LUISS

Dipartimento di Impresa e Management

Cattedra di Digital and Organizational Innovation

Digital Innovation in Agriculture: barriers and possible advantages.

Giuseppe Zoglio
Matricola 746261

CANDIDATO

Prof. Tommaso Federici

RELATORE

Prof.ssa Federica Ceci

CORRELATORE

Anno Accademico 2022/2023

Summary

LIST OF THE FIGURES 4

LIST OF THE TABLES 5

1. INTRODUCTION 7

2. LITERATURE REVIEW 13

2.1 **History of Smart Agriculture** 14

2.1.1 The Smart Agriculture 15

2.1.2 Challenges in Smart Agriculture 20

2.1.3 Relation between Agriculture and Sustainability 23

2.2 **Technologies** 26

2.2.1 Blockchain 26

2.2.2 Artificial intelligence (AI) 27

2.2.3 Machine Learning (ML) 28

2.2.4 Big data 29

2.2.5 Internet of Things (IoT) 31

2.2.6 Drones 32

2.3 **Technological innovations in agriculture** 33

2.4 **Theoretical Framework** 35

3. RESEARCH DESIGN 40

3.1 **Methodology** 41

3.2 **Subjects interviewed** 42

3.3 **Interviews** 45

3.4 **Relationship with the study of technologies** 49

3.5 **Units of analysis of the study** 50

3.6 **Duration and coding of the interview** 52

4. FINDINGS 54

4.1 **Relative advantage** 55

4.1.1 Precision farming 55

4.1.2 Reduced use of raw materials and human labour 58

4.1.3 Healthier product made in a sustainable way 60

4.2 **Ease of use of technologies** 61

4.3 **Technical compatibility and complexity** 63

4.3.1 Everything is mechanised 63

4.3.2 Technical capabilities 66

4.4 **Issues in the implementation of technologies** 69

4.4.1 Energy consumption 70
4.4.2 Connection 71
4.5 **Organizational changes required to implement these technologies** 73
4.5.1 High investments 73
4.5.2 Atmospheric and cultural factors 76
4.6 **Respondents' positions on the issues covered in the interviews** 83
5. DISCUSSION AND ANALYSIS OF THE RESULTS 85
5.1 **Perceived advantages** 85
5.2 **Barriers** 90
6 CONCLUSIONS 99
6.1 **Research Summary** 99
6.2 **Implications and Future Research** 100
6.3 **Limitations** 102
REFERENCES 104
MASTER THESIS SUMMARY 109

LIST OF THE FIGURES

Figure 1. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

Figure 2. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

Figure 3. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

Figure 4. Agarwal, Prasad 1998 A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. Information Systems Research 9(2):204-215.

LIST OF THE TABLES

Table 1. What we know and what we don't know about technological innovation in Agriculture.

Table 2. Key concepts of the Theoretical Framework.

Table 3. Summary of the subject interviewed.

Table 4. Summary of the main themes that emerged from LR.

Table 5. Brief description of the companies interviewed.

Table 6. Duration of the interview.

Table 7. Respondents' positions on the issues covered in the interviews (Advantages)

Table 8. Respondents' positions on the issues covered in the interviews (Problems)

Ai miei genitori,

a Francesca,

a Monica.

1. INTRODUCTION

With the scarcity of resources in the modern world, there is a strong need to optimize the use of these resources to meet the demands our planet makes of us. Being sustainable has now become an obligation for all businesses because if we continue to live in the world like we lived in in the years immediately after the industrial revolution we would bring our planet to depletion, and this could lead to our demise. So, we need to be sustainable and pay close attention to how we use the natural resources that our planet offers us that are by definition scarce. (Conti, 2020)

One of the areas where a lot of progress is being made in this regard is in agriculture, many are in fact innovations in the field of technology that are being adopted to achieve new ways of doing agriculture and arrive at the so-called "Smart Agriculture." Many companies are also active in this sense, for example among them we find A2A, which with the Smart City section is very active from the environmental point of view with the aim of making the world where we live a better place through better water management, better infrastructure management with the use of the most innovative technologies in the field. These technologies can lead to the optimization of inputs used in the agricultural field as they allow us to arrive at a new type of agriculture that we can call intelligent in that decisions in this field are driven by data and every single thing is executed in detail so as to optimize resources, time, soil, and any aspect that revolves around the cultivation of any natural product. (Rizzi, Santamauro, 2021)

The result of this phenomenon is the achievement of so-called precision agriculture that could bring many benefits in terms of environmental sustainability, for example, it is well known that among the Sustainable Development Goals we have some of them such as number 2 and number 3 that deal precisely with issues related to food security and good health that people can only have through good nutrition given by healthy and sustainably processed products; these goals can be achieved through the use of innovative technologies such as hydroponics, sensors, machine learning, artificial intelligence, big data and cloud computing in classical agriculture.

However, despite its undoubted advantages, smart agriculture is struggling to spread in Italy. According to data released by the Smart Agrifood Observatory of the Politecnico di Milano, only 3-4% of agricultural land is cultivated with 4.0 tools.

For this reason, I think that Smart Agriculture is a very interesting context to investigate. I think it is very important to go and understand what is happening in agriculture to also understand why, despite the many benefits that smart agriculture is supposed to bring, it has not yet taken widespread adoption. I have to go and understand what is important to look at in order to answer the research question of this paper and to give an answer to it.

The ultimate goal of the paper is to go and investigate what are the hidden aspects of smart agriculture and the motivations that drive or block its diffusion. So, I went to analyze and study the use of digital technology in agriculture and the impacts that this could have in terms of efficiency. But I also went to study the disadvantages of the use of this technology if there are.

I decided to address this issue because I have seen that there are some studies in the literature regarding smart agriculture; however, it is a topic that in my personal opinion has not been dealt with as thoroughly as others and I think that smart agriculture is a key element in reaching a world in the future that can be defined as truly sustainable because nourishment is the first source of energy of the human being and therefore I think it is fundamental to analyze how a sector that is fundamental to the nutrition of the human being can be increasingly sustainable, innovative and technologically efficient.

In addition, I hope that this research of mine can be a first step for other subsequent research because, as I said, I believe that this is an aspect of the circular economy that has not been fully addressed and therefore I think it is a very innovative topic to deal with and from which insights for another subsequent research can come.

The literature review that I have done has given me the impetus for this idea and has given me the feeling that I can contribute to these terms with my research to further study this issue and to be able to make a relevant contribution to this

topic. In addition, during my research I found many papers that ask precisely to investigate this area and that see smart agriculture as a new phenomenon that needs to be constantly studied precisely because of the high technological content and the continuous advances that are being made every year. Smart agriculture is also seen as something we strictly need to be sustainable, smart, efficient, and eco-friendly. So, it is essential to go and study what are the benefits of its application and the technologies used to achieve certain benefits. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

The purpose of my research was not only to go and analyse the world of smart agriculture, but my aim was to go and see what digital innovations have been put in place by organisations working in the field of agriculture in order to achieve certain results.

So, my research question was to analyze these digital innovations and see what the advantages, disadvantages and possible problems were in the opinion of two types of subjects, namely the users of these technological innovations and those who produce these innovations.

Therefore, the research question in my research paper is:

"What are the perceived advantages and the barriers in introducing technological innovations in Agriculture?"

I wanted to understand under what conditions it was possible to implement these technologies and under what conditions there were more problems that forced companies to make a greater effort to succeed.

So, I wanted to understand in which situations the implementation of these digital technologies led to enormous success and when it was a failure.

In order to do this, I analysed the problems that companies had when they had to implement the same technologies in an already functioning and operational agricultural system, the conditions that led to the success of the implementation, and at the same time, I went on to analyse the advantages and disadvantages that companies operating in the agricultural sector had as a result of the implementation of these technologies.

This analysis has been done from two main points of view, that is, on the one hand we have the companies producing digital technologies that are intended to be applied in smart agriculture and on the other hand we have the companies consuming these products, that is, the agricultural companies, agronomists, farmers, and consortia that have decided to adopt these technologies in order to obtain positive results from the implementation of these technologies.

This dual point of view is fundamental to my analysis in that in order to analyze the advantages, disadvantages, and problems of a product, it is not enough to analyze what the company that creates the product offers, but we must also analyze the point of view of those who actually use the product and can express an opinion as to whether or not that product has brought an improvement to the company's business compared to how the company worked before the implementation of that product.

However, it is important to keep in mind the fact that to talk strictly about advantages and disadvantages would require measurements and temporal or spatial comparisons, whereas the goal of my research, as mentioned earlier, is to go and derive the perceptions and differences in views on the two sides, namely producers and users.

Accordingly, my actual research question in my paper is to ask what the views of these two types of actors are regarding technological innovations in agriculture.

So, the goal of my research is to actually go and find out what these aspects are and go and analyze them in relation to the literature review done underlying this work.

As can be seen from these words, in order to answer this research question, one has to go and touch upon what these aspects are and talk directly with the people involved and it is in this reason that the choice of conducting this work through the methodology of interviews, which I will talk about later, is justified, that is, precisely to talk directly with these people and understand from them what are the perceptions and differences in views regarding this issue, that is, what are

the perceived advantages or disadvantages in the use of technological innovations in agriculture and therefore in their work.

To do that, I analysed multiple case studies that operates in the sector of smart agriculture. I interviewed many companies in order to make my research work.

I went to talk about real cases to analyze what can be the benefits and the problems related to the use of digital technology they have developed in terms of efficiency compared to the classic method of doing agriculture and how these technologies can be fundamental for other firms. I think it is also incumbent on me to talk in this part about the main challenges that these firms have faced during their life cycle and during the implementation of these technologies.

Regarding methodology, I based my work on interviews and a qualitative analysis of what are the benefits of these technologies and smart agriculture.

In order to do that, I got in touch with many companies operating in the agricultural sector and from them I selected the best ones to include in my research and to whom I submit my questions based on the literature review.

In terms of interviews, among the main figures, I have been in contact with and interviewed the CEOs and co-founders of five companies involved in producing certain products needed to implement a smart agriculture system.

Interviewing these companies was a crucial step in my research in that learning their views was crucial in going to understand what the goals of certain products are, that is, what benefits certain technologies should bring to the companies that use them.

However, the purpose of the interviews was to analyse not only the point of view of the products of these technological solutions, i.e., the producers, but also the point of view of the adopters of these technological solutions, i.e., all the agricultural enterprises that use these products to improve their business.

From this point of view, the support I got from the figures mentioned above was crucial as they allowed me to get in touch with other companies who were using their products.

Consequently, my analysis aims to investigate what are the most important aspects for what we can define as the adopters of these digital technologies. That is, companies or figures that use these technologies to improve their business and make it more efficient.

In my study, it will also be crucial to analyse their point of view because they are the ones who actually apply the technologies produced and therefore only, they can tell what the actual advantages are given by the application of these, and any problems encountered in implementing these technologies within a pre-existing business model.

As for the users of the technologies, to be precise, I interviewed six enterprises including farms and vertical farming companies. As mentioned, their word was crucial in order to fully understand the benefits and problems they had in implementing the technology because if the analysis had focused only on the side of the companies producing certain products I would have had a one-sided view made up only of the potential benefits promised by these companies, but I would not have had the view of those who had to implement these products in their business model and who therefore had to bring changes to their organization to achieve certain results.

2. LITERATURE REVIEW

In this part of my research, I plan to go deeper inside the world of smart agriculture, its evolution and the technologies applied in it.

I believe that this is the main focus of this part of the research since, as mentioned earlier, the goal of my research is to go and investigate the perceptions of actors who directly operate in the world of smart agriculture, both on the vendor and consumer side, to understand what their feelings are about this world and what, therefore, are any perceived advantages or disadvantages in the application of smart agriculture by them.

Therefore, in order to better understand this world, I went to do a careful review of the literature regarding the evolution of smart agriculture, starting from its inception to how it is articulated today.

In fact, in the first section of my review I outlined what recent studies have found about this world, while in the second part of the chapter I went to make a focus on the main technologies that are being applied in smart agriculture, also going to make a focus on the relationship of these technologies with the issue of sustainability, a very important issue in today's world.

Regarding the analysis of the world of smart agriculture, one of the key papers for my research work was “Everything You wanted to Know about Smart Agriculture” Cornell University from Mitra, A.; Vangipuram, S. L. T.; Bapatla, A. K.; Bathalapalli, V. K. V. V.; Mohanty, S. P.; Kougianos, E. and Ray, C., written in 2022.

This research paper, in fact, tries to encapsulate everything there is to know about the world of smart agriculture up to recent days, so its contribution was fundamental.

While, for the part related to technologies, there was a massive research work in order to find all the possible information on the technologies that we are going to talk about later, this part of the work is based on the analysis of many research papers because I believe that technology is constantly evolving.

Therefore, for this part, I preferred to look for the most recent papers possible and I gave priority to technical papers that focused on a specific technology in order to talk about that specific technology.

This literature review operation was crucial to my work as it allowed me to dig deep into how smart agriculture works and what are the advantages or disadvantages it is supposed to bring.

This analysis allowed me to understand what the crucial questions were to ask the subjects who became part of my research so as to investigate whether what was being said about the theory also occurred in the sample of subjects I analysed.

2.1 **History of Smart Agriculture**

Agriculture 4.0 therefore represents a technological revolution in this sector based on the use of new technologies and science that meets the needs of today's civilisation. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Before arriving at this stage, agriculture went through several phases, we have an initial phase of agriculture, the so-called Agriculture 1.0, in which elementary tools were used.

Then came Agriculture 2.0, here we saw the use by farmers of tractors and fertilizers, so agricultural work was not based only on human labour, but this was carried out with the support of machines and early scientific aids.

Later, there was the phase of Agriculture 3.0, which kicked off the current phase, as in phase 3.0 we began to see the use of monitoring systems for decision support.

These systems were then taken to their full power during the current phase that is Agriculture 4.0, in which we have a union of multiple technologies such as blockchain, internet of things, artificial intelligence, nanotechnology and many others as we have seen in Figure 1.

These technologies, in fact, bring the support to the farmers' decisions to the maximum power since the integration of these technologies allows to obtain optimal analyses which can lead the machines to elaborate by themselves the optimal strategy for the agricultural system analysed, eliminating any possibility of error through data analysis. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

2.1.1 The Smart Agriculture

Smart agriculture is a phenomenon that has emerged in recent years and is seen as a necessity to meet the world's growing population; in fact, it has been estimated that the world's population will reach 10 billion by 2050 and even could reach 11 billion by 2100. (United Nation Report)

In such a context, it becomes essential to use new methods of agriculture to be more efficient and to meet the growing demand for foodstuffs, as traditional agriculture based on manual labour was characterised by a low productivity that did not allow it to meet this growing population. To take this step forward in productivity, the incorporation of technology within traditional agriculture was crucial; the application of technological innovations brought about a significant increase in productivity and efficiency. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

The technologies that can be seen in the figure 1 below are those that have brought about the transition from traditional agriculture to so-called 'Smart Agriculture', or Agriculture 4.0, based on digital technologies.

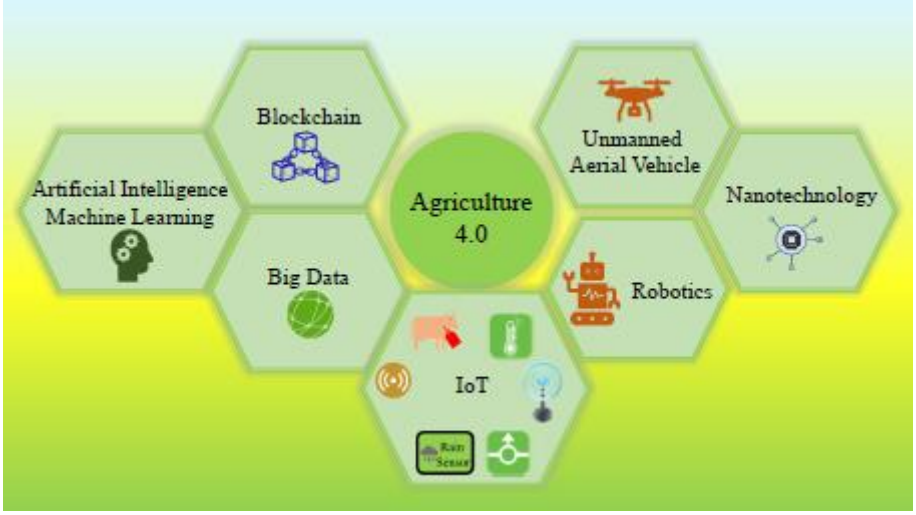

Figure 1. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

Among these technologies we have:

- Internet of Things
- Robotics
- Nanotechnology
- Big Data
- Blockchain
- Artificial Intelligence
- Machine Learning
- Unmanned Aerial Vehicle

These technologies form the basis of so-called smart agriculture, which is commonly referred to by other names, among them we have smart farming, precision farming, digital farming, agriculture 4.0; but all these terminologies are about the same thing that is a new type of agriculture that use technology and data processing to optimise agricultural processes and achieve better production standards, while also reducing human labour and inefficiencies. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Consequently, as can be understood from what has just been said, there is a strong need for smart agriculture to cope with the growing demand for food in

the coming years, achieving efficient food production is a key goal to feed the future population. A remarkable development of smart agriculture could strongly contribute to the goal set in the 2030 Agenda to eliminate world hunger. (United Nations Report: Food; Unicef Wfp Fao, Ifad and Who; 2020)

Smart agriculture is also seen as crucial for the support it can give to certain issues that are becoming a problem for our planet, among them we find:

- Water scarcity
- Soil erosion
- Climate change
- Lack of resources
- Greenhouse gas emissions

In fact, smart agriculture should enable better management of resources, thanks to the optimization achieved with the help of the aforementioned technologies, so this should lead to better land use and lower environmental impact, in fact it is well known how this smart agriculture revolution is fully in line with what are the new sustainability parameters of the modern world. This new type of agriculture has brought countless benefits over the traditional way of farming, now the main goal of every farmer is to optimize the resources he or she has in his or her possession and use these accurately in order to achieve the best possible result, and all this is possible thanks to the use of all these technologies that are so different from each other. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Among the main benefits that have been brought by smart agriculture in comparison with the classical method of farming we have:

- Water conservation
- Optimization of the use of fertilizers and pesticides. As a result, produce is more toxin free and nutrient rich.
- Increased crop production efficiency.
- Reduction of operational costs.
- Opening up of unconventional farming area in cities, deserts.
- Lower greenhouse gas emissions.

- Reduced soil erosion.
- Real time data availability to farmers.

These are just some of the benefits that smart agriculture has brought, many of these benefits are related to aspects of sustainability and the health of our planet, in fact, it is well known how smart agriculture is a key aspect in the 2030 agenda and how, for example, it is also a phenomenon that is always kept under observation when we talk about developing smart contracts for the creation of smart cities. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

However, the key aspect to analyze is what technology has brought to agriculture in terms of benefits, that is, what have been the benefits in moving from the previous phase of agriculture to smart agriculture, and these benefits are easily observed in Figure 2.

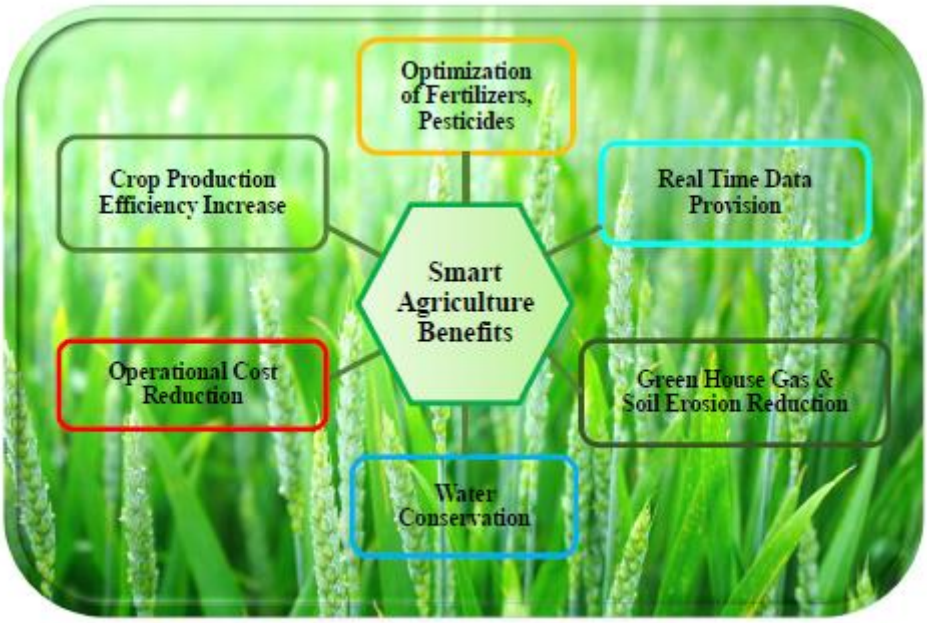

Figure 2. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

In this paper, it is noted how critical it is that all the technological objects that go to make up the entire agricultural ecosystem must be strongly interconnected in order to obtain these benefits; data must be processed and analysed in the right

way. From the sensors that collect the data are to the algorithm that processes it all must be optimally integrated in order to achieve the best possible result.

The connection between devices is a fundamental aspect of smart agriculture that should not be underestimated, and it is most important in implementing a smart agriculture system to verify that everything is working in the right way.

Sensors and cameras collect data in real time, and for this reason it is important that this data is sent in real time to those who instead process it in order to get the most accurate result possible.

This operation requires the analysis of a huge amount of data that are often held in the cloud in huge data sets, and it is important to consider that you need high computational power to process these, and you need a very powerful connection to get it all processed as quickly as possible.

However, it is also important to consider that the presence of these data brings some limitations with it, the first one as already mentioned is about the connection that needs to be very powerful to process them, then there are also limitations related to the security of the data itself, these data in fact could be stolen and used for purposes other than those for which they were collected, for this reason it is also to consider the aspect of privacy in smart agriculture as the data of each individual farmer are personal and should not be handled by people outside those who work in contact with the farmer himself. (Khattab, Abdelgawad, Yelmarthi; 2016)

However, the last few years have seen significant advances in terms of connectivity and hardware power, which has allowed for increased security and privacy of data, provided it is processed close to its point of origin. The elimination of data transfer from a centralized cloud has led to increased security and reduced dependence on the Internet. (López-Riquelme, Pavón-Pulido, Navarro-Hellín, Soto-Valles, Torres-Sánchez; 2017)

2.1.2 Challenges in Smart Agriculture

Those mentioned before are just some of the challenges that smart agriculture has faced and is facing in its development and evolution; we can observe the main challenges in Figure 3.

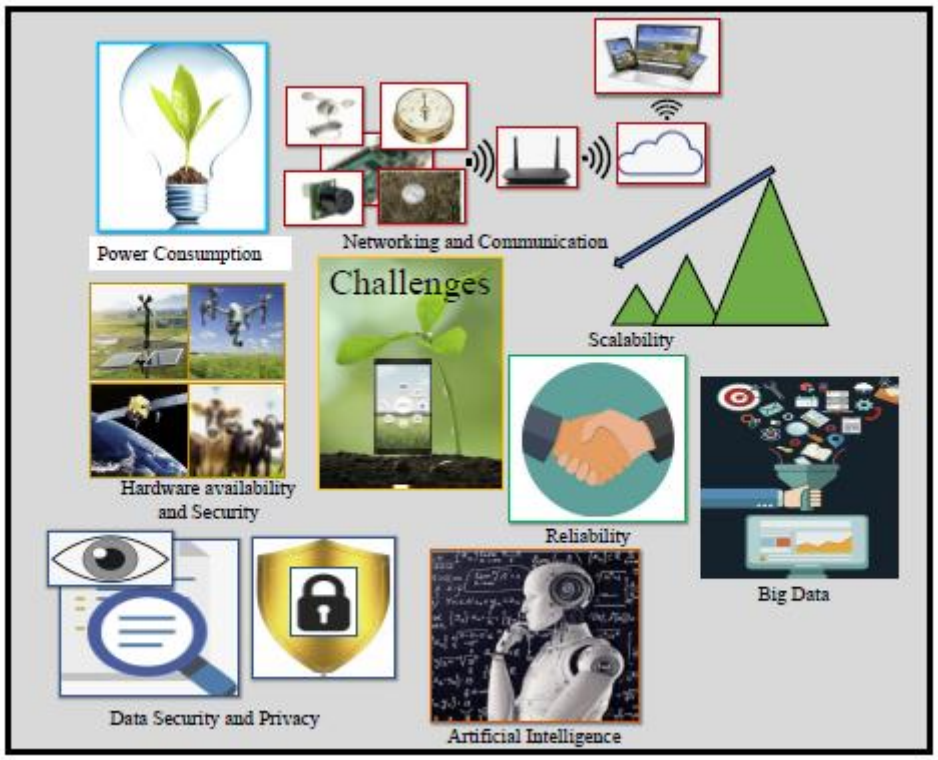

Figure 3. Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray 2022 "Everything You wanted to Know about Smart Agriculture" Cornell University

Among the main challenges of smart agriculture, we have the need to have a large amount of energy available to run the entire ecosystem of cameras, sensors electronic devices that make up the agricultural system.

The solution to this problem has been found by many farmers in the installation of renewable energy sources that use clean energy such as from the sun, wind, water, and air to have continuous power without interruption to give to machinery. (Liu, Chai, Xiang, Zhang, Gou, Liu; 2018)

However, there are issues related to the implementation of these energy sources, firstly we have the cost of installing these technologies and secondly, we have the problem of energy storage and transmission, as it is not always easy to pass the energy produced in this way from one location of the farm to another. (Kumar Ram, Ranjan Sahoo, Bandana Das, Mahapatra, Mohanty; 2021)

In this sense, there are still many studies and research that are trying to figure out what is the best solution to overcome this problem.

However, it is important to consider that in order to have a sustainable smart agriculture system, one must try to minimize the costs due to energy and thus energy use, so one must in every way find the most efficient source of energy according to one's situation. Of course, the fact remains that the decision about this is always up to the farmer as the farmer can decide to spend that energy cost against the benefits that he or she gets from the smart agriculture system. In addition, another issue with smart agriculture is that of the availability of the technologies that are needed to develop a smart agriculture system, in fact we have seen how this requires different types of sensors and devices to pick up all the different parameters that are needed to get the analysis of certain factors. Then, once all these data have been collected, they need to be processed, and to do this there is a need for the implementation of advanced technologies. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Technologies that obviously need to communicate with each other, so connectivity and communication between these technologies becomes critical to the optimal operation of the smart agriculture system.

The network concept becomes fundamental here, and any problems related to connectivity could create many problems in the implementation of a smart agriculture system.

In addition, these problems are also very common in rural areas, where farmers and ranchers often develop their businesses. A fast Internet connection is almost never available in these areas, and without it becomes difficult to implement such a system. (Precision Agriculture Challenges)

Another problem, mentioned earlier, is that of data security and the privacy of the individuals using these smart agriculture systems, in order to solve this problem, it is important that there is a robust cryptography system of the said data to prevent it from being stolen or taken maliciously during the transmission of the data itself. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

In this regard, the security protocols of the technologies implemented in the smart agriculture system are crucial. It also becomes essential to apply useful practices to increase digital security. Malicious actions against the processes of a smart agriculture system could lead the system itself to chaos since the system is usually totally automated and totally dependent on technological devices, so such a problem could have serious consequences on agricultural production. Another important challenge of smart agriculture is the one related to scalability and reliability as it is important to consider that agricultural farms have totally different sizes, there are small farms managed by small farmers and then there are large farms managed by large farmers, for the latter there is a need for a large number of technologies such as sensors to monitor the infinite number of hectares of land they have available. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

These sensors then generate a large amount of data and therefore it is important that each technology that goes to make up the smart agriculture system is scalable, so as to adapt to the different dimensions in which it is to be implemented, and the technologies must also be reliable as problems with the devices could lead to problems in production and an increase in costs.

Any technical malfunctions or damage to the technology could lead to serious damage to the technology itself that could lead to its replacement as these devices are very fragile and delicate.

Consequently, it is easy to see how multiple damages to the technology could lead to a failure of the smart farming system itself as the cost increase to replace all the equipment could be enormous.

Furthermore, another major challenge of smart agriculture relates to the need for substantial resources to implement a smart agriculture system. Indeed, it has been observed that many farmers do not have the capacity to make initial capital investments to implement such a system, and the phenomenon is even more prevalent in rural areas of developing countries where farmers work with very low profit margins and here there is just not the economic availability to invest in the technologies needed to implement a smart agriculture system. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Finally, a final challenge of smart agriculture is that there is no standard set of rules for the technologies that require such customized solutions. This increases the price of such technologies, and a uniform standard worldwide would solve this problem. (Precision Agriculture Challenges)

2.1.3 Relation between Agriculture and Sustainability

Sustainable food systems require an integrated approach with input from consumers, policymakers, researchers, and business operators, because sustainability-oriented innovations concern many different activities such as optimisation of farming and breeding practices, management and communication, distribution and retailing, and general consumer-oriented strategies: "Farm to Fork Strategy aims to accelerate our transition to a sustainable food system that should have a neutral or positive environmental impact, help to mitigate climate change and adapt to its impact and reverse the loss of biodiversity. Therefore, we understand that the contribution of all actors in the value chain is crucial, and an even more fundamental role is played by all the technological innovations that are applied in agriculture to achieve this sustainability that is talked about. (Riccaboni, Neri, Trovarelli, Pulselli, 2021)

Soil protection is one of the key issues in sustainability for the European Union; in fact, one of the main issues that is touched upon in the directives by the highest European authority is just soil protection. More specifically, Directive 86/278/EEC is precisely aimed at the use of improperly treated water during cultivation processes.

The incorrect use of this natural resource could bring a whole range of harmful elements, which are formed in stagnant water, into the soil; these harmful elements, later on, could be absorbed by the food that is planted in that particular soil and this could lead to the growth and marketing of a product that is potentially harmful to human health. So, there is a need to protect the soil in order to avoid such situations, and to do this there is a need for innovative solutions that limit the impact on the soil and potentially drastically reduce the use of soil needed to grow plants. Among these innovative solutions we have hydroponics, which allows growing without the use of soil, using water-based mineral nutrient solutions in aqueous solvents. (Duquennoi, Martinez, 2022)

Reducing the presence of elements harmful to the human body within foods is an essential step in achieving a food system that can be defined as sustainable and healthy for human beings. More specifically, it was examined that nitrogen, which is present in some foods, could be harmful to human beings. So, a system that allows the elimination of this substance can have a positive effect on the whole agribusiness system and its sustainability. (Xing, Lin, Hu, Lin, Liu, Zhang, Ye, Xue, 2023)

In this sense, in my research I analyze the innovative cultivation technology that is used to achieve certain results such as those mentioned above, as for example a system that can lead to the production of natural foods, which do not have within them any food that is harmful to human beings.

To do this, it was essential to talk to experts in the field such as agronomists and growers.

In addition, many studies have shown how crucial it is to use appropriate technologies in agriculture to achieve results that can be defined as in line with demand, and there are many risks in doing agriculture the wrong way and it is fundamental understand the kind of risks that arise and that can result from wrong cultivation techniques.

For example, even urban agriculture, which has brought countless results in terms of efficiency compared to classical agriculture, can lead to a series of phenomena that are harmful to the human body because of substances in the air

and on urban soil. This is why there is an increasing need for clear regulations in this regard to understand what adoptable solutions and those may be that lead to not-so-beneficial results compared to traditional agriculture. The goal is to find technological solutions that minimize the possibility of supplying the market with products that can lead to the manifestation of serious and even fatal diseases in the population. (Buscaroli, Braschi, Cirillo, Fargue-Leli`Evre, Modarelli, Pennisi, Righini, Specht, Orsini, 2021)

Among the most innovative technological solutions to be applied in agriculture to achieve benefits in terms of both efficiency and sustainability are the nature-based solutions; these solutions have been identified as possible solutions to problems related to the water-energy-food nexus. In this sense, it is necessary to adopt systemic thinking and promote the multifunctional design of NBSs to solve many environmental and agricultural problems. These solutions, in fact, represent a turning point to counter resource scarcity that is becoming more and more stringent due to the constant increase in the world's population leading to an ever-increasing demand for resources such as water, food and energy. (Carvalho, Finger, Masi, Cipolletta, Oral, T´Oth, Regelsberger, Exposito, 2022)

For example, among the solutions analysed in this paper we have the so-called aquaponics, this type of agriculture takes advantage of the hydroponics mode of farming to achieve a sustainable and more efficient type of agriculture, and around this type of farming a whole series of increasingly digital and high-tech solutions have developed that are expected to achieve extraordinary results for the companies that use them.

So, from that, I got the idea for my research paper.

More specifically, I went to analyze and study the use of digital technology in agriculture and the impacts that this could have in terms of efficiency.

But I also went to study the disadvantages of the use of this digital technology if there are.

2.2 **Technologies**

Now, before turning to the empirical part of my thesis, it is crucial in my research work to go and analyze in detail some of the major technologies that are being used in smart agriculture and how they fit into the context of the modern world, also in relation with the world of sustainability.

Among these digital solutions we have: Blockchain, Artificial Intelligence (AI), Machine Learning (ML), Big Data, Internet of Things (IoT), Drones, and others.

2.2.1 Blockchain

A shared, decentralized digital ledger can be created using the blockchain technology, which is used to handle smart contracts, trace the provenance of goods and services, streamline corporate transactions, and perform other tasks. Because the blockchain is distributed, it exists in various places and is not reliant on a single central organization or authority. Additionally, blockchain has the capacity to guarantee the immutability and integrity of the data entered it, making it especially appropriate for record-keeping and activity tracking. (Javaid et al. 2021)

By offering an encompassing distribution tool and incorporating cutting-edge technologies to accomplish more expansive corporate aims, the launch of this new technology will aid in amplifying the advantageous benefits brought about by Industry 4.0.

Blockchain technology is a database that houses information held by the business and makes it accessible through a network of computers called nodes.

Due to its decentralized style of communication, which enables it to increase the efficiency of information transmission between machines, blockchain is also viewed as a technology that will support efforts to achieve company sustainability and flexibility. The SDGs might be represented via blockchain, as seen in the example below.

Blockchain technology has the potential to end world hunger (SDG 2). According to data provided by the FAO (2019), around one-third of food is wasted, resulting in a loss of roughly 1.6 tons of food, even though the percentage of the population experiencing hunger and undernourishment is increasing.

By streamlining the supply chain and facilitating the agriculture sector's reduction of CO2 emissions (SDG 13) and biodiversity preservation, blockchain technology can assist to lessen these inefficiencies (SDG 14).

Also, blockchain can contribute to food security (SDG 2). Many organizations still do not have an effective mechanism for tracking the manufacturing cycle. This is due to the fact that the various functions make use of traditional technologies that are not interconnected (Klapita, 2021).

By transmitting and storing data regarding the source of food items, their quality, and the usage of any unethical activities, blockchain technology has shown to be a great tool for assuring end-to-end traceability and enhancing food safety. For instance, IBM and Walmart are creating a blockchain program to assure food safety by monitoring each step of the production of the item and making it accessible to consumers via a QR code on the label.

Another instance is the establishment of the first blockchain-based chocolates in Amsterdam by AltFinLab and the FairChain Foundation. The growth of this project will contribute to the supply chain's payment methods being improved. Moreover, it will provide customers the ability to trace every component used and confirm that it originates from ethical and sustainable sources.

2.2.2 Artificial intelligence (AI)

Artificial intelligence has transformed industrial dynamics by improving the effectiveness of management and production procedures (Schneider and Leyer, 2019). The capacity of electronic systems to learn and behave intelligently through the interpretation of gathered data is referred to as "artificial intelligence" (AI).

At the corporate level, such technology is employed to complete complicated jobs and issues faster. Putting AI into practice can also help us move toward social, economic, and environmental sustainability.

By encouraging more responsible and effective resource use, SDG 12 aspires to create new sustainable patterns of production and consumption. From this, it may be inferred that this SDG targets business, encouraging them to embrace new, more sustainable business models (Vinuesa et al., 2020).

By automating tasks and implementing an integrated knowledge architecture (human and artificial), which can collect and storing enormous volumes of data and enabling the most effective allocation and use of resources, AI may help a corporation increase its productivity capacity (Di Vaio et al., 2020)

In fact, AI can help ensure the delivery of many services, including, for instance, food and healthcare. AI can also assist in reducing CO2 emissions produced by cities by implementing particular technology like electric vehicles (Fuso Nerini et al., 2019). However, the use of such technology may make disparities that currently exist worse. As most rural economies lack access to these disruptive technologies, only the most developed economies would be able to profit from artificial intelligence's potential benefits, widening the gap between more developed nations and emerging economies.

2.2.3 Machine Learning (ML)

To produce effective answers and predictions, machine learning may study and analyze data. Machine learning models are systems that can take data, learn from it, and then develop algorithms to generate forecasts and deliver thorough findings (Gupta and Rawat, 2022).

Machine learning is a tool that may help businesses grow economically in other ways as well. In order to increase corporate efficiency and reduce environmental impact, more and more companies are implementing these models in areas like logistics, marketing, finance, and production. When machine learning is used in several processes, it may enhance automation, resulting in time and money savings. The implementation of machine learning may significantly increase

sustainability by optimizing resource consumption while increasing production capacity. In fact, employing ML models enables a wiser and more effective use of energy and resources, hence minimizing waste production and emissions (Cioffi et al., 2020)

Recently, there has been an increase in interest in the development of Statistical Machine Learning (SML). systems designed to analyze data from remote sensing. These data are used to provide statistics for the agricultural and environmental sectors. In order to monitor afforestation and deforestation using satellite data, for instance, algorithms can be utilized (Echeverría et al., 2006). Metrics created from data on, for instance, crop yield can be employed in the agricultural industry. Remote sensing may be used to measure these and other information on agricultural conditions, resource seas, etc., and machine learning algorithms can convert that information into statistical measures.

India's rice farming may be used as an example to examine the effects that ML models have. One of the most important agricultural practices for ensuring food security for the Indian population is rice production (FAO, 2018).

Unfortunately, the amount of suitable fertile land for agriculture has decreased because of exponential population expansion and rising climate criticality.

It is necessary to do an analysis on the real quantity of resources required to obtain optimum productive capacity in order to pursue sustainable agricultural production. In this situation, ML systems show to be the best method for assessing and forecasting the amounts of inputs required as well as the variables that have the most impact on production efficiency (Nandy and Singh, 2020).

2.2.4 Big data

Internet users engage on the network by unintentionally leaving behind "digital footprints," or an ongoing stream of data from their clicks, likes, and other network activity.

Big data is described by Gartner analyst Doug Laney as high-volume, high-velocity, and high-variety information resources that call for novel information formats, enable greater comprehension of events, and improve process automation. Big data can provide fresh approaches for achieving the SDGs, promoting social, environmental, and economic well-being.

Big data offer a special instrument for dynamic and cross-sectional analysis as well as delivering pertinent information. Each development indicator has a significant drawback since it is based on statistics applied to data obtained from a sample. Although this method has benefits in terms of bias, accuracy, and precision, it has the drawback that because the data is discrete, it is difficult to link (unless at the aggregate level) to other data (MacFeely, 2019).

By using so-called "contemporary forecasting," Big Data can give up-to-date and accurate indications, making it possible to identify problems and potential solutions earlier.

This will be essential for preventing future pandemics, financial crises, and natural disasters.

Food security may be achieved with the use of big data (SDG 2). Big data combined with other agricultural technologies like smart sensors, IoT, and cloud computing can help advance precision farming and smart agriculture by guiding decision-making through data gathered from agricultural management to improve agricultural productivity and quality, two elements that will then affect the price of agricultural products.

Water availability is a different goal to which big data may make a substantial contribution (SDG 6). It is feasible to remotely monitor reservoirs and water supply locations using satellite data.

Big Data can also be used to develop systems that analyze terrestrial and hydrological data to predict potential risks of flooding or other climate disasters, monitor water quality and pollution levels using chemical sensors, and perform more precise evaluations of water quality and water management in urban settings.

2.2.5 Internet of Things (IoT)

The term "Internet of Things" refers, according to Wortmann and Flüchter (2015), to a worldwide network architecture that may connect real-world and virtual items.

According to Wortmann and Flüchter (2015), in more detail, on the Internet of Things, objects are fitted with sensors or other devices that allow the collection of a variety of data and information. These objects are also connected to the cloud so that data and information can be stored and analyzed in order to monitor and coordinate the interactions between people, systems, and objects in a particular environment.

As it facilitates the collection of a vast quantity of data across a range of items of various sorts and placed in different places, the Internet of Things can significantly contribute to attaining environmental, social, and economic sustainability in several diverse application areas. The primary contributions that the Internet of Things may make to sustainability in relation to the SDGs are specifically identified by Atzori, Iera, and Morabito (2017).

For instance, IoT implementation in agriculture may enable monitoring of soil and crop conditions and optimize inputs and processes, which can contribute to food security (SDG 2).

The notion of Industry 4.0 is emerging, and it is supported by the Internet of Things.

According to Bai et al. (2020), the implementation of a global system of interconnected objects enables the acquisition of information about processes that enable monitoring and lowering the consumption of water, energy, and resources as well as emissions of hazardous substances, waste, and emissions using sensors.

According to Bai et al. (2020), this has a favorable effect on the economic performance of production by lowering corporate expenses, boosting productivity, and raising output.

The Internet of Things is a rapidly expanding phenomenon, but its implementation faces three main challenges, according to Wortmann and Flüchter (2015): the introduction of IoT could lead to difficulties related to the redesign of the business model; the implementation of IoT could lead to difficulties related to the modification of various operational processes; and the introduction of IoT requires the adoption of a multitude of technologies and could bring difficulties such as those related to their provisioning, standardization, and privacy.

2.2.6 Drones

When drones first entered the market, they were solely meant to be used by the military. As time has gone on, though, they have gotten more and more user-friendly, allowing them to be used in a variety of industries. There have been countless technical advancements since such instruments were semi-automated and required a human to aid in operating the aerial vehicle; now, however, thanks to advanced technology, they are fully autonomous and rely on GPS to function (Hafeez et al., 2022).

In contrast, drones are made up of a myriad of components, such as cameras that are designed to take precise pictures, both conventional and thermal, and at the same time special sensors that, when combined with artificial intelligence, can reprocess raw data, and make the drone, due to the amount of load it has, is able to implement effective solutions and automatically implement corrective behaviors. Drones are currently serving a crucial job in the agribusiness industry, optimizing productivity. Current business trends, such as rising population and declining output owing to natural disasters and continuous climate change, provide reason for the use of drones in agricultural production (Hafeez et al., 2022).

According to Hafeez et al. (2022), the use of this technology permits the abandonment of satellite imaging in the specific situation of the agrobusiness industry, which is particularly expensive and whose quality is entirely reliant on daily weather conditions.

The use of drones assures that two opposing goals will be pursued in the context of agricultural production: the first is to boost output, while the second is to make farmers' jobs easier by taking their place in some phases of the production process (Hafeez et al., 2022).

The availability of sensors and cameras, for instance, enables intelligent mapping of fields that may identify potential illnesses while also enhancing analyses of nutritional needs and the water component.

Also, the second role is spraying the appropriate fertilizers and insecticides. Some tasks may be carried out without the use of technology, which not only improves soil performance but also protects human health (SDG 3). Conventional pesticide spraying can really have a negative influence on farmers' health by causing various conditions that are often permanent, like cancer and asthma (Hafeez et al., 2022).

A practical example is provided by Saha et al. in 2018 (Hafeez et al., 2022), through the design and presentation of a drone system suitable for monitoring data using artificial intelligence, IOT and the adoption of algorithms, which can monitor crop health and identify corrective behaviors to be implemented in view of incremental production.

However, although the benefits mentioned, various problems, such data security, have been brought up by this technology.

2.3 **Technological innovations in agriculture**

After analyzing all these different technologies, it becomes appropriate to go and summarize what we know and what we do not know about technological innovations in agriculture, to closely relate what we have seen so far to the field we are going to study.

In order to do this, it is useful for us to summarize everything we have discovered through the literature review about technological innovations in Agriculture and what are still the unknowns regarding these issues in the table 1 below:

What we know	What we don't know
Smart agriculture could bring many benefits in terms of environmental sustainability. In fact, a remarkable development of smart agriculture could strongly contribute to the goal set in the 2030 Agenda to eliminate world hunger. However, despite its undoubted advantages, smart agriculture is struggling to spread in Italy.	Why, despite its undoubted advantages, is smart agriculture struggling to spread in Italy?
Smart agriculture is a new phenomenon that needs to be constantly studied precisely because of the high technological content and the continuous advances that are being made every year.	Hidden aspects of smart agriculture and the motivations that drive or block its diffusion.
Smart agriculture is also seen as something we strictly need to be sustainable, smart, efficient, and eco-friendly.	What are the benefits of Smart Agriculture's application and what are the technologies used to achieve certain benefits?
In Smart Agriculture we have a union of multiple technologies such as blockchain, internet of things, artificial intelligence, and others.	What are the perceived advantages and the barriers in introducing technological innovations in Agriculture?
Agriculture 4.0 bring support to the farmers' decisions since the integration of these technologies allows to obtain optimal analyses which can lead the machines to elaborate by themselves the optimal strategy for the agricultural system analysed, eliminating any possibility of error through data analysis.	Under what conditions it was possible to implement these technologies and under what conditions there were more problems that forced companies to make a greater effort to succeed.
The application of technological innovations brought about a significant increase in productivity and efficiency in Agriculture.	Advantages perceived from farmers implementing these technological innovations.
Technology and data processing allow to optimise agricultural processes and achieve better production standards, while also reducing human labour and inefficiencies.	Main difficulties or obstacles encountered in implementing these technological innovations.
The connection between devices is a fundamental aspect of smart agriculture that should not be underestimated, and it is most important in implementing a smart agriculture system to verify that everything is working in the right way.	Main differences between the current way of working and the way of working before using these technological innovations.
Sensors and cameras collect data in real time, and for this reason it is important that this data is sent in real time to those who instead process it in order to get the most accurate result possible and you need a very powerful connection to get it all processed as quickly as possible.	Were the technological innovations adopted compatible with the technologies already used in agriculture?
We have the need to have a large amount of energy available to run the entire ecosystem of cameras, sensors electronic devices that make up these new agricultural systems.	Main issues perceived or encountered from farmers in using these technological innovations.
Need for substantial resources to implement a smart agriculture system.	

Table 1. What we know and what we don't know about technological innovation in Agriculture.

2.4 Theoretical Framework

However, before moving on to analyze how the research work was carried out from the data point of view, it is necessary to clarify what is the theoretical framework of this research work.

This operation serves to define what are the guidelines of this research work and to go and establish what are the guidelines that will guide all the work and it is a fundamental operation also to go and understand what the best way is to go and extrapolate from the subjects participating in our research the data useful to us.

The theoretical framework of reference allows us to identify, based on what we have read in the literature review, what are the key aspects to go and ask the subjects participating in the research but more importantly it allows us to understand which subjects are best suited to answer certain questions.

The starting point for structuring the theoretical framework of this research was taken from the Diffusion model of innovation theory, more specifically in the version of Moore, G. C., & Benbasat, I. (1991) in their work: “Development of an instrument to measure the perceptions of adopting an information technology innovation”.

In this research work, the main objective is to find a way or an instrument to measure the various perceptions an individual may have regarding the adoption of a technological innovation within their pre-existing system.

In this paper, this identified tool is used as a starting point to analyze the initial adoption and eventual diffusion of a technological innovation within an organization.

This research work comes to show that measuring such perceptions turns out to be the best way to integrate what are the theoretical constructs that we can read in the literature so as to integrate theory with empirical results in order to obtain results that best represent the reality that one is going to study.

This operation makes it possible to give validity and reliability to the results of the research as we go to verify the convergence of all the aspects analysed in the words of the subjects directly participating in the innovation process.

Therefore, the choice of this work as a starting point for our research work does not seem obvious.

In fact, our work aims precisely to go out and investigate these perceptions regarding the topic of smart agriculture in order to corroborate what we read in the literature review, the ultimate goal being to find empirical corroboration in the theory and analyze the results that come out of the interviews.

Interviews that on the basis of what we have read will have to go to thoroughly investigate multiple aspects, and to do this there is a need for the greatest number of points of view in order to corroborate the reliability of the measures obtained in the interviews themselves.

For this reason, our research will focus on two points of view, representing the two macro categories of subjects participating in the study, namely:

- subjects/companies offering smart agriculture solutions on the market.
- subjects/companies using smart agriculture solutions.

From the perspective of the questions to be asked of these subjects, however, these, based on what has been read in this paper and in the literature review, should be based on four basic aspects:

- advantages.
- disadvantages.
- issues in implementing technologies.
- organizational changes required to implement these technologies.

It is important to keep in mind that the questions stipulated on the basis of the literature review for both subjects will be indifferent to the type of subject being interviewed because the goal of the research is to have a general perspective on the whole implementation of technologies in smart agriculture, so the point of view had to be binary on each individual aspect of the study.

Therefore, once we have clarified what is the theoretical frame of reference, who are the subjects to be interviewed and what will be asked of them, we go on to define specifically what are the questions to be asked in the interviews.

This will be done in the next chapter of this research paper where, as already anticipated, based on the literature review carried out earlier, we are going to formalize what are the research questions of the research paper that have the ultimate purpose of going to contribute to the answer of the research question of the whole paper; in fact, as can be read in Moore and Benbasat's article, the union of theory with the perceptions of those who apply the theory in the field is the best way to get an unambiguous, reliable and valid answer to answer a research question.

The work of Moore and Benbasat, however, was not the only work that helped form the theoretical framework for my research work. Another key paper for my work and the development of the theoretical framework for this research work was "A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology" of Agarwal and Prasad, in this research work they always analyze the theory of diffusion of innovations but from a different point of view than Moore and Benbasat.

Agarwal and Prasad develop a model which analyses what the adoption of technological innovation depends on, the two writers tell us that this adoption depends on various factors, among them we have technical compatibility and technical complexity as we can see in figure 4.

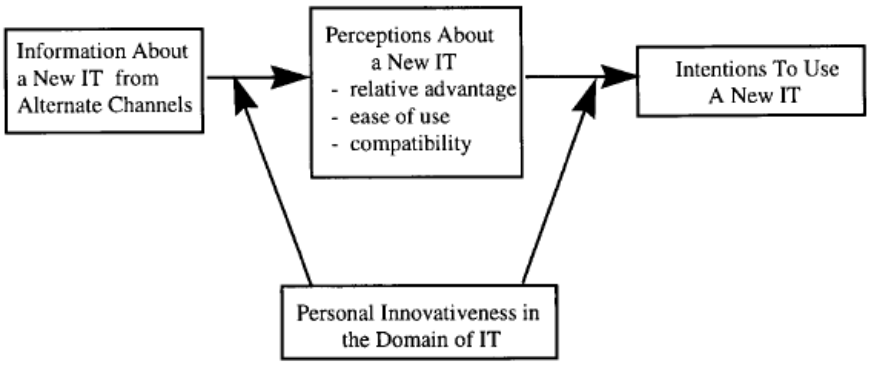

Figure 4. Agarwal, Prasad 1998 A Conceptual and Operational Definition of Personal Innovativeness in the Domain of Information Technology. Information Systems Research 9(2):204-215.

This model has been a clear theoretical reference to inspire my questions since in this research work I am going to talk to companies that have adopted technological innovations and therefore these factors have been crucial in the implementation and have definitely been analysed by the said companies before adopting or not adopting the given innovative technology.

Then, after adoption, the companies are able to say how much these factors that Agarwal and Presad told us influenced the whole process of adopting the technology innovation within a pre-existing business model.

This model therefore provides an ideal basis for the questions I will ask in my interviews, these will certainly focus on analysing whether the innovations introduced were technically compatible and complex.

In addition, another key factor in the adoption of a technological innovation, Agarwal and Prasad tells us, is the analysis of the relative advantage this adoption should bring to the way work is done compared to how it was done previously. Obviously, the implementation of a technology should bring benefits tell us the two authors, otherwise there is no reason for this technology to be adopted.

All of these factors together contribute to the positive or non-positive intention to use and adopt a technological innovation, if the evaluation of these factors is positive then they will proceed to adoption, but it is only after experience and having used that technology within one's own work that one can give feedback on the effectiveness or otherwise of this adoption.

The combination of what I read in the two research papers on the diffusion theory of innovations, by Moore and Benbasat and Agarwal and Prasad, respectively, gave me a solid theoretical basis to go on to structure the interview questions, which as mentioned earlier, will constitute a key phase of the research work and their elaboration will be made explicit in the next part of this research paper.

Finally, it is useful to represent in the table 2 below what are the concepts I use from Moore and Benbasat and what, on the other hand, are the concepts I take from Agarwal and Presad and how these are mixed in order to go on to form the theoretical framework of this research paper.

Moore & Benbasat	**Both**	**Agarwal & Presad**
Use of the various perceptions an individual may have regarding the adoption of a technological innovation.	The union of theory with the perceptions of those who apply the theory in the field is the best way to get an unambiguous, reliable, and valid answer to answer a research question.	Agarwal and Prasad develop a model which analyses what the adoption of technological innovation depends on, the two writers tell us that this adoption depends on various factors, among them we have technical compatibility and technical complexity.
Study of adoption and eventual diffusion of a technological innovation within an organization.	In order to best evaluate the adoption of a technological innovation, the subjects must have adopted the innovation being discussed and therefore must have experienced it in order to make judgments through their perceptions.	After adoption, the companies are able to say how much these factors that Agarwal and Presad told us influenced the whole process of adopting the technology innovation within a pre-existing business model.
Measuring such perceptions turns out to be the best way to integrate theoretical constructs with empirical results in order to obtain results that best represent the reality that one is going to study.	Empirical results given by technological innovations are a key part of the study as only these can give feedback on the actual usefulness of implementing these technological innovations.	The implementation of a technology should bring benefits tell us the two authors, otherwise there is no reason for this technology to be adopted.
Analysed the words of the subjects directly participating in the innovation process.	Whether or not one chooses a technological innovation depends on the theoretical expectations one has of it, but the result one gets depends on how well the benefits of the implementation have met expectations and thus depends on the benefits the user subject perceives in its use.	All of these factors together contribute to the positive or non-positive intention to use and adopt a technological innovation.

Table 2. Key concepts of the Theoretical Framework.

3. RESEARCH DESIGN

In order to answer the research question of this paper, a definite work plan has been designed; the design of the research work starts first of all with the identification of the method which is as follows.

To do that research work, I analysed multiple case studies that operates in the sector of smart agriculture, and I analysed many papers written in the literature related to this sector.

In fact, it is important to point out that the purpose of my research was not only to go and look for the desirable benefits of smart agriculture, but also to go and fill in the holes in the literature that I identified by going and doing a careful review of it.

First, I went into a deeper analysis of the relationship between digital technologies and issues related to world of agriculture through the literature review.

Going first to analyze what are the main digital technologies in today's world, among which we find machine learning, NFC technology, blockchain, NFTs, sensors, artificial intelligence, algorithms, 3D printers, big data, and cloud computing; and then going to see what is the contribution that each of these technologies is making to achieve different goals in this field.

In this part of my research, I made a focus on what are the technologies currently used in the field of agriculture and how they have changed the classical way of doing this kind of activity, both in terms of changes related to processes and aspects related to the organization of agricultural work itself.

Moreover, I went to talk about real cases to analyze what can be the benefits and the problems related to the use of digital technology they have developed in terms of efficiency compared to the classic method of doing agriculture and how these technologies can be fundamental for other firms.

In this section of my research, I have done a focus on what are the stakeholders involved in these projects and their history, talk about their products and the technological evolution that led them to be what they are now.

I had talk about the objectives of that are intended to be pursued with these projects and the benefits that these can bring both in terms of the use of natural resources but also in economic terms for businesses that are involved in agriculture.

So, I highlighted what is the value created by these products, what kind of value they create and for whom it is created.

I think it is also incumbent on me to talk in this part about the main challenges that these products have faced during their development cycle, the launch phase, and their life cycle.

So, I have concluded with what are the results obtained from the research that can be summarized in the explanation of the benefits that these kinds of innovations can bring in the world of agriculture and more precisely in the world of smart agriculture and therefore the problems for the firms and for who want to use these solutions.

3.1 **Methodology**

Regarding methodology, I based my work on interviews and a qualitative analysis of what are the benefits of these technologies and smart agriculture.

In order to do that, I got in touch with many companies operating in the agricultural sector and from them I selected the best ones to include in my research and to whom I submit my questions based on the literature review.

The link between literature review and interviews is crucial because, as mentioned earlier, smart agriculture is a rather new phenomenon, which therefore has been studied in the literature anyway, but whose studies have not covered all the available points.

In this sense, the literature review was crucial in order to go and understand what issues of interest were brought to the attention of the readers by the various

scholars and based on these go and structure the consequent questions for the various interviews that were conducted.

Indeed, it was necessary to understand what the crucial questions were to ask and what were the aspects to dwell on in order to go and find empirical feedback from the theoretical studies.

Moreover, the literature review was not only crucial to understand what the key points were to go and analyze through the interviews but also served as a starting point to reason about some issues which had not yet been addressed in previous studies, but which could still be the subject of analysis in this research.

3.2 Subjects interviewed

In terms of interviews, I have been in contact with and interviewed the CEOs and co-founders of five companies involved in producing certain products needed to implement a smart agriculture system.

Among the main figures, I was in contact with the CEO and Cofounder of WallFarm, Jacopo Teodori; the CEO and Cofounder of another company that is NidoPro, Andrea Carloni; the CEO & CTO of Agrobit, Ing. Simone Kartsiotis; the Head of Human Resources of Elaisian, Elia Fregola and Ing. Simone Cirocchi from Sigma Consulting.

Interviewing these companies was a crucial step in my research in that learning their views was crucial in going to understand what the goals of certain products are, that is, what benefits certain technologies should bring to the companies that use them.

These figures are very available for meetings, and I had an initial conversation with them in which I got a better explanation of their business realities and what they are about to see if there could be a fit between the work I would like to do and their companies.

In addition, these figures confirmed to me that there is a possibility of scheduling more interviews, not only with them, but also with other members of their organizations to get more views on how the work within their companies works.

So, I use this opportunity to make the most of the contact with them to go and conduct multiple interviews on what the benefits of this technology can be in the context of agriculture as well.

In addition, there is also an opportunity to speak with engineers to understand more specifically how the technical part related to the operation of their products works, and this was very helpful in understanding in depth how the aforementioned technologies fit into the practical operation of these product.

However, the purpose of the interviews was to analyse not only the point of view of the products of these technological solutions, i.e., the producers, but also the point of view of the adopters of these technological solutions, i.e., all the agricultural enterprises that use these products to improve their business.

From this point of view, the support I got from the figures mentioned above was crucial as they allowed me to get in touch with other companies who were using their products.

Consequently, my analysis aims to investigate what are the most important aspects for what we can define as the adopters of these digital technologies. That is, companies or figures that use these technologies to improve their business and make it more efficient.

In my study, it will also be crucial to analyse their point of view because they are the ones who actually apply the technologies produced and therefore only, they can tell what the actual advantages are given by the application of these, and any problems encountered in implementing these technologies within a pre-existing business model.

As for the users of the technologies, to be precise, I interviewed six enterprises including farms and vertical farming companies. As mentioned, their word was crucial in order to fully understand the benefits and problems they had in implementing the technology because if the analysis had focused only on the side of the companies producing certain products I would have had a one-sided view made up only of the potential benefits promised by these companies, but I would not have had the view of those who had to implement these products in

their business model and who therefore had to bring changes to their organization to achieve certain results.

In order to make order and be clear about the subjects interviewed and which side of my survey the subjects belong to, I have summarized the subjects interviewed in the table 3 below:

Subject Interviewed	**Company**	**Producer or Adopter?**	**Role**
Jacopo Teodori	WallFarm	Producer	CEO
Andrea Carloni	NidoPro	Producer	CEO
Simone Kartsiotis	Agrobit	Producer	CEO & CTO
Elia Fregola	Elaisian	Producer	Head of Human Resources
Simone Cirocchi	Sigma Consulting	Producer	Engineer
Mattia Dell'Orto	Arnaldo Caprai	Adopter	Director
Edwin Schilperoord	Innogrow	Adopter	Agronomist
Chiara Cichero	Sfera Agricola	Adopter	Marketing Manager
Matteo Benvenuti	Vertical Farm Italia	Adopter	Engineer
Philip Lee	Mono'	Adopter	CEO
Mahdi Alhindawi	Farmer	Adopter	Agronomist

Table 3. Summary of the subject interviewed.

The interviews done with all of these individuals aim to thoroughly investigate what are the obstacles, difficulties, and challenges in introducing technological innovations in agriculture, and then go on to analyze what are the perceived benefits after making use of these innovations.

As mentioned earlier, however, this analysis could not focus only on one side of the market since in order to fully understand these issues one must analyze the difficulties that exist both upstream but also downstream of the introduction of a technological innovation.

For this reason, I decided to interview the individuals represented in Table 3 who are part of both sides of the market as can be seen.

3.3 **Interviews**

As mentioned earlier, interviews are a key focus of this research work as this is an interpretive study of what is the phenomenon being analysed, namely technological innovations in agriculture.

An interpretive type of research is based on the analysis of the interviews conducted with the sample of people or companies examined and then go on to identify what are the main themes that emerge from the interviews on the basis of the questions carried out that have been previously carried out on the basis of the study of the literature on the topic examined.

Through the coding of the text of the interview responses, one is able to trace what are the points of similarities and differences in the analysis of the various themes that were decided upon. In this case, the decision to conduct a study of multiple case studies serves precisely to compare all these different points of view and then arrive at a conclusion that can be as unambiguous and accurate as possible.

As mentioned earlier, moreover, the formulation of the interview questions was also carried out following a study and analysis of the literature on the topic of technological innovations in agriculture, in fact at this stage it may be useful to summarize what are the main themes that emerged from the literature review which formed the main basis for the questions that will be explained later.

These main themes emerged from the study of the literature regarding smart agriculture, the technologies used in smart agriculture but were also the result of elaboration based on what is the theoretical framework of this entire research work.

In fact, as anticipated in chapter 2.3, devoted precisely to the theoretical framework, studies on the theory of diffusion of innovations were a fundamental basis for understanding what the key aspects were to be investigated in this research work.

These main themes that emerged from the Literature Review can be viewed in Table 4 below:

Main Themes	**How do we configure it within our study?**
• Technical compatibility	• Possible barrier to adoption
• Technical complexity	• Possible barrier to adoption
• Relative advantage	• Possible advantage
• Resistance to change	• Possible barrier to adoption
• Cost of implementation	• Possible barrier to adoption
• Management of resources (Water, Optimization of the use of fertilizers and pesticides)	• Possible advantages
• Efficiency	• Possible advantage
• Data Security and Privacy	• Possible barrier to adoption
• Networking and Communication	• Possible barrier to adoption
• Power consumption	• Possible barrier to adoption
• Increased crop production efficiency. • Reduction of operational costs.	• Possible advantages
• Opening up of unconventional farming area in cities, deserts. • Lower greenhouse gas emissions. • Reduced soil erosion.	• Possible advantages

Table 4. Summary of the main themes that emerged from LR.

Based on these themes, as mentioned above, the questions to be asked of the subjects mentioned above in Chapter 3.2, devoted to subjects interviewed, were developed.

It is important, however, before going on to list the questions in this research paper to make explicit the fact that the questions are different depending on the type of subject being interviewed.

These questions differ based on whether they are asked of the subjects producing technological innovations or of the companies consuming the technological innovations.

The rationale lies in the fact that the point of view of the questions shifts based on whether an upstream or downstream view of the issue to be addressed is adopted.

However, the latter remains the same and the purpose of the questions is to investigate the same phenomenon, and therefore the combination of the answers will go to form the basis for the subsequent analysis and discussion of the results.

The questions for adopters are as follows:

- What were your reasons for adopting these innovations?
- Why did you use that supplier?
- What advantages do you perceive you have gained from implementing these technological innovations?
- What were the main difficulties or obstacles you encountered in implementing these technological innovations?
- What are the main differences you have found between the current way of working and the way of working before using these technological innovations?
- Are there things you did not find in the innovations implemented compared to what you expected?
- From a technical point of view, did you find high complexity in adopting the above technological innovations in your business model? If so, why?

- Were the technological innovations adopted compatible with the technologies already used in your work?
- What are the main issues you now perceive to be encountered in using these technological innovations?

The questions for producers are as follows:

- What benefits should your technology innovations bring to adopters as a result of implementation?
- Why do you think companies adopt your innovations?
- What are the main difficulties or obstacles you have encountered in getting adopters to adopt these technological innovations?
- What are the main differences your customers have found between the way they work now and the way they worked before they used your technological innovations?
- Are there aspects that do not meet the expectations of companies adopting your innovations?
- From a technical point of view, have you found high complexity in getting the above technological innovations adopted into existing business models? If yes, why?
- Were the technological innovations adopted by your customers compatible with the technologies already used in their work?
- What are the main problems your customers now perceive in using these technological innovations?

So, these are the questions I went to submit to the subjects I mentioned earlier.

Of course, it must be specified that the individual questions were adapted according to the content of the interview and the specific company/adopter, in particular, each question was adapted to the specific innovation(s).

However, now before I move on to talk about what the results of my research with related discussion of are these, I would like to make a focus on how technologies are studied within this research work.

3.4 **Relationship with the study of technologies**

Digital innovation is a key focus of this research, and therefore technologies constitute a central role within this research, which is why I feel it necessary to make a focus on the ideal way to approach the study of technologies and then make explicit how this delicate relationship was handled within this research work.

Technological innovation plays a key role within organizations and therefore it becomes essential to have theoretical foundations that can act as facilitators to manage the relationship between technology and the organization in which it is to be inserted especially since it has been observed how technologies change constantly and at a disarming speed, which is why organizations need theoretical foundations to manage and understand these unpredictable changes in order to contain the impact of the technology being adopted in the organization. The adoption of new technologies impacts all parts of the organization and simultaneously, creating new interdependencies within and outside the boundaries of the organization; therefore, a multitude of new actors and factors come into play that must be considered for the achievement of organizational efficiency. (Bailey, Faraj, Hinds, Leonardi, von Kroghe; 2023)

Thus, technologies play a fundamental role within organizations and strongly influence their actions; in the current context, in fact, we can see technologies occupying a role that not only can be defined as central but also as constitutive of organizational processes themselves.

However, it is important to note how these new technologies, among which we have artificial intelligence, big data, robotics, etc., can be defined as emerging not only because of their recent development but also because the uses and effects of these technologies in a specific organization emerge over time and are not yet defined by specific sets of uses, but these vary precisely according to different organizations. So, these technologies are constantly evolving, and their application varies according to context and organization. (Bailey, Faraj, Hinds, Leonardi, von Kroghe; 2023)

On the basis of these words, my research work is structured in such a way as to give a theoretical answer to how these technologies fit into different organisations, in this case talking about organisations operating in the agricultural sector, and it is therefore essential to make a comparison between as many companies as possible, both on the producer and adopter side, in order to give as precise an answer as possible to try to answer the job search question and to find the relationship between the adoption of technologies and the organisations included in my study.

The aim of the study is similar to that of Bailey and the other authors of the paper "We Are All Theorists of Technology Now: A Relational Perspective on Emerging Technology and Organisations", that is, to understand how these technologies are incorporated into the organisations studied and how they influence organisational processes and main organisational phenomena in order to understand what the main development of these in the majority of the contexts is analysed, always bearing in mind that the evolution of these technologies is unstable and it is difficult to define a clear and indissoluble univocal canon.

In order to do this, therefore, a fundamental role has been given to technology and the central focus of the research work is to put technology at the centre of the organisation, since, as seen above, technology is now a fundamental resource of every organisation and therefore a method of study based on this view is what we need to satisfy this need for research based on this new method of study developed by Bailey and the other authors of the paper cited above.

3.5 **Units of analysis of the study**

This research paper is based on the study of multiple case studies, in this perspective it becomes essential for the purpose of a better understanding of the work to go to indicate what are the units of analysis of the work itself, that is, the companies interviewed and go to provide a brief description of the different realities that have been questioned to carry out this research work.
The description of said companies can be found in the table 5 below:

Company	Description
WallFarm	WallFarm is an innovative Italian start-up based here in Rome that focuses on smart agriculture and develops ground-breaking innovations for soilless farming methods. Their main creation is LIA. Hydroponic systems' LIA is a completely automatic water management tool that was designed to be expandable and adaptable. LIA, thanks to the module of Flow diverter, allows to grow up to 10 separate lines of plants simultaneously, each with a different size and hydraulic system. Without performing even a single manual water analysis.
NidoPro	NidoPro is an innovative Italian start-up that specializes in smart agriculture and creates game-changing technologies for soilless farming techniques. Their main creation is NIDO ONE V1 but in April 2023 they will launch the new version NIDO ONE V2. This product has more than 2000 installations worldwide. Hydroponic systems' NIDO ONE is a completely automatic management tool that was designed to be expandable and adaptable and through the NIDO app you can have control of the greenhouse at the click of a button.
Agrobit	Agrobit proposes a holistic approach to digital agriculture, leveraging a combination of various innovative technologies (drones, field sensors, DSS, 3D models and algorithms) to help farmers and technicians assess each plant and field accurately, efficiently, and cost-effectively in order to optimize agricultural production and reduce chemical use. Their main solution is iAgro, an app DSS that quickly and inexpensively enables precision agriculture by suggesting the right amounts of water and pesticides for phytosanitary treatments. The app will give information on plant biometrics (thickness, height, LAI), field parameters (TRV, LWA), and determine the optimal volumes of water for phytosanitary treatments and generate prescription maps for your tree crops (vineyard, orchard, olive grove, citrus grove, almond grove). However, their offerings are very broad, and among the main products offered are: • DSS: Apps and decision support systems to manage your farm sustainably while reducing costs. • Drones: Drone surveys to map crops and identify the most stressed or nutrient-deficient areas. • Sensors and predictive models to prevent crop diseases and optimize water resources. • Agricultural photogrammetry software.
Elaisian	Elaisian is an innovative Italian start-up based here in Rome that focuses on smart agriculture and is mainly concerned with almond, olive, and grapevine cultivation. Their offering is to provide farmers with precision agriculture weather stations with rain gauge and related app in order to give farmers decision support through algorithms and forecasting models.
Sigma Consulting	Sigma Consulting, founded in 1998, is a company with 30 years' experience in the design and integration of electronic and ICT systems for applications in the fields of Aerospace, Defense Electronics, Simulation, Intelligence, Homeland Security, Command & Control, and Integrated Logistic Support - the company's core business. Over the years, Sigma has further diversified its offerings: Sigma's Smart technologies also find application in the Civil sector, with solutions for Smart Cities, Smart Farming, Telemedicine.
Arnaldo Caprai	This company is engaged in viticulture and has 182 hectares of property in the area of the village of Montefalco, the area owned by the company is divided into sectors with similar soil characteristics, even arranged on different plots. Among their best products we have the Sagrantino DOCG that they export to 24 countries.

Innogrow	Edwin is a German manufacturer of small smart agriculture systems with various facilities around the world.
Sfera Agricola	Sfera Agricola is a company located in the heart of the Tuscan Maremma that was born from the idea of creating the first resilient agricultural production facility. Sfera combines hydroponic technology with best management practices to control all key factors and achieve efficient and environmentally sustainable production. Their core values are Sustainability, process quality, product quality, taste, and freshness; in addition, all Sfera products are certified Nickel Free. The absence of pollutants and heavy metals in Sfera products is ensured by laboratory analyses constantly carried out on the fruits, water, and nutrients to be fed to the plants.
Vertical Farm Italia	Vertical Farm Italia is a multidisciplinary group that welcomes within itself all the many skills necessary to realize complete projects of self-sufficient vertical gardens. Thanks to the experience gained in the field and the constant research work, we have developed an operational method that, combined with the close collaboration with the implementing companies, allows us to develop self-sufficient vertical greenhouses responding to the specific needs of the client. Vertical Farm Italia applies this wealth of knowledge to the particular context in which it operates, without preconceived notions or standardized products, so much so that it can operate not only in the agricultural field, but also in many other sectors (hotel, exhibition, school, social).
Mono’	Mono Premium Melon is a wholly Malaysian-owned company that focuses on locally grown melons. This company is involved in growing some of the world's finest melons, and it is all done with IoT technologies. The fruits are grown from the seeds of Arus melons, considered the most expensive melons in the world, that come from Japan.
Mahdi Alhindawi	Mahdi is from Abu Dhabi and does agricultural consulting and builds vertical farming systems; Mahdi specializes in building greenhouses but also tries to introduce technology for domestic installations such as on simple home terraces

Table 5. Brief description of the companies interviewed.

3.6 **Duration and coding of the interview**

To conduct this research work, 11 interviews were conducted, each with a key member of the company being interviewed, and in each of these the questionnaire previously shown was submitted to the interviewee.

In these interviews, there was a way to give each subject a chance to talk about their company and what technological innovations they used and then go to the heart of the research topic through the specific questions prepared as a result of the literature review.

The interviews lasted an average of about an hour, but to see in detail what were the during the interviews you can see the table 6 below:

Sigma Consulting	1:09:09
Arnaldo Caprai	58:14
Mono’	1:01:02
Vertical Farm Italia	1:41:41
Mahdi Alhindawi	1:03:28
Elaisian	49:58
Innogrow	1:02:20
NidoPro	1:22:58
Agrobit	40:50
WallFarm	1:30:18
Sfera Agricola	50:48

Table 6. Duration of the interview.

As for the coding of the interviews, they were coded through careful re-listening of the interviews.

I proceeded to transcribe them in order to identify what are the most important points that emerged within the discussions and in order not to miss any relevant information.

This work was done in order to identify precise clusters on which to then go on to base the breakdown of the exposition of the information obtained.

In the next chapter I am going to report what are the things that emerged from the interviews carried out grouped by clusters, that is, grouped by macro-themes and specific themes reporting what are the results obtained from the contact with these realities regarding the issues addressed in my research work.

4. FINDINGS

Regarding the findings of this research, I have decided to subdivide these according to the information that emerged during the interviews and according to what is the purpose of this research, this subdivision serves precisely to go and highlight and group some of the issues addressed in order to best proceed in the research work to then go and analyze and discuss them in the last part of this thesis.

However, it is important to point out that the subdivision I mentioned earlier was driven primarily by what was developed in the theoretical framework of this research work; in fact, the clusters identified go directly to each and every element present in the theoretical framework in order to create a strong and easy-to-analyze connection within the work to then go on to easily link the theory analysed in the literature review and the practical cases that emerged in the interviews.

Each element of the theoretical framework goes to group within it a series of elements that emerged within the interviews; the findings of this research work were therefore organized based on what are the key elements of the theoretical framework and for each element practical cases emerged in the interviews, therefore, for each element minor elements were found that will then go on to guide the final analysis.

For this reason, the clusters identified are as follows:

- Relative advantage
- Ease of use of technologies
- Technical compatibility and complexity
- Issues in the implementation of technologies
- Organizational changes required to implement these technologies

Within each cluster (macro-theme), there will then be specific themes that emerged during the interview that fall under that general macro-theme.

Therefore, as mentioned earlier, for each element identified in the framework, one or more specific themes were found within the interviews.

4.1 **Relative advantage**

During the interviews, it became apparent that there are many perceived benefits to farms or farmers as a result of implementing these technological innovations.

In fact, regarding the relative advantages over the traditional way of working in Agriculture, the positions of the interviewees were clear from the outset.

The users all agreed that they would not have implemented this new way of working and the new technologies of Smart Agriculture if there were no advantages over the previous way of working.

While, as for the manufacturers these were enthusiastic about their products and all agreed that they see a growth in the medium to long term of the market, thus an increase in profits between now and 10 years with a strong increase in customers of their technologies.

Within this cluster I have identified three specific themes, which are:

- Precision farming
- Reduced use of raw materials and human labour
- Healthier product made in a sustainable way

4.1.1 Precision farming

From the perspective of the benefits related to precision agriculture we see that the stakeholders who participated in this research work agree in identifying what are the benefits brought by the implementation of technological innovations and smart agriculture systems.

So, from this point of view, there was full agreement in the words of users and producers in identifying the benefits brought by precision farm in the field of agriculture; in the interviews the same kind of benefits emerged both from the words of those who offer innovative solutions to achieve these benefits and from those who use these technological solutions in order to achieve these benefits.

Among the main advantages that have been found as a result of the use of technologies such as sensors, probes or more advanced technologies for plant monitoring we have that of being able to know in detail what is the vegetative state of the plant, this allows to know in detail what to do and how to do it in order to increase the likelihood of florid growth of the plant and at the same time allows to reduce the number of interventions needed to go to repair unpleasant situations.

"Thanks to our decision support system, farmers know at any time if there may be any situations that go against the health status of the plants. In this way, they can prevent these problems and they do not have to act on it, and this allows them to make a more natural product with the use of fewer chemicals." (Elaisian – Producer)

Precision agriculture, in fact, has as its main objective to prevent certain plant diseases that could go to compromise the crop in order to increase the number of products harvested and therefore sales and revenues, at the same time these technologies allow to reduce the number of interventions to be made on the plant to recover the disease and therefore this leads to a significant reduction in costs.

"Our main objective is to prevent certain plant diseases that could go to compromise the crop in order to increase the number of products harvested and therefore sales and revenues of our clients." (Elaisian – Producer)

In addition, the non-loss of harvest is also an excellent factor as it avoids a loss of money that would otherwise have been unavoidable.

With the introduction of these technologies, farms have seen a dramatic reduction in crop loss, and this is a key factor in the current context in which we are facing great changes due to climate change, and agriculture is an industry that is highly dependent on the climatic conditions of our planet.

Among the technologies observed, to give an example, we have Lia, a product of WallFarm, which allows, among many things, to analyze water values in order to understand beforehand what are the nutrients values to give to the plant in order to make it grow in the best way and drastically reducing the risk of wrong growth.

In addition, artificial intelligence interfaces are implemented in such systems to analyze the millions of data collected in the servers and arrange the best ways to grow a particular plant and replicate those conditions whenever the same conditions occur.

One of the companies interviewed calculated that as a result of the introduction of monitoring systems, they found a reduction in water use of 90 percent, this means a huge optimization of the resources used for cultivation which was not only seen with water but also with the use of energy needed for lighting.

"Thanks to Nido, we found a reduction in water use of 90 percent, this means a huge optimization of the resources used for cultivation which was not only seen with water but also with the use of energy needed for lighting." (Mahdi Alhindawi – Adopter)

In fact, cultivation through these technologies leads to no longer having light problems as these plants are made indoors and this reduces the use of energy. Therefore, a reduction in the cost for the company, but also reduces the problem of seasonality and allows it to offer a healthier product.

Sfera Agricola for example, manages to produce tomatoes that do not have harmful substances such as nickel in them and this allows to offer a healthier and more sustainable product, in line with the goals for sustainable development dictated by the European Union.

"Thanks to technology, we produce tomatoes that do not have harmful substances such as nickel in them and this allows to offer a healthier and more sustainable product, in line with the goals for sustainable development dictated by the European Union." (Sfera Agricola – Adopter)

Indoor cultivation means that there is no presence of harmful substances that may be within the soil in the final product, moreover, these technologies used allow for the management of all the different nutrients in the crop and this allows for complete control over the growth of the plants, and this also allows for going to meet people who have food intolerances for example.

4.1.2 Reduced use of raw materials and human labour

Therefore, we have seen how a key issue is the reduction of resources used leading to a consequent reduction in costs for farms or farmers.

From the point of view of benefits related to the reduced use of raw materials and human labour, there was, again as in the previous point, a strong contact between the words of adopters and the words of producers of technological innovations in the field of smart agriculture.

In fact, although the issue emerged mainly from the words of users who talked about how their way of working has changed and how these technologies have enabled them to save money on certain aspects of production, producers were also aware of this factor by talking about this aspect as one of their strengths within the market, namely that of offering technological solutions that enable them to achieve certain results.

An example can be given by the fact that by irrigating less water, this resource is used less and therefore less use of it leads to a lower cost.

An example of this phenomenon was explained to me in detail by the company Sigma Consulting, which through their central software platform that uses artificial intelligence technologies linked to ground sensors, optical sensors and thermal sensors, as well as images acquired from ground drones, aerial drones and satellite images, offers its clients total and integrated coverage in order to support them in making decisions about their land to achieve maximum efficiency and minimization of risks.

"We offer our clients total and integrated coverage in order to support them in making decisions about their land to achieve maximum efficiency and minimization of risks." (Sigma Consulting – Producer)

This software platform that collects an infinite amount of data and then processes it with artificial intelligence in order to find the best solution for the farmer also gives information to the farmer about the direction of water, that is, the most efficient way to irrigate water in order to achieve faster and more efficient growth.

In addition, it has been observed how more efficient irrigation of fruit leads to fruit growing faster and thus being ripe and ready for sale sooner.

This allows the farmer to plant new fruit sooner because those that occupied the field previously were sold earlier than expected.

This means that in a longer time frame the farmer will sell more fruit and therefore have higher revenues.

The system also makes it possible to prevent certain crop diseases or pests that cyclically affect plants, these decision support systems in fact analyze the state of the plant and understand when the plant is most vulnerable and therefore when it needs to be intervened on to make it stronger and to avoid having to go and treat certain plant diseases.

This makes it so that the farmer can prevent instead of treating the plant and therefore there will be a lower cost because the farmer will use insecticides only when they are really needed, he will use less because he will not have to cover all the plants in his field but they are the ones that are particularly vulnerable but above all he will have at the end of the harvest a smaller amount of the crop that has become diseased and therefore he will have more crop to sell and therefore more revenue.

Another benefit that has been achieved with the implementation of a smart agriculture system is that of the reduction of personnel costs and the labour of the personnel themselves since much of the work that used to be done by human personnel is now done by the algorithms, so for example there is no longer a need for so many people going around the fields to check the ripeness of the fruit and in addition the few people working directly in the field also have to go around less since the bulk of the work is done by these algorithms, therefore, this drastically reduces costs for the farm and the manual labour to be done by staff.

"Through the introduction of Nido ONE v1, we have been able to optimize personnel costs by going to more efficient use of the resources at our disposal." (Vertical Farm Italia – Adopter)

4.1.3 Healthier product made in a sustainable way

Another of the main themes that emerged during the interviews is related to issues of sustainability and making a product that is healthier and made in a way that harms planet Earth and those who consume it as little as possible.

From the point of view of making a sustainable and healthier product, the interviewees, both producers and adopters, were perfectly aligned in talking about how in today's world it is most important to be attentive to sustainability issues, and that is why both producers and users operating in the smart agriculture sector pay a lot of attention to these issues; the former by trying to provide a product that can help customers as much as possible to make sustainable products and the latter by paying close attention to the agricultural production they make by trying to provide the market with products that are as healthy as possible, made with technological innovations that allow them to control any abnormal factors that could lead to the making of an unhealthy product for the end user.

This theme emerged from the very first interview in fact, conducted with Jacopo Teodori, CEO of WallFarm, where they talked about how they through LIA want to provide the market with a product that is sustainable and healthy, that allows the least number of pesticides to be used in cultivation, and that greatly reduces the waste of water, a resource that in recent years is becoming increasingly precious.

"Through the introduction of Lia, we want to provide the market with a product that is sustainable and healthy, that allows the least number of pesticides to be used in cultivation, and that greatly reduces the waste of water, a resource that in recent years is becoming increasingly precious." (WallFarm – Producer)

But the issue of sustainability was taken up in many of the interviews conducted, for example, Matteo Benvenuti of Vertical Farm Italia also spoke on the issue saying that their goal is to make our planet a better place and this can be done by acting sustainably through actions that can go, for example, to mitigate climate impacts.

Among these actions that are part of the development of a vertical farm system for example we have the reduction of food miles, thus the reduction of transportation that not only brings a cost benefit to the company but also brings a benefit to the planet through the reduction of emissions.

"Our goal is to make our planet a better place and this can be done by acting sustainably through actions that can go, for example, to mitigate climate impacts. We want to make cities more food self-sufficient through vertical farm systems and therefore consequently the goal is to make cities more sustainable thanks to technology." (Vertical Farm Italia – Adopter)

The goal of Matteo's company is to make cities more food self-sufficient through vertical farm systems and therefore consequently the goal is to make cities more sustainable thanks to these systems and technologies that enable so many natural and healthy food crops in a small space.

4.2 Ease of use of technologies

Another strength of these technologies must be ease of use; in fact, it has been observed that many companies have motivated their preference in adopting some technologies over others by the ease of use of these technologies.

In fact, from the point of view of the ease of use of these technologies, it quickly became apparent that this is an indispensable element for end adopters when choosing a particular product, and in fact there was a strong interest on the part of manufacturers of technological innovations in making products that are as easy for end adopters to use as possible.

So, from this point of view, there was full agreement in the words of adopters and producers in identifying this element like a key strength of these innovative technologies used in smart agriculture.

In fact, in the interviews this element emerged both from the words of those who offer innovative solutions for smart agriculture and from those who use these technological solutions in the field of agriculture.

For example, in this sense the words of Matteo Benvenuti of Vertical Farm Italia are very clear when speaking about NidoPro's product, namely Nido One V1: *"It is a product in which you have everything you need, from this you can control everything, and you don't need anything else." (Vertical Farm Italia – Adopter)*

Other customers of the company have also commented on this product, talking about its ease of use and how this system allows everything to be managed via a board that has multiple functions, including some relating to the switching on and off of light source systems.

In this sense, the use of smart plugs, which make the connection between different devices much easier, is fundamental.

By many adopters who have tried it, NidoPro's product has been described as: *"A professional bench-top fertigation set-up that allows multiple nutrient solutions to be managed efficiently and effectively". (Mahdi Alhindawi – Adopter); (Innogrow – Adopter)*

In addition, it emerged during the interviews that Nido's software allows you to control everything remotely and this is a key strength of the company as it allows farm managers to optimise their time by doing other activities related or unrelated to the business of farming.

For example, remote control is a key strength for Philipp Lee of Mono', who is able to control everything remotely and is able to make business trips in the meantime to install the same machinery in other enterprises in Malaysia.

Installation is also another strong point as this product installation lasts approximately 20 minutes and the whole procedure is guided and very easy to do; in addition, the product can be installed and taken anywhere due to its small and compact size.

"Thanks to Nido, I am able to control everything remotely and I am able to make business trips in the meantime to install the same machinery in other enterprises in Malaysia. I do these installations very quickly and the whole procedure is easy and takes approximately 20 minutes." (Mono' – Adopter)

Philipp Lee said it is very easy for him to carry out these installations around Malaysia and even easier to train those who will then have to go and use the product. Between the installation, the product presentation, and the training on how to use it, it takes about two hours, which is a very short time.

"The product can be installed and taken anywhere due to its small and compact size. It is very easy for me to carry out these installations around Malaysia and even easier to train those who will then have to go and use the product. The entire procedure, which includes installation, product presentation, and training on how to use Nido takes about two hours, which is a very short time." (Mono' – Adopter)

4.3 Technical compatibility and complexity

Another of the key themes that emerged within the theoretical framework and during the interviews was that related to the technical compatibility and complexity of these technologies, and it was essential to hear the stories of the companies, both on the manufacturers' side and on the users' side, in order to understand what were the technical difficulties and the benefits gained as a result of overcoming these difficulties for the companies interviewed.

Within this cluster I have identified two specific themes, which are:

- Everything is mechanised (Advantage)
- Technical capabilities (Issue)

4.3.1 Everything is mechanised

Another of the strengths of these technologies is that in these systems everything is integrated and mechanised to arrive at a given goal.

From the point of view of mechanization of systems and integration between different systems, it has been seen how this is a point strongly demanded by end users who need to incorporate these technological innovations within already operating systems.

For the same reason, precisely because of this motivation, the manufacturers of these technological innovations try to make solutions that are adaptable to all systems and can be easily integrated into any system already operating, both from the point of view of size and from the point of view of integration with other technologies, as we have seen for example with the insertion of smart plugs into certain technologies to facilitate this integration or in the creation of decision support systems that fully integrate with previously installed operating systems and other technologies used by the subjects.

From this point of view, then, we see how the aspect of integration between the introduced technology and the already operational system a key point in order is to have a successful implementation, and thus we see how there is full consonance between what is the point of view of adopters and the point of view of producers of technological innovations in the field of smart agriculture such as decision support systems.

These decision support systems for farmers are based on algorithms that return very accurate probabilities of a given event through constant monitoring.

An example is given by the weather station produced by Elaisian which constantly monitors the almond, olive and vine plants and then goes through an algorithm and various sensors that analyze data on climate, air and soil moisture, and also thanks to a rain gauge that analyses data on water, and also based on satellite images, to work out what is the best strategy for the farmer in order to optimize the use of resources, reduce costs and optimize production and therefore sales and revenues.

In this sense, everything becomes mechanized for the farmer who does not have to do anything but do what he is told by the algorithm and has no other thoughts as these technologies make sure that prevention is done on all plants and therefore there will be no need to go and buy fertilizers or do specific treatments to repair certain situations.

"Thanks to our decision support system, our clients do not have to do anything but do what he is told by the algorithm and has no other thoughts; there is no need to go and buy fertilizers or do specific treatments." (Elaisian – Producer)

It has been observed, by Elaisan's customers, how optimal use of this meter station leads to a 30 percent increase in production; also, you have this decision support tool available on application also available on phone that alerts us whenever there may be problems.

Finally, it was found that in addition to an increase in production, these systems lead to an increase in the overall quality of the product sold, also making it more sustainable as it is more natural given the lower presence of chemicals.

Here, some of Elisian's customer statements taken from the company's website that make these positive points about using their decision support system in Agriculture:

"Since 2017 we have been collaborating with Elaisian, which helps us h24 to monitor what is happening from day to day in our olive grove. The system allows us to have less waste and to act only at precise points. Given the era we are living in, I think it is really basic to have such a tool and marry technology in agriculture." (Olio ROI – Adopter)

"We have always wanted to combine tradition and innovation, and it was with this in mind that we decided to start in 2017 with Elaisian. The result to date has been excellent as it has allowed us to optimize the quality of the final product and harvesting operations." (Famiglia Malvetani – Adopter)

"We have installed the system with excellent results, very easy to use, extremely attractive and to be recommended to all farmers who want quality production. It is important for us to be able to predict the occurrence of diseases, but above all to optimize production and irrigation, to avoid waste." (Olio Canelli – Adopter)

"I would recommend this technology to everyone as it is easy to use, affordable for everyone, and most importantly, has a truly sustainable cost, for any type of company, from the smallest to the largest. You will realize that it will save you a lot of money and help you achieve quality that without Elaisian I think is difficult to achieve." (Olio Mazzarrino – Adopter)

"In 2018, we installed the Elaisian system and found excellent results in both overall management of the olive grove and prevention of Phyto-pathological attacks. Elaisian is a precision agriculture system perfect for olive farming." (I Benedettini – Adopter)

4.3.2 Technical capabilities

From the point of view of technical skills, this issue emerged mainly from the words of manufacturers who often found themselves having to explain in detail how to install equipment in order to avoid problems due to the lack of technical skills of the users.

From this point of view, it becomes even more important that the ease of use and installation of these technologies should be elevated to the maximum in order to minimize installation problems but especially problems in the use of these technological innovations in the field of smart agriculture.

This begins to be a critical research issue in that if not handled properly it can bring serious problems to the implementation of a technology innovation within a functioning system of agriculture.

From this point of view it was seen how there is discordance between the words of producers and the words of adopters, the former in fact, as mentioned earlier, try to offer their customers products that are easy to use and easily understood by them, however, it was noted that often these aspects are there but some customers still need support to use certain technologies due to lack of technical skills.

It was also revealed from the words of the manufacturers that many potential customers have not become end customers of the technologies because of the low propensity for technology, which is very high in the agriculture sector.

In fact, one of the main problems encountered in the implementation of these technological innovations is that related to the technical capabilities of the end customer who goes on to adopt the technological solution into their business model.

It has been observed that many of the people working in this sector do not have the technical skills to go and use certain technologies; therefore, this sometimes leads to insurmountable difficulties in implementing the same technologies within a business model already operating with the traditional methods of agriculture, it becomes difficult to go and connect what are these new innovative technologies brought by smart agriculture with the classic agricultural work methods.

Indeed, it has been observed that not all parties are able to install the aforementioned technologies quickly and this problem has not been overcome by all companies in an easy way; however, there are some companies that have nevertheless found a way to circumnavigate the problem.

Just think for example of the case of Sfera Agricola, they say that they had no problems in the implementation of technologies thanks to the know-how acquired with time but especially thanks to the help of specialized subjects such as specialized agronomists who already had experience with these issues and therefore with their support there were no problems, and this obstacle was overcome.

"We had no problems in the implementation of technologies thanks to the know-how acquired with time but especially thanks to the help of specialized subjects such as specialized agronomists who already had experience with these technologies." (Sfera Agricola – Adopter)

The issue of technical capabilities of end users is a key theme in this area of smart agriculture as it emerged during the interviews that ease of installation is a key issue that manufacturers focus on which is in high demand by end customers. Indeed, the latter prefer perhaps a product with fewer features but that is easy to use and understand.

This ease of use therefore is the fundamental goal of companies such as WallFarm, and NidoPro; these seek to give a product on the market that is the easiest for the end user to use and the easiest to install in order to minimize any problems.

This ease as a strong point was confirmed to us, for example, by Edwin, a customer of NidoPro, who said that he chose their product because of its ease of use and ease of installation as he considers himself to be someone who is not very technologically advanced as he has been in the agriculture industry for more than 30 years.

"I chose Nido ONE v1 because of its ease of use and ease of installation, compared to other systems I tried that I found more complicated." (Innogrow – Adopter)

Otherwise, a clear example of this situation transpired from the words of Mahdi who said: *"With Nido One V1 my life is much easier." (Mahdi Alhindawi - Adopter)*

Referring not only to the enormous benefits he has gained but especially to the ease with which he grows his business and the ease with which he has installed and uses the product.

Another example can be taken from the words of Matteo Benvenuti of Vertical Farm Italia, also a client of NidoPro, who says: *"Nido One V1 is very easy to install, in 20 minutes I did everything and also I can take it wherever I want to install it in other plants." (Vertical Farm Italia – Adopter)*

This last statement also refers to another of the strengths that emerged during the interviews, which is the compactness of the technology product that should makes it easy to transport and market.

In fact, it has been identified that a key point of the strength of Nido One V1 is the fact that this product is actually a very small block that easily connects to any smart agriculture system and that it allows you to have everything under control and have all the information you need at your fingertips, such as lighting management, fertigation, and irrigation.

Basically, you have everything under control from pH management to nutrient solution management and it is all, as mentioned earlier, totally automated.

And in addition, everything is connectable through smart plugs, which are the smart sockets that allow you to connect different devices in order to improve the functionality of the product and thus expand the range of benefits obtained.

In conclusion, it is important to say how despite the fact that the position of producers regarding this issue remains very much inclined to meet the needs of the adopter in order to provide technologies whose installation is as easy as possible, as well as we have seen in the above cases.

There are characteristics of the agricultural sector itself and those who work within it that mean that it is not always easy to implement such innovative technologies within an already integrated system, and this often turns out to be a strong barrier to innovative and technological change.

4.4 Issues in the implementation of technologies

As mentioned above, during the interviews, it became apparent that there are many perceived benefits to farms or farmers as a result of implementing these technological innovations.

However, it was also important to note how to achieve the benefits we discussed earlier there was an evolutionary path of implementation of the applied technology. In this sense, it was crucial to adapt the specific technology to the context in which it was going to be used.

This implementation process, therefore, did not always go smoothly and there are a whole series of factors that required adjustments or otherwise brought problems in the installation of the technology in an existing business model and the aforementioned factors are the ones we will discuss in the next pages.

Within this cluster I have identified two specific themes, which are:

- Energy consumption
- Connection

4.4.1 Energy consumption

One of the main problems regarding the use of these technologies is the energy consumption that these technologies make that inevitably has a cost; these technologies consume a lot of energy to operate, and farms are not always willing to accept this increased expense in order to obtain the benefits coming from the use of the same technologies.

In fact, the point of view related to energy consumption emerged mainly from the words of users of smart agriculture technology solutions, who spoke of this element as a downside of the technologies but which, unfortunately, has also been exacerbated in recent times due to the recent conflicts between Russia and Ukraine.

On this aspect, it has been noted that there is extreme consonance between the thinking of adopters and the thinking of producers in that all of these entities see high energy consumption as a fundamental aspect so many entities do not decide to implement smart agriculture technology solutions within their enterprises.

As a result, not all are willing to implement these innovative solutions because of this factor and the high related cost; therefore, this is a key factor that is considered when deciding whether or not to implement such smart agriculture solutions, and thus it becomes important to understand why the interviewed subjects decided to implement such solutions despite the presence of this barrier to entry.

However, during the interviews it became clear that many farmers are willing to accept this cost only after actually testing what are the benefits that these technologies can give, which is why among the companies interviewed there are companies that provide their customers with periods to test the technologies before going to apply that technology directly in the field.

In addition, the energy issue has become increasingly relevant especially after the recent events regarding the war in Ukraine, and the consequences are increasingly relevant on the smart agriculture sector.

Just think, for example, of Infarm, a 1 billion valuation company that raised 600 million euros with 1,000 employees that has had to lay off 500 employees in recent months because of this issue that is plaguing the whole world.

In addition, there are also many other small companies that have given bankruptcy.

"The issue of energy is one of the issues that has hit us the hardest in recent years. Just think, for example, of Infarm, one of the largest companies in the vertical farming industry that had several problems because of the war in Ukraine and its direct impact on energy prices." (Vertical Farm Italia – Adopter)

So, in this context, it is important to follow the advice of Andrea Carloni of NidoPro, who tells us that in this sector, companies require a lot of energy, and in order to make a sustainable business, you have to strongly consider the cost of energy.

"In the sector of Smart Agriculture, the use of technology means high energy use for companies; so, companies require a lot of energy, and in order to make a sustainable business, you have to strongly consider the cost of energy." (NidoPro – Producer)

4.4.2 Connection

However, one of the main issues that have been encountered in implementing a smart agriculture system is that of connectivity.

In fact, many of these technologies work only when connected to the Internet, and this turns out to be a problem in some remote places in the world where perhaps there is not such advanced connectivity.

The point of view of connectivity is a key point of the discussion that emerged most from the words of end users, who listed it as one of the main issues in implementing technological innovations in the field of smart agriculture.

So, on this aspect, it has been noted that there is extreme consonance between the thinking of adopters and the thinking of producers.

Both producers and adopters see a weak connection as a fundamental aspect so many entities do not decide to implement smart agriculture technology solutions within their enterprises.

However, as far as this issue is concerned, the manufacturing entities said they are aware of the situation and for this reason they try to find solutions to this issue, however, this is not always easy as much depends on where the equipment is placed and often nothing can be done to solve certain connection deficiencies.

For example, Sigma experienced this problem in offering its services in countries such as Ecuador, where in addition problems were also encountered related to electricity supply, in this country Sigma had to make a greater effort to succeed in its work and it took a close collaboration with the client to solve the problem through GSM connectivity technologies.

Obviously, these difficulties entailed higher costs of implementing the technologies; however, it was later seen that the benefits obtained satisfied the customer and thus were worth it.

"We experienced connectivity problems with one client in Ecuador and we had to make a great effort to succeed in our work; it took a close collaboration with the client to solve these problems and we do that through GSM connectivity technologies and in the end the effort paid off." (Sigma Consulting – Producer)

During the interviews, one of the first interviewees to expose this connectivity problem was Edwin from Innogrow, he was one of the first customers of NidoPro and he talked about how one of the main problems he had in implementing the Nido One V1 technology, implemented by Andrea Carloni's team, was related to the fact that without a stable connection the full potential of the said technology cannot be exploited.

"My first problems with Nido were to find a stable connection to have the product always working and connected in order to take full advantage of it; I had some problems in finding it, but the efforts made were fully rewarded by the benefits obtained at the end from the product." (Innogrow - Adopter)

The product allows the activity to be scheduled for weeks and therefore this continues to work even offline; however, this can only be done when the product is actually connected to a connection.

For this reason, Edwin talked about how one of his first thoughts was to find a stable connection to allow himself to have the product always working and connected in order to take full advantage of it; after this reflection, Edwin confirmed how the efforts made were fully rewarded by the benefits obtained from NidoPro's product.

4.5 Organizational changes required to implement these technologies

Finally, one of the key themes within the theoretical framework that emerged powerfully within the interviews is that related to the organizational changes required to implement such innovative technologies.

This theme emerged strongly and was recalled by all interviewees because the implementation of these technologies has always required changes and the focus that was made by all interviewees was to relate these changes to the sector where they are made, namely agriculture, which was defined by all as a sector that is very resistant to change and where it is therefore difficult to bring innovations such as those of smart agriculture.

Within this cluster I have identified two specific themes, which are:

- High investments
- Atmospheric and cultural factors

4.5.1 High investments

Another issue encountered is that related to the cost of these technologies; it is well known how these technologies require a high investment, not only for the energy it takes to run it, but also to remunerate the features of these devices.

On this aspect, it has been noted that there is extreme consonance between the thinking of adopters and the thinking of producers.

In fact, from the point of view of the investments required to implement innovative smart agriculture technologies, the end users of the technologies have shown themselves to be aware of the cost of these technologies, which is why it has been seen that they are willing to pay this high sum in order to obtain the benefits that the technologies bring with them.

On the other hand, fundamental is the understanding also on the manufacturers side in offering different solutions to meet what are the needs of the customer and to try to offer the same level of service, but at a lower cost.

A clear view of this situation was given by engineer Simone Cirocchi of Sigma Consulting who said: *"The business model of smart agriculture, equipped with these innovative technologies such as sensors, algorithms, and artificial intelligence, is not an adaptable model for every single investor." (Sigma Consulting - Producer)*

In fact, it is very rare to see small farmers decide to adopt such a solution and in fact the main customers they work with are consortia or large companies, which have great economic capabilities and can afford high investments.

This adoption then often leads to the desired benefits but often the cost to implement the desired technology within their business model is too high and does not allow small farmers to enter this market acting as a real barrier to entry.

To overcome this problem, companies such as Sigma Consulting have decided to adopt a dual business model with a different offering based on the type of customer availability:

- The first mode involves the sale of the technology and customized training for the company's employees who are going to use the technology.
- The second model, on the other hand, involves offering the service, i.e., Sigma offers its technology and its personnel for rent to the company that buys the service in exchange for the payment of a fee.

With the latter option, the cost of everything is greatly lowered and there is more flexibility on both sides to manage it in the best possible way and to be able to adapt to each individual situation and/or unexpected event.

The factor related to the cost of technologies is a key element to be considered in any business, and it becomes crucial to keep it under observation when talking about the use of such advanced technologies that have such a high cost due obviously to the high technological content they are made of.

In such a context, a decision regarding a single aspect of the use of these technologies can totally change the sustainability or otherwise of the business model and any adjustments to the original system have considerable costs that need to be considered.

For example, it emerged during the interviews how for one customer the introduction of a radio system into the overall system resulted in a considerable increase in costs that led the latter to reconsider the possibility of the economic operation.

"The addition of a radio system to the overall system resulted in a significant cost increase for one of our potential customers, which made the latter question the feasibility of the economic operation and led to the cancellation of the implementation." (Sigma Consulting - Producer)

In addition, it must be considered that the implementation of technologies in smart agriculture systems does not have immediate results, which is why it must be considered that these technologies are long-term investments, and it takes time to see the expected benefits.

However, this is a factor that is not always easy to understand, and it is often the task of the company providing the technology equipment to explain these phenomena and make the farmer understand the importance of waiting, which will be deeply repaid by the final results of the implementation.

4.5.2 Atmospheric and cultural factors

Another factor that should be strongly taken into account when deciding to adopt smart agriculture systems with such technological innovations is related to the fact that one must also take into account the geographical location of where these technologies and systems are implemented since each country in the world has different territorial, cultural and atmospheric characteristics that can lead to different consequences that must be carefully analysed in order not to have bad surprises as a result of the implementation of the aforementioned technological innovations.

This point of view was expressed by both sides (producers and users); in fact, it was found that the agriculture sector is highly dependent on atmospheric factors, and even if some technologies allow to limit these factors, many of them always strongly influence agricultural production.

In addition, the central theme that emerged is the cultural one, in fact, from this point of view the producers spoke about how the one where they operate is a sector characterized by strong barriers to technology, where agricultural producers hardly use production methods other than the traditional ones and therefore those who do are innovators, who see a little further and have more initiative.

This characteristic also emerged strongly from the words of users who are users of technological innovations, who said they were aware of this situation in the agricultural sector and therefore deeply agreed with the words of producers.

These factors, such as atmospheric factors, bring with them a whole series of risks that need to be managed such as humidity, rain, strong wind that could destroy the drones and therefore these risks need to be carefully analysed in order to prevent them or at least try to manage them.

Among these risks much has been observed by the company Sigma who through the words of engineer Simone Cirocchi said that it happened that during the testing of a system the drone broke down due to offensive environmental factors.

"Regarding some issues in the implementation of these technologies, for example, it happened that during the testing of a system the drone broke down due to a thunderstorm." (Sigma Consulting - Producer)

In addition, one of their major clients is in Ecuador where they produce bananas through smart agriculture systems and there it is very common for drones or sensors put in the field to be stolen by bandits in the area.

So, for example, this is a factor that has been strongly taken into consideration in that area and for which adjustments have been made at the security level in order to avoid or at least decrease this phenomenon.

Another issue that needs to be taken into consideration, as mentioned earlier, is that related to environmental factors, the system developed by Sigma for example uses satellite images and these go against clouds; that is, in the presence of clouds the satellite image is not clear and therefore easy to understand and for this reason in a country where there is high frequency of clouds in the sky this factor needs to be taken into high consideration.

However, problems such as these can be easily solved through the use of more advanced technologies, but which require a higher investment. For example, the problem of satellite imagery related to clouds can be easily circumvented through the use of SAR satellite imagery, i.e., imagery provided by a synthetic aperture radar, these technologies are very advanced and have no problem providing clear and defined images even in the presence of a lot of fog and clouds.

"Regarding some problems related to the implementation of these technologies, our system for example uses satellite images but in presence of clouds the image is not clear and therefore easy to understand. So, in a country where there is high frequency of clouds in the sky, we circumvented the problem through the use of SAR satellite imagery, but the use of this more advanced technology requires a higher investment for our clients." (Sigma Consulting - Producer)

Finally, it is interesting to include in the discussion the issue of the knowledge and propensity of adopters, or at any rate the general population, to adopt certain

innovative technological solutions in the field of agriculture in order to implement so-called smart agriculture.

In fact, despite its undoubted advantages, which have been exhaustively found and expressed in this research work, we saw in the literature review of this paper how smart agriculture is struggling to spread in Italy.

This situation is expressed by the data; in fact, it has been observed, according to data released by the Smart Agrifood Observatory of the Politecnico di Milano, that only 3-4% of agricultural land in Italy is cultivated with 4.0 tools.

Therefore, in this sense it becomes crucial to discuss qualitative factors that may be behind this lack of implementation in our country, and among the issues most discussed and that most emerged within the interviews we have the cultural factors peculiar to the agriculture sector that are seen as a strong barrier to entry to the entry of new players in the market willing to implement smart agriculture techniques or to the possibility that traditional farmers can implement their classic way of working to try something more innovative and experimental.

This cultural theme emerged in almost every interview and not only from protagonists of Italian descent; in fact, one of the first interviews in which this theme emerged is the interview conducted with Philip of Mono', who told us how one of the questions he has asked himself during his entrepreneurial life along with his colleagues is as follows: *"Why don't people use technology in agriculture?"* (Philip Lee – Adopter)

This is the question that we also want to answer with this research work and Philip's contribution was key in this regard; he has been in the agriculture sector for many years and told us how through his knowledge and through another company, which is called Irritec Technical Support, to help local agricultural producers in Malesia to implement smart agriculture solutions in their farms, if these are suitable of course with the farm.

Joseph's goal with this other activity is precisely to spread the use of innovative smart agriculture systems within the Malaysian country as he, after being pleasantly surprised by the benefits these technologies have brought to his company, wanted to help other businesses gain these benefits.

This activity allowed Joseph to get to know many people working in the field of agriculture and ah enabled him to develop very elaborate thinking on this particular issue.

He found that most of the problems in the implementation of these innovative smart agriculture technologies are mainly related to the activity of using these technologies, which turns out to be rather challenging for local farmers, and the reason lies mainly in the lack of skills of these individuals.

Joseph, however, expressed to us by talking about how in his opinion it is not totally the fault of these individuals who do not really understand the use of certain technologies, but it is also due to the system of the country in which he lives that does not help these individuals through activities that can foster awareness of these innovative technological aspects.

In addition, the farmer population in Malaysia is typically composed of people who are very advanced in age who are 40 to 50 years old and up, and this is not very conducive to the diffusion of these technologies as *"These people are not liked to use technology".* (Philip Lee – Adopter)

"They refuse to use IOT system". (Philip Lee – Adopter)

In this sense, therefore .it becomes very difficult for there to be widespread development of smart agriculture technologies as there is precisely a rejection of the prevailing population of farmers towards their use and this idea becomes difficult to blunt even following the demonstration of the benefits that these technologies can bring as these people are firmly convinced of their position and are not willing to change their minds, but prefer to continue working with traditional methods trusting their opinion more than the opinion of a machine.

In addition, Joseph spoke to us about how in his personal opinion this is not the only problem why there is no development of these technologies but there is another very important problem concerning school education in his country.

In fact, Joseph recounted how in Malaysia there is a really low level of education, and this goes against the implementation and use of innovative technology systems such as IOT systems which require a lot of technical skills

and therefore a lot of technical staff to be implemented as there is a need for skills to understand and use these systems.

This situation in addition to being a strong barrier to the implementation of these innovative technologies now, it also assumes a key role from a future perspective as without a commitment from this point of view it will be very difficult for the situation to change.

The next generations will always be resistant to change and unlikely to accept the idea of adopting these technologies but will always prefer to use traditional farming techniques in the absence of real knowledge of the innovations and advantages in the field of smart agriculture.

In this sense, therefore, support from local organizations to foster awareness and implementation of these technologies through study, cultural programs, events, and government incentives becomes crucial.

Or, the solution becomes to provide IOT systems that could be simple, easy and adaptable for farmers who were willing to try the way of smart agriculture, and that is what he decided to do, which is to use his skills and knowledge in order to be a solutions provider in the field of smart agriculture but in this sense the whole thing has to start from entrepreneurial and individual initiatives and in this way it is all more difficult.

For example, Joseph to address this issue with his company collaborates with the Malaysian government department of agriculture in order to organize events to show their demo farms and do exposure for farmers with the aim of raising awareness of these issues and introduce them to technologies that they would not have really considered before or did not even know existed.

As mentioned earlier, this issue came up not only in a few interviews but in almost all the interviews conducted, and so this makes us realize how this is a hot topic in the discussion around the implementation of Smart Agriculture systems.

Among the people who have been most vocal on this issue we find engineer Simone Kartsiotis of Agrobit who told us how, in his personal opinion, the

agriculture sector is one where there is little open-mindedness regarding the use of these technologies, many farmers prefer to use traditional farming methods as they do not trust the workings of machines and consider these just a waste of money.

While it would be enough just to make them better understand what are the benefits that these technologies bring to perhaps convince them to adopt certain innovative solutions, they should be shown the results that are obtained as a result of implementing Smart Agriculture systems and the increase in efficiency that these bring not only from an operational point of view but also from the point of view of the quality of the final product.

This process that could lead to the increased use of Smart Agriculture solutions, however, according to Simone is a slow process that could take a minimum of 7 years and is totally based on the exchange of information that is generated on these technologies.

These timeframes are due to the inherent characteristics of the field of agriculture in which to see and analyze continuous and stable results regarding crops takes time, but mainly because getting certain ideas and aspects understood by people who are not familiar with these issues is a process that must be approached very calmly and patiently but that in the long run could bring excellent results.

Another very clear example on this culture issue was provided to us by the Arnaldo Caprai company, and in my opinion their point of view is very useful to include in the discussion.

The head of the research and development area of this company, Mattia Dell'Orto, spoke to us about how theirs is a very innovative company that seeks to continually introduce new technologies within their production system to keep up with the times and constantly improve to the quality of the wine from their vineyards.

However, Mattia explained to us how following the implementation of these innovative technologies there are a whole series of cultural obstacles that take

up a lot of time as it is necessary to explain the innovations introduced to employees each time.

This path of introduction to technologies, however, is a fundamental step that cannot be skipped for the successful implementation itself, this process is very difficult and delicate as workers perceive the introduced technologies as something extra that is not useful for their work and therefore is superfluous and, for this reason, they reject the innovation.

However, it has been seen how proper implementation of this process of technology knowledge diffusion leads to successful implementation in all cases tested and eventually the workers themselves find it impossible or at any rate much more difficult to work without that particular implemented technology and find themselves wondering how they used to do without it.

In conclusion, it should be noted that these technological innovations used in the field of Smart Agriculture take advantage of very advanced and mature technologies, so it is most important to have a transfer of knowledge about these to the people who have to implement them.

If there is not this knowledge connection between actors producing the innovative solution and actors adopting it then this can be a major obstacle to the implementation of such innovative technologies.

In this sense, it was seen during the research work how crucial it is to have dedicated people or team to manage these technologies and who have technical skills in this field, there is a need for figures who help in the implementation of these technologies, otherwise the implementation of an innovative technology will never be successful or in any case if you manage to implement the technology in a working system, in the absence of these figures, you will most likely have problems with its use in the long run.

4.6 Respondents' positions on the issues covered in the interviews

Finally, before moving on to the analysis and discussion of the Findings it is necessary to provide an insight into what are the positions of each interviewed party for each of the topics covered within the interviews so as to better comment later on commonalities and differences between the issues that emerged from the words of the various interview subjects, both on the manufacturers' side and on the users' side.

It should be pointed out, however, that these two different categories of subjects are very homogeneous within themselves; in fact, it was observed that within each of these two macro categories, the companies interviewed had very similar characteristics, both in terms of the size of the company, the product offered, and the type of market served; moreover, the people I spoke with were all very young, which shows the tender age of the innovations made in the field of smart agriculture.

For this reason, for the sake of simplicity of analysis, in order to encapsulate the positions of these two categories of subjects, the analysis of this research work was limited to confronting the positions of the subjects producing smart agriculture technological solutions and the subjects using these technological innovations in order to provide a simplification of reality useful for the analysis to best pursue the objective of this research work.

In order to best accomplish this work, I have summarized what are the positions of each side of the interviewees regarding each topic covered within the following tables, which were divided according to the clusters identified through the analysis of the interviews and the support of the theoretical framework.

The final purpose of these tables is to go and divide the analysed elements between what are the advantages and relative opportunities given by the use of these technologies within the agricultural sector from the disadvantages related to the use of these technologies, going to summarize what are the positions of

users and adopters relatively to certain issues in the use of these technological innovations peculiar to the world of Smart Agriculture.

Precision Farming	All the participants of the research on precision agriculture unanimously recognize the advantages that arise from the adoption of technological innovations and smart agriculture systems.
Reduced use of raw materials and human labour	Both adopters and producers emphasized the benefits of reduced raw material and labour usage. Adopters mentioned the positive impact on their workflow and cost savings, while producers highlighted this aspect as a market strength, offering technological solutions for desired outcomes.
Healthier product made in a sustainable way	Interviewees unanimously emphasized the importance of sustainability and healthier products in the context of smart agriculture. Producers aim to offer sustainable solutions, while users prioritize healthy agricultural production. Both parties utilize technological innovations to control any factors that could compromise product quality and end-user health.
Ease of use of technologies	Ease of use is a critical factor for end adopters in selecting smart agriculture technologies. Manufacturers prioritize creating user-friendly products to meet this demand effectively.
Everything is mechanised	End users emphasize the need for mechanization and integration of smart agriculture systems into their existing operations. Manufacturers respond by developing adaptable solutions that can easily integrate with various systems, regardless of size or compatibility with other technologies.

Table 7. Respondents' positions on the issues covered in the interviews (Advantages)

Technical capabilities	Technical skills play a crucial role in smart agriculture, particularly highlighted by manufacturers who often need to provide detailed installation instructions to address users' lack of expertise.
Energy consumption	Users of smart agriculture technology solutions expressed concerns about energy consumption, considering it a drawback of the technologies.
Connection	Connectivity is a major concern expressed by end users in implementing smart agriculture technologies. Manufacturers acknowledge the issue and make efforts to address it, but resolving connectivity deficiencies can be challenging, as it is influenced by equipment placement and sometimes beyond control.
High investments	End users are cognizant of the investment required for implementing smart agriculture technologies, yet they are willing to pay for the associated benefits. Manufacturers recognize the importance of providing diverse solutions to meet customer needs and strive to offer comparable services at a lower cost.
Atmospheric factors	Both producers and users in the agricultural sector acknowledge the significant impact of atmospheric factors on agricultural production. While some technologies can mitigate these factors to some extent, their influence remains substantial.
Cultural factors	Cultural barriers were also highlighted as a key aspect, with producers emphasizing the sector's resistance to technological adoption. However, users of technological innovations and producers agreed on the importance of overcoming these barriers and recognized the role of innovators who embrace alternative production methods.

Table 8. Respondents' positions on the issues covered in the interviews (Problems)

5. DISCUSSION AND ANALYSIS OF THE RESULTS

In the final chapter of this research paper, I am going to go on to discuss on the basis of the theoretical framework developed earlier the relationships between what I have found and the relationships between what I have found and what we already have learned from the literature review.

In this way I am going to highlight the congruence factors and differences between these different aspects in order to answer the research question that is: *"What are the perceived advantages and the barriers in introducing technological innovations in Agriculture?"*.

This paper serves not only to highlight these aspects but also to go and highlight what are the new aspects that have emerged as a result of this study.

First of all, however, as anticipated, the research question of this paper must be answered, and for simplicity of analysis, it was decided to answer the first part of this question first, namely: *"What are the perceived advantages in introducing technological innovations in Agriculture?"*.

5.1 Perceived advantages

As far as the advantages of implementing innovative technologies in agriculture are concerned, we have seen that these mainly concern an increase in production and a decrease in costs through the minimisation of events that may represent costs in the short or long term for the farmer.

These technologies, in fact, bring the support to the farmers' decisions to the maximum power since the integration of these technologies allows to obtain optimal analyses which can lead the machines to elaborate by themselves the optimal strategy for the agricultural system analysed, eliminating any possibility of error through data analysis. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

A precision farming system, in fact, makes it possible, for example, to prevent certain plant diseases that can lead to loss of production, the intervention of an

agronomist, or intervention with chemical solutions; all scenarios in which the farm has to face costs in order to repair certain situations.

A software platform, on the other hand, makes it possible to automate a whole series of activities that are already present in the minds of farmers but that through the use of artificial intelligence and specific algorithms are perfected in order to function at their best, predicting and anticipating possible damaging events for crops.

Thus, these systems, in addition to reducing costs for the farm, drastically reduce the mental and physical work that the farmer has to do because all the work he had to do is now totally managed by an integrated technological solution that through the use of drones, sensors, satellites and algorithms manages to acquire crop data and then analyse it in order to do the same work that was done in the traditional way but more efficiently.

It becomes essential to use new methods of agriculture to be more efficient, as traditional agriculture based on manual labour was characterised by a low productivity. To take a step forward in productivity, the incorporation of technology within traditional agriculture was crucial; the application of technological innovations brought about a significant increase in productivity and efficiency. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Among other benefits we have observed that are achieved through the implementation of a smart farming system we have:

- Reduced use of human resources therefore less wages and less costs.
- Reduced waste of water and energy therefore reduced costs related to the supply of these two elements.
- Automation of the management of operations through digitization leading to an efficiency of work.
- Increased production and consequently revenue.

Therefore, starting from this last point, it was seen how through smart agriculture systems and technologies a more profitable business can be achieved than the traditional way of farming.

In fact, this new type of agriculture uses technology and data processing to optimise agricultural processes and achieve better production standards, while also reducing human labour and inefficiencies. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

Most of those interviewed talked about how this new way of doing agriculture is much more organized and technical than before, starting with the organization of the farms themselves which are organized in a more systematic way and therefore this allows for better planning of resource use, and this results in better utilization of resources and optimization of production.

Many interviewees talked about how drastically the way of doing agriculture has changed, now there is much less use of hands, even with these new technologies there is no need for good soil or even a good environment as crops can be grown indoors or even in industrial settings, just as if you were making a factory.

In fact, smart agriculture should enable better management of resources, thanks to the optimization achieved with the help of the aforementioned technologies, so this should lead to better land use and lower environmental impact, in fact it is well known how this smart agriculture revolution is fully in line with what are the new sustainability parameters of the modern world. This new type of agriculture has brought countless benefits over the traditional way of farming, now the main goal of every farmer is to optimize the resources he or she has in his or her possession and use these accurately in order to achieve the best possible result, and all this is possible thanks to the use of all these technologies that are so different from each other. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

These new technologies even make it possible to control the weather inside indoor crops, as well as lighting and heat sources; this means that everything can be adjusted and regulated so that production is better, as well as more controlled from a food safety standpoint, fully in line with the goals for sustainable development.

In summary, these technological solutions are a real shortcut to the traditional way of working, which is wasteful and done by a lot of manual labour.

These technologies make everything automated that was previously done manually, and this leads to an extreme simplification of work and a reduction of waste, for example, it has been measured that through the implementation of such technologies a 90 percent reduction in water consumption can be achieved.

A smart agriculture system allows the farmer to manage as many litres of water as are needed for two weeks of crop water management, this allows the farmer not to have to put in a lot of hands-on time as these devices make everything automated.

This brings several sensations to the farmer's mind among which we have:

- Feeling of having a guaranteed result.
- Feeling of security with respect to the success of the crop.
- Feeling of realizing better production and therefore producing better plants.
- Feeling that everything is going in an automated way and therefore there is no need for constant intervention.
- Better time management as it seems that the whole farming machine is working by itself.

Regarding this last point it is possible to give an example by taking an example from the words used by an interviewee who told how thanks to these technologies he is able to manage his business and his time in a considerably better way and as far as agriculture is concerned, he only takes care of putting water inside the system and also this operation is carried out when wanted.

These systems are totally connected to the Internet and through a simple connection you can control your crops at all times, this greatly increases the sense of control and security, this implies that you do not have to be physically present all the time and you can better manage your time, you can go on the road and do everything remotely through a connection and a phone.

These technologies make it possible to control everything from plant growth to crop ph., temperature, and water; and there is no longer a need to do this manually, but everything is done automatically by a robot.

Now everything is flexible and customized, everything can be controlled at the touch of a button, and sometimes you can allow the technology not only to do the analysis but also to make the decisions for the farmer in order to optimize production.

For example, it has been seen through interviews how many customers feel that these technological products made their lives easier, making the fertigation bench much more efficient through the implementation of this stable control unit that makes everything perfectly integrated and functional, at the right cost according to the adopters of the same product.

These types of ready-to-use systems are very simple and intuitive both to use and to assemble and provide, as mentioned earlier, the ability to have everything at the touch of a button on one's smartphone; this allows the farmer to manage his or her crops with high convenience as this control unit does 80 percent of the work.

Practicality is one of the key perceived advantages for those who implement such innovative technologies imprinted with smart agriculture; in fact, after implementation there are enormous benefits guaranteed by this practicality, first and foremost through the use of smart-plugs and apps, different systems can be integrated that allow for careful planning of agricultural activities, and this planning allows for established costs for the enterprise.

This allows for fewer problems and also from a maintenance point of view, having everything pre-established allows for fewer interventions and therefore lower costs for this practice.

Finally, another of the benefits perceived by the subjects as a result of the implementation of a smart agriculture system concerns the aspect of sustainability, through these systems in fact, an optimization of chemical and agronomic inputs can be achieved, which allows the production of more natural and sustainable products that are well seen not only within the farm but above

all give a good image outside the farm itself by increasing the intrinsic value of the farm and improving the consideration that external companies have relatively a particular agricultural activity.

Therefore, the implementation of such innovative technologies has a strong marketing value as it directly acts on the reputation of the company that made this decision.

5.2 **Barriers**

Now, the second part of the research question of this paper must be answered, namely: *"What are the barriers in introducing technological innovations in Agriculture?"*.

Regarding the barriers in the implementation of these technological innovations in the field of agriculture, it is important to specify how with the term barriers we go to indicate any problems or possible disadvantages encountered precisely in the implementation of these technologies.

First of all, one of the main aspects that emerged in almost all the interviews, in full correspondence with what we had read in the literature review regarding these topics, is that concerning the aspect of connectivity.

In fact, we have seen in the literature review how connectivity is a key aspect to foster the implementation of smart agriculture systems; otherwise, without the presence of considerable connectivity this can become a strong obstacle to the implementation of the said technology.

The presence of data brings some limitations to the use of these technologies, the first one is about the connection that needs to be very powerful to process them. (Khattab, Abdelgawad, Yelmarthi; 2016)

During the interviews it became clear that the biggest problems in the implementation of these technological innovations are related to connectivity; in fact, it was seen that in some countries where it is not possible to have a stable connection this factor led to the failure of the implementation of these technologies.

Technologies obviously need to communicate with each other, so connectivity and communication between these technologies becomes critical to the optimal operation of the smart agriculture system.

The network concept becomes fundamental here, and any problems related to connectivity could create many problems in the implementation of a smart agriculture system.

In addition, these problems are also very common in rural areas, where farmers and ranchers often develop their businesses. A fast Internet connection is almost never available in these areas, and without it becomes difficult to implement such a system. (Precision Agriculture Challenges)

The issue of connectivity can be solved through the use of more advanced technologies that make it possible to get a stable connection to even the most remote countries in the world.

The last few years have seen significant advances in terms of connectivity and hardware power, which has allowed a reduction in dependence on the Internet connections. (López-Riquelme, Pavón-Pulido, Navarro-Hellín, Soto-Valles, Torres-Sánchez; 2017)

However, these types of technologies have a very high cost, and it is rare that an entity decides to incur these costs to overcome this issue.

In fact, a major challenge of smart agriculture relates to the need for substantial resources to implement a smart agriculture system. Indeed, it has been observed that many farmers do not have the capacity to make initial capital investments to implement such a system, and the phenomenon is even more prevalent in rural areas of developing countries where farmers work with very low profit margins and here there is just not the economic availability to invest in the technologies needed to implement a smart agriculture system. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

The issue of cost is a central theme in any business decision, and it becomes even more so when you need to change your business model in order to implement a technology that will innovate your existing business model.

One of the main problems associated with the implementation of these systems is the cost of installing these technologies. (Kumar Ram, Ranjan Sahoo, Bandana Das, Mahapatra, Mohanty; 2021)

In fact, the issue of cost was addressed in almost all of the interviews, and it was noted that the general knowledge is that these technologies have a rather high cost because they precisely represent technological innovations that bring significant improvements over the classic traditional method of working in agriculture.

However, the issue of costs cannot be treated so simply but must be analysed in depth to understand the dynamics that may be moving behind it; one of the most interesting aspects that emerged during the interviews was the fact that many companies producing smart agriculture solutions changed their business model in order to go out and offer a better solution to their customers that could better marry with their economic needs.

For example, there may be provision for offering a service rather than selling such technologies in order to lower costs for both parties, producer, and end user.

In fact, the former will be able to reuse his equipment once he has finished providing the service to the adopter while the latter will pay a commission only for the time he wants to use such technologies.

The issue of cost is particularly sensitive because, as noted by every producer of these technological innovations in the field of smart agriculture, after outlining the benefits that the proposed technologies can bring the first question is always about the cost of these technologies, so this is always a first hurdle to overcome in order to start implementing these technologies.

This initial aspect is crucial, and it is equally crucial to make it clear to the adopter right from the start that to see results as a result of implementing these smart agriculture technologies takes time and that you do not immediately get what you want, and this is due precisely to inherent characteristics of the agriculture sector.

In this area, in order to have initial results following the implementation of these technologies there is a need for a long acquisition of data and images relative to the crops, and often a full cultivation cycle must be completed to touch the benefits, and this can sometimes take up to six months.

These technologies bring the support to the farmers' decisions to the maximum power since the integration of these technologies allows to eliminate any possibility of error through data analysis but there is a need for the processing of a huge amount of data to optimise agricultural processes and achieve better production standards, while also reducing human labour and inefficiencies. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

These technologies can lead to the optimization of inputs used in the agricultural field but to do that there is a need for the processing of a huge amount of data and every single thing must be executed in detail so as to optimize resources, time, soil, and any aspect that revolves around the cultivation of any natural product. (Rizzi, Santamauro, 2021)

For this reason, as anticipated earlier, many companies producing these technological innovations offer different business models, trying to give the opportunity to everyone to make these implementations, even those who do not have the ability to purchase the said technologies, for these types of people the offer of smart agriculture service is provided in exchange for payment of a commission as long as this service is used.

Otherwise, another solution to try to solve the problem and meet the needs of adopters is to offer a trial period of the technological innovations to adopters; in this way, another of the main problems encountered in the implementation of these technologies can also be solved, namely that of the adaptations to be made to best integrate the innovation within the existing business model.

In fact, by offering a trial period, we are able to best accompany the adopter in the first phase of implementation and this allows us to define together what are the aspects that need to be adapted to the context, which are precisely identified in this first period of experimentation that is done together.

In order to avoid problems that may occur in the race, in this first trial period we are going to adapt everything according to the specifics of the individual customer and individual requests so that a customized solution is made based on the customer's needs that does not have to be readjusted in the future.

In fact, one of the main problems regarding the implementation of these smart agriculture systems and the innovative technologies that are part of them has turned out to be the lack of flexibility of the end product, these innovative products must adapt to the characteristics of the end adopter otherwise the implementation of such systems will never be successful.

The issue of flexibility and adaptability of the technologies is crucial as it emerged a lot during the interviews how a large scale product cannot be suitable for companies that do small scale production and conversely; this implies that the systems have to adapt and also consequently the technologies that are part of them otherwise it becomes difficult to manage solutions created to solve certain problems but to solve different problems from those for which they were created.

This new type of agriculture has brought countless benefits over the traditional way of farming, all this is possible thanks to the use of all these technologies that are so different from each other and thanks to their integration with each other and with the system where they are to be inserted. (Mitra, Vangipuram, Bapatla, Bathalapalli, Mohanty, Kougianos, Ray, 2022)

So, a smart agriculture system that is suitable and can be successfully implemented within a farm for example has to be carefully adapted to the farm through even tentative processes in which it is tested and repeated until a suitable and best solution is found to handle that particular situation.

Some of the factors that can influence these adaptations may be, for example, the different weather conditions one has from one country compared to another, or simply the different cultural characteristics between the countries themselves, or there may be different settings that need to be implemented accurately in order to take advantage of the product in a given situation.

To do these adaptations, there is a strong need to be very precise and technical, but there is also a need for strong help from the technology itself that is implemented, which needs to be flexible and adaptable to the various different contexts that arise, all without ever forgetting the quality that must be kept high in order to make an excellent product.

An example of the adaptation that had to be made in order to implement the technological solution within an already functioning system was provided to us by Mahdi who talked about how he was not okay with the fact that the algorithm decided everything, specifically the problem concerned the irrigation system that is fully managed by the algorithm.

The latter, therefore, decides how many times the plant should be irrigated, and if the farmer wants the system to perform an extra irrigation cycle this is not possible; moreover, in this structured system the farmer does not even have the ability to decide when these irrigation cycles should be carried out.

Based on these observations it can be seen that therefore for a successful implementation of a given technology there is a need to give a minimum of autonomy to the farmers with these systems so that they can have the support of the technological system but at the same time ensure that they can carry out as many irrigation cycles as they want and ensure that they can do them when they want to, without any limitations.

Another aspect that can be used as an example at the basis of this part of the discussion is related to the delivery of solvents within the soil, it was observed that even for the division and delivery of solvents everything is totally managed by the algorithms.

In this way it is not possible for the farmer to divide the solvents in a different way than the algorithm provides and therefore it is not possible to make ad hoc adaptations; in this sense it was seen how many of the interviewees solved the problem through the implementation of an additional system connected to the main one in order to regulate only that particular aspect.

Or, for example, other problems in implementation were experienced by other adopters regarding the webcam or the light dimming system, and these were solved through integration and use of other smart agriculture systems.

Therefore, in this sense in order to succeed in the total implementation and integration of the above technology there was a need to implement an additional application aimed at solving the problem of the query system and water mix.

So, the implementation of a manual option within these systems can provide farmers with a degree of autonomy that meets their demands, which is why the inclusion of a button that allows them to manage a particular aspect through an on/off system could also be critical to an easier and more successful implementation of the technology.

However, the fact remains that these adjustments can also be made in relation to the manufacturer of the implemented technology itself; in fact, cases have also been observed where there was a need to make adjustments from the starting system, and these were made as a result of a chat and collaboration of both parties.

This is the example of the collaboration between Vertical Farm Italia and NidoPro, in fact, in this case it was observed how the execution of particular ad hoc adjustments for the specific case of the aforementioned adopter led to an increase in the functionality of the control unit.

These smart agriculture systems are built to be rigid systems but this is done deliberately by the manufacturers of these solutions in order to make systems that are simple to use, ready to use, and easily adaptable; however, this system makes the final product suitable for all situations but to work best in any given situation it must, as mentioned earlier, be adapted according to specific needs and requirements.

However, rigidity is seen as an advantage by producers of these innovative technological solutions because this allows them to have a standard product with stable costs and with which it is easy to do work planning.

Rigidity makes it possible to have a product that adapts to all situations and that even though it cannot do everything manages to do many things in most situations.

This element of rigidity brings multiple advantages to the manufacturer in that it allows him to have fewer problems during implementation since everything is more standardized and at the same time with such a product the maintenance of the product itself becomes easier since it is generally always the same elements that need to be adjusted.

However, as anticipated, sometimes all this rigidity and simplicity does not fully satisfy the customer, who perhaps in certain solutions would prefer to have a product designed specifically for their needs with the implementation of more difficult elements, such as the usefulness of smart plugs, which are very practical and inexpensive, has been observed, but some adopters have expressed a desire to perhaps have something more elaborate and controllable, such as an actual electrical panel.

In conclusion, with regard to this issue of the rigidity and adaptability of a smart agriculture system therefore, it is understood that there is a need to carefully manage this trade-off between what is a standardized product aimed at satisfying multiple demands and the individual demands of each adopter so as to obtain the benefits of both situations.

Indeed, it has been seen that the rigidity of these innovative technologies brings countless benefits but at the same time it is important to meet the individual demands that arise so as to have successful implementations of these technologies because as mentioned in advance each situation is different and therefore these technologies must be adopted to the context in which they are implemented.

Finally, it is interesting to include in the discussion the issue of the knowledge and propensity of adopters, or at any rate the general population, to adopt certain innovative technological solutions in the field of agriculture in order to implement so-called smart agriculture.

In fact, despite its undoubted advantages, which have been exhaustively found and expressed in this research work, we saw in the literature review of this paper how smart agriculture is struggling to spread in Italy.

This situation is expressed by the data; in fact, it has been observed, according to data released by the Smart Agrifood Observatory of the Politecnico di Milano, that only 3-4% of agricultural land in Italy is cultivated with 4.0 tools.

Therefore, in this sense it becomes crucial to discuss qualitative factors that may be behind this lack of implementation in our country, and among the issues most discussed and that most emerged within the interviews we have the cultural factors peculiar to the agriculture sector that are seen as a strong barrier to entry to the entry of new players in the market willing to implement smart agriculture techniques or to the possibility that traditional farmers can implement their classic way of working to try something more innovative and experimental.

This cultural theme emerged in almost every interview and not only from protagonists of Italian descent as we have seen extensively in the findings chapter of this research work.

In conclusion, it should be noted that these technological innovations used in the field of Smart Agriculture take advantage of very advanced and mature technologies, so it is most important to have a transfer of knowledge about these to the people who have to implement them.

If there is not this knowledge connection between actors producing the innovative solution and actors adopting it, then this can be a major obstacle to the implementation of such innovative technologies.

In this sense, it was seen during the research work how crucial it is to have dedicated people or team to manage these technologies and who have technical skills in this field, there is a need for figures who help in the implementation of these technologies, otherwise the implementation of an innovative technology will never be successful or in any case if you manage to implement the technology in a working system, in the absence of these figures, you will most likely have problems with its use in the long run.

6 CONCLUSIONS

This final section discusses the most interesting findings of the research; in addition, the limitations of research and implications for future research are indicated.

6.1 Research Summary

The research question of my thesis is:

- *"What are the perceived advantages and the barriers in introducing technological innovations in Agriculture?"*

The goal of this thesis was to examine how digital innovation is used in the agricultural sector, particularly how it may be used to gain certain operational and economic advantages.

I made the decision to approach this application from a broad perspective in order to examine as many components as I could.

In fact, one of the main focuses of this research was speaking with both those who create technological solutions used in agriculture and those who have embraced particular innovative solutions.

By contrasting the producers' and adopters' comments, I was able to analyze the themes that arose in the interviews at greater length. This was made possible by getting the perspectives of both sides of the market.

The main findings of the study are briefly outlined to help readers comprehend them.

The primary goal of this study is to comprehend the many perspectives on the adoption of digital innovation in agriculture, as stated in the introduction (Chapter 1) of the study.

To do this, I began by analysing the body of literature in order to clarify the ideas surrounding agriculture, sustainability, technologies, and technical advancements already applied to this subject (Chapter 2).

The material required to respond to the primary research question was gathered through open-ended interviews with managers from 11 different organizations using a comprehensive approach and several case studies.

After gathering the data, it was analysed by comparing it to the review of the literature and considering the theoretical framework that was created for this research activity in order to get a complete picture and better address the research issue of the paper.

The aggregate statistics of the several respondents questioned were compared in order to finally provide an answer to the research question of this study.

According to the interviews and from the analysis of the findings, and considering the constraints listed below, the tables 7 and 8 of this research paper can provide an answer to the study question.

In these tables, respondents' positions on the issues covered in the interviews are summarized, both from the point of view of advantages and problems.

6.2 Implications and Future Research

In this section, we will describe what may be useful of this research work for practitioners and researchers for possible future research work.

In fact, as I pointed out in the introduction of this research paper, I decided to address this issue because I have seen that there are some studies in the literature regarding smart agriculture.

However, in my own viewpoint, this subject has not received as much comprehensive attention as other topics, I believe that smart agriculture plays a crucial role in achieving a genuinely sustainable future world.

This is because nourishment is the primary source of energy for human beings; therefore, I consider it essential to examine how a sector that is vital for human nutrition can become more sustainable, innovative, and technologically efficient.

I hope that my research can serve as an initial stride towards further investigations; as I previously mentioned, I perceive this aspect of the circular economy as one that hasn't been adequately explored.

Consequently, I believe it to be an exceptionally innovative subject to delve into, offering valuable insights for future research endeavours.

The primary objective of this research is to enhance our comprehension of the concept of smart agriculture, including its advantages and challenges in implementing smart agriculture technologies.

Furthermore, based on the analysis conducted, producers can utilize the insights gained from this research to enhance their offerings.

By understanding which aspects of this tool align with consumer needs and which ones do not, producers can make informed decisions and effectively implement smart agriculture practices.

This research provides a valuable information base that enables producers to optimize their strategies and cater to the demands of the market.

This tool can also be utilized by adopters to gain a better understanding of the primary challenges that arise during the implementation of these innovative technologies, as well as the benefits they can derive from them.

By exploring the research findings, adopters can identify potential hurdles and develop strategies to overcome them.

Additionally, they can assess the advantages and opportunities presented by smart agriculture technologies, enabling them to make informed decisions about adoption and integration into their operations.

Consequently, this study serves as a valuable tool in enhancing the understanding of the impact that smart agriculture can have on both professional and personal lives.

From a literary standpoint, the research uncovers disparities between theoretical and empirical findings.

The primary objective of the study is not only to bridge this gap but also to shed light on new dimensions that warrant further investigation, given that the field of study is relatively nascent.

By addressing these gaps and exploring uncharted areas, this research contributes to the advancement of knowledge in the field of smart agriculture.

As for future research, there are a number of intriguing subjects that could be addressed in future study.

First off, it would be intriguing to do a follow-up study after organizations have used additional technology to see if their perceptions of the positive and negative aspects have remained constant or if they have been affected by other variables.

It would also be intriguing to know whether or not the existing considerations for the adoption of smart agriculture in the future would be recognized.

Additionally, comparing more units of analysis would allow for a more extensive comparison, confirming the degree to which the organizational context in which businesses operate affects how those businesses are perceived.

Finally, it would be interesting to carry out research in an industry that has adopted the same technologies, but different from agriculture.

In this manner, it would be feasible to compare the two various circumstances and determine whether any elements of these inventions may be standardized.

6.3 Limitations

The sample size is the first restriction on this study.

The study covers the data gathered from 11 interviews with managers from various businesses in Italy and throughout the world.

The examination of more businesses or the comparison of more case studies would make it possible to gather more data and, as a consequence, produce more reliable conclusions.

The challenging predicament that the agricultural sector is going through as a result of the energy situation brought on by the conflict between Russia and Ukraine has made it more challenging to interact with managers and companies in this sector.

The research methodology employed is the second constraint. In order to increase the case studies' validity, other information must be gathered in addition to interviews, such as internal records or business reports.

In fact, I focus on perceptions rather than advantages and disadvantages of applying smart agriculture technologies because measurements and temporal/spatial comparisons are needed to determine these aspects, whereas interviews can only provide perceptions and the divergent perspectives of the two sides of manufacturers and users.

We lack any prior internal reports or papers that might be used to measure it and make temporal/special comparisons because it is a novel phenomenon. As a result, the research is restricted to comparing empirical data from the interviews with previously published studies.

The third limitation is related to the nature of the interviewees. In fact, the fact that manufacturers and users almost always agree on everything is a bias probably due to the fact that the users are customers of the manufacturers themselves.

In this sense, it becomes essential to analyse the research results with a very critical eye and to analyse them in close contact with the literature and the theoretical framework developed in the thesis itself in order to validate the results obtained.

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Precision Agriculture Challenges

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MASTER THESIS SUMMARY

Introduction

With the scarcity of resources in the modern world, there is a strong need to optimize the use of these resources to meet the demands our planet makes of us. Being sustainable has now become an obligation for all businesses because if we continue to live in the world like we lived in in the years immediately after the industrial revolution we would bring our planet to depletion, and this could lead to our demise. So, we need to be sustainable and pay close attention to how we use the natural resources that our planet offers us that are by definition scarce. (Conti, 2020)

One of the areas where a lot of progress is being made in this regard is in agriculture, many are in fact innovations in the field of technology that are being adopted to achieve new ways of doing agriculture and arrive at the so-called "Smart Agriculture." Many companies are also active in this sense, for example among them we find A2A, which with the Smart City section is very active from the environmental point of view with the aim of making the world where we live a better place through better water management, better infrastructure management with the use of the most innovative technologies in the field. These technologies can lead to the optimization of inputs used in the agricultural field as they allow us to arrive at a new type of agriculture that we can call intelligent in that decisions in this field are driven by data and every single thing is executed in detail so as to optimize resources, time, soil, and any aspect that revolves around the cultivation of any natural product. (Rizzi, Santamauro, 2021)

The result of this phenomenon is the achievement of so-called precision agriculture that could bring many benefits in terms of environmental sustainability, for example, it is well known that among the Sustainable Development Goals we have some of them such as number 2 and number 3 that deal precisely with issues related to food security and good health that people can only have through good nutrition given by healthy and sustainably processed products.

These goals can be achieved through the use of innovative technologies such as hydroponics, sensors, machine learning, artificial intelligence, big data and cloud computing in classical agriculture.

However, despite its undoubted advantages, smart agriculture is struggling to spread in Italy. According to data released by the Smart Agrifood Observatory of the Politecnico di Milano, only 3-4% of agricultural land is cultivated with 4.0 tools.

For this reason, I think that Smart Agriculture is a very interesting context to investigate. I think it is very important to go and understand what is happening in agriculture to also understand why, despite the many benefits that smart agriculture is supposed to bring, it has not yet taken widespread adoption. I have to go and understand what is important to look at in order to answer the research question of this paper and to give an answer to it.

The ultimate goal of the paper is to go and investigate what are the hidden aspects of smart agriculture and the motivations that drive or block its diffusion. So, I went to analyze and study the use of digital technology in agriculture and the impacts that this could have in terms of efficiency. But I also went to study the disadvantages of the use of this technology if there are.

The purpose of my research was not only to go and analyse the world of smart agriculture, but my aim was to go and see what digital innovations have been put in place by organisations working in the field of agriculture in order to achieve certain results.

So, my research question was to analyze these digital innovations and see what the advantages, disadvantages and possible problems were in the opinion of two types of subjects, namely the users of these technological innovations and those who produce these innovations.

Therefore, the research question in my research paper is:

"What are the perceived advantages and the barriers in introducing technological innovations in Agriculture?"

I wanted to understand under what conditions it was possible to implement these technologies and under what conditions there were more problems that forced companies to make a greater effort to succeed.

So, I wanted to understand in which situations the implementation of these digital technologies led to enormous success and when it was a failure.

In order to do this, I analysed the problems that companies had when they had to implement the same technologies in an already functioning and operational agricultural system, the conditions that led to the success of the implementation, and at the same time, I went on to analyse the advantages and disadvantages that companies operating in the agricultural sector had as a result of the implementation of these technologies.

This analysis has been done from two main points of view, that is, on the one hand we have the companies producing digital technologies that are intended to be applied in smart agriculture and on the other hand we have the companies consuming these products, that is, the agricultural companies, agronomists, farmers, and consortia that have decided to adopt these technologies in order to obtain positive results from the implementation of these technologies.

This dual point of view is fundamental to my analysis in that in order to analyze the advantages, disadvantages, and problems of a product, it is not enough to analyze what the company that creates the product offers, but we must also analyze the point of view of those who actually use the product and can express an opinion as to whether or not that product has brought an improvement to the company's business compared to how the company worked before the implementation of that product.

To do that, I analysed multiple case studies that operates in the sector of smart agriculture. I interviewed many companies in order to make my research work.

I went to talk about real cases to analyze what can be the benefits and the problems related to the use of digital technology they have developed in terms of efficiency compared to the classic method of doing agriculture and how these technologies can be fundamental for other firms.

Methodology

Regarding methodology, I based my work on interviews and a qualitative analysis of what are the benefits of these technologies and smart agriculture.

In order to do that, I got in touch with many companies operating in the agricultural sector and from them I selected the best ones to include in my research and to whom I submit my questions based on the literature review.

In terms of interviews, I have been in contact with and interviewed the CEOs and co-founders of five companies involved in producing certain products needed to implement a smart agriculture system.

Among the main figures, I was in contact with the CEO and Cofounder of WallFarm, Jacopo Teodori; the CEO and Cofounder of another company that is NidoPro, Andrea Carloni; the CEO & CTO of Agrobit, Ing. Simone Kartsiotis; the Head of Human Resources of Elaisian, Elia Fregola and Ing. Simone Cirocchi from Sigma Consulting.

Interviewing these companies was a crucial step in my research in that learning their views was crucial in going to understand what the goals of certain products are, that is, what benefits certain technologies should bring to the companies that use them.

These figures are very available for meetings, and I had an initial conversation with them in which I got a better explanation of their business realities and what they are about to see if there could be a fit between the work I would like to do and their companies.

In addition, these figures confirmed to me that there is a possibility of scheduling more interviews, not only with them, but also with other members of their organizations to get more views on how the work within their companies works.

So, I use this opportunity to make the most of the contact with them to go and conduct multiple interviews on what the benefits of this technology can be in the context of agriculture as well.

In addition, there is also an opportunity to speak with engineers to understand more specifically how the technical part related to the operation of their products works, and this was very helpful in understanding in depth how the aforementioned technologies fit into the practical operation of these product.

However, the purpose of the interviews was to analyse not only the point of view of the products of these technological solutions, i.e., the producers, but also the point of view of the adopters of these technological solutions, i.e., all the agricultural enterprises that use these products to improve their business.

From this point of view, the support I got from the figures mentioned above was crucial as they allowed me to get in touch with other companies who were using their products.

Consequently, my analysis aims to investigate what are the most important aspects for what we can define as the adopters of these digital technologies. That is, companies or figures that use these technologies to improve their business and make it more efficient.

In my study, it will also be crucial to analyse their point of view because they are the ones who actually apply the technologies produced and therefore only, they can tell what the actual advantages are given by the application of these, and any problems encountered in implementing these technologies within a pre-existing business model.

As for the users of the technologies, to be precise, I interviewed six enterprises including farms and vertical farming companies. As mentioned, their word was crucial in order to fully understand the benefits and problems they had in implementing the technology because if the analysis had focused only on the side of the companies producing certain products I would have had a one-sided view made up only of the potential benefits promised by these companies, but I would not have had the view of those who had to implement these products in their business model and who therefore had to bring changes to their organization to achieve certain results.

In order to make order and be clear about the subjects interviewed and which side of my survey the subjects belong to, I have summarized the subjects interviewed in the table 3 below:

Subject Interviewed	**Company**	**Producer or Adopter?**	**Role**
Jacopo Teodori	WallFarm	Producer	CEO
Andrea Carloni	NidoPro	Producer	CEO
Simone Kartsiotis	Agrobit	Producer	CEO & CTO
Elia Fregola	Elaisian	Producer	Head of Human Resources
Simone Cirocchi	Sigma Consulting	Producer	Engineer
Mattia Dell'Orto	Arnaldo Caprai	Adopter	Director
Edwin Schilperoord	Innogrow	Adopter	Agronomist
Chiara Cichero	Sfera Agricola	Adopter	Marketing Manager
Matteo Benvenuti	Vertical Farm Italia	Adopter	Engineer
Philip Lee	Mono'	Adopter	CEO
Mahdi Alhindawi	Farmer	Adopter	Agronomist

Table 3. Summary of the subject interviewed.

The interviews done with all of these individuals aim to thoroughly investigate what are the obstacles, difficulties, and challenges in introducing technological innovations in agriculture, and then go on to analyze what are the perceived benefits after making use of these innovations.

As mentioned earlier, however, this analysis could not focus only on one side of the market since in order to fully understand these issues one must analyze the difficulties that exist both upstream but also downstream of the introduction of a technological innovation.

Findings

Regarding the findings of this research, I have decided to subdivide these according to the information that emerged during the interviews and according to what is the purpose of this research, this subdivision serves precisely to go and highlight and group some of the issues addressed in order to best proceed in the research work to then go and analyze and discuss them in the last part of this thesis.

However, it is important to point out that the subdivision I mentioned earlier was driven primarily by what was developed in the theoretical framework of this research work; in fact, the clusters identified go directly to each and every element present in the theoretical framework in order to create a strong and easy-to-analyze connection within the work to then go on to easily link the theory analysed in the literature review and the practical cases that emerged in the interviews.

Each element of the theoretical framework goes to group within it a series of elements that emerged within the interviews; the findings of this research work were therefore organized based on what are the key elements of the theoretical framework and for each element practical cases emerged in the interviews, therefore, for each element minor elements were found that will then go on to guide the final analysis.

For this reason, the clusters identified are as follows:

- Relative advantage

- Ease of use of technologies
- Technical compatibility and complexity
- Issues in the implementation of technologies
- Organizational changes required to implement these technologies

Within each cluster (macro-theme), there will then be specific themes that emerged during the interview that fall under that general macro-theme.

Therefore, as mentioned earlier, for each element identified in the framework, one or more specific themes were found within the interviews.

During the interviews, it became apparent that there are many perceived benefits to farms or farmers as a result of implementing these technological innovations.

In fact, regarding the relative advantages over the traditional way of working in Agriculture, the positions of the interviewees were clear from the outset.

The users all agreed that they would not have implemented this new way of working and the new technologies of Smart Agriculture if there were no advantages over the previous way of working.

While, as for the manufacturers these were enthusiastic about their products and all agreed that they see a growth in the medium to long term of the market, thus an increase in profits between now and 10 years with a strong increase in customers of their technologies.

Within this cluster I have identified three specific themes, which are:

- Precision farming
- Reduced use of raw materials and human labour
- Healthier product made in a sustainable way

Another strength of these technologies must be ease of use; in fact, it has been observed that many companies have motivated their preference in adopting some technologies over others by the ease of use of these technologies.

Another of the key themes that emerged within the theoretical framework and during the interviews was that related to the technical compatibility and complexity of these technologies, and it was essential to hear the stories of the

companies, both on the manufacturers' side and on the users' side, in order to understand what were the technical difficulties and the benefits gained as a result of overcoming these difficulties for the companies interviewed.

Within this cluster I have identified two specific themes, which are:

- Everything is mechanised (Advantage)
- Technical capabilities (Issue)

As mentioned above, during the interviews, it became apparent that there are many perceived benefits to farms or farmers as a result of implementing these technological innovations.

However, it was also important to note how to achieve the benefits we discussed earlier there was an evolutionary path of implementation of the applied technology. In this sense, it was crucial to adapt the specific technology to the context in which it was going to be used.

This implementation process, therefore, did not always go smoothly and there are a whole series of factors that required adjustments or otherwise brought problems in the installation of the technology in an existing business model.

Within this cluster I have identified two specific themes, which are:

- Energy consumption
- Connection

As a result, not all are willing to implement these innovative solutions because of these factors; therefore, these are key factors that are considered when deciding whether or not to implement such smart agriculture solutions; in this sense, they represent real barriers to entry.

However, as far as these issues are concerned, the manufacturing entities said they are aware of the situation and for this reason they try to find solutions to these issues.

Finally, one of the key themes within the theoretical framework that emerged powerfully within the interviews is that related to the organizational changes required to implement such innovative technologies.

This theme emerged strongly and was recalled by all interviewees because the implementation of these technologies has always required changes and the focus that was made by all interviewees was to relate these changes to the sector where they are made, namely agriculture, which was defined by all as a sector that is very resistant to change and where it is therefore difficult to bring innovations such as those of smart agriculture.

Within this cluster I have identified two specific themes, which are:

- High investments
- Atmospheric and cultural factors

Conclusion

According to the interviews and from the analysis of the findings, and considering the constraints listed below, the following tables can provide an answer to the study question:

Precision Farming	All the participants of the research on precision agriculture unanimously recognize the advantages that arise from the adoption of technological innovations and smart agriculture systems.
Reduced use of raw materials and human labour	Both adopters and producers emphasized the benefits of reduced raw material and labour usage. Adopters mentioned the positive impact on their workflow and cost savings, while producers highlighted this aspect as a market strength, offering technological solutions for desired outcomes.
Healthier product made in a sustainable way	Interviewees unanimously emphasized the importance of sustainability and healthier products in the context of smart agriculture. Producers aim to offer sustainable solutions, while users prioritize healthy agricultural production. Both parties utilize technological innovations to control any factors that could compromise product quality and end-user health.
Ease of use of technologies	Ease of use is a critical factor for end adopters in selecting smart agriculture technologies. Manufacturers prioritize creating user-friendly products to meet this demand effectively.
Everything is mechanised	End users emphasize the need for mechanization and integration of smart agriculture systems into their existing operations. Manufacturers respond by developing adaptable solutions that can easily integrate with various systems, regardless of size or compatibility with other technologies.

Table 7. Respondents' positions on the issues covered in the interviews (Advantages)

Technical capabilities	Technical skills play a crucial role in smart agriculture, particularly highlighted by manufacturers who often need to provide detailed installation instructions to address users' lack of expertise.
Energy consumption	Users of smart agriculture technology solutions expressed concerns about energy consumption, considering it a drawback of the technologies.
Connection	Connectivity is a major concern expressed by end users in implementing smart agriculture technologies. Manufacturers acknowledge the issue and make efforts to address it, but resolving connectivity deficiencies can be challenging, as it is influenced by equipment placement and sometimes beyond control.
High investments	End users are cognizant of the investment required for implementing smart agriculture technologies, yet they are willing to pay for the associated benefits. Manufacturers recognize the importance of providing diverse solutions to meet customer needs and strive to offer comparable services at a lower cost.
Atmospheric factors	Both producers and users in the agricultural sector acknowledge the significant impact of atmospheric factors on agricultural production. While some technologies can mitigate these factors to some extent, their influence remains substantial.
Cultural factors	Cultural barriers were also highlighted as a key aspect, with producers emphasizing the sector's resistance to technological adoption. However, users of technological innovations and producers agreed on the importance of overcoming these barriers and recognized the role of innovators who embrace alternative production methods.

Table 8. Respondents' positions on the issues covered in the interviews (Problems)