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Usage AI and RS in Agriculture 4.0
The links between sustainability pillars and smart technological development.

Relatore
Ch. Prof.ssa Cinzia Colapinto

Laureando
Giovanni Pezzolo
Matricola 866683

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To me.

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EXECUTIVE SUMMARY

The aim of this thesis is to explore the topic of Agriculture 4.0. In particular, the use of technologies such as artificial intelligence and remote sensing. The work has been carried out by focusing on sustainability, an issue that is often the subject of political debates and decisions, following the publication of the UNO Agenda 2030. Furthermore, the post-pandemic scenario accelerated this change in the business models and operations. Companies that embrace sustainability and digitalization have better performance. Study like *"The European double Up"* (Accenture, 2021) shows binomial green-digital as driver of success. "Twin Transformer" is the name used to categorize companies that will have 2.5x possibility to be tomorrow's leaders. Investments in tech innovations, digital instruction, and a sustainable business model are some short-term goals that Twin Transformers aim to achieve to both win the competition into the market and promote a sustainable development. Clearly there's no formula for sustainability, and digital doesn't mean sustainable. A common path and shared commitment are necessary to direct utilization of new technologies towards new sustainable solutions.

The planet is desperate: We are in the situation where we are aware of the problems we face, but at the same time, we are not doing enough to reverse this status. The sum of our behaviour has led to a partially irreversible situation. Irreversible because, as of today, the deadline set by the UN for achieving the 17 Sustainable Development Goals is close, compared to the progress we still must make. The data speak and the signals the planet is giving us support this.

Meanwhile, we are experiencing a complex revolution in everyday life: the fourth industrial revolution. It, also called "digital" or "4.0", concerns the introduction of digital innovations capable of increasing the interconnection and cooperation of resources: human and IT.

The agri-food sector, in addition to being a sector deeply affected by the 4.0 revolution, is also one of the sectors both responsible and affected by climate change.

This thesis does not set out to solve the problem of climate change, but rather aims to explore the use of smart technologies in the agri-food sector aimed at the adoption of sustainable practices. By smart technologies we mean innovations 4.0, while

sustainable practices mean activities in line with the goal of achieving sustainable development. To do this, three chapters have been developed:

Firstly the reasoning started from the need to find a link between the use of smart technologies and sustainable development goals. We are living 4.0 revolution. Technologies move every moment to the future discovering new solutions and innovative methods. At the same time, “green” is becoming always more important for environmental and political/financial reasons. Commitment to find solutions to solve environmental problems is shared all over the word. But, till now, commitments are just worlds not translated into concrete actions. Meanwhile, scholars and researchers continue exploring data to show solutions or evidence about the binomial innovation 4.0-sustainability. In fact, the literature is full of studies which mention a relation between the adoption smart-technologies and achievement of sustainable development goals. It extols them adoption to obtain “green results”. But, after all these studies why we are not able to implement common strategies? After all, is there a real connection between 4.0 innovations and SDGs? First, it has been introduced sustainability: tracing the main historical steps that led to the drafting of the 2030 Agenda, the concept of sustainable development and the 17 SDGs. Then I moved into agriculture 4.0, the second central theme of the thesis. Finally I ended with the project work. During the first four/five months of writing, me and other three colleagues collaborated to conduce a deep review of the main scientific literature. Is there the possibility that government, or some other institution, is bad investing financial resources because it isn’t aware? Main literature speaks about technological drivers to achieve sustainability; but is there a real link and a usage-effect relation or is it only an umbrella term? Are there demonstrations of the benefits generated by the adoption of smart technologies? These are some of the questions to be answered. The analysis brought out interesting evidence regarding the main technologies discussed, the SDGs that are most affected by the 4.0 revolution, the reasons to use smart techs, the ways in which them impact on sustainability in agricultural practices, and others.

The following part focuses the discussion on agriculture 4.0, and, particularly, on the use of artificial intelligence and remote sensing. During the project work I felt interest for these two technologies, so, after it finished, I decided to continue my work deepen them. How are these two technologies used to promote sustainability in the agri-food sector? Using scientific literature and other secondary sources, recent history, how they work, and the main types known are introduced. Artificial Intelligence is one of the most used 4.0 tech in agri-food sector. It finds large use in this field: agrochemical analyses, crop management, water management, weather forecasting, soil management, and livestock management. The increase in the use, and awareness achieved, is led by the benefits it brings. In economical perspective it drives to a reduction of costs and increase of production, consequently profitability, according to SDG 1 and 2. In a social perspective it impacts in the role of workers, reducing responsibility in decision process, creating new roles, and reduce risks and danger, according to SDGs 8. In a environmental perspective its adoption helps to reduce climate impact, reduce waste of resources, and preserve ecosystem, according to SDGs 6, 7, 11, 12, 13, 14, 15. Remote sensing finds numerous applications in the sector: crop identification, stress monitoring, detection and diagnosis, yield estimation and mapping, weather forecasting, soil analysis and land cover mapping. Moreover, it is considered a great opportunity for agri-food sector, because it impacts with considerable benefits. In economic perspective remote sensing reduce costs and increase profitability, according to SDGs 1 and 8. In social perspective remote sensing affects increasing food safety, according to SDGs 12, helps decision process, and reduces operators work stress. In environmental perspective telemonitoring avoids waste of recourses, combats desertification and soil degradation, according to SDGs 13, 14, 15.

The thesis ends with reports on company interviews. After reviewing the main scientific literature, a further step to explore these issues was to bring in testimonials. I thought that no one could provide a real, authoritative, and better point of view than industry practitioners. Moved by this motive, from June to September I carried out a qualitative analysis. Reading articles, blogs, and authoritative sources I selected 15 companies to contact. I kept contacts with all of them but only seven decided to participate. Some ones responded to a written interview shared online, while some others liked more to organize a meet online, during which the interview questions were discussed. The chapter concludes by outlining the common patterns that characterized the interviews conducted and an opinion about the future and the work I conduced.

CHAPTER 1.

PROJECT: “Linking sustainability pillars to smart technological development in agri-food”

This first chapter of the thesis is the most substantial part of the paper. The aim is to provide an overview of two main topics: sustainable development and agriculture 4.0, and to illustrate the project on which the writing of this thesis was based.

A first introductory part on sustainability addresses the main steps that led the UN to draw up the 2030 Agenda, what sustainable development is, and what the 17 sustainable development goals are. The second part deals with agriculture 4.0, particularly the agri-food sector, how the industrial revolution 4.0 is affecting the supply chain, and the main technologies adopted today.

Understanding these first two paragraphs is important because they introduce the paragraph devoted to the project that motivated the writing of this thesis. This initiative came about with the aim of finding a link between the adoption of 4.0 technologies and the achievement of sdgs. The literature continually mentions sustainability as a goal to be pursued. Furthermore, it speaks of technology as a tool that can help in achieving this goal. An in-depth analysis of the main scientific literature tried to find a link between agriculture 4.0 and the SDGs. The results of months of analysis led to some evidence such as: which are the main technologies discussed; which SDGs are most mentioned; what is the potential of 4.0 innovations; and others.

WHAT ARE SDGs

Today, the world, and humanity in general, is faced with numerous challenges. These threats that undermine its future are interconnected but at the same time well diversified. Even though sustainability can no longer be considered a trend topic, but rather has become (almost) mainstream, it remains the link that unites all these challenges.

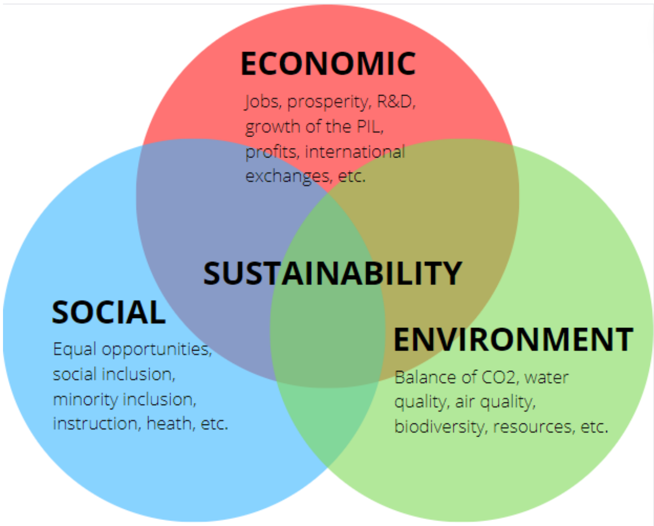
Sustainability, specifically, assumes the role of linking: the continuous and unceasing development of economic activities and the equally continuous progress of society, with the protection of the nature that surrounds us and the biological diversity. For this reason, all the major challenges of our time are associated with this word: environmental protection, the management of climate change that is damaging our planet, the continuous increase in poverty, the economic imbalance dictated by unequal progress, and many others.

In this sense, although the daily contribution of each individual is a fundamental part of achieving positive and tangible results, the greatest role is played by the industry.

Sustainability should concretely take a leading role in corporate business. The “social” and “environmental” dimensions should materialize in corporate sustainability. Corporate sustainability means the set of policies that enable a company to pursue value generation without neglecting the three dimensions of sustainable development (see Fig.1): the economic dimension, the ecological dimension, and the social dimension.

By integrating sustainability into the business model, it is possible to generate value in a long-term perspective (Ventitrenta, 2018).

Figure 1: The three dimensions of the sustainable development.



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In the internal corporate sphere, what has been referred to corporate sustainability is called Corporate Social Responsibility. The European Commission, at its meeting in Lisbon in 2000, defined to this word the *“voluntary”* integration of social and environmental issues into business activities, or more generally into the business model, and into the relations with different stakeholders (CCE, Green book, 2001, pg.7).

It has to be specified that although this is a relatively innovative concept, as one of the first interpretations dates to 1984 from an essay by R.E. Freeman (2010), this phenomenon has more historical roots dating back to the late 19th and early 20th century, when issues concerning corporate philanthropy in America were first discussed.

Leaving aside all the historical background, publications, and declinations that this concept has undergone over the years, since 1945 the United Nations has been (and still is) playing a primary role in promoting “sustainable development” (a theme that will be taken up specifically later).

In particular, the last noteworthy action of the 193[1] member states is the adoption of the 2030 Agenda. This framework, which represents a strong commitment, constitutes a program of action that aims to instill a cultural change. It pushes all actors in society (institutions, companies, people, etc.) to think in a long-term perspective for sustainable development.

The program, which came into force in 2016, consists of 17 Sustainable Development Goals (SDGs) that approach all the main challenges we constantly face. Moreover, although the program involves all actors in society, the private sector has been identified as the most important one for its implementation: it is the engine of progress, innovation, and change.

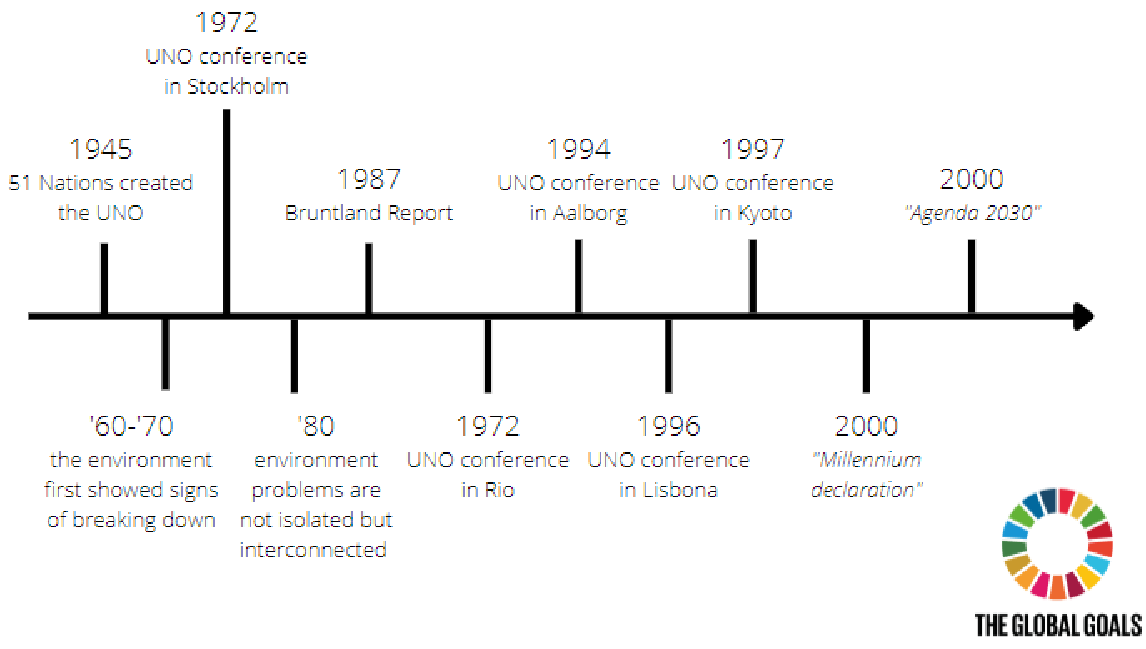
"*The new Agenda is a promise from leaders to all people around the world. It is an Agenda for people, for eradicating poverty in all its forms, an Agenda for the planet, which is our home*” these were the words of UN Secretary-General Ban Ki Moon at the time of the Agenda's release (25th September 2015).

Before delving into the 17 Sustainable Development Goals that make up the Action Plan and the meaning of the term “sustainable development”, it is only fair to briefly illustrate the historical path that led up to the publication of the 2030 Agenda.

[1] The last state to join the UN was South Sudan in 2011.

THE HISTORICAL STAGES, FROM 1945 TO AGENDA 2030.

Figure 2: The most important historical stages of United Nations.



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Starting from the beginning, the United Nations was founded in 1945, when 51 nations decided to commit themselves to preserving peace and security by cooperating with each other. The members of the UN are not a world government and do not legislate, however, their charter lists the four functions for which this organization was created:

- To maintain international peace and security.
- To develop friendly relations among nations.
- To cooperate to solve international problems and promote respect for human rights.
- To represent a center for the harmonization of different national initiatives.

Returning to history, in the 1960s, the UN's efforts became more and more intense. Starting in those years and particularly in the 1970s, the prevailing economic theories began to be questioned. This happened because the environment, at that time, first showed signs of breaking down. It clearly highlighted how the assumption of unlimited development was not in truth with the current situation.

It was during these years that the concept of sustainable development began to spread. In 1972 the UN Conference on the Human Environment was held in Stockholm and during it the major environmental problems were highlighted. At the end of it, the goal set by the member states was to *“protect and improve the environment for present and future generations”* (Stockholm Declaration, 1972, pg.1).

In the 1980s, it increased the awareness that environmental problems are not isolated but, on the opposite, affect many areas. Therefore, considering the interconnectedness of different fields of action, becomes crucial to finding effective solutions. It was 1987 when the Brundtland’s Report was published by the World Commission on Environment and Development. The report, named *“Our common future”*, provides for the first time a definition of sustainable development, describing it as progress that simultaneously meets the needs of the present generation without compromising the ability of future generations to do the same. To do this, it has been identified three dimensions to be harmonized: economic growth, social inclusion, and environmental protection.

These are the years in which we become aware of the fact that, up to now, too much importance has been placed on economic growth, while the other two dimensions have been almost completely neglected.

The 1990s are extremely important for the future of sustainable development. First there was the conference in Rio de Janeiro in 1992, which led to the publication of five different documents that, from then on, formed the guidelines for action by member states (The International Conference on Environment and Development, Rio de Janeiro, 1992):

- The United Nations Framework Convention on Climate Change (UNFCCC).
- The Convention on Biological Diversity.
- Agenda 21.
- The Rio Declaration on Environment and Development.
- The Principles on Forests.

Three more conferences were subsequently held in Aalborg in '94, Lisbon in '96, and Kyoto in '97. The latter is undoubtedly the most famous, as it stipulated a pact (the “Kyoto Protocol”) that sealed the commitment of the member states to implement measures to safeguard the environment and particularly to reduce greenhouse gas emissions.

The 2000s are marked by the publication of the “Millennium Declaration”. The year 2000 is a very important historical moment: after years of disseminating and promoting an idea of development that embraces all three dimensions of sustainability, member states decide to commit themselves to eight Millennium Goals (MDGs). These eight goals to be achieved by 2015, however, on one hand highlighted the states' effort and intention to actively change the course of history; on the other hand, showed two shortcomings. The first one was the lack of interconnection between them; and the second one was the subjects to which they have been addressed: the developing countries (DCs).

Coming almost to the present day, in 2015 the United Nations General Assembly was held; it was attended by all 193 member states and at the end of it they decided to adopt the 2030 Agenda for Sustainable Development.

The agenda, which consists of 17 primary goals (SDGs) and 169 sub-goals (targets), is a major step forward compared to the previous “Millennium Declaration” for several reasons. First, while the MDGs were imposed by the UN, the SDGs were defined according to the participation of states. It was the common consensus that defined them. Then, they do not have target states. While previously only the developing countries were the recipients, now all the countries must take action to bring about concrete results. Finally, the Agenda is the first major global program to recognize that companies, or the business world in general, have a key role to play in achieving sustainable development.

"*These global goals, if adopted and then implemented, will represent a substantial change in the way the world tackles poverty. Unlike the MDGs, the SDGs will be able to achieve results for everyone, not just developing countries, although the central focus will remain on fighting poverty*." Helen Morton - Post-2015 Global Lead, Save the Children.

The next paragraph will be dedicated to go into more detail of the sustainable development. Then, the last one will argue the content of the 2030 Agenda: the 17 Sustainable Development Goals.

THE SUSTAINABLE DEVELOPMENT.

The paradigm of sustainable development assumes that we only have one planet. Therefore, we must learn to live with the limits that nature imposes on us. This translates into a great responsibility and a duty to not deplete our ecosystem at the expense of future generations. This is the greatest contemporary challenge.

While nowadays this term has become ubiquitous in business plans, corporate strategies, slogans, and many other areas, few people know its origin and understand its meaning. The literature provides lots definitions of the word development; one of the most accurate is found in the one provided by Richard Peet in his book *“Development Theory”* published in 1999, where it was defined as *“an evolutionary process in which human capacity increases with respect to the creation of new structures, in coping with problems, adapting to continuous change, and making an effort in an objective and creative way to achieve new goals”* (Peet R., 1999). The same argument can be made for the word sustainability, as academics and scientists have always wondered what exactly this term means; Basiago, in his article *"Methods of defining sustainability"* published in 1995, relates the term to the concept of futurability, and translates it as the ability to preserve an entity, or an outcome, or a process, over the long term (Basiago, 1995).

As introduced in the previous paragraph, the 1987 Brundtland report was the first document to provide a comprehensive definition. The reason for this was because in those years (between the 1970s and 1980s) there was a growing awareness that the consumption and production pattern of industries was not compatible with the environment, and it was unsustainable in the long term. We lived for a very long time as if there were two planets instead of one, exploiting the ecosystem and living beyond the limit set by the environment. Over the years, however, it was realized that only the awareness was not enough, and that ignoring all the signals the planet was sending us would undermine growth opportunities for future generations. This last quote has been the slogan that has motivated UN interventions for more than 30 years. For all these reasons, it was necessary to act. Starting from the Millennium Declaration published in 2000, the UN obtained the consensus of all member states and drew up a list of goals to be achieved (presumably) by 2030 at the latest.

The next section will focus on this document, listing and illustrating the goals drawn up by the member states.

THE SUSTAINABLE DEVELOPMENTS GOALS

This section will be devoted to elaborating on the SDGs and explaining what they consist of.

As previously mentioned, there are 17 SDGs, 169 sub-targets and more than 240 monitoring indicators. They outline the set of global ambitions that states together commit to pursue, and achieve, by 2030.

Today, the value that the term SDGs carries is more important than it was a few years ago. This is because despite numerous promises and apparent commitments, the situation does not seem to be changing, but rather worsening. On the one hand, the SDGs are a great step forward because they denote a stance of countries realizing the unsustainability of the current system, but on the other hand they are identified by many as the last resort to steer the future towards a more sustainable and resilient path. For this reason, they involve many components of society and require considerable commitment, including economic.

The concepts underlying the drafting of the 17 objectives are 5:

- People.
- Peace.
- Prosperity.
- Partnership.
- Planet.

From these starting points, the following objectives were drawn up:

1. No poverty: the aim is to end, to eradicate, all forms of poverty.
2. Zero hunger: to eliminate hunger in the world by guaranteeing and improving nutrition, achieve food security and promote sustainable agriculture.
3. Good health and well-being: ensuring health and well-being for all people, regardless of age, reducing infant and child mortality rates, and taking action to improve health services.

4. Quality education: providing opportunities for all to learn by providing education that is quality, inclusive and equitable.
5. Gender equality: ending all forms of discrimination by promoting gender equality and empowering women and girls.
6. Clean water and sanitation: ensuring access to functioning sanitation facilities for all, ensuring the availability and sustainable management of water and protecting aquatic ecosystems.
7. Affordable and clean energy: aim to ensure access to affordable, reliable, and modern energy services for all by promoting and incentivizing investments in clean energy.
8. Decent work and economic growth: ensure decent employment for all, enabling long-term, durable, and sustainable economic growth.
9. Industry, innovation, and infrastructure: building quality infrastructure, promoting industrialization, responsible and sustainable innovation.
10. Reduce inequalities: reduce inequalities within nations, particularly economic inequalities; support inclusion and promote economic, social, and political equality.
11. Sustainable cities and communities: making cities safer and more sustainable.
12. Responsible consumption and production: reduce waste and promote consumption patterns that minimize waste.
13. Climate action: implement practices to combat climate change, raise awareness and get everyone working together in the same direction.
14. Life below water: protecting the marine ecosystem, conserving it, and promoting its sustainable and lasting development.
15. Life on land: like the previous one, the terrestrial ecosystem must also be protected and restored.
16. Peace, justice, and strong institutions: combating all forms of violence, censoring it and promoting peaceful societies that allow inclusion and promote sustainable development.
17. Partnership for the goals: promote joint participation, from developing countries to stronger countries, to enable sustainable development.

Several years later[2], although some progress has been made on some of the issues addressed above, the report drawn up by the UN and published in 2019 showed that there is still a long way to go and, above all, there is a need for fast action and policies that are targeted and cost-effective.

All these critical issues and difficulties that are emerging make it increasingly difficult to achieve the pivotal objective that has motivated all action from the outset: sustainable development.

AGRICULTURE 4.0

The preliminary paragraphs of this chapter have been entirely dedicated to introducing the topic of sustainability, starting with the historical evolution of the term, then moving on to the topic of sustainable development and finally explaining the 2030 Agenda and its contents.

Now the lens shifts to the second central theme of this paper, namely the agri-food sector and the innovations that are increasingly affecting this sector as time goes by.

In order, the reference sector will first be introduced, giving a definition that allows it to be framed within the market. Next, the topic of smart technologies will be addressed, i.e., the development driver that is revolutionizing this supply chain, going on to see what the most common practices are and how they are used.

This section will also act as an introduction for the project I worked on in collaboration with three other colleagues, under the supervision of the four promoting professors and a tutor[3]. It is called: "*Linking sustainability pillars to smart technological development in agri-food"*. Regarding to it, it will be exposed the reason that motivated the promoters to undertake the study, the working methodology applied during the months of practice, and finally the scientific literature reviewed.

Overall, this final part of the first chapter will be useful to introduce chapter two, which will be dedicated to some specific smart technologies, and, in particular, which are the benefits they bring, and why them uses could help to achieve the sustainable development.

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[2] The SDGs have been in force since 2016.

[3] All five are an integral part of the team that makes up the Agri-food management & innovation lab

AGRI-FOOD SECTOR

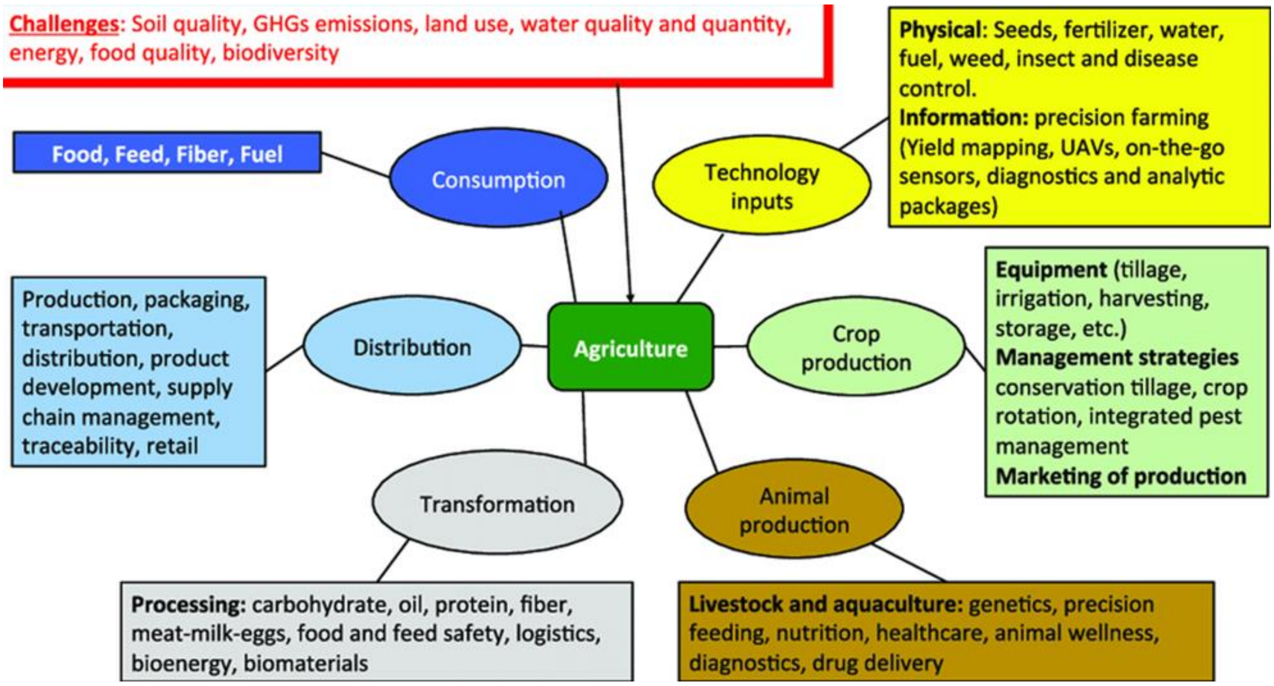
Agriculture was born many hundreds of years ago as an indispensable practice for survival and an alternative to hunting and gathering practices. This science that has always accompanied human history has undergone countless practical transformations, and new implementations, but it has always remained true to the reasons for which it was implemented. The word agriculture encompasses an enormous range of interconnected techniques and disciplines, but, in the most literary sense of the term, it denotes *“The art of working the land, to obtain the greatest and best possible fruit from it, compatible with the nature of the soil and the levels and technical systems”* (Oxford Language).

Agricultural practice originally began as a subsistence technique, but later acquired the connotations of a business practice. Over the years and the development of the economy, moreover, agriculture has assumed an increasingly transversal role within business, so much so that it is now very difficult to think of agriculture without associating to it the term agri-food. This term, which continues to evolve day by day, represents an internal economic system. Agri-food, in fact, encompasses the entire set of activities aimed at the primary production, distribution, and consumption of food and non-food products. It consists of practices involving the entire value chain, from supply to storage, transport to marketing, etc., and not just the production activity itself. Overall, therefore, the term denotes the entire business related to food production. Specifically, it is called Food Value Chain, which is referred to all the stakeholders that are involved in the production and value creation activities necessary for the processing of raw materials into food products (Neven D., 2014).

Nonetheless, even if the agriculture is only one branch of the broad agri-food sector, linking back to the definition given above of the term, two important keys emerge that also involve the remaining part of the chain. The first is “*to obtain the highest and best possible fruit*” and the second is “*compatible with the nature of the soil and technical levels and systems*”. Efficiency and sustainability.

While the goal has always been to obtain the maximum results that the environment allows, the other has been to find a way not to over-exploit and impoverish the raw material. Precisely for this reason, the agri-food sector is continually the subject of studies aimed to identify new practices and new technologies that allow both of these objectives to coexist: efficiency and sustainability.

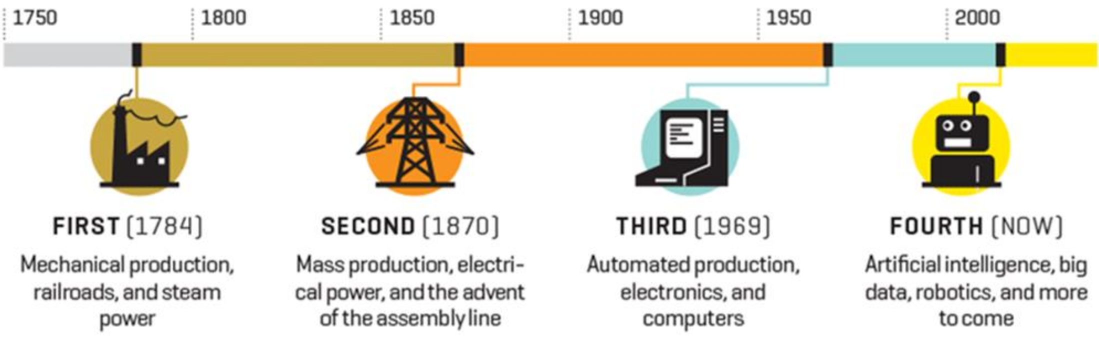
Figure 3: Agricultural system.



Source: Antle, J. M., et al. (2017). Pg.265.

As the image above shows, the agri-food sector involves many different economic actors and sectors. Despite data published annually by famous observatories such as ISTAT, FMCG, Agri-food Tech, Ecostat, etc. show that its role in the modern economy is less influential than one might think, it continues to be the subject of great debate and a reason for research. Historically, the sector has been one of the most influenced by the famous revolutions that have characterized industry: the discovery of the steam engine in the 19th century that led to the mechanization of production; the advent of electricity, the use of petroleum as a fuel and the internal combustion engine in the early 20th century began mass production; and finally digitalization, the spread of the internet and digital manufacturing in the late 20th century ushered in the digital era and broke down borders, amplifying the phenomenon of globalization (See Fig.4).

Figure 4: Timeline of Industrial revolutions



Source: Horváth, B. (2018). pg. 75.

Currently, we are in an elaboration phase regarding the fourth revolution, the main subject of which is the use of data and the automation of processes. These will lead to autonomous but interconnected production, during which the role of technology will surpass the role of man in importance. The fourth revolution, commonly called 4.0, will is the result of continuous technological innovation.

The goal of Industry 4.0 is to integrate technologies[4] with each other in order to utilize the enormous mass of collected data to derive value from it, which translates into: increasing flexibility, facilitating process management, improving communication and overall efficiency, effectiveness and working conditions (IBM, September 2019).

The term Industry 4.0, introduced in the business environment during the Hannover Fair held in 2011 (Wikipedia), is today what is most associated with the concept of the near future. When applied to the agri-food sector, it incorporates the set of digital tools and technological innovations that are revolutionizing this sector.

Having finished this excursus on the agri-food sector, and introduced the topic of Industry 4.0, the next section will be dedicated to Agriculture 4.0, the fourth industrial revolution applied to the agri-food sector. After an overview of the meaning of the term, the most widespread innovations will be presented. This part will act as a preamble to the following paragraphs dedicated to the project, and to the second, and central, chapter in which some of the most applied technologies will be analyzed in more detail. And liked with sustainable development topic.

[4] IoT, cloud technology, big data, but even other ones, how it will be showed in the next paragraph.

AGRICULTURE 4.0

There has been talk of a technological revolution in the agri-food sector for a long time. The term “Agriculture 4.0”, which brings with it the spread of techniques for precision farming and smart farming, is certainly a modern, and forward-looking concept, but it was board years ago from an awareness.

The way of farming has changed radically. While at the turn of the 1970s the objective was to maximize yield, and all practices exploited and abused the raw material to the extreme, in the last 50 years the target was focused on the preservation of the land. This evolution that grew in the minds of the economic actors cooperating within the Food Value Chain FVC has increased their attention to the production process and to the sensibility to the ecosystem that surrounds us.

In more detail, the food industry today must find a solution to numerous challenges that are not only related to the production and performance aspect, but also have a social character. The decreasing mortality rate, the increasing life expectancy, and the consequent increase in world population (Data Commons, 2020), lead to a demand problem. A study by researchers at the University of Washington estimated that the increase in demand for food in 2050 will be between 35% and 65% (Morley et al., 2021). This will lead to very problematic consequences for the environment. A further problem is climate change. In this case, agriculture both contributes to it and is negatively impacted by it. Due to countless negative environmental factors such as droughts, rising temperatures, the use of fertilizers and harmful products, and others, the soil is being degraded, and with it the entire ecosystem. At the same time, agriculture is one of the leading causes of greenhouse gases (Agenzia europea dell’ambiente, settembre 2015). Urbanization is another one, because leads to the expansion of cities and the reduction of arable land (De Clercq et al., 2018). Food security, trade margins, legislation, etc. (Bonneau V., 2017) can be added to the list of problems, but the ultimate need always remains to find new solutions that allow the coexistence of competitiveness and sustainability.

In support of this, as mentioned earlier, Industry 4.0 comes to the rescue. In fact, the “marriage” between 4.0 technologies and the agri-food sector (which gives rise to Agriculture 4.0) was born with the intention of using the digital innovations to benefit the entire trade.

To begin, what do we refer to when we talk about Agriculture 4.0? The term refers to the evolution and integration of precision agriculture, implemented with the help of technologies and tools that collect, process and exploit data and information (European Investment Bank, December 2020). The synergetic use of these innovations is intended to support the actors involved in the decision-making process of everyday activities, so that a better interpretation of data leads to better economic, environmental, and social sustainability (McCormick, November 2021).

Thus, the *“information technology”* revolution that is sweeping through the sector does not concern the individual farmer but the entire process. It is not just about machinery, computers, or physical tools, but mostly about data, software, and sharing systems that connect the different actors and levels of the FVC. They break down the boundaries of the individual enterprise.

The digital solutions that are more utilized in the agri-food sector are: Internet of Things, Big Data, Artificial Intelligence, Drones, and sensors, and Blockchain.

INTERNET OF THINGS.

Internet of things is one of the major technologies that become famous with the advent of Industry 4.0. It is the digital trend that is revolutionizing the world of agriculture. The first device traceable to an IoT technology dates to 1990 when John Romkey created a toaster that could be turned on and off using the Internet. Whereas the term IoT was used for the first time by Kevin Ashton, a British-born technology pioneer, who in Berlin in 1999, during a presentation for Procter & Gamble, used it to identify a radio-frequency identification system of his own invention (Bassi et al., 2013).

“IoT refers to the networked interconnection of everyday objects, which are often equipped with ubiquitous intelligence" (Xia et al., 2012, pg. 1101). IoT denotes a set of technologies that aim to turn a set of objects into "smart": it means to connect them to the Internet. The purpose of this system is to collect, process and transfer data and information in the shortest possible time, to speed up and improve decision-making.

IoT translates to integration and connectivity, and since its introduction it has taken on a very important role in the market so much so that its applications are potentially endless; as proof of this, the areas of use range from utilities to healthcare, from public administration to the agricultural sector.

The application of IoT in the agri-food sector is one of the central themes of this paper. In the second chapter, in fact, an in-depth literature review will emphasize the different areas of use and why it bring the enterprises to achieve sustainability goals. It has been spread throughout the entire supply chain: procurement, production, sales, after-sales, etc., and the set of benefits it brings are incentivizing many startups to invest in it (Ossevatorio Smart Agri-food, March 2019).

BIG DATA ANALYTICS.

The current historical period is certainly characterized by the large number of technologies that enable the use and dissemination of information. This huge amount of data is known as "Big Data" and takes on a strategically crucial role in decision making. Gartner Inc. defines it as: *"high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making"* (Gartner Glossary).

The use of Big Data represents the strategic core for most sectors. In particular, the agribusiness sector is observing significant expansion and adoption of Agri-analytics strategies. According to the report *"Agriculture Analytics Market - Forecast to 2027"* published by Meticulous Research, the agriculture analytics market is expected to reach $2.27 billion by 2027 (Meticulous Research, March 2021). These numbers testify to how farmers are becoming convinced of the benefits and are adjusting their strategies, identifying this technology as a driver that offers numerous opportunities for growth.

The scope of application of big data in the agri-food sector is vast; from agricultural soil enhancement, water management, livestock vital parameters control, and plant health monitoring (Sandeepanie S.I., 2020). Data collection, data analysis and data sharing are driving the 4.0 revolution in the agri-food sector.

ARTIFICIAL INTELLIGENCE.

The application of artificial intelligence is one of the most modern trends within the "Agriculture 4.0" cluster. It has only recently taken hold within the industry, having been identified as the most important potential driver to make up for the food supply/demand imbalance (Zha J., 2020).

AI, also called machine learning, is one of the key areas of computer science and concerns the development of hardware, software, programs, and algorithms to be associated with machines so that they can autonomously make real-time decisions and can complete tasks without the need for human intelligence to support them (Ziyad S., April 2019). The main uses of artificial intelligence in agriculture are robotics and management software, both of which aim to increase flexibility, performance, accuracy, and improve resource management.

The success of AI in the industry is certified by the numbers. From 2020 to 2026, investment in techniques and tools involving AI has been projected to quadruple, from 1 billion to 4 billion (Tech4future, 2020). In addition, its wide deployment is due to the almost unlimited areas of application, such as crop forecasting, disease diagnosis, soil monitoring, resource management, and others (Bannerjee et al., May 2018).

DRONES AND SENSORS.

Among the precision farming technologies within the 4.0 revolution drones and sensors are incredibly increasing them awareness and uses. Drones are certainly not a new technology, but their application in agriculture yes. They are small autonomous aircraft, capable of driving themselves or being guided remotely, that are used to collect data, images or information in real time, with the aim of improving and speeding up decision-making (i.e., water management, climate data, soil analysis, etc.) (De Clercq et al., 2018). Sensors, on the other hand, are instruments placed in various locations in fields with the purpose of recording events and capturing information of various types, such as soil conditions, climatic factors, or plant needs (Pogorelskaia, July 2020).

Both technologies are closely related to IoT and Ai technologies. In fact, only by creating a network of tools capable of exchanging and processing the vast amount of data that is collected can they be transformed into useful knowledge for economic actors.

BLOCKCHAIN.

Blockchain, which became famous for being the technology behind cryptocurrencies, has also spread widely in the agribusiness sector. *"Blockchain is a shared, immutable ledger for recording transactions, tracking assets, and building trust"* (IBM site). This ledger of information is structured as a blockchain (hence the name), within which transactions are contained. Blockchain is spreading across many industries, including agri-food. In the latter it is being applied with the aim of improving food safety, transparency, and traceability throughout the supply chain; but also, to improve connectivity, coordination and information sharing among stakeholders.

These are the digital solutions that are most prevalent in precision agriculture. All six technologies, although they have different applications, act in connection with each other to bring improvements to the economic system and impact social, economic, and environmental dimensions. That is, the dimensions of sustainable development. Indeed, by combining these precision farming tools together, the goal is precisely to promote sustainable agriculture that combats climate change and soil degradation, acts to preserve biodiversity, secures food demand, and counteracts social inequalities.

PROJECT WORK.

After devoting the first two paragraphs of the first chapter, in order, first to the codification of the meaning that the term sustainability takes on and its historical evolution, and after that, to the presentation of the "Agriculture 4.0" phenomenon and the best practices related to it, the next two paragraphs will conclude the chapter by presenting one of the pillars of this thesis, the project work.

An integral and fundamental part of the writing of this paper concerns the project in which I had the opportunity to participate during this year. The project, named "*Linking sustainability pillars to smart technological development in agri-food"*, was sponsored by the Agrifood management and Innovation lab. This and the next paragraph, therefore, will be devoted to the project, whose study approach and methodology applied during its implementation, and the scientific literature reviewed, will be explained in order. Antecedent to this, however, will be briefly introduced the initiating body of all this, namely the Agrifood Lab.

The Agrifood M&I Lab was established as an internal laboratory of the Department of Management at Ca' Foscari University of Venice and combines the expertise of professors and lecturers, including those from different disciplinary fields, to carry out theoretical and applied research. The lab turns its attentions to the agribusiness sector, and, particularly, to issues of management and innovation. Efforts are mainly focused on delving into four strands: Digitization in the food sector, Consumer analysis, Evolution, and renewal of business models of enterprises in the sector and complementary supply chains, and Entrepreneurship in the food and wine sector; and research activities are aimed at publishing articles and reports, with different cadences. In addition to this, the team is also committed to disseminating the assimilated knowledge by participating in events and conferences and organizing moments of discussion with important economic actors in the relevant territory.

Having finished the presentation of the project's sponsoring body, it is now time to discuss what, initially, motivated the production of this paper.

The project: "Linking sustainability pillars to smart technological development in agri-food," as the name already calls out, is rooted in the two central themes of the previous paragraphs, namely sustainability and smart technologies. Digital transition and sustainability are at the center of public debate and economic recovery plans. At the same time, however, some questions arise: *"Is there a risk of misallocating the resources allocated to the various revitalization plans due to widespread misinformation?"; "How much substance is there behind the terms "industry 4.0" and digital revolution?"; "Has the literature over the years already provided demonstrations regarding the positive effects resulting from the application of new smart technologies?"* These questions were the starting point of the project.

In addition, to add to this, there is a further doubt: Do the technological drivers that are driving this digital transition within the agribusiness sector have a concrete and positive impact on the economic and sustainability performance of companies in the sector, or is it just an "umbrella" term that only hides words and promises that are then not kept?

So, starting from these reasons, the main literature on the subject was, first identified, and, subsequently, reviewed.

METHODOLOGY

The initial phase of the project, which lasted five months, was crucial in laying its foundation and properly directing the work.

First, a large dataset of about five hundred documents including papers, editorials, abstracts, and scholarly articles was created. Each paper was downloaded in accordance with the Social Science Index in the Web of Science using keywords that would allow the search to be directed to precise areas. The Social Sciences Citation Index is a multidisciplinary database that contains bibliographic information from approximately 2,500 journals, books, conference proceedings, or technical reports, making it possible to quickly derive the number of citations obtained over time by an article, or author, in the social sciences and humanities (Wikipedia). The purpose is thus to facilitate information retrieval.

Then this large dataset was further divided into four sub-samples each containing a list of about a hundred titles for detailed review. Nothing was left to chance; in fact, a strict and precise coding protocol was drafted to be followed before the project began. This was so that the systematic analysis of the scientific literature would be unified, and all group members would be able to navigate through the dataset knowing that they would find correct and standardized information.

The sources of the articles varied among themselves, ranging from research departments, university faculties, journals, science centers and laboratories, and others. For this very reason, after an initial reading, the first step was to identify the type of article:

- Review article: also called literature review, this kind of article summarizes the state of knowledge regarding a determined topic. It provides a detailed overview of current thinking on a topic and discusses, drawing conclusions from, previously published articles and studies. It often offers insights for new future research but does not present experimental results.
- Research paper: also called an empirical paper, it consists of an essay in which the author discusses a topic in depth by reporting what he or she has learned by consulting sources such as Internet sites, books, articles, and interviews. It is an original contribution, as this paper often contains the results of an analysis conducted by the author to substantiate his or her opinion.
- Conceptual paper: this type of paper does not originate with the aim of presenting new data or empirical results; rather, it contains an overview of the literature regarding a particular topic and presents content that the author considers useful in directing future research. Overall, it attempts to fill a knowledge gap by following a path already outlined by previous authors.
- Commentary paper: also called an editorial paper, this is a secondary source of information in that it is a commentary or opinion that the author writes about a particular topic or issue. It is often contained in newspapers or journals, and the authors may be regular editors of the paper, or, alternatively, researchers or invited journalists.

These four types of items are certainly not the only ones in the literature, but they have been identified as the most popular and best for categorizing the considerable number of items to be coded.

Also, at the end of the first reading, and part of the first step of analysis, a key step was to categorize the topic covered by the article and assign it the relevant reference color. In case the paper was exactly centered with the focus of our research (that means that it argued the use of a smart technology in agriculture or agri-food sector and the benefits of its use for the sustainability) it should not have been labeled; the color was white. In case the paper discussed neither topics within agriculture or agri-food, nor the use of smart-technologies, it should have been labeled red and neglected. In case the paper discussed topics within agriculture or agri-food and about sustainability issues, but without any mention regard the use of a smart technology, it should have been labeled green. In the case when the paper discussed topics related to agriculture and agri-food and about the use of smart technologies, but it did not discuss sustainability topic, it should have been labeled blue. The last case was to label the paper in orange in case it dealt with the topic “climate smart agriculture”.

After this first step was completed, the paper had to be carefully reread a second time to derive useful information for filling in the boxes in the dataset. In addition to the type of paper, the categories to be filled in consisted of:

Paper characteristics:

- *Geographic localization*: continent, region, country, or cluster of countries if there were more than one, to which the reading referred.
- *Methodology*: the method applied to carry out the study, such as duration, number of observations, and sample size if there was an empirical analysis.
- *Theoretical framework*: theories or paradigms used in the research or mentioned within it (i.e., climate smart agriculture).

Technology:

- *Technology*: what kind of technology is discussed (if any) by the author (i.e., robots, sensors, AI, blockchain, etc.). Even in case a group of technologies was discussed more generically, such as smart farming technologies, the goal was to identify as much detail as possible.

- *Reasons/aims*: reasons, goals, challenges, problems or motivations behind the choice to use a particular smart technology.

Supply chain:

- *Actors*: which economic actors are involved in the discussion and how the use of a technology impacts their sphere. Farmers, vendors, providers, and others are examples of some of the categories identified.
- *Supply chain node*: what part of the industry is affected using the smart technology discussed. For example, farming, distribution, selling, etc.
- *Transformations*: what, precisely, are the transformations, brought into the journey of the actors involved, resulting from the use of the discussed technology. This is the description of the operations and impacts.

Sustainability: this section required a lot of effort and attention because, as the name of the project implies, the goal was to understand whether the literature had already identified a link between the use of smart technologies and sustainability. In particular a relationship with the modern SDGs.

- *Sustainability challenges*: these are the challenges that humanity or the agri-food sector is about to face or is facing. Moreover, a further step was to match these "challenges" with the corresponding sustainable development goal. For example, if the challenge is to make up for the lack of food to meet the world's population growth, the relevant SDG is number 1 "Zero hunger."
- *Environmental sustainability*: this is the environmental dimension of sustainability, understood as the ways in which the use of smart technologies impacts the environment.
- *Economic sustainability*: this relates to economic factors that have to do with the supply chain (i.e., factors related to profitability, efficiency, competitiveness, etc.).
- *Social sustainability*: this is the dimension that deals with the social sphere and how the discussed technology impacts it. For example, working conditions, worker protection, physical and mental state, etc.
- *General / not categorized*: here those factors that cannot be categorized as sustainability pillars have been included.

- *Institutional actors and factors*: this section is used to identify the institutional actors mentioned (if there were any) and their role, whether they took a role as promoters or limiters.

A master dataset was created once the initial literature review was completed with the papers deemed relevant to the purpose of the study.

LITERATURE REVIEW.

This last part of the first chapter will present the main conclusions that emerged from the coding of the final master dataset. Some categories showed clear patterns, others not at all, while still others showed correlation, which I have called "theoretical" for the occasion.

The master file with all the analyzed papers has 568 scientific papers. These were labeled in the following manner:

Table 1: labeling of analyzed documents.

CATEGORY	RELEVANT	TOPIC	NUMBER OF PAPERS
TOTAL			568
WHITE	V	Agri-food I Sustainability I SF I ST	132
RED	X	-	89
ORANGE	X	CSA	110
GREEN	X	Agri-food I Sustainability	204
BLU	X	Agri-food I ST I SF	27
GREY	X	NOT FOUND	6

For the purposes of our research, the relevant papers to consider were white papers as they discussed the application of smart technologies in the agri-food sector, with regard to sustainability. So, the papers from which the conclusions in this section were drawn are 132.

Table 2: labeling of white relevant documents

TOTALI	132
REVIEW ARTICLE	34
RESEARCH / EMPIRICAL PAPER	78
CONCEPTUAL PAPER	6

NOT ANALYZED	14

Table 2 shows that this topic is predominantly covered in depth. More than 75 percent of the literature analyzed falls within the scope of review articles or research papers. This means that we certainly have at our disposal a considerable amount of information that allows us to go in depth with the widespread knowledge in this area; but at the same time, more than half are empirical articles; therefore, in addition to discussing the already known literature, they report studies that corroborate the new theses and hypotheses that the author proposes.

Geographically, no clear pattern can be discerned. Although discussions mainly involved areas in Europe (33 times) and Asia (27 times), many articles did not discuss a specific area (43 times). In addition, studies often involved, or were referable to, macro areas composed of countries on different continents (e.g., EMEA, APAC, LATAM, etc.).

The same consideration can be made regarding the category's methodology, theoretical framework, and supply chain. In order, regarding method, each author applied a different approach to discuss their thesis; therefore, it is very difficult to find a common path followed by most of them.

Similar discussion can be made for the theory category, as many authors have supported paradigms such as Climate Smart Agriculture: (e.g., *"A Review of Climate-Smart Agriculture Applications in Cyprus"* (Adamides G., 2020), *"Integrated-Smart Agriculture: Contexts and Assumptions for a Broader Concept"* (Martinho V. J. P. D., 2021), *"Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from the Netherlands, France, Switzerland and Italy"* (Long et al., 2016), etc.), Industry 4.0 (e.g., *"A General Outline of a Sustainable Supply Chain 4.0"* (Cañas H., 2020), *"Artificial Intelligence in the Industry 4.0, and Its Impact on Poverty, Innovation, Infrastructure Development, and the Sustainable Development Goals: Lessons from Emerging Economies?" (Mhlanga D., 2021)*, *"Leveraging blockchain technology for circularity in agricultural supply chains: evidence from a fast-growing economy"* (Sharma et al., 2021), etc.), or smart farming (e.g., *"Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions"*

(Pigford et al., 2018), *“Drivers and challenges of precision agriculture: a social media perspective”* (Ofori M., 2020), etc.), which for the purposes of the study are too general to provide us with a useful result or information.

Last was the supply chain, which unlike the other two categories saw the alternation of two dominant patterns, namely farming and no information. Farming was the most common reference by far; sometimes mentioned along with other nodes in the chain but always present. The absence of a specific reference to the node, on the other hand, characterized many articles.

Continuing with the analysis, the actor category notes a dominance of farmers as the subjects most affected by the use of smart technologies. This result does not bring out anything special since even before the analysis it was expected that agriculture and farmers would be the most affected sector and actors. The next two most mentioned categories are consumers and (what I decided to call) "actors in general". The latter encompasses all those actors such as engineers, various stakeholders, cooperatives, consortium, and all those economic actors named so few times that could not form a cluster.

The first significant results appear by considering the categories of technology, reasons, and transformations. First, regarding technology, it quickly becomes apparent how difficult it is to study them individually. It means that the literature jointly considers the use of multiple technologies simultaneously, and the discussion of a single technology is sporadic; especially when combined with an empirical study. Concretely, there are 51 articles that discuss the use of technologies attributable to the Internet of Things, but the number of articles that discuss only it, without mentioning other technologies, is 3. The same argument can be made for Big Data. The number of articles addressing only big data is one, while if the use of big data is combined with the use of additional technologies (e.g., IoT, robots, sensors, etc.) the number rises to 21. This first result is further emphasized for other technologies such as sensors, drones, or blockchain, to name a few. Specifically, we do not count articles that deal individually with the use of these technologies but are always combined with others.

This first result emphasizes how Agriculture 4.0 is an interconnection of technologies. It is based precisely on the joint application of tools and technologies that can communicate with each other and exchange information. For example, the use of sensors is only conceived together with IoT and Big data analytics technologies. Overall, these last two ones enable to archive, process, and transfer the data collected by the sensors.

Clearly, this relationship is also reflected in the two categories closely related to it, namely reasons and transformations. The former, as mentioned, are the motivations for using a smart technology; while the latter are the impacts and changes that their use brings to the journeys of those involved. Below are three examples to substantiate this thesis:

1. Mhlanga D. (2021) argues the industrial revolution and specifically points to the use of AI to achieve SDGs 1 (Zero hunger), 2 (No poverty), and 9 (Industry, Innovation, and Infrastructure). The article centers its discussion on the application of AI, but also argues for the use of additional technologies in synergy such as sensors, drones, robots, and IoT. The "No poverty" goal consequently involves increasing and optimizing productivity, improving health, and management in the farm environment. The goal "Industry, Innovation, and Infrastructure" involves the consequent improvement of infrastructure, and particularly transportation.

How do these innovations impact achieving these goals? In states such as Kenya, Tanzania, and Mozambique, drones collect images and sensors information; both technologies communicate with each other through IoT and share the amount of data collected with farmers and relevant authorities. Next, by applying AI-based algorithms, self-controlled robots can be used to monitor the health of plants by countering diseases such as plague. This improves crop management, increasing yield and food security, and positively impacting poverty and food demand (SDGs 1 and 2). Another example, in this case to achieve SDG9, takes place in Rwanda, where drones guided by AI algorithms are used for delivery service with the aim of reducing traffic. Again, the application of AI in shipping increases fuel efficiency and reduces greenhouse gas emissions by reducing the number of unnecessary routes.

2. S. Lieder and C. Schröter-Schlaack (2021) argues the application of smart farming technologies to reduce the negative impact of agriculture on biodiversity, greenhouse gas emissions, and the environment in general. The author identifies the innovations discussed as "smart farming technologies," which in concrete terms are IoT, Big data analytics, analytics software, AI, small-scale robots, and sensors. SF technologies

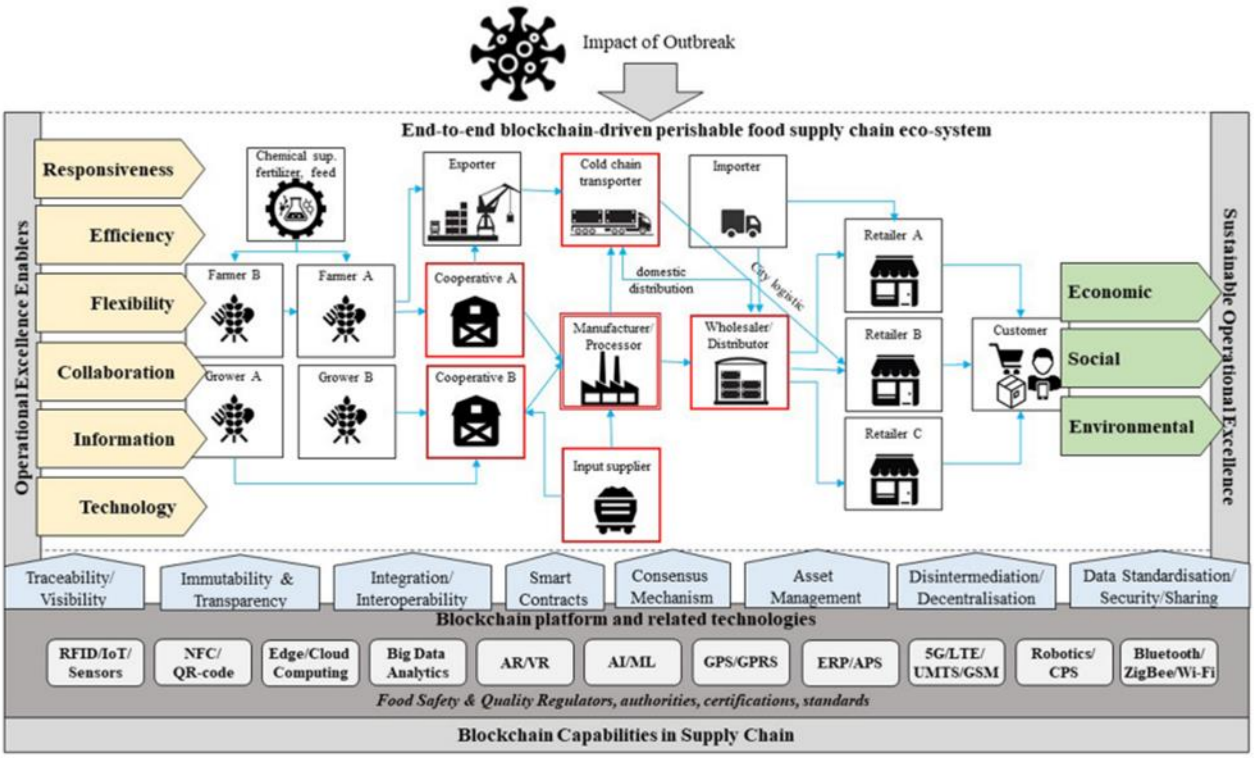
impact by reducing the use of insecticides, pesticides, fungicides, and fertilizers; they also improve soil management by optimizing yields and reducing water waste.

How do they impact? The sensors collect data, which is then processed through AgroDDS big data analytics software to simulate scenarios that generate soil management recommendations. Still the sensors can be used to collect data regarding soil water requirements and subsequently use small-scale robots controlled through AI algorithms to optimize management and reduce waste.

Again, sensors are used to collect soil data and create maps. Then, by communicating with robots through IoT technologies, planting, harvesting, plowing, etc. are optimized while chemical use is minimized.

3. Y. Kayikci et al. (2021) explores the implementation of emergent innovations such as IoT, AI, ML, sensors, big data analytics and blockchain, for improving efficiency, quality, traceability, safety, and visibility along the PFSC.[5]

Figure 5: PFSC and how Blockchain interacts with other smart technologies.



Recourse: Kayikci, Y., Durak Usar, D., & Aylak, B. L. (2021). pg. 14

[5] Perishable Food Supply Chain.

Figure 5 summarizes the entire PFSC and how blockchain interacts with other smart technologies for achieving operational excellence. On the one hand, the author emphasizes how, at this stage of the study, the results cannot yet be generalized; on the other hand, he emphasizes how the more data is collected and shared along the ecosystem, using different STs synergistically, the more it increases the ability of blockchain to drive the achievement of operational excellence in PFSC.

These just outlined are three situations in which the effect of a single technology is not isolated, but rather, the benefits of Agriculture 4.0 as a sum of interconnected uses are emphasized.

And this is exactly the concretization of the 4.0 paradigm: *"...various new digital (Information & Operational) technologies integrate with traditional physical systems by interconnecting all business resources (people, products, machines) in order to increase the competitiveness of companies, enabling concrete supply chain integration/collaboration"* (Osservatorio smart agrifood, 2020).

The last section of analysis is the sustainability section. All the papers under review discussed the challenges the industry faces (and will face in the future), and how the use of 4.0 innovations promotes sustainable development.

The most important result that emerged from the coding of the dataset is that the potential of innovations 4.0 is almost unlimited. Of all the goals listed in the 2030 Agenda, only five are not mentioned even once: SDGs 4, 5, 10, 16, and 17. The rest, however, are all discussed. Goals number 1, 12, and 13 are the most discussed. However, the result is not surprising; in fact, these are the correspondents of the most argued reasons: the productivity gains needed to cope with increased demand for food, and climate change, which is to be combated by promoting sustainable practices and by making consumption and production responsible. Reason motivates smart technology, and ST promotes the resolution of a "challenge." This is the logic behind the literature review.

Overall, the environmental dimension, compared to the social and economic dimensions, is the most stressed in the list; but, despite this, the three dimensions are interconnected, and the goals branch out with each other. For example, starting with SDGs 13, which sets the goal of combating climate change, one can branch out into Goals 14 and 15 (conserve the marine ecosystem, the terrestrial ecosystem, combat phenomena such as desertification, water pollution, and deforestation, which are degrading flora and fauna), which are the closest conceptually; but also into Goals 7 and 11 (ensure and promote the use of renewable and sustainable energy, and make cities and buildings safe, resilient, and sustainable).

A firsthand account of this connection between the Agenda's goals comes directly from the person dedicated to illustrating it: Jakob Trollbäck. He is the Swedish-born designer hired for the SDGs communication strategy. Inspired by the need to engage the entire planet for a common purpose, the stated goal was to easily communicate the goals to different continents and different cultures. To that end, in addition to the storytelling associated with each goal, Jakob envisioned the list of goals as the chemical elements that make up the periodic table. *“You cannot think of solving "Zero hunger" without solving "No poverty"; and you cannot solve "No poverty" without solving "Good health and well-being”, "Quality education”, etc. This periodic table represents the SDGs as universal elements that communicate with each other”* (Jakob Trollbäck, Stockholm University, 2022).

CONCLUSION.

To recap, this first chapter was concerned with introducing the project work, "Linking sustainability pillars to smart technological development in agri-food," in the best possible way. The logical path followed a well-defined thread: first the topic of sustainability was introduced, retracing the most significant historical stages that led to today's definition of sustainable development and the drafting of Agenda 2030; then another very important topic was introduced, Agriculture 4.0. The historical stages of this too were retraced, and then best practices that have revolutionized and are revolutionizing the agri-food sector were illustrated. To conclude, the bridge that allowed the two topics to be connected and open a discussion that will be continued in the next chapter was described, namely the project. Its underlying motivation, the working group, the literature review methodology and the most significant results that emerged from it were described.

CHAPTER 2.

Usage of Artificial Intelligence and Remote Sensing to promote sustainable development and achieve SDGs in agriculture.

This second chapter of the text contextualizes the adoption of artificial intelligence and remote sensing. In particular, for both, the recent history, the main definitions found in the literature, and, especially, the uses and benefits that their adoption brings to the agri-food sector are explored.

The decision to delve into these two technologies stems from the literature analysis carried out for the project. Among the most widely adopted technologies is artificial intelligence, and this is often used in conjunction with remote sensors. This, combined with a personal interest in the two technologies, led to the drafting of this paragraph.

ARTIFICIAL INTELLIGENCE

Over the years, and with the succession of different industrial revolutions, production, cultivation, and breeding methods have evolved and become more efficient. Today, thanks to the numerous technologies present, evolutions and progress are much faster and lead to evidently positive results. The agrifood sector is one of the sectors that is most evolving and modifying commonly used practices, progressing all the time. The road taken is towards the realization of a sustainable economy and development.

The agri-food world produces an incredible amount of data at any given time. Encoding them into useful information, however, requires enormous effort, which translates into time consumption activities that companies cannot afford. To fill this gap, smart technologies are taking on an increasingly primary role. In this sense, artificial intelligence tools support actors along the supply chain in performing tasks that would require too much mental effort. With its ability to calculate, process, and predict, artificial intelligence is becoming a useful ally.

A recent study conducted by the International Data Corporation (February 2021) estimated that spending on AI software, systems, and tools will grow from the current € 87.7k mld in 2021, to over € 247k mld in 2025, with an estimated annual growth rate of 17.5% and related revenues of € 557k mld. These numbers are emblematic of the importance it is assuming day by day.

According to the head of research, Jennifer Hamel, the pandemic has slightly slowed down developments in artificial intelligence research; but at the same time, the sense of awareness as a tool to increase productivity and support business resilience has increased.

Today, 60% of farmers employ at least one 4.0 technology, while 40% employ at least two. The most popular ones are management, monitoring, and machine control software, i.e. applications that belong to the AI category.

DEFINITIONS.

In our everyday lives we regularly come into contact with numerous artificial intelligence technologies, such as voice recognition tools (e.g. Alexa, Siri, Cortana), translators, and games for smartphones or PCs (e.g. chess, backgammon). What seems distant from us in words is part of everyday life.

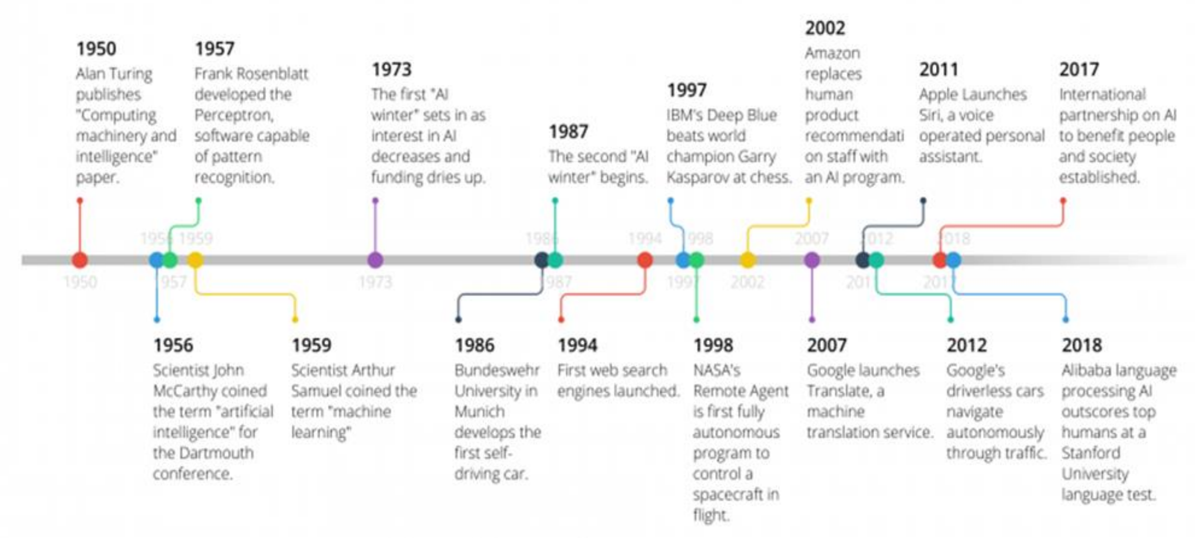
Some of the definitions given to artificial intelligence:

- According to Encyclopedia Britannica: *"Artificial Intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience".*
- According to Encyclopedia of Science and Technology: *"Artificial Intelligence studies the theoretical foundations, methodologies and techniques that make it possible to design hardware systems and systems of software programs capable of providing the computer with performances that, to the ordinary observer, would appear to be the exclusive domain of human intelligence".*
- Grosan and Abraham (2011) define AI as: *"creating machines which solve problems in a way which, done by humans, require intelligence".*
- According to Biacabe et al. (2017): *"AI describes the work processes of machines that would require intelligence if performed by humans"*.

In accordance with the various definitions given, the commonalities of AI are the presence of a software, a hardware, a computer, or a robot; which autonomously solve problems that normally require human intelligence; applying reasoning skills; and learning from previous experience.

The foundations of the AI concept date back to 1936, when Alan Turing developed a machine that was independently capable of performing any kind of calculation. This, called the “Turing Machine”, was the ancestor of the modern PC and paved the way for numerous attempts to answer a fundamental question: do machines possess the faculty of thought? The search for an intelligent, thinking machine drove many scholars to relate to the subject, but the birth of the term “Artificial Intelligence” is due to John McCarthy. In 1956, during the “Dartmouth Summer Research Project on Artificial Intelligence” held at Dartmouth College, he introduced the possibility of devising machines that would perform, autonomously, operations where human intelligence was required. Since then, efforts have been directed towards the development of computers capable of solving problems, the development of human-machine dialogue, and the reproduction of typically human capabilities such as emotionality, creativity, and reasoning. The real turning point came in the 1990s, when the birth of the Word Wide Web, and the spread of the Internet, made a huge amount of information and knowledge available, greatly broadening the prospects for artificial intelligence technologies. From that moment until the last decade, in fact, the goal was to develop algorithms and applications that, given the enormous amount of unstructured data, would allow them to be encoded and processed to extract knowledge.

Figure 6: most important historical stages of AI development



Source: www.metronews.co.nz

ARTIFICIAL INTELLIGENCE STRONG vs WEAK.

Taking the human brain as a reference model, and the goal of having a machine that can simulate its functioning, an AI technology is capable of emulating some of its typical functions: thinking to solve a problem with cognitive functions, reasoning rationally by exploiting logic, and acting efficiently by initiating a process to obtain the best result with the least expenditure of resources. From this, two types of AI can be distinguished: weak and strong.

Weak AI was created with the intention of building a machine that can simulate the behaviour of the brain and act *"as if"* it was. Searle J., in his article *"Minds, Brains and Programs"*, referred to weak AI as, essentially, a group of pc programs that need human input to test hypotheses in an extremely precise manner. Hence, problem solving programs (Searle, 1980).

Strong AI, on the other hand, is no longer just a support tool, but becomes very similar to the human mind and possesses a cognitive capacity. The technology behind AI is that of expert systems, i.e. programs capable of reproducing the performance of a human mind that is expert in a field. These expert systems, therefore, develop their own intelligence. An example of strong AI is the Instagram's algorithm, which shows us contents based on our preferences and actions in the app. It is not static and learns from our behaviour.

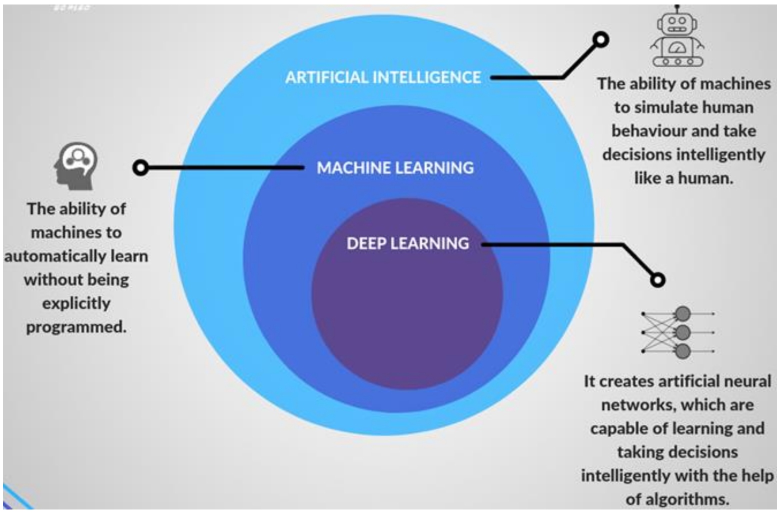
MACHINE LEARNING vs DEEP LEARNING.

Artificial intelligence is a broad concept, applied in many fields, and continuously evolving. Grosan and Abraham (2011, p. 1-2) describe AI as the sum of three phases:

1. Firstly, a Hardware is developed to process data efficiently and in the shortest possible time, storing it in memory.
2. Secondly, AI technology requires software so advanced that it can simulate the functioning of the human brain, processing the data and drawing conclusions.
3. Finally, data must be collected by a device/instrument in a structured manner, so that it is available in the form of output relevant to solving the initial task.

The learning method is what qualifies AI from a technological point of view. This distinguishes Machine learning from Deep Learning, two areas within AI.

Figure 7: Fields inside AI category



Source: www.blog.quantisti.com

Machine learning consists of programs that use algorithms, regressions, computational statistics, etc. to encode data and make predictions. The algorithm behind machine learning is programmed to improve itself.

In addition, input data, a task to be solved, and qualitative metrics are needed to assess the goodness of its performance.

ML can be categorized into four families (Grosan and Abraham, 2011, p.266):

- Reinforcement learning: learning is automatic, and the system is developed to recognize correct and incorrect actions through feedback received step by step.
- Supervised learning: learning is influenced by input and output examples, which are already classified. In this way, the model already knows how it would "behave" if it had to classify new data and predict new relations/outputs.
- Unsupervised learning: in contrast, this model discovers relationships and makes predictions without any input. The system is therefore asked to discover new relationships or clusters autonomously.
- Active learning: is also called optimal experimental design and is a model like supervised learning. This is because there is already categorized input data but differs from the former in that the model can "interact" with the user to improve the final classification of the data.

Machine learning techniques are applied in agriculture in various ways. For example, predictions can be made about future harvests based on data from previous ones. Or the water requirements of a soil can be calculated based on soil quality data.

Different from machine learning, however, is deep learning. DL is a subset of ML, and consists of models that try to emulate the functioning of the human brain. It is an automatic learning method, based on multiple layers of neural networks, capable of analyzing a very large dataset to draw conclusions with great precision. These algorithms have become especially popular during the last few decades, in parallel with the advent of big data. The peculiarity of these models is that they can compute very large training sets, eliminating the data pre-processing phase typical of ML; so, they do not require structured data, and also encode text and images (IBM, May 2020).

In everyday life, DL technologies are used for investigative analyses to foil fraudulent activities, for trading activities, for customer support via chatbots, etc.

In the agri-food sector, deep learning algorithms are used, for instance, to recognize an animal breed (by receiving a massive amount of data and images to distinguish one animal from another), a disease (e.g. Agrio, Plants Disease Infection), or even to estimate the water requirements of a piece of land by receiving aerial images as input (one can map the moisture level and estimate the irrigation needed).

USES AND BENEFITS OF AI IN THE AGRIFOOD SECTOR.

Agriculture, and the agri-food sector in general, is being called upon to be more sustainable and efficient at the same time. In this sense, precision agriculture and the use of AI technologies are a useful ally in greening cultivation and breeding.

The predictive power of artificial intelligence contributes substantially to building a sustainable ecosystem, acting transversally at all stages of the supply chain. Yield prediction, supply optimization, consumption efficiency, are some of the applications of AI in the sector.

The fields in which artificial intelligence is applied are many:

- Agrochemical analyses.

Agrochemical analyses are a key activity in drawing up a fertilization plan. Taking soil samples, labelling them, sending them to the laboratory, and subsequently analyzing them, is a time- and resource-intensive process. Artificial intelligence helps to perform this task in real time and without the need to travel from the farm to the laboratory. An example of AI applied in this field is AgroPad, launched by IBM in 2018, which consists of a paper device the size of a business card, inside of which is an analysis chip. Once a soil sample or a drop of water is placed on the AgroPad, a colorimetric test is returned in about ten seconds showing the amounts of chemicals contained in the sample. Then, by framing the card with the application, the farmer receives the result of the chemical analysis (IBM, September 2018).

- Crop management.

Crop management encompasses a set of practices adopted to predict the harvest, detect diseases, and prevent them, increase yields and quality, and recognize the presence of insects and pests. In this, the analysis and prediction capabilities of AI can play an important role. For example, the application of deep learning can automate the detection of diseases and pests. In fact, using image-based recognition technology one can monitor the health of plants (e.g. apples (Guan et al., 2017) and tomatoes (Liu, 2020)) by detecting diseases. Another example is the development of an AI algorithm that can detect the maturity rate of crops (e.g. wheat (Yanjun et al., 2016) and tomatoes (Peng et al., 2018)), thus reducing the farmer's workload and increasing yields. 4grapes is an application that uses artificial intelligence to monitor the phenological, production and phyto-pathological situation in real time.

- Water management.

Water is an essential input in the cultivation of fields. Its management is a very important factor, especially in relation to current challenges such as population growth and climate change. The use of artificial intelligence to optimize water management involves the use of real-time collated data to build efficient irrigation systems. The goal is to optimize water use, reducing water wastage, improving soil health, and maximizing yields (Sharma et al., 2021). For example, devices and platforms can be used to collect raw data in real time, encode it, and consequently develop optimal strategies or discover malfunctions/inefficiencies in water systems.

- Weather forecasting.

Meteorology is the science that studies atmospheric phenomena and which we rely on to make predictions about future climate. This science is prone to errors, which can be very problematic when considering agriculture. The application of artificial intelligence in this field consists of processing hundreds of data inputs using machine learning techniques to facilitate calculations and obtain more correct predictions. For example, a study by the University of Washington and Microsoft Research showed how AI, particularly deep learning, can be used to study past weather patterns to accurately predict future weather phenomena (Weyn et al., 2020).

- Soil management.

Increasing population and demand for food are two problems that plague the agri-food sector and require optimal management of arable land to solve them. Soil management consists not only of tillage practices such as sowing, ploughing, pruning, etc., but also of soil conservation and the development of strategies that maximize yields. For example, Terroir from space is a start-up that uses an AI model to process data from satellites and develop medium- to long-term strategies capable of enhancing land (currently cultivated and still uncultivated) through viticulture.

- Livestock management.

The demand for food is continuously increasing while the number of farmers is decreasing. It is estimated that the demand for meat and eggs will grow by more than 65% within the next 40 years. This, caused by the continuous population growth, creates a need for increased productivity on every farm. Precision livestock breeding is a set of practices that allow the farmer to closely monitor, and in real time, the behaviour and health status of the animal, and remotely manage activities such as feeding, cleaning, milking, and others. The company Seker has developed a remote monitoring system called Piguard that, thanks to intelligent cameras and deep learning algorithms, allows the farmer to monitor the pigs' physical activity, feeding and behaviour. Farm4trade is a start-up that has developed a suite of applications based on AI algorithms to monitor and improve animal welfare and enhance food traceability throughout the supply chain.

As is to be expected, the adoption of a new technology brings with it novelties and implications in several areas. The application of artificial intelligence technologies has been shown to have positive impacts in three areas: economic, social, and environmental.

Regarding the economic benefits artificial intelligence is having in the industry, the most significant results relate to profitability. Indeed, these technologies increase productivity and reduce costs throughout the production chain. If we think about productivity, the use of AI models makes it possible to fight diseases, insects, and weeds; monitor climatic phenomena, reducing their negative impact on the harvest; analyses soil characteristics and develop medium- to long-term strategies to maximize the yield of a field; but also control livestock, managing their health and welfare to make them more productive. Furthermore, AI reduces the costs that farmers and breeders have to bear; for instance, by lowering expenses for chemicals such as fertilizers and minimizing the waste of resources (e.g. water). Finally, using AI technologies automates many tasks for which personnel would have been needed, reducing the cost to the farmer or rancher.

Artificial intelligence not only impacts the “wallet” of economic actors, but also influences the role of all workers within the supply chain. A first very important, and often overlooked, aspect is that there is no positive relationship between the use of this technology and job losses. In fact, a study published by PwC (2017) shows that AI will create as many jobs as it replaces (+200k, ed.). This is because its adoption on the one hand eliminates some roles, but on the other creates new ones. Moreover, as PwC chief economist John Hawksworth reported, historically the introduction of a new and disruptive technology leads to job replacements generating new roles and large gains. These gains increase the level of spending and create demand for labor.

The introduction of AI will have further impacts on the world of work. Indeed, the use of robots and the automation of certain high-risk activities reduces the danger to workers. Again, it reduces human error and increases efficiency. Overall, rather than a substitute, AI should be seen as a synergistic tool that can increase productivity and worker well-being (Ransbotham et al., 2021).

Agri-food and the environment are two strongly interrelated areas. Agriculture and animal husbandry strongly affect aspects such as climate change, food demand, resource use, and economics. The use of artificial intelligence in the agri-food sector aims to make the whole chain more sustainable. If we think of this technology as a tool to increase profitability and reduce inefficiencies, it can be said to help reduce poverty and promote economic growth and employment: SDGs 1, 8). Again, if its adoption leads to increasing the yield of cultivated land or livestock farming, it can be argued that it helps generate supply to meet the ever-increasing demand; and thus reduce world hunger: SDG 2. To conclude, in operational terms, AI aims to reduce waste, safeguard resources, and promote the use of renewable resources, preserve the ecosystem (both land and sea), and combat climate change. Consequently, it participates in the achievement of all the environmentally oriented goals: SDGs 6, 7, 11, 12, 13, 14, 15.

REMOTE SENSING.

Agriculture and animal husbandry are the two fundamental sources of raw materials that allow humanity to continue living. Both sectors play a very important role in the modern economy and are confronted with two important standards: productivity and sustainability. Productivity relates to the growth cycle of vegetation, weather conditions, soil characteristics, and the landscape in general; sustainability, on the other hand, relates to the challenges these sectors are faced with increasing population and demand for food, resource scarcity, climate change, damage to the ecosystem, etc. Among the technologies that can ensure that these two conditions are met is remote sensing (Duveiller et al., 2020). Remote sensing allows farmers and breeders to govern unstable or unfavorable environmental and climatic conditions to maximize yields and reduce the environmental impact of their activities (Khanal et al., 2020).

“Remote sensing is the science of acquiring information about the Earth's surface without actually being in contact with it” (CCRS, 2019).

Remote sensing is one of the pillars on which precision agriculture is based and is a very useful diagnostic tool when combined with other data management and data analysis technologies. Sensors and drones are used as support tools, able to collect images and data remotely to optimize the decision-making process of economic actors, and steer decisions towards achieving better profitability and environmental sustainability (Khanal et al, 2020).

DEFINITION

The term “remote sensing” is somewhat new. It dates to the 1960s, when it was used to describe this field for the first time. However, the first forms of remote sensing date back just over two hundred years, after the discovery of photography. In the 1800s, the camera was invented and soon after, people also became interested in aerial photography from hot air balloons. The first one dates to 1850 and was taken by

Gaspard-Félix Tournachon, who immortalized a French village (Humboldt State University, 2020).

The first developments in aerial photography date back to the beginning of the 20th century, when small cameras were mounted on kites and pigeons to take photographs from above. The cameras were very light and took photos automatically triggered by a timing mechanism.

The first photograph from an aircraft dates back to 1909, shortly before the start of the First World War. From then on, the use of cameras mounted on airplanes for military purposes grew rapidly. During the Second World War, new techniques were developed such as infrared photography and thermal sensors, both of which were used for military purposes such as night bombing. In 1956, CIR (Color infrared photography) was used for the first time for the classification and recognition of plant species, and the detection of diseases and diseased plants. After the cold war, this technique was used in different fields. For example, in topography to produce maps, replacing traditional ground surveys, or in fields such as geology and forestry.

The first use of aerial photography in agriculture dates to the 1930s, when it was used for agricultural programs in the USA by the Agricultural Adjustment Act. From then on, this technique was used for the purpose of land conservation and planning.

The turning point in this sector, however, came with the start of the "Space Race". After 1957, when Sputnik was launched into space by the Soviet Union, the development of satellite remote sensing began. Since then, developments in the satellite and imaging fields have been remarkable. In fact, from the first launch to the present day, thousands of satellites, both governmental and commercial, have been sent to orbit the Earth to acquire information, data, and images about it.

Remote sensing is a technique that uses several instruments to make observations or measure a certain target. The target is normally at such a distance that it is not possible to perform the same actions without the aid of these instruments. This technology is used in fields such as geography, meteorology, ecology, health, geology, and widely in the agri-food sector.

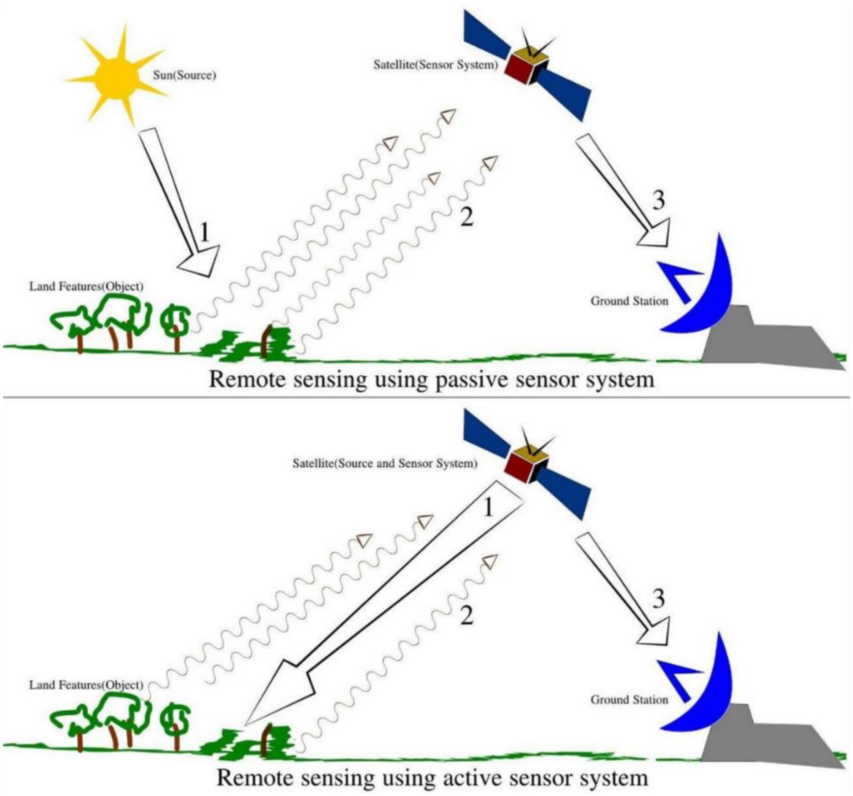
According to Aronoff (1995), "*Remote sensing is the art and science of obtaining information from a distance, i.e. obtaining information about objects or phenomena* *without being in physical contact with them. The science of remote sensing provides the instruments and theory to understand how objects and phenomena can be detected. The art of remote sensing is in the development and use analysis techniques to generate useful information"*.

Therefore, remote sensing refers to activities carried out remotely with the aim of collecting information, observing phenomena, and sensing objects or events (Sharma et al., 2017). The mainly used sensing and monitoring platforms are sensors, drones, satellites, aircraft, GPS, radar, sonar, and probes.

PASSIVE RS vs ACTIVE RS

The main difference between remote sensing technologies is active and passive. Passive remote sensing measures electromagnetic radiation from another source. This radiation is reflected, or emitted, by the investigated target surface. It is the most common in agriculture (Nowatzki et al., 2017) as it uses the sun as the energy source and plants as the reflecting surface. Active remote sensing, on the other hand, does not involve the sun as source, but the detector instrument. It independently irradiates the surface and then detects the returning electromagnetic radiation.

Figure 8: Passive and active remote sensors.



Reference: www.dragonflyaerospace.com

These systems are commonly mounted on equipment or aircraft which are autonomously driven and controlled by an AI software.

COMPONENTS OF REMOTE SENSING.

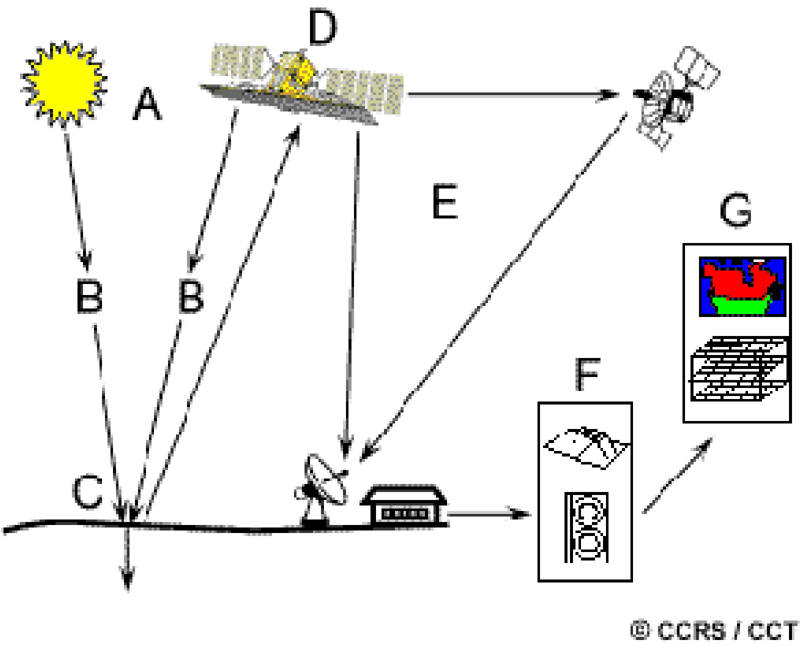
Shibendu's definition of remote sensing (2005): *"... by detecting the characteristic electromagnetic radiation that is reflected/emitted by the earth surface"* emphasizes the first component of remote sensing, which is the source of energy or illumination. This, as mentioned earlier, also determines the difference between active and passive remote sensing, but, in any case, constitutes the fuel that allows the instrument to function. But what are the other components of remote sensing?

The methods of data collection, processing, and interpretation may differ from one another, but they are united by certain elements that are essential to the functioning of the system (Panigrahy and Ray, 2006, Sharma et al., 2017):

A. Energy source.
B. Radiation and the atmosphere: from the source to the natural surface, electromagnetic radiation meets the many particles that make up the atmosphere, e.g. gas, dust, vapor, etc. This aspect must be considered when analyzing the data as it is precisely the atmosphere-radiation interaction that can generate phenomena, such as refraction, that modify the radiation itself.
C. Interaction with the target: The energy emitted by the source, which may be the sun or the sensor itself, reaches the surface and is absorbed, or re-emitted, or even reflected. These changes depending on the physical characteristics of the surface and other features.
D. Recording of energy by the sensor: after the electromagnetic radiation has been emitted or reflected from the target surface, it reaches the sensor. This is placed at varying distances (near the earth, or satellite) from the target, and has the task of recording the radiation.
E. Transmission, reception, and processing: the overall electromagnetic energy collected by the sensor is transmitted to a station often in electronic form and then, once received, is converted into an image.
F. Interpretation and analysis: the image is processed in order to extract useful information about the analyzed surface. Usually, the final product is a thematic map of the target.

G. Application: the last element of the remote sensing process consists of applying the information extracted from the image to solve a problem.

Figure 9: Fundamentals of remote sensing



Reference: Canada Centre for Remote Sensing (CCRS)

USES AND IMPACTS OF REMOTE SENSING IN THE AGRI-FOOD SECTOR.

According to Ohio State University, *"Remote sensed imagery can be used for mapping soil properties, classification of crop species, detection of crop water stress, monitoring of weeds and crop diseases, and mapping of crop yield"*.

In the field of agriculture, the use of this technology is gradually increasing, because of its applications in numerous areas:

- Crop identification

To plan and forecast imports and exports, national governments often use remote sensing technologies to obtain precise information on the spatial distribution of crops. If the crop calendar is known, the reflectance level can be exploited to discriminate crops and estimate plant cover in the area of interest. Furthermore, by combining plant growth cycle data and data obtained from remote sensing, statistics can be collected, forecasts can be made, and the productivity of a given area of interest can be mapped (Sharma, 2017, McKenzie et al., 2016).

- Identifying stressed plants.

Chlorophyll photosynthesis is the functioning process of plants and for it to occur, solar energy is needed. Chlorophyll, during the process, absorbs energy and therefore has a direct effect on the amount of energy that is reflected. Using remote sensing, one can measure the amount of chlorophyll present in a crop; then calculate the level of reflectance; and finally, based on the vegetative indices obtained, determine the health of the plant. Modern technologies make it possible to localize the problem and the plant's state of ill-health even before it occurs, allowing prompt remedial action to be taken. Following a similar principle, water can be used to control the plant's state of stress. In the absence of water, the plant's temperature increases. Remote sensing can detect this increase in heat that results in water stress in the plant (Moran et al., 1997, Sharma et al., 2017).

- Detection, Diagnosis and Control of Plant Diseases.

Remote sensing can help detect possible attacks of pests, fungi, or bacteria on plants. If agricultural knowledge and sensed data are combined, it is possible to prevent this and intervene in the early stages when a crop is affected, limiting damage and treatment costs. Furthermore, by using chlorophyll similarly to the detection of stressed plants, insect attacks can be detected. An example is orange rust in sugar cane, which can be ascertained using hyperspectral images from the Hyperion satellite (Apan et al., 2004).

- Yield estimation.

By exploiting the way electromagnetic energy is reflected by crops, the state of the crop can be monitored in real time. Then, by combining this data with vegetation indices, a forecast of the final yield can be made (McKenzie et al., 2016, Sharma et al., 2017).

- Yield maps.

By exploiting data on the distribution of plant biomass within the area of interest, and additional biophysical parameters, yield maps can be produced. Yield maps are used by farmers to determine fertilization and irrigation plans, but also to plan chemical treatments (Sharma et al., 2017, Trevisan et al., 2019).

- Weather forecasting.

Using data such as wind movement, atmospheric temperature, atmospheric chemical concentration, etc., remote sensing can be used to improve weather forecasting. The result is better planning of vegetative treatments and improved crop management.

- Soil analysis and mapping.

By combining spectroscopy data with remote sensing data, much information about soil composition, such as PH, moisture level, texture, etc., can be retrieved. this use of remote sensing allows for better soil mapping and soil sampling; thus, more suitable strategies can be implemented.

- Land cover mapping.

Soil mapping is one of the most important uses of remote sensing. Estimating the area of forest, agricultural use, urbanization, etc. reflects how humans are using the available land. This information is essential to define agricultural and environmental policies but is also used to monitor other ecological aspects such as the level of erosion (Jwan et al., 2020, Sharma et al., 2017).

Currently, technological advancement has made remote sensing technologies accessible and affordable for the agricultural community (Khanal et al., 2020). Remote sensing is considered a fringe technology for development and expansion opportunities within the industry (BioAksxter, 2019). Already today, however, this precision agriculture technology has a significant impact on the sector.

From an economic perspective, the adoption of remote sensing in the agrifood sector brings considerable benefits. The main goal of any economic entity is profitability (Schröder et al., 2008), and in this sense, remote sensing reduces costs and increases efficiency (Sott et al., 2020). This perspective leads to achieve SDG 1 and 8. In particular, monitoring the health status of plants and detecting possible vegetative stresses makes it possible to reduce the use of chemicals (cost reduction) and decrease yield losses. For the same reasons, the use of remote sensing in the field of meteorology is also aimed at reducing weather damage and optimizing yields (by forecasting frost or hailstorms, one can intervene in good time and activate precautions that limit losses). This increase of productivity leads to achieve goal number 2. Another benefit is the possibility of recovering fallow land (Sakellariou et al., 2021). For example, the start-up company terroir from space uses satellite data to identify and classify unused sites, and subsequently (thanks to the integration of an AI algorithm) develop strategies to cultivate vineyards using sustainable agronomic practices. As well as having a positive environmental impact, this enables farmers to generate income from land that would otherwise go unused.

The social impact that can be seen because of the use of remote sensing affects both the operators in the sector and the consumers. The adoption of remote sensing reduces the use of pesticides and other chemicals; consequently, it has positive effects on food safety (Sott et al., 2020) and leads to achieve SDG 12. Again, the integration of remote sensing and technologies such as machine learning or deep learning, becomes a useful decision support system. Working in synergy, these tools automatically collect and process data and support the farmer in the decision-making process. For example, the start-up Agricolus integrates GIS systems, satellite data, sensors, and an ML algorithm to provide farmers with a DDS (Decision Support System) that supports technicians and farmers by suggesting best practices to implement. Finally, the use of remote sensors in livestock management would facilitate the work of operators, reducing their work stress (Masters, 2021).

To conclude, the adoption of telemonitoring in the agri-food sector also has a significant impact on the environment. By mapping the land and monitoring vegetation, strategies can be implemented that optimize the use of resources and avoid waste, and oriented towards combating soil degradation, and desertification (JP68). Overall, it leads to achieve goals number 13, 14, 15. For example, Finapp is a start-up that produces CRNS (cosmic ray neutron sensing) probes capable of measuring the amount of water contained in soil, biomass, or snow in real time. The aim is to know more about where and how much water is present, to manage this resource more profitably and responsibly. A further goal of telemonitoring is to reduce the negative environmental impact of agricultural practices (Schröder et al., 2008) and to improve animal welfare (Masters D. G., 2021). In the latter case, remote sensors are used to control behaviour, and monitor characteristics (such as temperature, posture, heart rate, etc.), of animals (Fogarty et al., 2018). The aim is to produce health indicators that support farmers in making decisions to improve the welfare and health of livestock (Masters, 2021).

CHAPTER 3

The interview: real experiences of smart technology and sustainability in agri-food sector.

This final chapter concludes the paper. It collects seven interviews, some written, some oral, held with industry professionals. The Italian start-ups identified for the interviews were decided based on their merits and achievements in the agri-food and sustainable agriculture sector. All operate through the use of smart technologies to implement sustainable agriculture, or livestock farming, practices.

INTRODUCTION.

The idea behind the drafting of this last chapter was to delve into the topics discussed so far first-hand. For this reason, retrieving information and considerations from those who work and deal with these issues on a daily basis was considered the best, and most effective, method for obtaining information of a primary nature.

For this analysis, it was decided to adopt a qualitative method. Specifically, through a structured interview-based research we analyze non-quantifiable data to find patterns. The decision to adopt this method stems from the fact that the sample, being small, could not be significant in defining attributes or properties common to the sector. Therefore, it was preferred to delve into the experiences, opinions, and business ideas of some professionals who deal with sustainability and agriculture 4.0 on a daily basis.

As anticipated, between June and September 2022 some interviews were conducted orally, when it was possible to organize a meeting; others were conducted digitally, so a pdf document containing the questions was shared and the company contact person was asked to answer them. With the latter solution, where doubts arose or the idea of deepening some topic arose, virtual meetings were organized or, alternatively, everything was resolved by e-mail.

The start-ups interviewed were chosen without empirical criteria. First of all, personal interest in the business idea and the connection to the technologies discussed in chapter two played an important role in the decision. Then, magazines and blogs such as “Startup Italia”, “Agrifood.tech”, “best startup.eu” were consulted, but also company references from operators who had direct experience with these companies were used. 15 companies were initially contacted, of which 7 responded to the first contact. Two requested a call to discuss the interview, while the others responded online. With almost all of them, follow-up messages via email or social (LinkedIn) followed the interview.

For the drafting of the paragraph, in addition to the data obtained from interviews and conversations with individual contact persons, only the company website was used as a secondary source.

THE INTERVIEW.

The interview to which the interviewee was asked to respond consisted of eleven questions: some aimed at introducing the company's business, others at investigating the interviewee's opinion on sustainability, SDGs, and agri-tech, and still others (the concluding ones), aimed at investigating the next business steps.

The structure of the interview could be divided into four sections. The first part, which consists of the first two questions, serve to introduce the company and the motivation that motivated the founders to invest in it. The second part, which consists of three questions, explores the concept of sustainability in the industry. The aim is to find out what employees think about it, whether sustainability is recognized as an important issue and whether the 2030 Agenda has awareness. The third part, which consists of four questions, explores the technological landscape in the sector, critical issues, lack of know-how, and limitations that might arise during business. Finally, the last part consists of two questions about the future of the company.

The reason behind this part of the thesis is that: literature says that exists a link between smart technology and achievement of SDGs. But, workers, entrepreneurs, and operators perceive sustainability as a real problem? Are they working to solve it? Do they believe in Agenda 2030, and do they consider SDGs when they are planning business activities? Are smart technologies positively promoters of sustainable development?

Here there is the interview I conducted:

1. *Could you introduce the business in which (Start-up’s name) operates and briefly explain what it does?*

As the GEM (Global Entrepreneurship Monitor) emphasizes, the entrepreneurial propensity in our country is a factor that has been weakening in recent years. Despite this, it will remain the determining factor for accelerating the post-crisis recovery and for orienting it towards objectives of economic, environmental, and social sustainability. So:

2. *How did the idea of founding (Start-up's name) come about and what motivated you to enter this business area?*

Sustainable development is a challenge that has been challenging the world economy for several years. All the more so since 2015, when the 2030 Agenda with the 17 SDGs was published, sustainability has become a trend topic. Despite this, however, several studies underline that awareness alone is not enough and the situation is worsening. In particular, an analysis published (on 30/05/2019) by the "Breakthrough National Center for Climate Restoration" in Melbourne illustrates and explains how 2050 will be the year of "no return" and the ecosystem will collapse. From this point the question arises:

3. *Do you think we still have time to achieve the 17 SDGs that the UN initially committed to achieving by 2030? Or is it too late now?*
4. *Following the logic of the previous question, do you think (Start-up's name) is working to help the system achieve these goals? If so, how and which ones?*
5. *Could you associate your goals with the SDGs listed in the 2030 Agenda? Do you plan to expand this number in the future and aim to reach more, further contributing to environmental sustainability?*

In Italy half of the farms already use a digital solution and 25% use two or more. The Smart Agrifood Observatory of the School of Management of the Politecnico di Milano and of the Rise laboratory of the University of Brescia photographed the sector and measured a 47% increase in investment in digital-connected machines and equipment between 2020 and 2021. Italy ranks first in terms of number of start-ups, but at the same time last in terms of average funding (only 1% of total funding).

6. *Why did you decide to invest in precision farming and smart agriculture technologies despite this?*

One of the major problems and limitations to the use of technologies in agriculture is the lack of knowledge and know-how.

7. *What do you think could be a solution to this?*

For several years now the agrifood sector has been overwhelmed by the 4.0 revolution, and companies are adapting accordingly. By reviewing the most important literature, it emerges that IoT, Blockchain, AI, drones, sensors, and agri-data analytics are the main technologies applied by companies.

8. *Would you like to add others to these? And, in your opinion, what will their future evolutions be?*

Also from the study of the Smart Agri-food Observatory it emerges that the control of production costs and the increase in production are the most urgent needs to be met by companies; while the needs related to the acquisition, processing and interpretation of data are not yet considered a priority.

9. *What are the needs that prompted you to invest in (Start-up's technology)? And why do you think it was a winning choice compared to opting for other technologies?*
10. *What will be the next step for (Start-up's name)?*

Taking up the theme of sustainability, we first introduced the SS, it is the declared objective and main challenge that the contemporary economy is facing, and has its roots on three dimensions: economic, social, and environmental sustainability.

11. *If you had the chance, what other business would you invest in? Would it be a choice dictated by current economic opportunities or weighted on the basis of one of the three dimensions listed above?*

The Start-ups I interviewed are: Agricolus, Bluetentacles, Elaisian, Farm4Trade, Finapp, Regrowth, e Terroir from space.

AGRICOLUS.

FOUNDER	AGE	EDUCATION
Andrea Cruciani	48 yo	Software architect and communications engineer at the university of Perugia.

Agricolus is a company founded in 2017 in Perugia (Umbria, Italy) with the aim of supporting farmers and professionals in simplifying their work by using cutting-edge technologies to collect data and analyze them. The idea stems from the founders' desire to help Umbrian farmers, but, in particular, from the intuition to import technologies to our country that would help combat climate change and monitor/manage crops.

To this end, this start-up operating in the field of digital agriculture has developed a platform, made up of the best Agritech tools, that supports the farmer in agronomic management: from the mapping of fields through GIS (Geographic Information System) to satellite images of the fields with relative vegetation indices, to forecasting models for diseases and harmful insects, irrigation, phenology, and fertilization.

The great advantage is that all these technologies are within a single, easy-to-use platform. Data from the different sources are collected and integrated; subsequently, a DSS intervenes to advise the user, in real time, on the best crop operations (irrigation, treatments) according to the needs of the crop or a specific area of the field.

Those who want to adopt this technology can do so in varying degrees of complexity. There is a free version (Agricolus Free) for those wishing to approach digitization of agricultural practices for the first time; or more advanced versions, offering different degrees of monitoring and analysis (Agriculus Easy, Observa, and Plus). In addition, there is a version for associations, cooperatives, etc. that need to manage communication and analysis throughout the agri-food chain (AgriTrack).

The solutions offered by Agricolus are distinguished by the crops for which they have been developed: olives, grapes, tobacco, maize, wheat, or tomatoes; but by the integrations available, namely two applications dealing with forecasting models and mapping of areas of interest as well.

Entrepreneurial spirit was not a problem for the founding of Agricolus, as the founders were motivated: on the one hand by the desire to put at the service of farmers and agri-food operators a solution that would help them cope with constant climate change, international competition, and sustainability goals; on the other hand, by a passion for the land, considering that each of the members has/had a farmer in the family and hectares under management.

Shifting to the topic of sustainability, they believe awareness alone is insufficient, as the deadline is getting closer and closer. They call for a common action is needed. Individuals, governments, and institutions at high levels must commit to certain processes, establish new ones, and take concrete action to achieve tangible results. *"We are behind schedule and if we do not take action we will have to deal with a very difficult situation".*

In this sense, Agricolus is actively working to promote sustainability in the sector: *"One thing we are always very pleased to report is that Agricolus has been recognized by the United Nation Global Compact as one of the start-ups promoting and fostering sustainable development worldwide in the agriculture sector"*. The company, in fact, adopts an approach to sustainability dubbed *"Triple-Win"*. Using the platform enables three 'wins' on three fronts:

1. Reducing environmental impact.
2. Contain the farm's costs.
3. Improving food quality.

The awareness we spoke about earlier is manifested in their words: *"Today, agriculture has a great task related to production and, at the same time, sustainability. We know from FAO reports that the world population will increase by more than a third by 2050: we will therefore need 60% more food than is available. Increasing productivity must therefore go hand in hand with reducing the inputs used - water, fertilizers, plant protection products - in favor of the environmental and economic sustainability of agricultural production".*

At the same time, however, words are followed by deeds. Since the year of its foundation, in fact, Agricolus has been working to contribute to the achievement of 8 of the 17 goals listed in the Agenda: 2. Zero Hunger; 3. Health and Well-being; 6. Clean Water and Sanitation; 8. Decent work and economic growth; 9. Industry, innovation and infrastructure; 11. Sustainable cities and communities; 12. Responsible consumption and production; 13. Climate action. In addition, their platform is evolving and becoming more and more enriched, therefore: *"In the future, we will certainly do further evaluation with respect to new SDGs".*

Confidence in the use of smart technologies is high, so much so that the temporary lack of popularity and know-how among insiders, which limits their spread, does not frighten Agricolus: *“We believe that these technologies are the immediate future, which in Italy has certainly not yet “depopulated”, but we are talking about fundamental tools to support agricultural production”.* Furthermore: *“Updating in the field of professionalism and skills is fundamental. Professionals in the agricultural sector, such as agronomists, surveyors, and technicians, must know and deepen their use of digital tools and then transfer their value to farms”.* Again, a driving factor to ensure that in the future there will be a change of course are the Next Gens: *“Certainly the young people who are now attending agricultural colleges and universities are already dealing with Smart Farming issues and are acquiring increasingly specific skills in this field”.*

The last topic discussed concerns the evolution of the tech landscape and what Agricolus expects from the future. IoT, Blockchain, AI, drones, sensors, and agri-data analytics are the main technologies applied by companies today, but *“Future evolutions will definitely concern applications on machinery and the integration between different data to offer farmers more and more complete Decision Support Systems”.* This is because the acquisition of data and the correct interpretation of it is becoming crucial, not only for purely environmental reasons, but for reasons related to cost control and increased production. *"However, the farmer, whose experience and intuition in the field are always worth a lot, also needs to make data-driven, data-driven decisions in order to optimize interventions and reduce the waste of inputs and resources. And this is also the reason that motivated us to invest in Agricolus”.*

The next steps for Agricolus are quite definite: R&D department continues to work on the evolutions of the platform that meet farmers' needs, while the company is increasingly involved in international research projects focused on developing solutions for innovation in the Italian supply chain. One future goal is *“To create an innovative farm: in processes, in the technologies adopted, in the approach to environmental protection”.* This may sound obvious, but it is not at all. Moreover, although it may seem like a decision dictated by economic reasons, this is not: *“It would be nice to be a testimony of a virtuous example of the application of sustainable agronomic practices”.*[6]

[6] I would like to thank Agricolus for their availability and Valeria Morè, Communication Manager of Agricolus, for giving me her time.

BLUETENTACLES.

FOUNDER	AGE	EDUCATION
Marco Bezzi	47 yo[7]	Graduated and PhD in environmental engineering at the University of Trento.
Silvano Pisoni	49 yo	Environmental engineer at the University of Trento, and first level master in characterization and recovery of contaminated sites in Urbino.
Carlo Pellegrini	-	Agricultural expert and expert in installation and maintenance of irrigation systems.

BlueTentacles is a start-up company from Trentino Alto Adige, founded by three professionals with great experience and expertise in the field of agricultural irrigation and a clear objective: to make a concrete contribution to reducing water wastage, in the knowledge that freshwater scarcity will be one of the biggest challenges of the 21st century. Over the years, the team has expanded to include engineers, agronomists, computer scientists, electronics, etc. Because "*The challenge of water scarcity must be met (and overcome) with the best of teams. All in the service of precision agriculture. The latter bases all its functionality, and effectiveness, 'on the intra- and inter-variability of crops".*

BlueTentacles currently operates in five provinces: Agena, Aosta, Ferrara, Trento, and Verona. At the heart of BlueTentacles' products are numerous sensors that work to gather information: from probes that monitor humidity, to huts that track weather data, or sensors that monitor crop stress, and satellite images to map areas of interest. Algorithms (BlueTentacles's produced) analyze the data and make recommendations on how best to manage water resources. Then, of course, it is up to the farmer to put this into practice. The highest degree of automation is to connect the system with the DSS, which activates or interrupts the irrigation system when needed.

The strength of this technology lies in its scalability: it was developed with the precise aim of working anywhere, regardless of geolocation and crop (it is a modular technology). The only requirement is the collection of data. The more, the better the system will work. In addition, BlueTentacles also works as a support for farmers who do not have all the data available, providing information on weather forecasts, or satellite information to improve water management.

[7] This age is obtained by personal researches but not confirmed by the subject.

Most of the solutions that help manage water resources have a very high cost, because the goal is to build a new irrigation system. The products offered by BlueTentacles are based on a low-power, low-cost sensor network, which makes these technologies more accessible. The aim is not to replace the irrigation system but, on the contrary, to "retro-fit" it: the infrastructure remains intact, but thanks to the addition of BlueTentacles sensors, companies are able to collect data from the fields and use it to improve water performance. *"BlueTentacles is a retrofit solution; beneficial not only because it improves water and energy performance, but also because it reduces the cost of transforming traditional irrigation systems into precision irrigation systems".*

By 2050, we will have to provide 60% more food to meet the ever-increasing demand. In addition, we will face the problem of 20 per cent less arable land per capita and a 25 per cent deficit in water supply demand. *"Water rationing could become mandatory, and agriculture is the sector where the demand is greatest. The first action to be taken is the transformation of systems from water-intensive (surface and sprinkler) to highly efficient (drip irrigation). The second action is to introduce a real improvement in water management for all these systems. It is time to stop irrigating with time-based schedules".*

It is clear, then, that the idea of founding BlueTentacles stems from the need to take action to turn the tide of climate change, with solutions that help companies and guide them on the path to converting to precision irrigation. *"Use less, grow more"* is the motto of BlueTentacles.

Even the name is emblematic in explaining the path this company is following: "*Blue like water and Tentacles like the many connections in our network capable of acquiring different types of data and controlling many water valves in the field".* Tentacles can be seen as partnerships with companies, and *"Many tentacles can be very powerful to take on the biggest fish and turn the future around"*. Behind the name, then, is a desire to respond to climate change and find a solution for a sustainable future.

As far as sustainable development is concerned, certainly the 2030 Agenda is very ambitious, but we are behind schedule. The initial target set for 2030 is too close compared to the progress we still need to make, but perhaps 2040/2050 are more realistic dates if a common and clearer path is defined.

It is certainly working towards that. The blue economy is one of the most impactful issues today. According to the World Bank, agriculture accounts for 70 per cent of global water withdrawals, so conserving water resources is key to combating water scarcity. In this, BlueTentacles, by promoting its solutions, aims to decrease its incidence by 20/40%.

An important aspect that emerged from the interview is the consideration of the SDGs contained in the Agenda: *"It is not something we look at. We are focused on contributing in our own small way, so we prefer to leave these things to people who need them for marketing"*.

Although it may seem counter-intuitive, this statement emphasizes that the company is clear about what its task is, and how it must work to have a positive impact on the environment. One cannot look at the Agenda with the claim that one can play a determining role in its success. BlueTentacles was born with a clear objective, independent of the Agenda. Therefore, communicating the SDGs, or as in this case not doing so, would not affect the success of its mission.

Nor does the critical nature of an industry that is historically bound by tradition frighten the company. *"Our solution is intuitive. By now everyone has a smartphone and is able to use software. That's all it takes. Backend and BlueTentacles software do the rest and take care of the entire data collection and processing process themselves"*.

The tech landscape of the industry is also quite defined. Certainly technologies like blockchain or drones are powerful, but *"I don't see what other technology I could use other than sensors".* The cost is low, they are intuitive to use and work efficiently in small or large areas. *"Horses for courses"* is the ultimate motivation. Efficiency and experience.

To conclude, the next step for BlueTentacles will be mass deployment. As mentioned before, more tentacles increase the overall impact, so *"We like to establish new partnerships, especially with emerging start-ups in the agri-tech sector and each of our connections is like one of our tentacles. Once we find a good connection, we strengthen it to grow faster and faster in a new paradigm of synergy".* Furthermore, always considering efficiency as an economic goal, *"we would like to integrate other types of sensors".*[8]

ELAISIAN.

FOUNDER	AGE	EDUCATION
Damiano Angelici	28 yo	Bachelor's degree in business administration at La Sapienza University.
Giovanni Di Mambro	28 yo	Bachelor's degree in business administration at La Sapienza University and a master in social media marketing at IUSVE.

Elaisian is a start-up founded by Damiano Angelici and Giovanni Di Mambro, two young men born in 1994, colleagues at the Faculty of Economics. During their university years, the two took part in specialization courses, starting out in the world of start-ups. Angelici, who owns a family-run olive farm, first set out to solve the problem of pathogen attacks in the field. In 2015, they participated in Mama Crowd and were among the selected projects. That's when they created their first piece of hardware: a weather station that collects data. After processing the collected data, they noticed that it was possible to predict the attack of pathogens accurately. From that moment, in 2016, Elaisian was born, which today has 25 employees and collaborators. The two founders, thanks to their success to date, have been selected by Forbes-Italy magazine as one of the Under 30 2020 in the Manufacturing & Industry category. Their vision of the future includes the combination of agriculture and digital technologies, and their imagination has propelled them to great heights on a global scale. The market has proved them right.

To modernize and support agriculture by providing a tool that is within the reach of anyone working in the sector. This is in a nutshell what Elaisian aims to do. Although there is much more, such as the commitment to combat climate change and the environmental impact of the agri-food sector.

Elaisian offers a precision farming service that enables disease prevention in olive groves, vineyards and almond orchards and continuous decision support for field interventions. The service is based on DSS related to pest management and DSS

[8] I thank BlueTentacles and especially Andrew Sentance, Chairman of the company, for their time.

related to satellite imagery. In this way, farmers can reduce phytosanitary treatments and optimize fertilization and irrigation. Elaisian proposes the installation of weather stations in the field connected by an app where notifications, and alerts, are sent in real time on the development of pathogens.

The solutions offered by Elaisian are different: *"We have different types of offers that allow us to give accessibility to farms of all sizes and therefore with different economic possibilities".* The pathogen forecasting service is applied for olive groves, vineyards, and almond orchards. After that, the use of their own algorithms makes it possible to calculate the development of pathogens and plants, which, when correlated, make it possible to calculate the infection rate of pathogens with extreme precision. *"We also use satellite images to calculate vegetation and water indices that are useful for monitoring soils and always have a control for optimizing fertilization and irrigation".*

The offer proposed by the company is vast and covers several aspects. The main benefits of adopting these technologies are savings on treatments, reduced labor and consumption, increased production quality and quantity, and reduced environmental impact.

For both boys, the issue of sustainability is fundamental. It involves improving processes and preventing negative impacts caused by agronomic practices. When it comes to the deadline set by the UN for 2030 to achieve the Agenda's goals, however, it is a little more difficult. Both reaching them and answering the question. *"Difficult question. If most (not to say all) companies managed to reduce the amount of polluting products emitted, if the population started a system of self-awareness, and if states made more restrictive laws and proposed measures aimed at the use of recyclable and sustainable products, it might still be possible".* Clearly, however, this is the best possible prediction.

What is certain, however, is that Elaisian is concretely working towards this end. *"Elaisian works with digital data that can be processed quickly and with minimal energy wastage. Furthermore, the system makes it possible to predict pathogen attacks in the field, thus reducing the use of plant protection products used. Furthermore, thanks to the use of satellite images, we are able to monitor vegetation and water content, helping producers to optimize fertilization and irrigation, limiting the use of polluting* *products and the waste of water".* A multitude of activities that certainly place the company at the forefront of the pursuit of sustainable development.

During the interview, the interest in, and focus on, the SDGs, and not just sustainability in general, also emerges. *"Elaisian contributes directly, and indirectly, to achieving the following SDGs: 8. Decent work and economic growth; 9. Business innovation and infrastructure; 10. Reducing inequality; 12. Responsible consumption and production; 13. Combating climate change; 15. Life on earth. Obviously, some of these points are fulfilled directly using the service, while others are pursued through the shared mindset of the entire company".*

About smart technologies adoption, they initially went through a period of adjustment. In the first period they had to implement some strategies to learn knowledge and know-how inherent to the sector in which they had to operate. *"Being a new technology we had to start somehow, with time and thanks to the collaboration with professionals and other companies we learned all the useful techniques to start and grow the service".* Now the confidence and awareness that these technologies bring considerable benefits is high. So much so that the traditionalism and lack of knowledge that characterizes this sector is not frightening: *"Certainly it is important to do a lot of training in the different sectors and to try to encourage the start-up of companies operating in the sector, as this will provide more shared knowledge. We use different solutions that intersect with each other such as IoT, machine learning, software and hardware".* Moreover, rather than expecting the advent of new technologies, the important thing will be to learn how to exploit them properly, especially the huge amount of data we will have at our disposal.

Another aspect that emerged during the interview was the conviction that investing in the production of a DSS was successful. *"DSS, as developed by us, had very little, if any, application in the past. Furthermore, we chose to start the service for olive growing, a traditional sector that had not yet seen the introduction of digital. This choice was successful because there are many olive growers in Italy and the service has grown with them. Today, more and more olive growers have relied on us, and we have improved: over time we have increased the number of pathogens and crops we are able to monitor. The decision to invest in this technology was mainly functional, as it was the best solution for monitoring pathogens (Angelici's initial goal)".*

Before saying goodbye, we also had a chance to talk about the future of Elaisian, and what the next step will be. *"Certainly economic, social and environmental sustainability are key points in Elaisian's development policy. We aim to grow every year by acquiring new skills, hiring new employees and collaborators, and increasing our offer. We have several algorithms in our drawer that we slowly develop and launch on the market based on the market and farmers' needs".* Moreover, the idea of investing in other fields is not one of their greatest needs. Rather: *"We want to focus on growing the service we currently offer. We are initiating and have already initiated several collaborations for new investments. You will hear about them, but for the time being we cannot anticipate anything".*[9]

FARM4TRADE.

FOUNDER	AGE	EDUCATION
Andrea Capobianco Dondona	43 yo	Doctor of Veterinary Medicine at the University of Perugia, master's degree in animal health and veterinary epidemiology at the University of Edinburgh, specialization in animal laboratory science and medicine at the University of Naples.
Ercole Del Negro	-	ICT engineer at University of Padova.
Francesco Di Tonto	40[7]	Graduated in marketing and communication at Urbino university.

Farm4Trade Srl (F4T) is a technology data company founded in 2016, whose corporate purpose is the development, production and marketing of innovative products and services with high technological value for livestock farmers, public and private institutions in the agrifood sector. The aim is to provide an information management system throughout the production chain to collect data, analyze it and return it in the form of useful information to improve livestock industry practices, preserve animal health and welfare and ensure safety throughout the supply chain. The company specializes in improving traceability, and productivity, along the entire livestock supply chain. F4T works to achieve human, animal welfare, and food safety. This is done through the adoption of technologies that enable the analysis of data. In

[9] I would like to thank Simone Fiorentino, Head of Agronomy and Agro-Marketing Departments at Elaisian, and the company very much for their time.

particular, making them more transparent in order to encourage sustainable practices and resource savings.

The idea was born from professionals operating in the sector (Andrea Capobianco Dondona, Ercole Del Negro, and Francesco Di Tonto), and as such fully aware of the needs and limitations of the sector at all levels (governments, farms, abattoirs, consumers, etc.), with a precise mission: *"Our mission is to improve confidence in food quality by making livestock farming more efficient, becoming the reference company for governments and international bodies in the field of crowdsourcing data collection systems".* To do this, the company has developed, and sells, innovative high-tech digital services.

F4T's product suite is full of easy-to-use tools that enable the tracking of data streams to monitor production, herd health, nutrition, and other parameters. The F4T lab, on the other hand, is a set of solutions based on artificial intelligence and computer vision, which allow individual animals to be identified and their characteristics analyzed in order to monitor their health.

During the interview, much awareness and ambition of the company emerged, especially with regard to the impact it wants to have in the pursuit of sustainable development: *"Farm4trade develops solutions with an important environmental and social impact. For example, phaid technology (a contactless biometric recognition tool that uses Ai to identify livestock and facilitate their traceability) aims to replace traditional animal identification systems, with the environmental result of reducing the production and disposal of materials needed to manufacture these media. Furthermore, being a low-cost system would open up opportunities for developing countries where animal identification systems are almost always lacking".* Again, since their founding in 2016, the company has been able to participate in three international cooperation projects, during which they have worked towards the achievement of goals 2. Zero Hunger; and 8. Decent work and economic growth. These are certainly not the only objectives they contribute to. In fact, their social impact involves the environment, farmers, livestock breeders, industry (more generically as a context in which to promote innovation), and other actors.

At the same time, however, they are clear about the current situation; to the point that the achievement of the goals listed in the 2030 Agenda is still a long way off: *"The hope* *is that a lot can be done but it will probably never be enough considering the historical problems, among them population growth".*

The tech landscape is also well defined. In this sense, the company expects the technologies applicable in the world of agrifood to expand: *"The evolutions are and will be increasingly surprising and hopefully to the benefit of many".* Furthermore, to combat the entropy caused by lack of knowledge, they must be simple and user-friendly. Only then are training and the transfer of technological knowledge facilitated. They should not add work but reduce it: "F*or example, if a technology involves keep recording activities but is not automated, it is doomed to fail".*

The interview ended with the usual good intentions for the future: *"to grow exponentially".* This is the primary objective. But also to continue to contribute to international cooperation projects, to foster innovation in the agrifood sector, and to collaborate with organizations whose funding supports them in their activities.[10]

FINAPP.

FOUNDER	AGE	EDUCATION
Luca Stevanato	36 yo	Doctorate in nuclear physics at the University of Padua, PhD in physics, and researcher in applied nuclear physics.

Finapp was born in 2018 thanks to Luca Stevanato, at the time a researcher in Nuclear Physics at the University of Padua, who together with the help of two other researchers, Marcello Lunardon and Sandra Moretto, and entrepreneur Angelo Amicarelli. This start-up is one of the most interesting on the agri-tech scene, especially in the Veneto region. During his research activities, Dr Stevanato developed a detector capable of detecting radioactive material at great distances. It was later discovered that the same detector could measure water using cosmic rays. Hence the idea of being able to revolutionize the world of precision agriculture thanks to a unique and new knowledge of the water content in the soil. *"Clearly the possibility of creating a profitable business was an important driver, but we would never have continued if our business had not*

[10] I would like to thank Francesco Di Tonto, one of the founders of Farm4Trade, and the whole company very much for their time and availability.

been focused on sustainability. This is because minimizing water wastage in irrigation can make a big contribution to preserving Life on Earth".

Specifically, Finapp produces next-generation CRNS - cosmic ray neutron sensing - probes that are able to measure the water content within the soil, biomass, snow in real time, over a large area (several hectares), and at depth (50cm in the ground, meters in the snow with a single, lightweight, compact probe that works everywhere). *"Finapp, using cosmic rays, has in fact created a new way of measuring water and a new scale of measurement. There are many markets in which we operate, precisely because there are many markets in which water plays a major role: agriculture, water resource management at basin or regional level, hydropower production, water losses along aqueducts and 360° environmental monitoring".*

Here, one aspect that particularly emerged during the interview is the company's purpose, which is decidedly dedicated to sustainability. The droughts and climatic phenomena that we are experiencing and negatively impacting us worldwide are a sign that should not be overlooked at all. This is why the company is committed to acting now to help mitigate these phenomena and improve the future. Speaking of the future, it is clear that we are lagging behind if we look at the 2030 Agenda: *"We often proceed in random order, with various "stop & go". What is needed is a global policy accepted by all UN member states. Clearly this is a very difficult goal to achieve given the huge differences between the various countries*". A difficult goal, which however does not prevent Finapp from contributing "on a daily basis".

The company pursues an idea that is as simple as it is tangible: *"A new and much better knowledge of water in the soil, in biomass, in snow, allows for a much more conscious and ultimately more profitable management and use of water resources".* To sum it up in SDGs, Finapp can help achieve the following goals: 2, Zero Hunger; 11, More Sustainable Cities; 13, Combating Climate Change.

At the same time, however, association with the SDGs does not imply greater proactivity, or something that affects corporate action. Starting with the aim of: *"Creating a more sustainable world by reducing water wastage in agriculture, but even more so by helping to identify water losses along aqueducts"*, we can then branch out into further goals that can be achieved indirectly: *"In addition to this, we can improve water management at the basin level, a sadly topical subject, by estimating much more* *accurately how much water is in the snow. Indirectly, then, we can contribute to the creation of more sustainable cities and help fight world hunger. This is because with the same amount of water we can irrigate much more land, and thus produce more food. Finally, knowing soil moisture on a large scale, and in depth, will improve the performance of weather and climate models, being able to manage climate change more consciously".* So many actions, one influencing the other, in order to achieve a result that contributes to environmental sustainability.

Shifting the focus to the technological landscape of the agri-food sector, the lack of know-how is not intimidating. Firstly because the market is proving the founder right and Finapp is enjoying considerable success, and secondly because: *"To adopt a technology, you don't need to understand it. I have no idea what my smartphone actually looks like, yet I use it and billions of people like me. So our approach is twofold: on the one hand to provide farmers with data that is very easy to interpret and on the other hand to "get straight down to business". Finapp allows for optimized irrigation that results in a more abundant and healthy harvest. In short, an increase in turnover for the farm. These arguments are always winning".*

As far as technology is concerned, however, the conviction that having invested in the development of CRNS probes has been a winner is utmost: *"The technology of the future is CRNS because it brings real technological innovation, with a number of significant advantages. We are not talking about a simple sensor, but a completely different way of measuring water".* He goes on to say: *"There was no particular need for us to make the choice: It would be like asking why to invest in digital cameras in the late 1990s when the market was already saturated with analogue cameras. Here, ours is not a simple "sensor", but rather an innovative platform technology that revolutionizes the way water is measured".*

As usual, the conclusion of the interview included an in-depth discussion on the future of the company. The next step for Finapp will be: *"To capitalize on the capital we have received to grow as a company, having just closed a seed investment round. Furthermore, our goal is to build a series of services based on the measurements provided by our probes, in our unique selling point".* Asked about a possible extension of the business, however: *"We could certainly never invest in companies that do not make sustainability a focal point. At the same time, nothing is zero-impact, but the* *merits and flaws of each reality must always be carefully assessed".* Environmental sustainability can be pursued through economic sustainability. *"Personally, I believe that Finapp does and can do a lot for environmental sustainability; therefore, I would like to invest in a different company, one that deals with social issues".*[11]

REGROWTH.

FOUNDER	AGE	EDUCATION
Michael Odintsov Vaintrub	34 yo	Degree in veterinary medicine from the university of Teramo, PhD in Teramo and master's degree in soil science from the university of Marche.
Pierfrancesco Di Giuseppe	-	Graduated at scientific High School in Teramo.

The idea for Regrowth was born during the early years of the two founding partners' working careers. Pier Francesco Di Giuseppe, an agricultural entrepreneur and environmental engineer, and Michael Odintsov-Vainstrub, a veterinarian and doctoral candidate in the European EIT Food Global Food Venture program, identified a pressing need during their early careers among the Teramo area's farms. That is, to find adequate tools for extensive livestock management, communication and contact with end customers: *"Being a veterinarian and an agricultural entrepreneur, we were looking for tools that could help us in our activities. When we did not find them, we decided to develop them ourselves to solve the problem for everyone. The fact that our target sector (mountain agriculture) is one of the most mentioned and important sectors in the SDG Agenda came up in the process. Our project hits 9 different goals out of the 17 'goals', but mainly because few use extensive animal husbandry integrated into the local ecosystem".* Regrowth knows that the road to economic and social sustainability of mountain environments necessarily passes through the conservation and regeneration of natural resources. Therefore: *"Solving several problems in this sector will necessarily also allow the other related objectives to be met".*

Regrowth is an innovative start-up that develops precision livestock farming (PLF= Precision Livestock Farming) technologies for the extensive livestock farming sector. We are talking about the mountain and marginal farming sector characterized by small

[11] Many thanks to Angelo Amicarelli, CMO of Finapp, and the company, for their availability and time.

numbers, extensive grazing, and family farming. *"We are developing IoT technologies to collect data in the field per individual animal based on its daily behaviour. This makes it possible to identify diseases in advance, thus reducing breeding costs, antibiotic use, and other production parameters".* Other advantages of the system are the possibility to rationalize grazing for regenerative management, and the possibility to transmit good farm practices directly to the end consumer. *"This sector is special and is considered a niche market, complex technologically and from the end user's point of view".* Despite the difficulties, our work shows that it is precisely the farmers themselves who are more open to many ideas and products compared to the industry.

Since Regrowth's inception in 2019, the company has received numerous awards for its day-to-day activities and commitment to sustainability. This pro-activity, despite being directly related to the achievement of the SDGs, is not geared towards fulfilling a list of points just to comply with unified policies. In fact, regarding the 17 goals listed in the 2030 Agenda: *"Achieving 17 very different goals, often related to natural systems and with very slow response times, has always been very complex. Often the goals are conflicting, and policies adopted to push one inevitably cause the other to retreat. Just look at the latest clashes in the Netherlands between farmers and the government. The SDGs read with a technical eye often look like a "wish list" of different points of interest, but only those with the strongest political lobby will be achieved".* Furthermore, the corporate position is equally clear: *"Regrowth does not aim to help "the system" but several farms with common problems that represent our market. The stabilization, innovation, and transition of practices in this sector will have a strong impact on the ecosystem, and consequently on the various SDGs. However, this does not mean that we see it as our main goal to put a tick on one target or the other. Such a corporate strategy can only work with large corporations interested in "greenwashing" tools".* This is why environmental sustainability is not achieved by communicating that we achieve X and Y goals, but by initiating activities and practices that contribute results, not just communication.

During the interview it emerges that the Italian agri-tech landscape is less developed than the data show. *"It is difficult to find reliable data on digital products acquired by farms 'as is' and for their recognized value. The best source are scientific publications with sectoral user analyses and direct questions. This is because often only business software, mail services, cloud services, etc. are considered digitization".*

So, in fact: *“Agri-tech start-ups on the Italian scene are counted, because unfortunately the reduced funding, and the reduced incidence on the national GDP, make the sector unattractive”.* Annual growth is estimated at around 1,000 new companies per year, but these contribute less than 1% of the national GDP. In neighboring countries, such as Israel, this figure reaches 15%.

Overall, Regrowth gets straight to the point: *“Our most pressing goal is to digitize farm data automatically through our IoT systems. As a first step, our software is centered on the direct business reality to return the value invested by the farmer”.* Therefore, even when talking about penetration difficulties, the situation is not frightening: *“The main barriers for smart tech agriculture companies in Italy are: the small average farm size (5 ha), the medium-low production volume (9,000-13,000 euro/year), the average age of farmers (>60 years) and the unsuitability of many products for typical Italian production (small, specialized, biodiverse, and artisanal). This is undoubtedly a difficult market to penetrate, but it is also a hungry one for a solution in its size. We did our market surveys, questionnaires and interviews and realized that there is room for a solution along the lines of the one we are offering, even though most agri-tech companies in Italy fail to penetrate the market”.* Furthermore, there is now a gap between the technologies of Agriculture 4.0 and their actual applicability in the field: *“The solution to this is to concretely adapt the products to the measures and needs of farms, even if it means that they sound simpler to the ears of investors and the media. We need to reduce costs, introduce modularity, simplify functionality, etc. These are steps that Agri-tech developers must keep in mind if they want to work with the agricultural sector”.*

Still talking about the tech landscape, Regrowth is very convinced of the choice made: *“AI for us is a tool to cross-reference data from different sensors to create a unique profile. As it is a more complex process than a simple export of data from a single source, the product needs such a component. This choice allows us to significantly reduce the cost of hardware, system costs and communication difficulties. As I described before, reducing the price of the product significantly is one of the biggest goals in order to penetrate the Agri-tech sector”.* Furthermore, the choice of integrating AI with big data is based on a real need, and not just on the beauty of the sector: *“Data analysis is a very beautiful and interesting sector, but if it is not linked to an actual (and perhaps automated) output, it has little value in practical terms. For example, if I know* *that my sheep in the mountains are particularly hot this week thanks to a satellite survey, what can I do? Go and build a shed? Or accept the loss of production? And why do I need this specialized and targeted information if I know that the quality and quantity of production drops in summer anyway? In essence, any current adoption, and any future development must have an immediate output of the data collected, otherwise they are worthless. Furthermore, data collection and its management cannot have a separate cost for the company. Finally, UI-UX will have to adapt to the needs of companies, simplifying many aspects and, above all, making it easier for users to use and trust it".*

Of course, the interview ended with some insights into the future of the company: first investigating the near future of the company *"The next step after a successful launch of our product on the market would be to integrate the data collected by us with other members of the supply chain. In particular, with the production of raw materials and with the sales sector. This would open up a secondary market for valorization of the supply chain, providing real-time data of resource consumption and ecosystem services. In this way, raw material producers will also be able to enter the emerging Green Economy market by directly communicating their value to other actors";* and subsequently investigating possible business expansions. *"The main choice would be based on the knowledge of the team and the relative advantage we have over the current market situation. In our case, it would probably be IoT technologies for domestic wild conflict management, renewable bioenergy, geomatics, or robotics in the field. All areas with which we have first-hand experience, are underdeveloped, and represent an emerging market. Since they predominantly deal with the precise management of natural resources, agricultural practices, and management of natural systems, they fall under the aspects of sustainability. This is related to the fact that the agricultural and bio-economy sectors are currently closely linked to the environmental, economic and social sustainability of various actors along the food chain".*[12]

TERROIR FROM SPACE.

FOUNDER	AGE	EDUCATION

[12] Many thanks to Michael Odintsov Vaintrub, Co-founder and C.O.O. of Regrowth, and the company for their time and availability.

Alessandro Saetta	30[7]	Aerospace engineering graduate at Politecnico of Milano and master graduate in space engineering at Politecnico of Milano.

Climate change is an element that has a major impact in the wine sector: environment, soil, and climate, i.e. terroirs. In order to guarantee a qualitatively satisfactory product, today, a lot of data must be used to analyze the evolution of the terroir and adapt to it. In this sense, space technology is a field that is helping a lot.

Terrorir from space is the brainchild of Alessandro Saetta, an Aerospace Engineer at the Milan Polytechnic and a wine enthusiast. *“We are a small group of innovators who believe it is possible to adapt and mitigate the effects of climate change on agriculture”.*

Since its foundation in 2020, the start-up has been offering services to survey sites that are unused because they are deemed unsuitable for vineyards. Earth observation (EO) data from satellites are exploited to obtain various parameters associated with soil, climate, etc. Then, these data are processed by the AI algorithm, which has been properly trained, to detect, and classify, these new sites, in order to make them usable and develop long-term valorization strategies. Not only that, Terroir from space also offers a monitoring service for already operational vineyards, offering advice on risk assessment or best practices to be implemented.

“We want to promote adaptation to climate change for the wine sector. As these climate changes have degrees of diversity and vary from area to area, we have developed AI algorithms to take advantage of satellite and in situ data in order to provide a service to wine producers and consortia (who are our customers). In particular, we want to provide, a service of land identification, i.e. to go and identify those soils that are not yet cultivated, but optimal for future wine creation, and after we are aware that at the same time there are climatic shifts taking place. So, our focus is not on monitoring the area of interest on a daily or weekly basis, but on an M-L term basis”.

The company takes a strategic resilience-oriented approach: it identifies uncultivated or degraded land and reverses its use, making it productive. to uncultivated or degraded land. *“Our intention is to do something concrete to help change, as the political, economic and social consequences that climate change is bringing are evident, so we want to take concrete action”.*

The focus on agriculture is because being located in Italy there is an aspect of tradition and history, because this sector in our country has always been one of the most appreciated. Moreover, behind this choice, there is certainly an aspect of personal interest of the team members, but also an economic aspect: *"It is a very big market and vines are among the crops that are suffering the most on an environmental level. Huge market, start-up, suffering vine = terroir from space. Now we are also spreading it abroad by starting to talk to producers in various parts of Europe".*

As far as sustainability is concerned, the company's objectives emerge clearly during the interview. At the same time, there is a lot of awareness about sustainability and the consequences of neglecting this issue: *"We do our part and try to make our contribution, but it is clear that we alone are not enough. Our whole business revolves around actors, such as wine producers, because they are the ones on whom the impact falls and they are the ones who have to implement actions to mitigate the negative effects".*

Regarding the SDGs, on the other hand: *"The subject of sustainability and the GSEs is a hat, under which we stand, but we did not start from that. We started from reality. Clearly then from a communicative point of view (because everyone does it a little bit), and also from a political point of view, we tried to understand which SDGs we could help to achieve, and among the various SDGs certainly 13 and 15 are the ones that we obviously contribute to solving. The 13th was the starting point, the 15th a consequence, as all these precision technologies help precisely to reduce water consumption, waste of resources, use of pesticides, chemical fertilizers, etc. while still obtaining a high-quality product".*

Terroir from space, in its day-to-day work, tries to respond to the real needs of those who need its help: *"We try to respond to the problems that growers have. We can also only help to reduce costs, if that is the problem, then clearly that is not our vertical. We think, in our own small way, that a phenomenon as big as climate change needs action in the long term, rather than in the short term. So 'mitigation' is a necessary technique, but it is no longer enough, we must also try to move forward and think in the long term".*

Furthermore, he is keen to point out: *"Going back to the SDGs, there are certainly other goals that affect our business, in the sense that vertically they are not our primary goals but horizontally they are. For example, if we think of viticulture, we have to consider* *that it is still a crop, or a generic factor, that has social and economic implications, and being a valuable and long-term product, there is a social aspect because it generates work and economic income. Then there is also a traditional aspect because it is part of our history, but if we think abroad this sector is booming in countries to the north, for example. It is wrong to label. It is difficult to define a field and boundaries because any economic activity, or any action, has very broad implications that cannot be categorized. It is difficult today to consider the verticality of one's actions; rather, it is a question of balance, we know that a certain action has consequences in other X fields".*

Widening the field and including the UN Agenda 2030 in the discourse, the company has a very definite vision of the near future: *"I think so. We are lagging behind. Just look at the global upheavals of recent times. The problem, unfortunately, is that it is also political. If the directions taken are not unified and point towards the same end goal, it is inevitable that results will not be achieved. Change has to come "from above", if money does not go in that direction, it is difficult to direct activities towards that end. Objectively, we are lagging behind. Between devastating environmental impacts, and missing state aid, the risk will be that many companies in agriculture will be forced to close down. The SDGs, in their form, are also correct, but I personally think it is a bit consequential and something I only talk about when asked".*

"We have now reached a point of no return where it is necessary to intervene and do something concrete". This something concrete for the company takes the form of day-to-day activity. The decision to invest in agriculture stems both from a common background of some team members and from the desire to positively impact the reality in which we live. *"Clearly, when it comes to agriculture 4.0, they are not the only start-up, but they are trying to emerge in their own way: we have put ourselves in the wake of others but trying to differentiate ourselves. We decided to invest in it because it is the future of the sector and because it brings tangible results to the actors involved".* They also predict that soon a new technology could be recognized as impactful and increase its adoption rate: *"Genomics. There are several academic institutions but also private actors such as entrepreneurs or investment funds that are investing in this field. Genetic engineering that studies which are the best clones or varieties in agriculture, which resist changes and improve yields. In Italy, for example, there is the Edmund Mach foundation (in Trentino)".*

Before the farewells there was the routine discussion of future expectations and next steps for Terroir from space. With honesty: *“I have to be honest, we have so much to do that it's hard to think of anything else”.* However, before concluding: *“If I really had to find another business, it would be to send our own satellites into space. We would love to answer agronomic problems with a primary source of data, and specific parameters collected personally. And why not, to be our own customers and perhaps we first reuse a piece of land identified through our technologies”.*[13]

CONCLUSION: THE EVIDENCE.

The concluding paragraph of this third chapter corresponds with the conclusion of the thesis. In it, the evidence from the interviews conducted will be collected. Obviously, these similarities cannot be considered as patterns or be generalized, as the sample analyzed is very small. Furthermore, looking for similarities or commonalities is also not easy, because since this is an interview and 7 start-ups, it is difficult for one opinion to be shared by all.

At the same time, however, I believe that these considerations can provide a starting point for future studies or, possibly, a deepening of this work. In addition, I think these interviews were interesting to compare what emerged from the literature review carried out in the first chapter. Having an insight from someone who deals with these issues daily provides a view that goes beyond the document and information. It reports the reality as perceived by the stakeholders.

In particular, three aspects emerged that caught my attention:

- Everyone, without distinction, is aware that the 2030 Agenda is unrealizable. Now there are too many things still to be done. The situation is problematic, we are lagging, and we are proceeding without investing time and resources sensibly. Perhaps a realistic date is 2040/50, but we need everyone's support and proactivity there. At the moment, unfortunately, sustainability, and the funding directed towards it, is still seen as something very close to politics. The

[13] Many thanks to Alessandro Saetta, founder of Terroir from space, and the company for their time and availability.

strongest lobbies direct expenditure, without considering what the environment really needs.

At the same time, everyone is convinced that they are on the right track to set an example. Each interviewee expressed his or her conviction of *"being in the right"* and working every day to change the status quo.

- As far as the SDGs are concerned, opinions are mixed. Some start-ups were *"in favor"* and stated that they faithfully pursue the Agenda and consider it part of their business. Others, however, consider it a wish list of goals that has more to do with marketing than with reality. The corporate mission is a clear objective and the fact of promoting one goal rather than another does not affect its success. Rather, the step between concreteness and greenwashing is a short one. In addition, it is also difficult to identify oneself with the stated objectives. This is because the practices implemented often contribute transversally to the objectives, rather than vertically. Therefore, between direct and indirect, the list is inevitably long, and the risk is that a company will appear as 'greener' just because it communicates more goals.
- The last consideration concerns future innovations in the industry. Apart from genomics, there were no strange innovations that I was not aware of. However, the lowest common denominator for everyone was usability. The user must be able to use the technology easily, must not find friction in the experience. This must be as scalable and modular as possible: in essence, adaptable to multiple situations. It is not necessary to fully understand how it works, but it must bring tangible results. It is not necessary to invent a new tool, but it will be essential to improve knowledge, learn how to exploit current technologies and process data efficiently.

I conclude this work by quoting the letter of Yvon Chouinard, the founder of Patagonia, who recently caused a stir by his decision to "donate his company to the environment". Yvon begins his letter like this: *"Our only shareholder now is the planet. If we hope to have a living and prosperous planet - and not just a living and prosperous company - we must all do what we can with the resources, we have"*. This is enough to get the message across. And it is the same message that came through in the interviews I conducted. The planet is in a dramatic situation, we need to act collectively and each one of us needs to do what we can to hope to lift it up. Perhaps we should believe more in smaller but highly motivated realities, rather than ones chasing “God profit”.

I do not believe that the situation will improve from here. This is because I am convinced that the interests of a few, strong, and rich people will prevail over the idea of guaranteeing a future for the next generations. Today people prefer to reap rather than sow. If this is the situation, no change or results can be expected.

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