methods, agrivoltaics offer a continuous, passive contribution, without additional energy consumption or the need for manual intervention to "work."

The benefits of agrophotovoltaics are not limited to frost. Partial shading can reduce heat stress during the summer months, improve water use efficiency, and stabilize

growing conditions throughout the season. This leads to a more "calm" environment for the plant and greater consistency in crop production.
At the same time, the producer gains access to on-site clean energy production. The electricity generated can support operations, reduce energy costs, or provide an additional stream of value, depending on the model applied. This enhances economic resilience while keeping agricultural activity at the center.

Similarly, crops help the panels because the moisture they produce increases their efficiency. At the same time, crop management costs are reduced and the risk of fire is greatly reduced because the area is free of dry grass.

b. Agro-photovoltaics in greenhouses

Agro-photovoltaics can be installed on greenhouse roofs, covering part of them, while at the same time producing the energy needed to operate the greenhouse.
In greenhouses, the goal is not simply to install a panel, but to maintain control of

the growing environment. A greenhouse is a system that works with light, temperature, humidity, and ventilation. Therefore, the solution must be compatible with all of these factors.
Here, power generation takes on particular importance, because the energy needs of greenhouses increase significantly, especially during the summer months. Cooling and maintaining acceptable temperatures often rely on the continuous operation of equipment such as cooling systems, which consume electricity for many hours a day.

In greenhouses where half of their surface area was covered with photovoltaics, agricultural production decreased by 64%, but this was offset by electricity generation.

The disadvantage of the panels absorbing part of the solar radiation is eliminated by the use of "Transparent Photovoltaics," which are manufactured using innovative materials that allow visible light to pass through and enhance plant growth by:

- Converting ultraviolet radiation into the red spectrum, which is more favorable for photosynthesis.

- Creating a favorable microclimate, increasing biomass production by up to 50%.

Translucent photovoltaics allow the light needed for cultivation to pass through while producing energy. And the crucial point is that transparency is not the same in every case. It is adjusted based on the type of crop. This makes the solution applicable in many more scenarios than one might think, such as "the panels will darken my greenhouse."

Increased crop yields have been demonstrated in certain crops such as: Basil - Broccoli - Celery - Corn
Lettuce - Potatoes - Spinach - Tomatoes

Agro-photovoltaics can offer dual land use: crop preservation and parallel energy production. In addition, they can help stabilize conditions in the field or greenhouse, which is valuable when the weather becomes more extreme and unpredictable. At the same time, they improve crop yields thanks to Brite's nanotechnology. In addition, in open fields, they collect rainwater for the farmer to use for irrigation while reducing evaporation levels.

5.2.1. What should farmers know before deciding to use photovoltaics?

The mistake most people make is to start with the question "How many kilowatts should I install?"

For agricultural use, the correct sequence of questions is:

1. The type of crop and production target.
2. What is the microclimate of the area and the needs of the field or greenhouse?
3. Choosing the appropriate technology for the specific crop and light requirements.
4. If it is an open-field crop, the appropriate height for installing the panels and their layout in the space.
5. Construction costs and economic benefits. Remember that the installation is adapted to production and not the other way around.

5.3. Pollination Assistance

Many tree crops experience fruit set problems due to poor fertilization caused by adverse environmental conditions, which are created and intensified each year by climate change.

Adverse weather conditions create various pollination problems in orchards, such as difficulty or complete inability of bees to fly or be active during flowering (e.g., strong winds, heavy rainfall, unusually low temperatures, etc.), a drastic reduction in the time that pollen is receptive on flower petals (e.g., drought, high temperatures, etc.), damage to pollen viability (e.g., washing away by rainfall, drying out due to unusually high temperatures, etc.), destruction of the sticky material on the stigma where the pollen grain adheres (e.g., unusually warm winds, heavy rainfall, etc.), inhibition of pollen tube germination or growth (e.g., temperatures higher or lower than safe limits, etc.) and many others. It should also be added that the extreme instability of weather conditions in spring, from cold to hot and vice versa, problems arise with asynchronous flowering of the main and pollinator varieties or of cross-pollinated varieties within the same orchard. We should also mention a frequently occurring phenomenon, due to the rigidity of the entire genetic material marketing system, namely the existence of an unsuitable pollinator variety or its complete absence. All of the above create problems of poor pollination, reduced fruit set, and, of course, reduced tree productivity.

A method that is gaining ground in advanced arboricultural countries (e.g., Italy, Chile, etc.) is to assist pollination by spraying pollen from UAVs (Unmanned Aerial Vehicles), commonly known as drones. Please note that this method is supplementary to traditional pollination methods such as placing bees in the field; it does not replace

bees or other pollinating insects, and pollen is applied in parallel with the presence of hives in the orchard (Photo 1) and does not threaten beekeeping in any way. It simply provides additional assistance to crop pollination using natural methods.
The truth is that the method is still undergoing continuous improvement, with studies of the conditions of application and results, as well as the economic return. Questions and concerns also arise, such as:
Is frozen pollen from the previous year effective enough, or is it better to use fresh pollen from the same year from earlier-flowering varieties than from the host crops?
Can the material and technical requirements and the cost of collecting pollen, which is a delicate and time-consuming process, be offset by the expected increase in production?
Is it recommended that the method also be applied to self-fertile varieties that naturally produce sufficient fruit, without impacting the final size?
Are repeated applications necessary, and if so, how many and when is it best to apply them? And many more questions.
Initial positive assessments indicate, in some cases, up to a 20% increase in production (in various crops) or even normal production in years with adverse weather conditions for pollination.

Chapter 6

Good Practices

1. NASA's Veggie Program

This is a vegetable production program by NASA that has been implemented on the International Space Station for use by astronauts since 2014 to provide fresh vegetables during long-duration missions.

For details, visit: https://science.nasa.gov/mission/veggie/

2. Aerofarms (New Jersey and Virginia)

One of the largest vertical farming facilities in the world Uses hydroponic and aeroponic systems to grow vegetables.

Produces up to 390 times more products per square meter compared to traditional farming methods.

For details, visit:

https://www.aerofarms.com/store-locator/

3. **Bustanica Farm in Dubai (UAE)**

Established in 2022 in a huge 31,000 m² greenhouse, it produces 1,000 tons of high-quality vegetables each year with minimal water and soil. Production takes place in multi-level towers up to 12 meters high.
For details, visit:
https://www.hdrinc.com/au/portfolio/bustanica-emirates-crop-one-vertical-farm


4. **Aspasia Pastrikou: - Greece**

From London to the island of Kos and the cultivation of tropical fruits and herbs

Tropical fruits from Kos and herbs such as oregano, thyme, and sage mark the beginning of Aspasia Pastrikou's journey into agriculture. Leaving her life abroad behind, she returned to her hometown of Kos in 2021 to see what life on the island was like.
In 2024, she decided to get involved in product manufacturing, and today she has managed to produce her first small batch of herbs. She estimates that by March 2025, her products will be ready for packaging with the "Votanima" logo.

"I studied mechanical engineering and lived in England for eight years, working for large companies. I then returned to Greece, where I also worked for a large company in my field. In 2021, however, I decided to return to Kos. There, I realized that the entire lifestyle of the residents is geared towards tourism. This gave me the initial impetus to do something different," Aspasia describes to "YX."
As she was trying to find her footing on the island, she created a vegetable garden for her own use. "The process of seeing the seed become food fascinated me, and so the idea of farming began to take root in my mind. At the same time, I stumbled upon the Piraeus Bank's Equal program for women in agri-food, in which I participated. There, we had a lesson on aromatic plants, and I thought to myself that I was on the island of Hippocrates and we didn't have our own herbs. So, I decided to look into it further, and that's how I got started," she points out.
She got in touch with people who had started growing herbs on the island but couldn't keep it up because of other commitments, so she took over the fields. At the same time, she made use of the land her family had available.

Growing tropical fruits
Having Australian roots and having visited the country several times, Aspasia was inspired to try growing tropical fruits in Kos. As she explains, "I thought that the weather is changing due to climate change and we should adapt and try other crops that may benefit from this change. Having experienced Australia and memories of fruits such as mangoes, which thrive there, I decided to try them. So far, the crops are doing very well. They survived the winter without any problems.
Right now, I'm growing 13 different types. Some of them are mangoes, papayas, pineapples, lychees, star fruit, passion fruit, two different types of guava, and dragon fruit. There are other producers in Kos who grow these types of fruit, which is good for me because it seems that these products thrive both in Kos and the rest of the Dodecanese.

Companion planting
Aspasia is currently in the planning stage of her business because, as she explains, "this year, I had my first small harvest from my herb garden. I am constantly trying to read up on the subject, because it requires constant effort and learning, since I have no agricultural background. I estimate that the packaging will be ready in March 2025."
She also received assistance from her participation in the Agro-Development program of the New Agriculture New Generation Organization, as well as from the EWA program for the empowerment of women in the agri-food sector, organized by EIT-FOOD. In the second competition, Aspasia won second place and the €5,000 prize.
As she points out, "this distinction made me feel more confident about my activity and my idea to apply the method of companion planting, which is based on regenerative agriculture and agroforestry ( ). From the research I have done, it seems to suit both the area and the species I want to combine, as it can be applied when there is low and high vegetation."
Future plans
Aspasia's next plans are to increase the cultivation of herbs, while her immediate plans are to set up her own workshop. Finally, with the prize money from the EWA competition, she will invest in precision agriculture, specifically in soil sensors, as, she points out, "temperature and humidity play a very important role. Water is also

precious, so as much as I can, I want to control what goes into the field, so that it is only what is necessary, nothing more."

5. **Dimitra Spiliopoulou - Greece**
   A historic olive grove in the age of smart farming

Dimitra Spiliopoulou manages an olive farm dating back to 1860, located in the Amaliada area of Ilia. She recently decided to participate in the "Agriculture with Intelligence" project – Digital Transformation of the Agricultural Sector, implemented by the Ministry of Rural Development & Food, with contractors NEUROPUBLIC, the OTE Group, and the advertising agency SKARMUTSOS GEORGIOS, and she shares her experience with us.

Tell us a little about yourself...
I started in 2012 with seminars at the Institute of Agricultural Sciences on the cultivation of aromatic plants, olive growing, beekeeping, and apitherapy, and then on the preparation of herbal cosmetics. I immediately applied to convert an abandoned family plot of land into organic land, and in 2012 I planted an olive grove, which now has about 1,000 olive trees.
My studies in biology and my general teaching experience in sustainable development and sustainability (17 Sustainable Development Goals, UN 2015-2030) led me to Regenerative Agriculture, for which I will be certified at the expert level this year. As a result, the olive grove now hosts a vineyard with a rare Zakynthian variety that they are trying to revive, as well as plants that are natural enemies of the olive fruit fly, such as thyme, mastic trees, and carob trees.
The fruit trees, the vegetable garden, the centuries-old oak trees, and the uncultivated areas complete the permaculture structure and now attract visitors. They are offered a guided tour and information on all aspects of sustainable land management, as well as olive oil tasting and food pairing with the award-winning organic extra virgin olive oil DIA ELIS that we produce.

Do you believe in smart agriculture?
What was your first contact with the "Agriculture with Intelligence" project?
Smart agriculture is absolutely essential in order to make targeted interventions that lead to improved production in terms of quantity and quality and to the conservation of natural and economic resources. My first contact with the "Agriculture with Intelligence" project was during the installation of the Data Collection Station in the olive grove. I followed the process from start to finish and found it very interesting. I worked harmoniously with the technicians because I wanted it to be placed in a location that would be visible to both visitors on guided tours and from the new Patras-Pyrgos National Road, but at the same time be suitable for collecting the required data.

What do you expect to gain from the data that will be immediately available to you?
First of all, the data will help us compile a detailed log of the weather conditions prevailing in the olive grove during each growing season. This will guide the interventions to be followed (watering, fertilization, planting, etc.) and will result in optimized production and reduced costs.

Do you think that the producer's experience and know-how can be combined with smart farming systems, or do they cancel each other out?
They can and should be combined! It is certain that, in most cases, know-how confirms the experience gained in the right way and with respect for nature!

6. **Christos Mylonas - Greece**
   Herbs from Magnesia are put into coffee capsules

The aroma of tea was a childhood memory that has now become his profession, continuing a 50-year family tradition that has evolved into an innovative business. This is the story of Christos Mylonas from the village of Vryna in Magnesia, which is built on Mount Othrys and is famous for its tea cultivation. The 31-year-old farmer now cultivates 200 acres of mountain tea, oregano, sage, lemon verbena, mint, and more. As he himself states in "AgroΚΟΣΜΟΣ", "Vryna was the first village in Greece where mountain tea was cultivated and it remains the main crop of the inhabitants to this day". Christos continues his grandparents' cultivation, developing it and packaging the mountain tea so that its aroma can travel to foreign markets. He is also a member of an innovative team that puts Greek herbs in Nespresso capsules, offering consumers a new way to enjoy them.
Christos also belongs to a group of five people who are innovating by putting Greek herbs in capsules that are compatible with Nespresso machines, under the name "OTHRYS HERBS."

Exports
Christos cultivates his land organically and, together with his family, has managed to set up a packaging facility. "We package oregano and mountain tea in both small packages for home use and large packages for distribution to restaurants.
Through these processes, we have managed to add value to our products and target other markets," he emphasizes. The company's products ( ) can be found in Greece, both in the Almyros area and in Athens. As Christos says, "90% of our production is exported to countries such as the USA, Germany, France, Italy, Canada, and smaller quantities to Japan, Lithuania, and Poland. We have regular customers, as there is demand, and others are added over time."

Herbal capsules... in coffee machines
The 31-year-old farmer also belongs to a group of five people who are innovating by putting Greek herbs in capsules that are compatible with Nespresso machines, under the name "OTHRYS HERBS." "After hours of discussion, we came up with the idea of creating capsules that would not contain coffee, but herbs from our region," says Christos.
He explains that the team was formed as part of the "New Agriculture for the New Generation" program. "I participated with a friend of mine in one of the seminars held in the Almyros area on aromatic plants. After the seminar, five people who stood out were selected to create an innovative product. We knew that our region is famous for its mountain tea and other aromatic plants, and we were thinking about how we could create a new product. A member of the team suggested capsules, and after conducting market research, we saw that there was nothing similar with Greek herbs," he concludes.

7. **Barış ARSAL – Türkiye**

Barış ARSAL is the founder and owner of an innovative greenhouse enterprise producing curly lettuce on a 1,070 m^2 area. Located in Adana, Çukurova, his company Arsal Agricultural Products has developed a notable production model featuring a closed-circuit soilless farming system and a shared energy model. As a young agricultural engineer and entrepreneur, Barış shares his experience with us.

Tell us a little about yourself...

I am an agricultural engineer and in the business I founded in 2025, I use a closed-circuit (recirculating) soilless (hydroponic) farming system. Thanks to this system, we continuously recycle water, experiencing only 5% evaporation loss—which translates to 95% water savings. We monitor and optimize critical parameters inside the greenhouse such as temperature, humidity, and pH in real-time using IoT sensors. We supply all of our annual production of 100,000 heads of lettuce to the domestic market. We meet our energy needs by using a neighboring factory's solar energy system, implementing a shared energy model.

Do you believe in smart agriculture?
What was your first contact with the "Agriculture with Intelligence" project?

My introduction to smart agriculture stems from my academic work and graduation thesis in the Department of Horticulture at Çukurova University in Adana. During that period, my research on resource efficiency and controlled environment systems clearly showed that traditional methods would fall short in the face of water scarcity and climate change. Seeing the potential of IoT and closed-loop systems, I decided to establish a business in this field after graduation. As a young farmer, I am excited to turn theoretical knowledge into practice and create a resource-focused, sustainable model.

What do you expect to gain from the data that will be immediately available to you?
The data from IoT allows us to manage the production process entirely based on data. For example, we can adjust the nutrient solution instantly by observing pH changes and minimize plant stress by predicting temperature and humidity fluctuations in advance. This means more consistent quality, less resource consumption, and higher yields. Additionally, thanks to this data, we can calculate our production costs more accurately and plan accordingly.

Do you think that the producer's experience and know-how can be combined with smart farming systems, or do they cancel each other out?
They absolutely should be combined! As an agricultural engineer, knowing plant physiology and cultivation principles is the key to using technology in the right place and in the right way. To interpret humidity data from a sensor, you need to understand the plant’s needs. When experience and technology come together, not only does productivity increase, but a sustainable, flexible, and climate-resilient agricultural model also emerges. In my view, smart farming tools are assistants that enhance the farmer's observation and intuition.

8. Abdullah KÖYMEN - Türkiye


Abdullah Köymen is the Operations Manager of Leoberry Agricultural Enterprise, a high-tech soilless strawberry greenhouse spanning 165 decares in Adana. Abdullah oversees the integration of an IoT-based greenhouse control system and a 150 kWp solar power plant at the facility. He shares his experience with us.

Tell us a little about yourself...

At Leoberry Agricultural Enterprise, we operate a soilless strawberry production greenhouse that was commissioned in 2025, covering 16.5 hectares. We use a combination of hydroponic and aeroponic systems. Thanks to our IoT sensor network, we continuously monitor greenhouse parameters such as temperature, humidity, radiation, and nutrient solution levels, and can make real-time interventions via a mobile app and central control panel. With an annual production capacity of 1,500 tons, we export to both domestic and international markets. Additionally, our 150 kWp rooftop solar power plant meets approximately 70% of the energy needs for irrigation, cold storage, and climate control systems.

Do you believe in smart agriculture?
What was your first contact with the "Agriculture with Intelligence" project?
In modern agricultural management, smart systems are no longer a luxury but a necessary investment for efficiency and sustainability. At Leoberry, we have operated with this mindset from the very beginning. Our enterprise was financed through a low-interest agricultural credit provided by the Ministry of Agriculture and Forestry, and from the investment planning stage, IoT infrastructure and renewable energy integration were among our top priorities. Together with our technical team, we designed a system that maximizes both production efficiency and energy savings.

What do you expect to gain from the data that will be immediately available to you?
The data collected via IoT not only provides immediate control but also shapes our long-term production strategies. Historical data on the greenhouse microclimate makes planning for future seasons much easier. By optimizing irrigation and fertilization schedules, we reduce water consumption and improve plant health. Furthermore, we can seamlessly meet the traceability and certification requirements demanded especially in export markets, thanks to this digital data flow.

Do you think that the producer's experience and know-how can be combined with smart farming systems, or do they cancel each other out?
Absolutely. In fact, without this integration, achieving real efficiency is very difficult. Our field experience and ability to read plant behavior help us make sense of the raw data provided by technology. For example, we recognize the signs of stress in a strawberry plant through experience, but with IoT data, we can identify which environmental parameters are causing that stress and take quick action. Ultimately, the synergy between accumulated knowledge and technology enhances both production quality and the competitiveness of the enterprise.

1. **Gülbin EREN & Yusuf Kenan EREN - Türkiye**

Yusuf Kenan Eren completed his undergraduate education at the Faculty of Agriculture of Çukurova University and entered the sector as an agricultural engineer by establishing Erenler Tarım Ltd. Şti. in 1994. Eren, who has been carrying out agricultural activities in the fertile lands of Çukurova for 26 years and providing employment to local farmers, began his first production experience in 2006 on a piece of land considered barren in Küçükçınar Village.

He shares the following guiding principle:

"Fruits need the sun to grow, young people need advice to mature. And both need time to ripen."

Focusing on pomegranate and olive production, Eren started a long-term production process by planting 4,500 olive trees (Ayvalık and Trilye varieties) and 1,000 pomegranate saplings (Hicaz and Wonderful varieties). With increasing yield over time, together with his wife Gülbin Eren, he established Yusuf Kenan Eren Agricultural Enterprise and launched a boutique processing facility for olive oil and pomegranate molasses with a daily capacity of 50 tons of olives. The most distinctive feature of the enterprise is its high-quality boutique production and its possession of numerous national and international quality awards. In 2022, he developed a pioneering model with a 70 kWp solar energy system that meets both the drip irrigation needs of the orchards and the energy requirements of the processing plant. He shares his experience with us.

Tell us a little about yourself...

We operate olive and pomegranate orchards and a processing plant with a daily capacity of 50 tons of olives for olive oil and pomegranate molasses at our family farm. The most fundamental characteristic of our business is our commitment to high-quality boutique production, an approach that has been crowned with many national and international quality awards. The 70 kWp solar power plant we established in 2022 now forms the heart of our operation. This system meets 100% of our drip irrigation energy needs in winter and 80% in summer. The same system also fully covers the electricity demand of our processing facilities, eliminating our dependence on fossil fuels.

Do you believe in smart agriculture?
What was your first contact with the "Smart Agriculture" project?
Smart agriculture is not just about sensors and software; it is first and foremost about a clean, sustainable, and uninterrupted energy infrastructure. For us, the path to smart agriculture started with solar energy. Controlling energy costs and reducing our environmental footprint was a fundamental step that paved the way for any advanced technology investment. When establishing this system, we considered both irrigation and processing processes as a whole and designed it to achieve energy autonomy.

What do you expect to gain from the data that will be immediately available to you?

Our solar energy system provides valuable data on the balance between production and consumption. We can track in real-time how much energy we produce, how much we use for irrigation, and the consumption in the processing plant. This data guides us in using energy in the most efficient way. In the future, by adding IoT systems such as soil moisture or weather condition sensors on top of this infrastructure, we aim to use energy not only for consumption but also for making smart production decisions.

Do you think that the producer's experience and know-how can be combined with smart farming systems, or do they cancel each other out?

They definitely combine and even create a magnificent synergy. My knowledge as an agricultural engineer and my experience in these lands have been my compass in deciding where, how, and when to integrate technology. For example, I know when olive trees are more sensitive; technology shows me how to irrigate most efficiently and economically during that period. Experience tells us the "why," and technology tells us "how best" to do it. When the two come together, a sustainable, profitable, and future-resilient agricultural enterprise emerges.

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