From traditional agriculture to AgTech: Towards a Sustainable Business Model

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Stefania Stoccuto

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Stefania Stoccuto

Student number: 4937821

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Graduation committee

Chairperson	: Dr. G. van de Kaa, Section Economics of Technology and Innovation
First Supervisor	: Dr. A.Y. Ding, Section Information and Communication Technology
External Supervisor	: Dr. Batukhtina, Business Development Manager at Kubota ICE

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\- Stefania Stoccuto

Executive summary

Agriculture is a fundamental element of every economy. However, global issues such as climate change, land deterioration, and a continuously growing population are strongly impacting the sector. It is estimated that by 2050 the population will increase by two billion, reaching 9 billion people to be fed. The sector thus needs to deal with a triple challenge consisting of feeding a growing population, providing a livelihood for farmers, and protecting the environment. In the past 34 years, numerous researches investigated the use of potential technologies impacting the major efficiency and productivity of the sector. Examples of these technologies are Artificial Intelligence (AI), Internet of Things (IoT), Machine Learning (ML) and Computer Vision (CV), sensors, and robotics.

The readiness of these technologies and the positive impact that they do have on the sector is proven by numerous studies done in the literature. However, these technologies are still not enough diffused within common farming practices. Adoption rates are very low, as well as the full understanding of the technology from the farmers' perspective. Without a shift towards the digitalization of farming practices, the agriculture sector could be damaged, highly impacting on the future of society and, from a business perspective, on the general economy. This is why a change in the actual regime of production is needed: from traditional agriculture to AgTech (the use of technology applied to the sector).

In this report, one possible solution to challenge this issue is proposed. Through interviews with winegrowers and analyses of the technologies proposed by vineyards start-ups in the field, an understanding of future market development is derived. The concept of sustainability is investigated as one of the major drivers towards the change of regime. In this context, the AgTech sector is seen as a niche market that lays the foundations for future development and new regime stabilization.

More specifically, the study has been conducted on the viticulture domain, tackling in a very context-specific manner the problems concerning this branch of the field. To do so, growers' interviews and start-ups desk research have been conducted. The insights gathered have been then analyzed. Deriving the main needs of the growers and the degree of technology adoption, a set of to be used criteria by start-ups during the development of their business model is ideated.

The criteria, or archetypes, have been developed on the base of the Sustainable Business Model Archetypes ideated by Bocken et al. (2014). A new model is proposed, starting from the triple bottom line dimensions (social, economic, and environmental). In each dimension, archetypes matching the needs of the growers, as well as sustainability issues are presented. Through the development of a business model that matches the objective of these archetypes, start-ups can

implement a sustainable business model that tackles both the right market needs and the growth towards sustainable agriculture business.

Technology is considered as a driver that applies to each archetype of the three dimensions mentioned. More importantly, the level of analytics of the technology (descriptive, diagnostic, predictive, and prescriptive) are explored and integrated into the final model, guiding both the start-ups and the market towards an incremental digitalization of the sector. Doing so, the technology adoption can also be gradually introduced to the growers, through the use of visible benefits impacting on their business.

The model is therefore thought of as a tool for start-ups in the AgTech field to be applied to develop a sustainable business model matching, as far as possible, the needs of the growers. Also, it is considered to be the first step to lead the sector's digitalization, increasing the growers' technology adoption rate, and helping start-ups to reach a better understanding of the market. The model represents the major contribution of the report to current literature.

Moreover, another important contribution is represented through the presented process and methodology. Even though the model is context-specific, the study represents complete guidance on how to perform research for the basis of new model creation. This process can thus be repeated in the required field in order to obtain a closer model to the type of crop under evaluation. A potential result is that this process of model creation can be generalized for different sectors within the agriculture field.

The model is thus a starting point towards the shift of regime and the digitalization of the agriculture field. Potentially, the applicability and usage of the model, as well as theoretical studies in the understanding of the impact of the archetypes on the transition from niche to the regime can be explored in the future.

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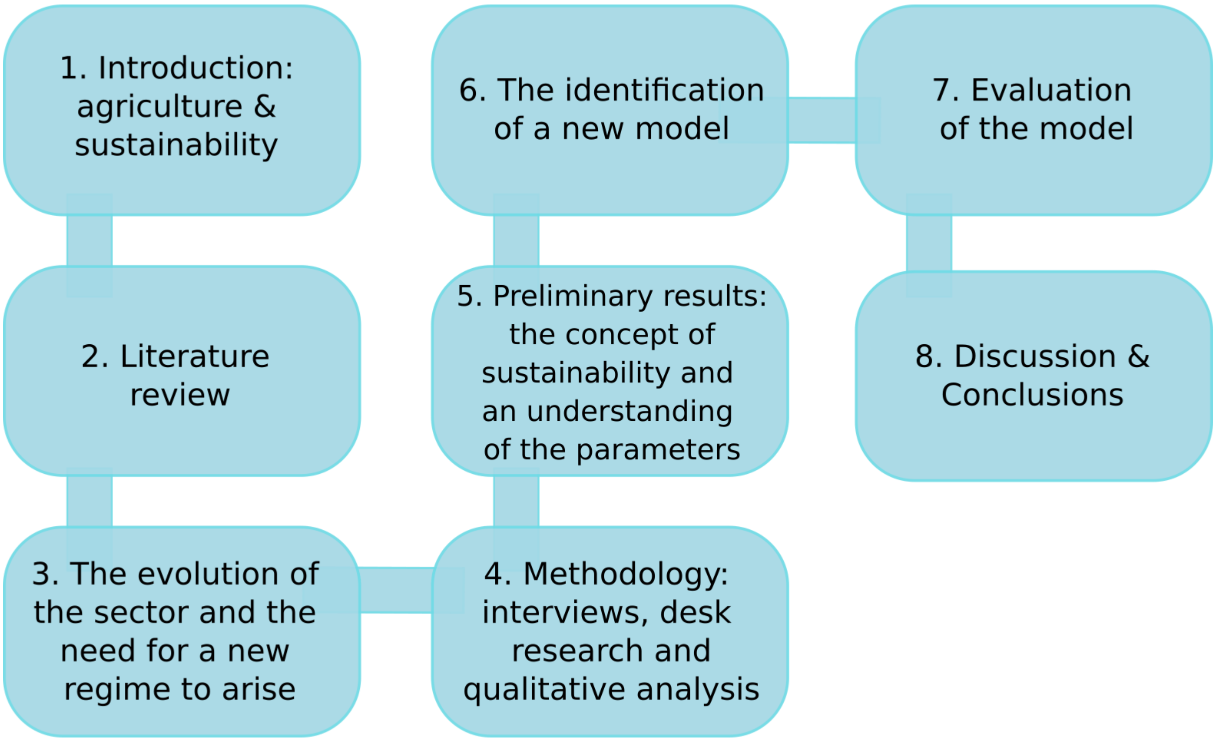
1. Introduction



Given the growing issues such as climate change and an increase in population, agriculture is progressively facing difficulties in the sector. In this chapter, starting from an overview of the main issues related to the topic, a brief introduction concerning the digitalization processes ongoing, as well as the role of sustainability as a driver of the previous one, is presented. The chapter aims indeed at giving an overview of the problematics and current situation, identifying a gap to be investigated in the literature, and on the base of which the full project will be developed.

The main research objectives, as well as the methodology and full project planning, are following illustrated. The schematic map represented on top of the chapter will guide the reader through the project with a clear focus of the steps undertaken through the full study.

1.1. Background

Agriculture is a fundamental element of every economy in the world. It plays an important role in the economic growth of a country and for thousands of years, it has been "a vital activity to the survival of humanity" (Alreshidi 2019). In the past, the main agricultural activities were mainly related to food and crop production and management. Nowadays, the concept of agriculture is broader, including activities along the whole supply chain such as production, management, marketing, distribution, etc. (Eli-Chukwu 2019).

Not only does the agricultural sector cover the feeding needs of a global population, it also strongly impacts the Gross Domestic Product (GDP) of a country. Based on a country segmentation elaborated by The Word Bank Group, the role of agriculture impacts differently on the GDP of a country depending on its level of development. Five main groups are listed: agriculture-based countries, pre-transition countries, transition countries, urbanizing countries, and developed countries (Van Arendonk 2015). Depending on the level of development, the share of agriculture on a country GDP ranges between 25% (low level of development) and 10% (more developed countries). The impact of the sector is, therefore, significant.

1.2. Problem statement

Due to the global issues currently existing such as climate change, land deterioration, and a continuously growing population, the agricultural sector is facing many difficulties. "Such an area of extreme importance is agriculture where about 30.7% of the world population is directly engaged on 2781 million hectares of agricultural land. Such a venture is not so smooth running; it faces several challenges from sowing to harvest. The major issues are pest and disease infestation, inadequate application of chemicals, improper drainage and irrigation, weed control, yield prediction, etc." (Bannerjee, Sarkar et al. 2018).

The sector needs to deal with a triple challenge consisting of feeding a growing population, providing a livelihood for farmers, and protecting the environment. It is estimated that by 2050 the population will increase by two billion, reaching 9 billion people to be fed. Also, developing countries will have access to a more complete diet. Therefore, population growth and richer diets will require us to roughly double the number of crops we grow by 2050 (Alreshidi 2019), (Eli-Chukwu 2019), (Dharmaraj and Vijayanand 2018), (Reshma and Pillai 2016). The continuously changing environment requires fast adaptability of farmers (Milestad, Dedieu et al. 2012), and the environmental challenges linked with the sector concerning, for example, energy consumption, space allocated for agriculture (around 70% of the earth's surface), water usage (70% of global water use), and greenhouses gas emissions (11% on a global scale) need to be faced (Brooks, Deconinck et al. 2019).

The relationship that people always had with this sector has resulted in the advancement of agricultural activities over the years. Initially, through the time-consuming methods of traditional agriculture. However, the issues presented have now led to an urgent need to balance demand and supply and to transform the sector towards a more sustainable one. A possibility to achieve this is through the use of new technologies.

A technology that shows promise for this use is Artificial Intelligence (AI). “Via the application of AI technologies, the impact on natural ecosystems can be reduced, and worker safety may increase, which in turn will keep food prices down and ensure that the food production will keep pace with the increasing population” (Eli-Chukwu 2019). Many studies have already been conducted in the field and the concept is not new. Indeed, the researches that have been done until now cover more than 34 years of studies (Bannerjee, Sarkar et al. 2018). This report will present some of the main techniques used today. However, it will simply touch upon the techniques used in the agriculture field, without deeply discuss them, since this will not be the main scope of the research.

1.3. The role of sustainability

The always more connected world in which we live and the continuous development of technologies has led to the gathering of data concerning every daily life aspect. This allowed the fast development of AI in many industries. Agriculture has been one of the slower adopters due to limitations such as remote data access and connection (Smith 2018), (Eli-Chukwu 2019). This is why analyzing the value derivable by the use of the technology with an analytics spectrum tool, describing mainly four analytical approaches - descriptive, diagnostic, predictive, and prescriptive (Banerjee, Bandyopadhyay et al. 2013), the main actual value that farmers can derive from the use of AI in the sector is mainly a descriptive and/or diagnostic one. The technology mainly provides data and/or correlation of data linked by causalities that the farmer can evaluate later on. Further improvements can still be done moving from descriptive to prescriptive analytics. “Once an ability to record some actionable information has been shown, it is then very typical to attempt to extend that to developing computational capabilities that automate processes or perform further analytics” (Smith 2018).

Studies were done in previous literature, however, demonstrated until now that the best outcomes derived by the conjunction of use of different technological advances, including “big data analytics, robotics, the Internet of Things, the availability of cheap sensors and cameras, drone technology, and even wide-scale internet coverage on geographically dispersed fields” (Eli-

Chukwu 2019). “This highlights that the highest value capabilities appear to be those in which multiple different areas of AI applications are brought together, such as robotics, digital traceability, and decision support. In going through these different areas, it also became clear that many of the capabilities will build on from or complement each other” (Smith 2018).

AI in the field can be applied in four main dimensions: smart farming, smart crop management, smart irrigation, and smart greenhouses. The focus of this paper will concern mainly the second dimension, the one of smart crop management, since “it is seen that increased crop production output and productivity tend to contribute substantially to the overall economic development of a country” (Eli-Chukwu 2019).

Some cases will be presented giving insights into the positive outcomes of AI operating on crop management, showing how production and efficiency can be improved, waste avoided and more sustainable business arise. The main goal of technology adoption is indeed concerning efficiency, costs reduction, land/production optimization, traceability, predictability, and quality improvements. However, while the technological efficacy of the technology is highly proven, one of the main problems persisting concerns the real sustainable impact of AI in the sector.

Nowadays, the agriculture sector is indeed facing a transition towards digitalization. This transition is just at the beginning, delineating the novel concept of AgTech (the application of technology to the field). AgTech is seen as a niche market that is increasingly shifting towards a new regime. “Transitions occur only when niche-innovations are enough robust to challenge the dominant socio-technical system. The robustness and maturity of the niche are two necessary conditions to ensure its scaling up and out” (El Bilali 2019). However, a great issue linked to the scale-up of a niche involves the possibility of the niches core values loss, amongst which sustainability plays a crucial role (El Bilali 2019).

An investigation of the roles of sustainability for different parties involved in the sector in Europe will be presented. The identification of the gap in the meaning of sustainability in the literature, especially between growers (farmers) and start-ups (AgTech industry), is discussed. Following, a research methodology to fulfill the research objectives is presented.

1.4. Research Objectives and Research Questions

Here following the different research objectives under investigation will be presented. The objectives have been subject to changes during the whole project development and the ones hereby presented, represent the final objectives chosen at the end of various elaborations to fulfill the project.

The main final objective of the report is the creation of a model, derived from the sustainable business model archetypes ideated by Bocken et al. (2014), that better match the field of application. These archetypes can then be a starting point for the development of a sustainable business model for start-ups in the AgTech sector.

The main research question driving the research is: "*How could the sustainable business model archetypes be re-adapted for future sustainable innovations in AgTech?*"

In order to achieve this bigger goal, some sub-questions are identified:

- What is the main concept of sustainability and how does this differ from the grower and start-up point of view?

- Which parameters need to be monitored during the crop production in order to achieve a sustainable implementation in the smart crop management field?

- How can these parameters be measured? Is there any technology able to measure these parameters within the technologies already developed in the AgTech sector?

- Which kind of criteria need to be implemented into an AgTech start-up business model in order to develop a sustainable business model that meets the market needs?

- How do these criteria differ or resemble the sustainable business model archetypes ideated by Bocken et al. (2014)?

After the identification of the main sub-questions and research questions, additional questions for future researches on the topic are presented. These questions could be seen as an interesting starting point for further research, leading the study towards a more complete research to be empirically used. The questions for the future research are following proposed:

- How does the integration of sustainability into the AgTech start-ups business model impact on the industry shift towards digitalization?
- Can these archetypes push the AgTech sector in its transition from niche to the dominant regime, overcoming the traditional agriculture business?

1.5. Research Methods

At the base of the methodology of this study, there is the use of the Design Science Research Methodology (DSRM) Process Model ideated by Peffers, Tuunanen et al. (2014).

This model proceeds in steps, for a total of six steps. The first one concerns the problem identification and motivation. This point puts together different researches previously done integrating, for example, the need for a research problem definition with the integration of theoretical and applied aspects (Peffers, Tuunanen et al. 2014). The main problem concerns the presence of a gap in sustainability between two main actors in the AgTech industry: farmers and start-ups. This specific point is also the research entry point. The second step defines the objectives of a solution from the problem definition and knowledge of what is possible and feasible. These objectives can be both quantitative and/or qualitative. The solution is planned to be built mainly on the identification of the criteria to be used for the generation of a sustainable business model through integration of the market's needs, sustainability, and technology into the smart crop management field. The study is developed through the gathering of information from farmers and start-ups and to be demonstrated and evaluated through different technologies application already in use in different types of start-ups and with the help of experts from the field. However, as clarified by the theoretical model, the design choice is an iterative process in which new information generates new insights leading to continuous modification and validation of the process (Peffers, Tuunanen et al. 2014). A graphical overview of the methodology is given in *Figure 1*. Following more detailed information about the planned methodology.

<u>Interviews and researches</u>

To understand the two different perspectives, the following steps are considered:

1. Conduct interviews with growers to understand their point of view.
    a. What are the main parameters they would like to be measured to improve their business and make it more 'sustainable'?
    b. How can the use of technology measure these parameters?
2. Once these data have been collected, deeply analyze the start-ups' database.
    a. How do they perceive the concept of 'sustainability'? What are the main parameters driving their innovations, business models, and technologies?
    b. How can their technological solution improve the level of 'sustainability' (as intended by growers)? Can their solution measure the parameters established by growers?

All the parameters that will be investigated concern exclusively the crop smart management systems, more precisely in relation to the viticulture process.

Insights derivation and desk research

After the explorative phase, once all the data have been collected, a set of criteria is derived. The criteria are meant to be consulted by the new start-ups to innovate into the agriculture field (smart vineyard management systems) through the use of technologies such as AI, IoT, robotics, etc., ideating their business model starting from the concept of 'sustainability' (environmental sustainability). The criteria establish a trade-off between the concept of environmentally friendly business and the achievement of a competitive advantage over the market by integrating technology, maximizing efficiency, and minimizing costs. Once the criteria are identified, a new model is developed. The model is a re-elaboration of the original Sustainable Business Model Archetypes developed by Bocken et al. (2014), whose model is following explained.

Evaluation

For the final evaluation of the model, few experts' opinions will be consulted (i.e. experts from university, government, and industry). However, it is very important to underline that the evaluation phase needs to be performed during the whole project. This is why confirmations through interviews and literature review need to be implemented as well.

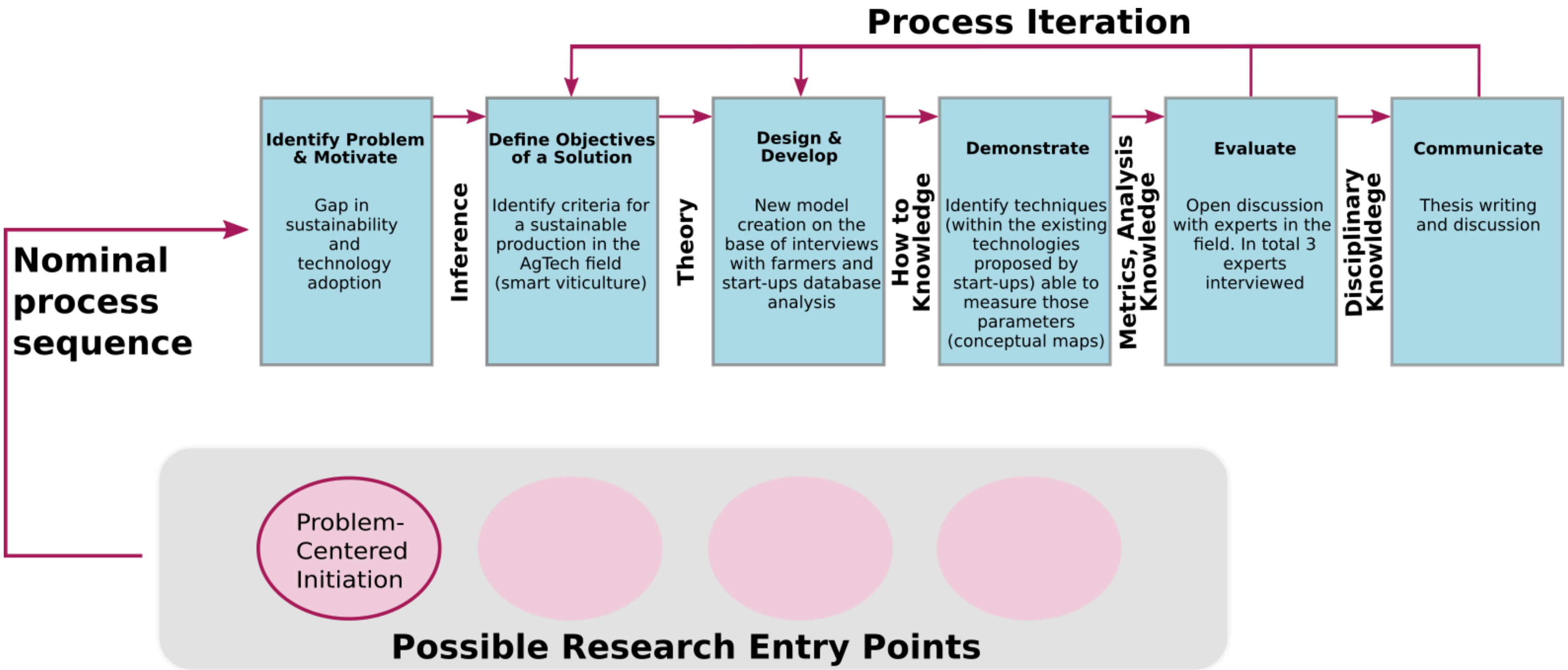


Figure 1: Design Science Research Methodology (DSRM) Process Model by Peffers et al., (2014) readapted

1.6. Research Planning

In this section, there is an overview of the forecasted planning for the research activity. The study is expected to last 5 months. A table with more detailed information concerning the time of the planned activities is presented. Following a more detailed explanation of the activities identified to perform the study. The planned time and steps have been subject to changes during the development of the project. Here an updated version, mirroring the final time frame used for the project (*Table 1*). Graphical representation in *Figure 2*.

Table 1: Table with expected research planning

Expected start date	Expected end date	Description	Duration (days)
24-Feb	3-Mar	Thesis proposal writing	8
3-Mar		Kick-off meeting	
10-Mar	10-Apr	Start-ups categorization per technology and type of crop	31
22-Apr	20-May	Investigating growers' perception	28
11-May		Mid-term meeting	
20-May	30-May	Insights derivation	10
30-May	20-Jun	Identification of parameters and creation of a model	21
20-Jun	30-Jun	Evaluation	10
10-Mar	9-Jul	Writing of MSc thesis	121
16-Jul		Greenlight meeting	
27-Aug		Thesis defense	

After the initial kick-off meeting, the following activities will be performed:

- Preparation of material for interviews. Farmers/growers interviews for a detailed understanding of their concept of sustainability; dimensions to be monitor in order to reach the goal of sustainability; the impact of AI, IoT, and robotics in the achievement of this goal.
- Analysis of start-ups through the use of the Kubota Corporation start-ups profiling database. Identification of the technologies and procedures available to measure the dimensions identified by the farmers.
- Creation of fundamental criteria to be integrated into the AgTech start-ups business model to achieve a sustainable business model. Differences and similarities are drawn from the sustainable business model archetypes identified by Bocken et al. (2014). A new model is created.
- Evaluation of the model with few experts.
- Identification of the added value of these criteria to the transition from traditional agriculture to the AgTech industry.

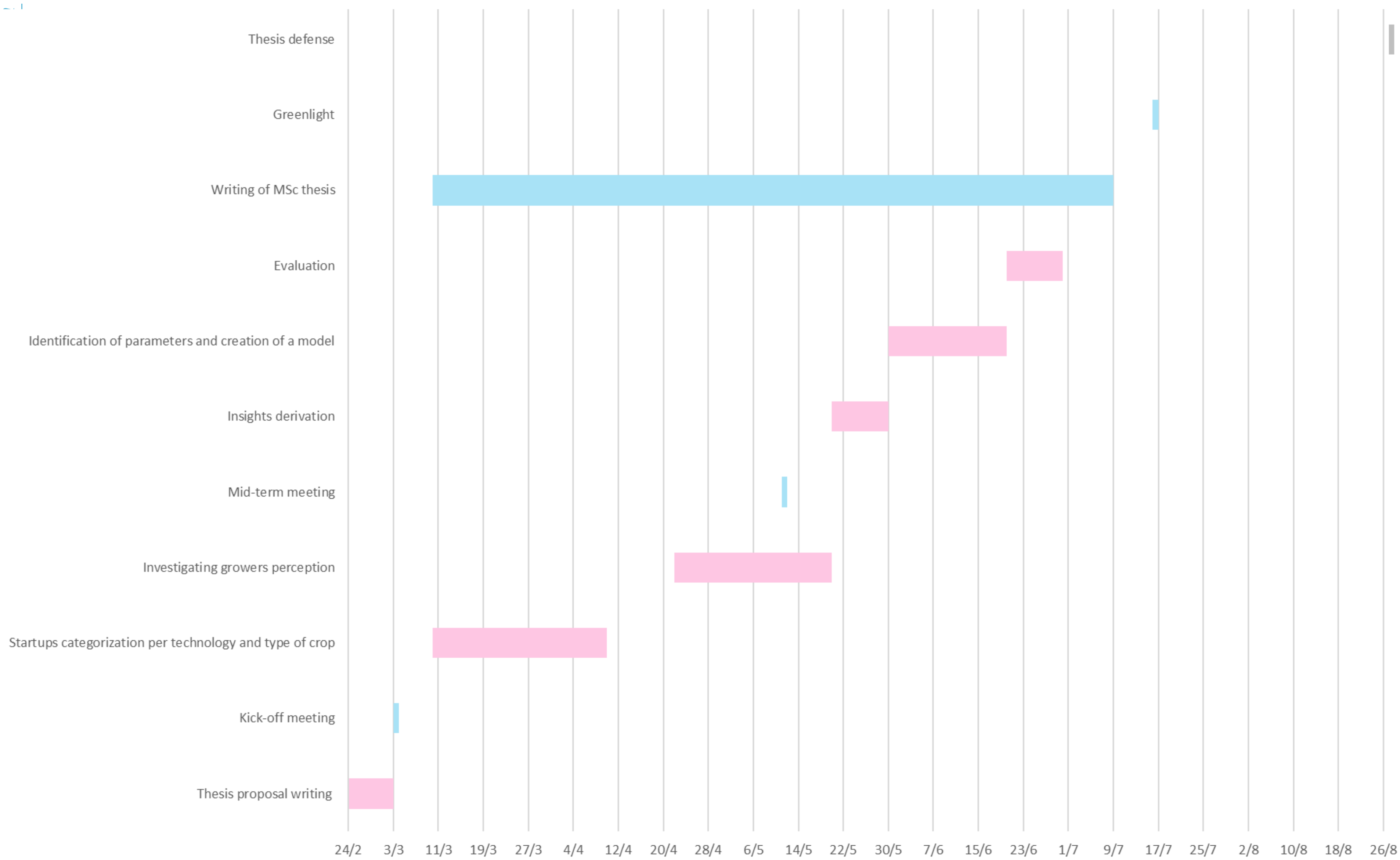


Figure 2: Graphical representation of research planning

2. Literature review

In this chapter, a literature review of the topic presented is operated. The literature review is divided mainly into four sections. These sections identify the main dimensions taken into account during the study. Firstly, the efficacy of the use of Artificial Intelligence, often combines with other technologies, in the AgTech field is proven. This section, more specifically, aims at giving an overview of the different possible applications of the technology in the industry, showing how the technological element of this innovative system is already stable, and strengthen. The second section investigates the uncertainties linked to the farmers' acceptance of the technology, showing how, even though the technology is already sufficiently developed, there are still several reasons limiting the adoption of it. This issue bridges the next section. Indeed, one of the main reasons why growers are reluctant to adopt the technology concerns the concept of sustainability and the different perception compared to start-ups. Finally, the emergence of a new trend is discussed: the shift from the traditional agriculture industry to the AgTech industry, in which the application of technology – especially software and hardware technology – plays a major role in the field.

2.1. AI in Crop management

A single clear definition of the concept of AI is difficult since the subject has raised many doubts through time and a single formal definition did not arise yet. However, AI can be described as an area of computer science as well as a simulation of human intelligence processes operated by machines, robots, computer systems, etc. The main characteristics of the technology can be grouped into three cognitive skills: learning, reasoning, and ability to apply self-correction.

Since "agriculture is a dynamic domain where situations cannot be generalized to suggest a common solution" (Bannerjee, Sarkar et al. 2018), techniques provided by the introduction of AI, enabled us to better perceive and analyze some details of each situation in the sector. It can also provide an optimized solution for that particular problem. This is especially visible in the smart crop management sector.

"Crop management starts with sowing and continues with monitoring growth, harvesting, and crop storage and distribution" (Eli-Chukwu 2019). One of the techniques used in the field is defined as precision crop management (PCM), which is "an agricultural management system designed to target crop and soil inputs according to field requirements to optimize profitability and protect the environment" (Eli-Chukwu 2019).

Some of the studies already performed in literature concern the development of prediction models to avoid frost formation in the Sicilian fields with the use of neural networks; soybeans crop growth models created for an increased production of the same; image analysis selection for the distinction between weed and crop with an accuracy superior of 75%; use of artificial neural networks (ANN) algorithms for crop prediction in smartphones. And again, in the use of wireless systems networks for paddy crops and agriculture farmland monitoring (Jha, Doshi et al. 2019). A relevant study in this field is the one conducted by Kalaivani et al. (2011), in which the approach of ZigBee in agriculture is discussed. "This algorithm is present to train the normal data sensed by the sensors and report any aberration in temperature, humidity, or leaf wetness which can result in grape disease to the farmer via SMS" (Jha, Doshi et al. 2019).

Figure 3: An example of AI application. Plant and weed detection using computer vision and AI, (Ampatzidis 2018)

As already discussed, the aim of this review is not to go into detail about the processes behind the technology. However, the examples retrieved from literature show the empirical positive effect in terms of productivity improvements in the field with the operation through AI. Besides limitations already mentioned in the studies, such as connection issues in remote areas and lack of big quantities of data to improve the technology itself (Smith 2018), (Eli-Chukwu 2019), one of the major limitations is the possibility to draw from these different cases. This concerns the use of combined technologies to derive a better outcome. Some studies in this direction still are present, such as the one conducted by Shahzadi, Ferzund et al. (2016). In their paper, they describe the ‘expert system’ developed. This system is based on smart agriculture systems. What is important to highlight with this study is the use of AI, IoT, sensors, and wireless systems together. “The concept of IoT in this system is to send the data to the server so that actuators of the field should be able to take appropriate decisions. For that, the server should be intelligent enough to take decisions independently. This system consists of temperature, humidity, leaf wetness, and soil sensors” (Jha, Doshi et al. 2019).

Even though some cases are present, single isolated applications of the technology prevail. The development of technology should go in the direction of conjunction of effort from different technologies. For a more efficient outcome, the application of the technology needs to be considered as much as the context of the system in which it is inserted. It is then possible to speak of an innovation system, and not a single technology anymore. The innovation system can be defined as “the organizational arrangements to manage innovation processes and the institutional arrangements that support, stimulate and regulate the management of these processes and the subsequent diffusion of technology" (Ortt and Smits 2006).

As underlined by Smith (2018), many changes took place in recent years. Many advances in the scientific and technological domain have led to development improvements in AI, following the growth of the use of this in many industries. Another remarkable advance has been the "ubiquitous availability of fast computation". Thus, improvements in the possibility to gather more data and information from mobile devices, sensors, equipment, personal computers, and the cloud. This is why, as graphically represented in the author studies (*Figure 4*), the technology can significantly grow in less than ten years, developing an increased value for the agricultural sector reaching the ability to perform tasks such as 'supply-demand optimization', 'active learning', 'performance predictions', etc. (Smith 2018).

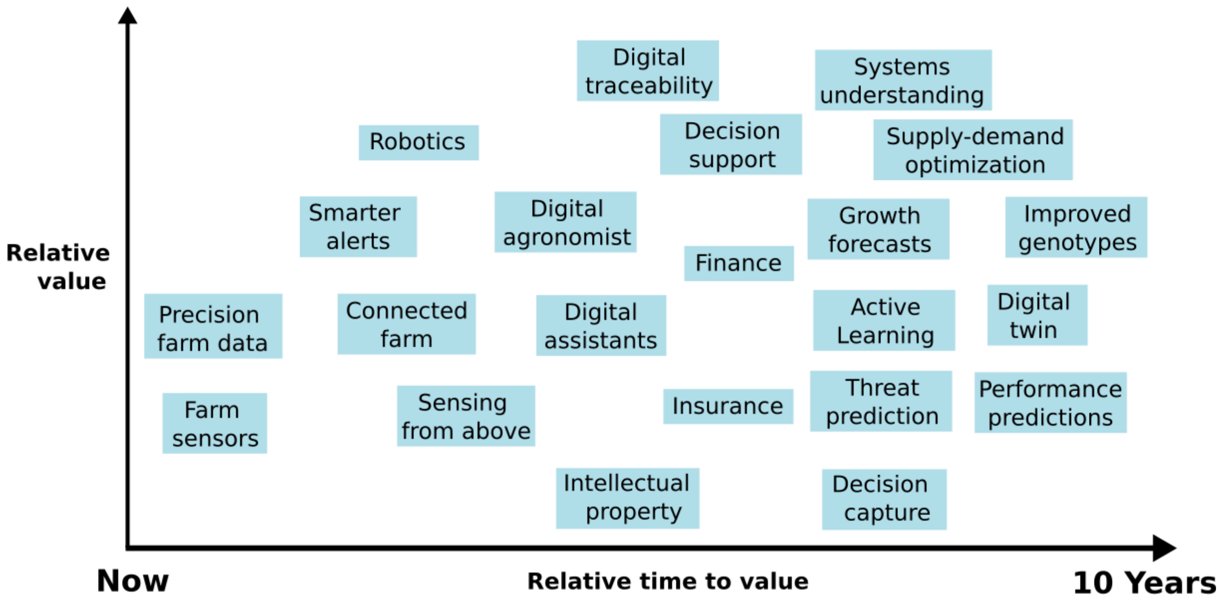


Figure 4: AI-enabled capabilities bringing value to agriculture in 10 years, (Smith 2018)

All of this does not come without any issue. Indeed, one of the major limitations that still persist concerns the technology acceptability from the farmers. This leads to the second section.

2.2. Farmers acceptance of the technology

Farmers nowadays find themselves in front of the need to deal with two main trends: the introduction of technology and market expansion created by a strong reliance on external inputs and technological machinery. Also, in addition to numerous global issues, such as climate change, increasing population and land deterioration, high-demanding quality, and closer customer relationships have become critical elements for sustainable development. "Farmers have to juggle with a broad range of changes on a daily basis. These changes affect both the material dimension of farming (e.g. technological change or markets) and the social dimensions which are linked to changing perceptions and shifting expectations. The sources of change are both endogenous and exogenous to the farm" (Milestad, Dedieu et al. 2012).

What is interesting to analyze in this context is the lack of studies about the farmers' perception concerning the introduction of technology (in terms of hardware and software) into the crop production field and the way they cope with the necessity of an environmentally friendly production. Many pieces of research concern broader general studies conducted on the existing correlation between innovations adoption and acceptability behavior of farmers. The majority of studies are especially conducted in developing countries. Some examples are given by the correlation between crop insurance and technology adoption in Chile, investigated by Salazar, Jaime et al. (2019); the Technology Adoption Behaviors of Litchi Farmers in China Li, Huang et al. (2019) and the correlation between technology adoption and the dynamics in the agriculture sector in Senegal (Diagne, Tamini et al. 2019).

Amongst the reasons Fujisaka (1994) presented on why farmers do not adopt innovations that are intended to improve sustainability, he identified that often the innovation addresses the wrong problem, either because it is not an experienced problem by the farmer or because the innovation addresses a side problem, incorrectly identifying the key problem. Another key reason concerns the costly expense of the technology since costs are immediate, but benefits are risky and accrue in the future.

What equates all these researches is that the level of adoption of the technology from different groups of farmers strictly depends on their level of culture, experience, and training. "While education, farming experience, income, farm size, land, access to credit, information, and yield are consistently found to be positive determinants across the studies reviewed, age and cost of innovations are consistently negative determinants of farmers' willingness to pay and acceptance" (Olum, Gellynck et al. 2019). Therefore, these characteristics also impact the level of adaptability of farmers.

Understanding this starting point allows us to see this change in the sector no longer as a disturbance, but as a "trigger for the reorganization of resources, and for the renewal of the farm organization and activities" (Darnhofer, Bellon et al. 2010). Therefore, if implementing the technology in the sector does not come without costs, farmers inevitably need to tackle the trade-offs between efficiency and adaptability. Resilience, diversity, and flexibility are indeed three key concepts related to the sector. However, more studies towards this direction, as well as the farmers' perception of technology implementation, are needed.

2.3. The concept of sustainability: two different perceptions

The thematic concerning sustainability is here discussed since the introduction of technologies such as AI in the business model of an operating business in the agriculture sector delineate the transition between different regimes drawing from the model built by Berkhout, Smith et al. (2004). More specifically, from a type of regime described as 'endogenous renewal' in which responses to an external factor such as the need for an increase in production due to a growth in population are searched within the internal resources of the sector (i.e. increasing the land suitable for agriculture matters through deforestation), through incremental steps to a different type of regime: 'emergent transformation'. This dimension arises from uncoordinated pressure and it is quite radical. Also, the resources used are deriving from an external context, which in this specific case can be seen as the introduction of AI, which purpose did not emerge for the sector (*Figure 5*).

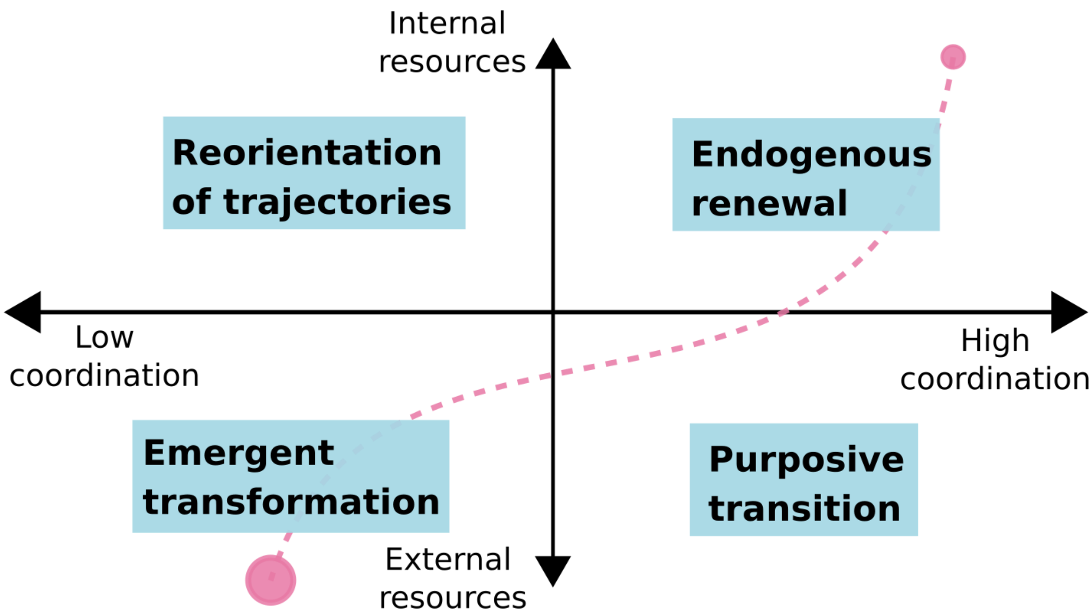


Figure 5: Expected transition context map on the base of Berkhout, Smith et al. (2004) model

This creates the precondition for a transition towards a new type of business model: a sustainable business model. Business model innovations for sustainability are defined as "Innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organization and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions" (Bocken, Short et al. 2014).

On the base of the eight archetypes ideated by Bocken, Short et al. (2014), represented in *Figure 6* the introduction of Artificial Intelligence in the agriculture sector would transform this last one towards a more sustainable business. The shift from a more traditional one to a more technology-integrated sector would impact especially on the "creation of value from waste", 'maximization of material and energy efficiency', 'adopt a stewardship role', and 'repurpose for society/environment'.

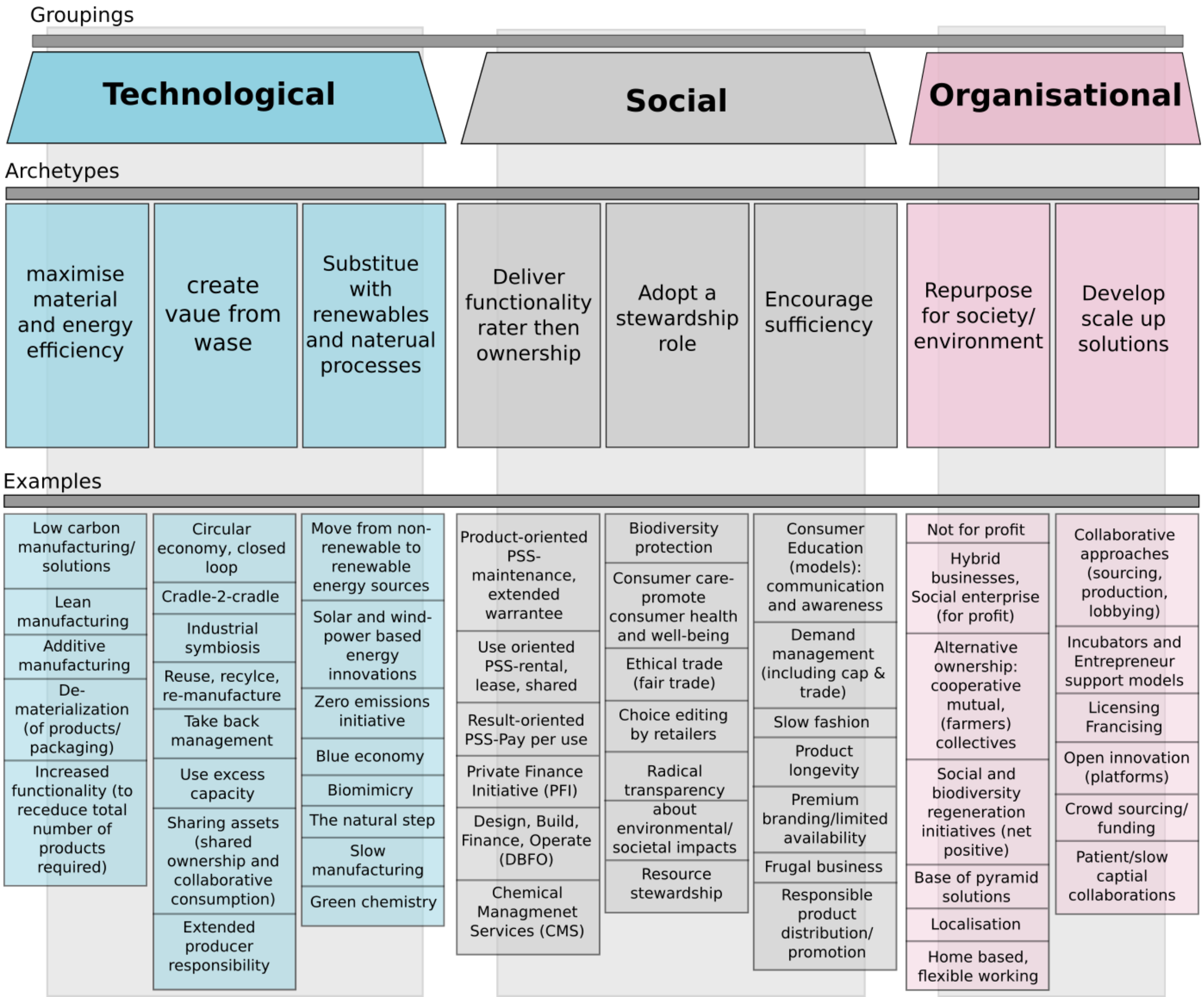


Figure 6: Sustainable Business Model Archetypes (Bocken, Short et al. 2014)

Even though this last model is quite flexible and therefore its use fits into different situations, the novelty around the emergent sustainable business arising in the smart crop management sector requires a more specific model or a set of criteria able to better integrate the needs of the sector. There are indeed several issues linked to this model application in the agriculture field. Firstly, the role of sustainability meant as social and environmental sustainability should prevail. Moreover, some of the original archetypes of the model do not apply. An example is given by the archetype 'Encourage sufficiency'. A more detailed explanation of the issues at the base of the non-applicability of the model to the field will be further discussed (*Chapter 6*).

This problem arises especially from the present gap in the concept of sustainability, that is also considered to be the first hypothesis of the project to be verified:

- sustainability for farmers involves environmental issues. Their business becomes sustainable whenever water/energy/pesticide consumption levels are reduced, the land is maximized, fewer levels of CO_2 are emitted, etc.
- sustainability for companies and, concerning the agriculture sector especially start-ups, regards mainly the achievement of sustainable competitive advantages. Thus, it concerns mainly the reduction of costs, maximization of profit, development of newer technologies, acquisition of bigger market shares, etc.

However, very little information can be retrieved in the literature about this thematic.

Numerous researches have been done in this direction; the main keywords and research queries used both on Google Scholar and Scopus are the following:

- TITLE-ABS-KEY ("sustainability" AND "AI" AND ("farmers acceptance" OR "farmers adoption")) → the query does not produce any result in SCOPUS. The same keywords have been tried in Google Scholar as well without productive results.
- TITLE-ABS-KEY ("agtech" AN "start-ups" AND "sustainable business model") → the query does not produce any result in SCOPUS. The same keywords have been tried in Google Scholar as well without productive results.
- TITLE-ABS-KEY ("start-ups" AND "sustainable business model" AND "agriculture") → the query does not produce any result in SCOPUS. The same keywords have been tried in Google Scholar as well without productive results.
- TITLE-ABS-KEY ("start-ups" AND "sustainable business model" AND "crop management") → the query does not produce any result in SCOPUS. The same keywords have been tried in Google Scholar as well without productive results.
- TITLE-ABS-KEY ("start-ups" AND "sustainable business model") → 11 results; however, these results were not useful for the research.

Given the few research results found, the necessity to explore further into this field and gather empirical data is confirmed. This creates then the conditions for a research study.

2.4. From traditional to digitalized: a common trend

Nowadays, with the development of science and technology, digitalization is a must for every company independently by the sector. Digitalization- “i.e. the networking of people and things and the convergence of the real and virtual worlds that is enabled by information and communication technology (ICT)” (Kagermann 2015) started the third revolution and it has been forecasted as “the most powerful driver of innovation over the next few decades and will act as the trigger of the next wave of innovation” (Kagermann 2015) transforming all the different type of infrastructures and industries in varies field such as energy, mobility, healthcare, and manufacturing. More generally, technological innovation can strengthen processes and organizational structures in different fields by the exploitation of automation and information and communications technology. One study affirms that “digital technologies at the base of precision agriculture are the assets to leverage when dealing with two major challenges for modern agriculture: on one hand, the need for an increase in production quantity by optimizing production factors and, on the other, complying with production standards by combining appropriate quality levels and limited environmental impact” (Trivelli, Apicella et al. 2019).

However, after numerous research into this direction, it became clear that there is a lack of literature about the transition from a more traditional type of business in the agriculture sector to a digitalized one.

The multi-level perspective (MLP) transition framework (Loorbach, Frantzeskaki et al. 2017) helps in giving a better understanding of the actual situation. The Transition-niche approach uses MLP to study the socio-technical system. In this, the system is divided into three different levels, socio-technical landscape (macro-level), socio-technical regime (meso-level), and niche (micro-level).

The macro-level or landscape consists of slow-changing external factors, providing gradients for the trajectories. It entails a wide range of factors that can be taken into account, such as macro-economic factors, corruption, power differences, or cultural aspects. It is the one that has the slowest dynamics. The meso-level of the socio-technical regime explains the existing technological development and trajectories in the already stable patchwork. It is, therefore, the level of established technologies. These technologies are generally mature and stable, and there is resistance to new new-technologies. Finally, the micro-level of niches accounts for the generation and development of radical innovations. It is characterized by low stability and dynamism (Geels 2002).

In this context, the emergence of the AgTech sector, thus the application of technology to improve the efficiency of the agriculture field, can be considered to be the micro-level/niche. This trend, if adequately pushed can shift into the creation of a new affirmed regime, overcoming the traditional agriculture techniques. However, "the literature highlights that niche development is necessary but not sufficient to induce a regime shift" (El Bilali 2019). Indeed, new trends developed in the general landscape can help the transition, as affirmed by the author El Bilali (2019): "the literature on the MLP posits that the socio-technical landscape has two main functions in sustainability transition processes: putting pressure on regimes to change and creating opportunities for niches"; "an important role of the landscape is also that of offering protection of niches against the dominant regime". A possible way is indeed through the introduction of regulations, as demonstrated by the actual situation in which the government plays a fundamental role in determining regulations to protect the environment. Therefore, sustainability could become one of the drivers pushing the transition towards digitalization.

However, the studies conducted in this field are still too scarce and thus will be investigated through the report.

2.5. Conclusion of the literature review

The literature review above illustrated, guided the reader into different aspects of the overall topic that will lead this research. Drawing from the main issues affecting the agriculture sector during the present days – climate change, population growth, land scarcity, environmental sustainability, and market demand, a clear starting point arose. The traditional agriculture method cannot be sustainable anymore.

To deal with this, since a few decades, numerous technologies have already started to be developed. The most efficient technology concerning the sector resulted to be Artificial Intelligence (AI). The feasibility and applicability of the technology in different ranges and dimensions of the agriculture aspects have been fully proven. Moreover, continuous improvement in technology creates hope for a future application of it on a large scale.

However, this has been demonstrated that does not come without complications. If the presence of data, connectivity in remote areas, and implementation costs show some of them, some more social aspects need to be included in the picture as well. The acceptability of the technology introduced in the new operating business is one of these. Indeed, it has been demonstrated that resilience, diversity, and flexibility, are fundamental in the transition towards acceptance. This introduces then the concept of adaptability of the farmer to new possible concepts of business.

Another fundamental aspect discussed is the necessity of more detailed theoretical models for the creation of a more sustainable business model. This aspect is particularly important given the different visions of sustainability from a farmer's perspective and the industry one. Sustainability is one of the most recurrent aspects treated lately by every industry. The environmental problems affecting the globe and the introduction of the sustainable development goals led to a general business model rethinking process in order to keep the business competitive within the limited resources of our planet. However, concerning the agriculture sector, this transformation is still too slow.

Lastly, it has been demonstrated that there is essentially scarcity towards the development of researches about a shift into digitalized business concerning the agriculture sector. It is discussed that every industry nowadays can be considered included in the digital sector, even if the core value proposition of the company concerns primarily a different sector (i.e. retail, real estate, or manufacturing). A valuable example is indeed given by the hotel chain Citizen. Even though as a hotel primarily operates in the accommodation sector, the full processes and operations of the service are completely digitalized, defining, therefore, the company as belonging to the digitalized sector. This shift is what has not been proven yet in the agriculture sector.

However, the increasing digitalization trend, whenever supported by bigger triggers present into the landscape dimension, can push away the actual traditional agriculture regime, creating space for the developing niche as previously discussed. Sustainability can be seen as the main trigger. Therefore, the identification of detailed criteria for the development of a sustainable business model in the smart crop management field could be considered as the first move towards a bigger picture: the strategic renewal of the sector towards digitalization and servitization of the industry.

This is why this literature review builds the premises to investigate the creation of fundamental criteria for the development of a sustainable business model for start-ups in the AgTech sector. The criteria will be derived from the starting model ideated by Bocken et al. (2014). On the base of these new archetypes, the creation and development of a new model will be presented.

However, to understand the full project, firstly a theoretical chapter guiding the reader through the full digitalization process of the agriculture sector will be discussed. In the chapter, the more theoretical aspects that delineate the transition of a sector into a new transformed one will be treated through the use of different explanatory tools. Sustainability is seen in this bigger picture, as the key driver of the process.

3. The evolution of the sector and the need for a new regime to arise

Through this chapter different theoretical concepts will be explored. These concepts are needed to understand the further development of the project and the choices related to it. They will indeed lead the reader through the understanding of the evolution of the sector, following understanding major concepts such as 'landscape', 'regime', and 'niche' and how sustainability plays a role in this picture.

Firstly, an introduction to the concept of Industry 4.0 and the role of digitalization across all the industries are presented. More specifically, the focus is on the digitalization of the agri-sector and the technologies developed through the years in this context. Following a general S-curve, the curve representing a technology life-cycle, and its application in relation to the agriculture technologies are discussed. The various ways to commercialize the technology in the market are also discussed. High importance is given to the concept of niche, in which the current technologies in the agriculture sector belong to. From there, a wider understanding of the context surrounding a niche is presented, through the introduction of the concept of regime and landscape.

These last concepts lead to the description of the concept of sustainability and the identification of it as one of the main drivers towards a new regime introduction. In order to do so, the sustainable business model archetypes ideated by Bocken, Short et al. (2014) are discussed, as well as the limitation of these in the agriculture context. To overcome the limitation, some environmental parameters are explored, showing the precondition for the following study.

3.1. Digitalization and the advent of Industry 4.0: the use of Big Data

During the past decades, many researchers tried to come up with a homogenous definition of Industry 4.0. The term was first coined in 2011 at the Hannover Fair event in Germany, with the idea to symbolize the change towards a new technological revolution (Tay, Lee et al. 2018). Before the arrival of this concept, there have been previous industrial revolutions. Starting from the first and second industrial revolution, which marked the passage from the traditional manufacturing industry to the use of steam power and mass production techniques. Following, the third industrial revolution moved towards a 'Digital Revolution', through the development in computers and Information and Communication Technology (ICT) industries, laying the foundations for the new revolution to come (Tay, Lee et al. 2018).

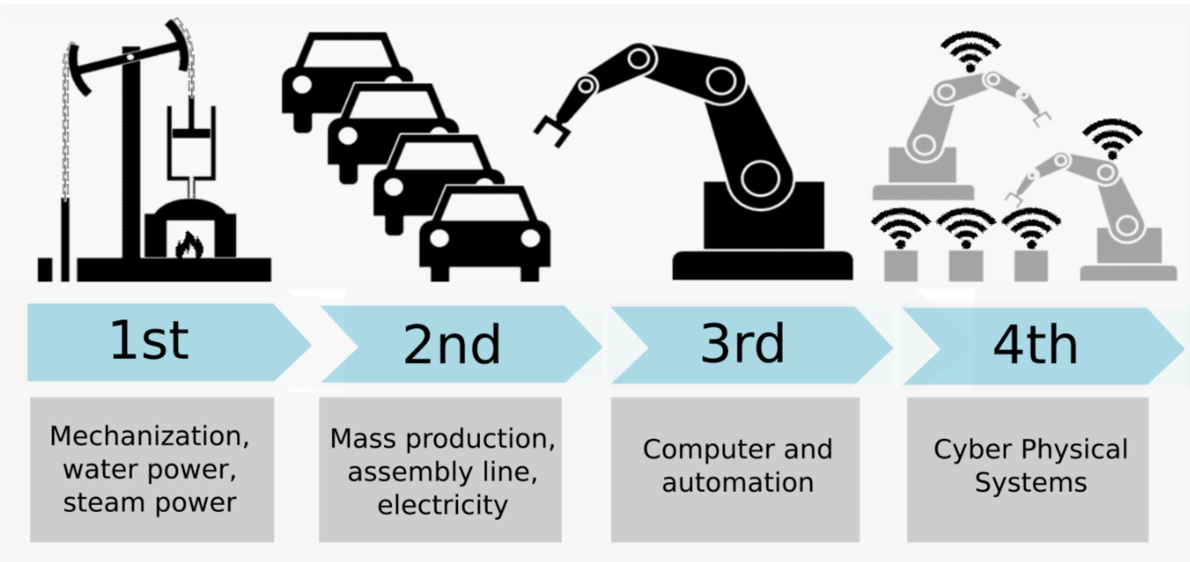


Figure 7: The Industrial Revolutions

Following the study conducted by Tay, Lee et al. (2018), the most common factors within the diverse definitions of Industry 4.0 are the 'costs reduction' and the 'efficiency improvements'. These can be achieved due to the "easy exchange of information and the integrated control of manufacturing products and machines acting simultaneously and smartly in interoperability" (Tay, Lee et al. 2018). This concept easily applies to the agriculture field as well, where the main goal of 'Smart Agriculture' – an approach to farm that utilizes the 4.0 technologies – is to maximize economic returns, guarantee the preservation of resources, carefully taking into account the environment protection (Annosi, Brunetta et al. 2019).

However, while the firsts industrial revolutions have shown some visible benefits for the agriculture field too, improving it greatly, the shift towards digitalization in the agriculture field is still subject to many discussions.

The agriculture sector has been quite active in digital innovations for some decades already. As briefly discussed, the third revolution led to substantial changes in agriculture. The advances in precision agriculture, and later on, in remote sensing, Farm Management Information Systems (FMIS), and Decision Support Systems (DSS) have laid the groundwork for a digital transformation in farming and food (Lezoche, Hernandez et al. 2020). These technologies play an important role in the development of the sector. Between the many benefits that they provide, they do allow to "fertilize according to real needs, monitoring and control of machines and equipment, and the storing of historical data" (Annosi, Brunetta et al. 2019), providing useful insights and traceability to be used during decision-making processes. These benefits are real and enabled today by the most recent developments in Cloud Computing, Internet of Things, Blockchain, Robotics, Artificial Intelligence, etc. The success of these technologies is given by the use of Big Data – "information assets with a high volume, velocity and variety" (Belaud, Prioux et al. 2019). These technologies will indeed "let the agriculture evolve in a data-driven, intelligent, agile, and autonomous connected system of systems. The operations of each agricultural process will be automatically integrated into the food chain" (Lezoche, Hernandez et al. 2020).

All of these technologies can provide indeed benefits due to the use of insights produced by the analysis of the data gathered through the use of them. And this is why, as Belaud, Prioux et al. (2019) affirm in their paper, "one of the core principles of Industry 4.0 is data management".

This principle has been quite well defined by Lezoche, Hernandez et al. (2020), who described the future of the agriculture domain by the identification of four types of crop-based uncertainties: product, process, market, and environment, affirming how the core problem lies in the management. The correct management of these dimensions will lead to the creation of "resilient and sustainable farming" (Lezoche, Hernandez et al. 2020). The data and correct use of them, is thus the "lifeblood of any business" (Lezoche, Hernandez et al. 2020), without exceptions towards agriculture; and since agricultural "data management and exploitation is the central node between digital transformation capabilities and the agriculture concerns", the objective of the future lies in the identification of the technological gaps knowledge between traditional methods and technological advanced ones, increasing efficiency, sustainability, flexibility, agility, and the resilience along the whole supply chain from the farmers to the final customers. This means that there is a need to move away from 'business as usual' and to embrace the implement of new solutions and technologies (Lezoche, Hernandez et al. 2020).

3.1.1. Digitalization in the agriculture field: towards the use of new technologies

If at the beginning of the revolution the focus was mainly towards the manufacturing sector, nowadays, almost all the sectors are affected by this digitalization shift. Examples are the automotive, engineering, chemical, electronics field, but also the hospitality industry and the agriculture sector.

Concerning this last one, there have been different stations in agricultural development. The agriculture sector indeed developed through the years to maximize efficiency as well. The first station dates back to the early 20th century, where the labor-intensive system was experiencing a low production. This system was indeed able to feed the population but a high number of small farms were required. In the second station, the use of nitrogen and new tools like synthetic pesticides, fertilizers, and more efficient specialized machines led to an increase in the yield of production. The concept of 'precision farming' started only around the mid-90s, once military GPS signals were made available for public use (Kovács and Husti 2018). Techniques concerning the monitor of the vehicle fleets, sensing & control, and data management (with the firsts farming software) were then already developed. It is only through the shift towards Agriculture 4.0, the fourth station, that the agriculture field has been boosted further ahead.

From the early 2010s, the evolution of some technologies led to further developments in agriculture, boosting the sector towards new efficiency goals. Some of these technologies are (Kovács and Husti 2018):

- Cheap and improved sensors and actuators;
- Low-cost microprocessors;
- High bandwidth cellular communication;
- Cloud-based ICT systems;
- Big Data analytics;
- Smart control devices (on-board computers);
- Sensors for the operation of the machine and the agronomic process;
- Advanced automation capabilities (guidance, seed placement, spraying, etc.);
- Communication technology (telematics) embedded in the vehicle.

The use of these technologies enabled further discoveries in the application field. The digital agriculture arose, offering new opportunities thanks to the availability of highly interconnected data-intensive technologies. As affirmed by Kovács and Husti (2018), "smart farming makes use of GPS services, machine to machine (M2M) and Internet of Things (IoT) technologies, sensors and big data to optimize crop yields and reduce waste".

As shown in *Table 2* it is possible to observe some of the most recent technologies in agriculture and their possible application, benefits included.

Table 2: Enabling technologies for digital agriculture (revisited), (Kovács and Husti 2018)

Production environment	Type of technology	Purpose and benefits
Cross-cutting technologies	Computational decision tools	Use data to develop recommendations for management and optimize multitudes of farm tasks
	The cloud	Provide efficient, inexpensive, and centralized data storage, computation, and communication to support farm management
	Sensors	Gather information on the functioning of equipment and farm resources to support management decisions
	Robots	Implement tasks with efficiency and minimal human labour
	Digital communication tools	Allow frequent, real-time communication between farm resources, workers, managers, and computational resources in support of management
Field	Geo-locationing (GPS, RTK)	Provide precise location of farm resources (field equipment, animals, etc.), often combined with measurements (yield, etc.), or used to steer equipment to locations
	Geographic information system	Used computerized mapping to aid inventory management and to make geographical crop input prescriptions (fertilizer, etc.)
	Yield monitors	Employ sensors and GPS on harvesters to continually measure harvest rate and make yield maps that allow for identification of local yield variability
	Precision soil sampling	Soil at high spatial resolution (in zones) to detect and manage fertility patterns in fields
	Unmanned aerial systems	Unmanned aerial systems (UAS, or drones). Use small, readily deployed remote-control aerial vehicles to monitor farm resources using imaging UAS
	Spectral reflectance sensing	Measure light reflectance of soil or crop using satellite, airplane, or UAS, imaging, or field equipment-mounted sensors, to make determinations on soil patterns, crop
	Auto-steering and guidance	Reduce labour or fatigue with self-driving technology for farm equipment (including robots); can also precisely guide equipment in field to enable highly accurate crop input placement and management
	Variable rate technology	Allow continuous adjustment of application rates to precisely match localised crop needs in field areas with field applicators for crop inputs (chemical, seed, etc.)
	On-board computers	Collect and process field data with specialized computer hardware and software on tractors, harvesters, etc., often connected to sensors or controllers

More specifically, the use of Artificial Intelligence and Machine Learning techniques, through the use of camera and sensors as well, can offer precise information and potential forecasting. Concerning topics are for instance weather conditions, fluctuations in commodity prices, illnesses, pathogens, and weeds detection. Moreover, the use of a platform can help to monitor and analyze the data, allowing to be up to date with the ongoing processes and eventually to intervene faster (Lakota, Stajnko et al. 2019). "The consequences are improving general health, disease tracking, etc." (Lakota, Stajnko et al. 2019).

It is however important to highlight that, although these technologies on their own can provide useful information about a specific activity within the farming processes, the true potential of the data comes instead from the combined use and integration of technologies. Each of these technologies will either perform descriptive and diagnostic capabilities (i.e. monitoring, sensing, and analyzing). However, to reach a more informative level of data one needs to have technologies that perform predictive or prescriptive capabilities (such as decision-making and adaptive learning processes). "This allows intuiting the suitability of using them as complements with the others" (Lakota, Stajnko et al. 2019).

3.2. S-curve and Large-scale diffusion

In this chapter the concept of S-Curve in technology diffusion is given, as well as the application of it on the actual traditional agriculture S-Curve. After the understanding of the need for new technologies to emerge in order to keep on innovating - thus introducing the concept of discontinuous technologies - a re-adaptation of the Gartner hype cycle in the agriculture sector is proposed. Through this model, it is possible to evaluate the readiness of technology on the market and the stage of development and diffusion in which it is. Following, different diffusion patterns are discussed, evaluating why some technologies fail to arrive to the market even though they are technologically ready. Finally, the concept of niche is given, explaining how often technology can have more success in arriving from the development to market with a niche strategy, compared to a direct competition against the traditional technologies.

3.2.1. Evaluation with S curve of traditional farming methodologies and new technologies

Schilling and Shankar (2019) affirm that "both the rate of a technology's performance improvement and the rate at which the technology is adopted in the marketplace repeatedly have been shown to conform to an s-shape curve". The S-curve is a framework commonly used to define the current stage of a technology life-cycle and the diffusion path of this into the market.

As seen in *Figure 8*, the s-curve derives from the performance of the technology plotted against the time span.

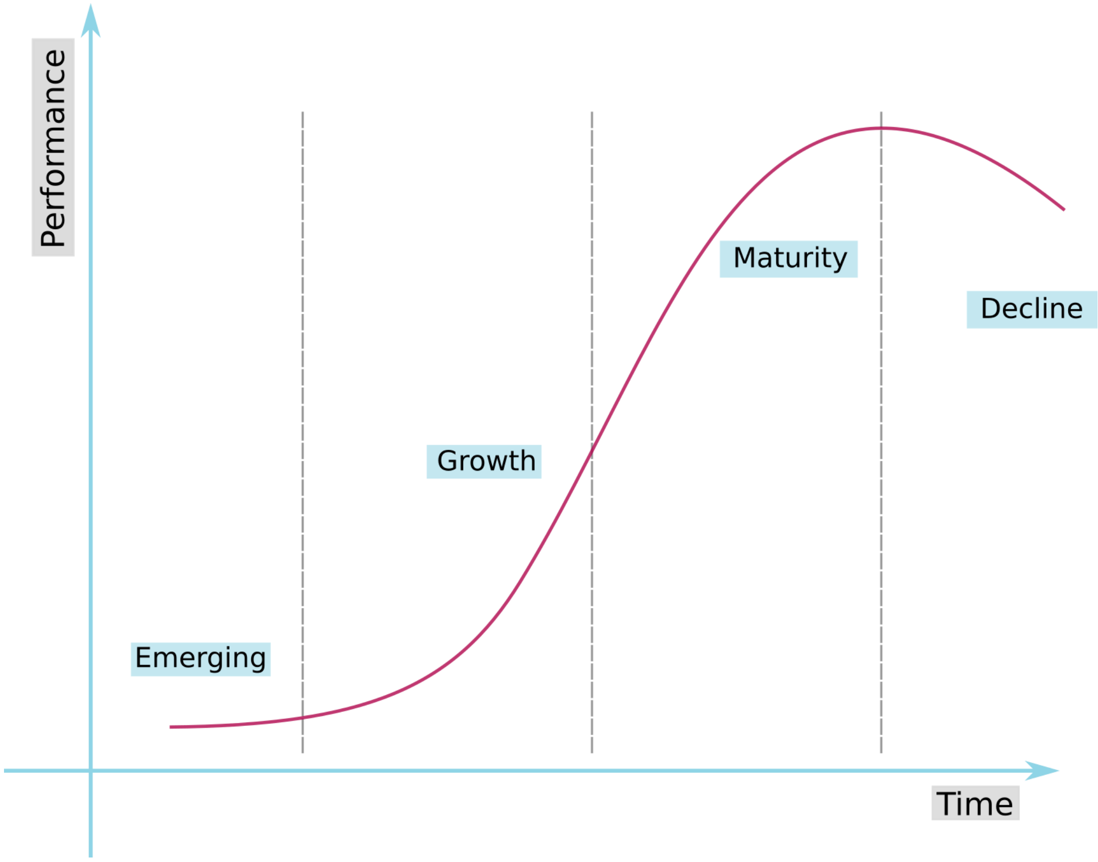


Figure 8: S-Curve of technology performance

The curve initially shows some slow improvements, increasing significantly through time before finally slowing down again. These improvements phases are connected to the main technology development phases: emerging, growth, maturity, and decline. These four phases are also better known as the phases of ferment, take-off, maturity, and discontinuity (Taylor and Taylor 2012); (Schilling and Shankar 2019).

- The era of ferment: this is the first phase of the curve, in which a dominant design did not arise yet, therefore the product/service is still completely new. There is a lot of competition between players in the market and therefore most of the resources are spent on research & development.

- Take-off: following the product/industry is adopted by the early majority, crossing the chasm in the product's diffusion curve – that is the gap between early adopters and the early majority (discussed more in-depth in the next section). This happens due to the technological superiority of the innovation, or the ability to satisfy the market's demand.

Therefore, from now on the market will be characterized by rapid growth, as shown by the steep slope.

- Maturity: this is the phase in which the technology is almost fully adopted by the society reaching its physical limit. Most of the resources are spent in incremental innovation, trying to improve and make more efficient the processes. This is due to the strong competition that there is between different players in the market.

- Discontinuity: finally, since the technology reached its limits, a new s-curve pattern arises, thus an innovation occurs from the opportunity of a saturated market and new market demand arising from different target groups, the innovator or early adopter segment. Therefore, a new product/service life cycle will begin, disrupting the previous technology. This process is better explained through the use of a graphical representation, as shown in *Figure 9*.

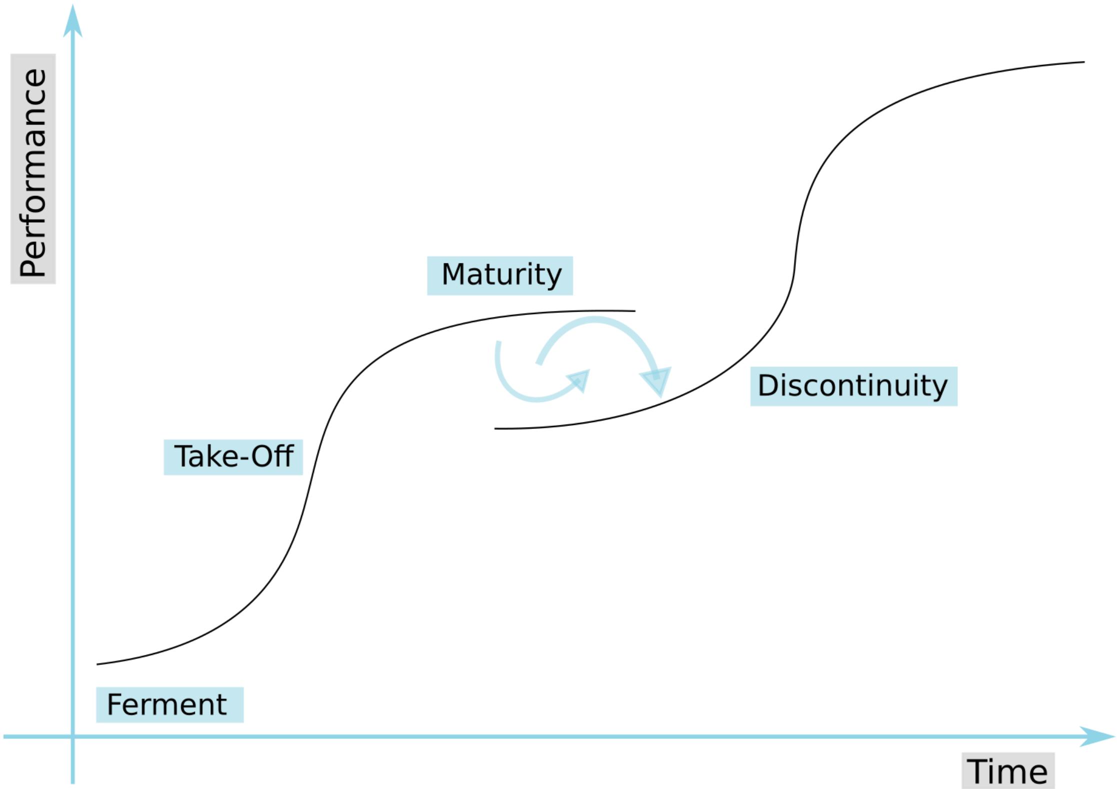


Figure 9: Technology life cycle. Discontinuity phase.

Sometimes a discontinuity occurs even before the technology reaches its maturity, due to the unexpected possibilities offered by the market. "Technologies do not always get the opportunity to reach their limits; they may be rendered obsolete by new, discontinuous technologies" (Schilling and Shankar 2019).

Once a new technology is launched on the market, during the emerging phase, the effort that it is invested in the new technology might acquire very low returns compared to the incumbent technology. This might happen also because the 'newness' element might represent a high risk for the companies, that are therefore reluctant to switch towards the second technology. However, if the second technology has a very steep growth phase (or take-off phase) it might end up overcoming the first technology (see *Figure 10 a*). A second possible scenario is represented by *Figure 10 b*, in which the new technology overcomes the first due to a higher performance limit (Schilling and Shankar 2019). This is, indeed, the case of Agriculture 4.0, or AgTech. Considering the traditional agriculture techniques as the first curve and the modern technologies discussed in the previous section represented by the second technology curve, the second scenario discussed (10 b) describes the transition process of the disruptive innovation that is happening nowadays in this industry.

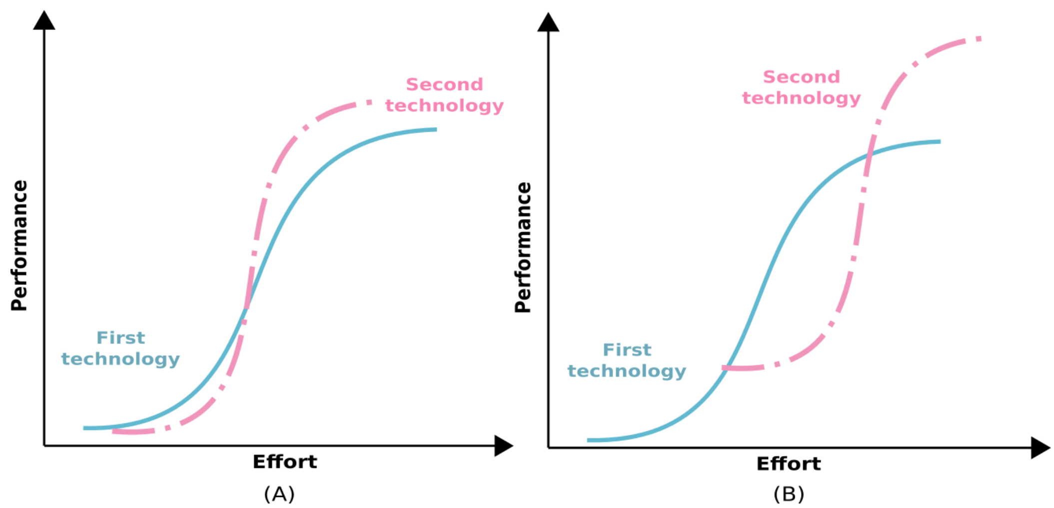


Figure 10: Disruptive technology's curves, (Schilling and Shankar 2019)

The development of these technologies started already a few decades ago; they are now ready to be launched on the market since proven efficient and effective. So why do firms shift towards the new technology more slowly than others, even though the new technology is significantly improved compared to the old one? "The answer may lie in the complexity of the knowledge underlying new technologies, and in the development of complementary resources that make those technologies useful" (Schilling and Shankar 2019). Also, some of the technology knowledge might be tacit. Therefore it requires the transmission from person to person, and thus an initial adoption by early adopters, so that later on the technology can be spread to followers and fully adopted by the market (Schilling and Shankar 2019). A more practical example concerns the use of Decision Support Systems (DSS) already developed in the field. Quite often they are not understood yet by growers, and therefore not adopted even if the efficiency in production and the reduction of costs derived from the use of them would allow many benefits.

As studied by Ortt (2010), each phase during the technology life cycle can vary or in some specific situations disappear as well. The development of technology often follows a more complex and unpredictable process than the one simple described by the s-curve. More into detail the actors that are involved in the commercialization of a new high-tech product may face different types of pre-diffusion scenarios (described in *Figure 11*). Either a long innovation phase follows the invention, meaning it takes quite a long time before a new product/service is introduced in the market (scenario 1). When a product is introduced in the market, shortly after the invention, it doesn't diffuse immediately since it takes a long time to adapt to the market and be understood. Therefore, after the invention, there is a long adaptation phase before entering the market (scenario 2). Or, finally (scenario 3), there is a complete elimination of both the innovation and adaptation phase. The product/service diffuses on the market almost directly after the invention. As discussed before, due to the complexity of the knowledge underlying new technologies, the development pattern of the new high-tech technologies in the agriculture field follows scenario 2. The innovation phase has been quite short since the technologies have been deeply studied in other sectors first, following introduced in the agriculture sector. However, due to the need for a better understanding of the market and the re-adaptation of the technologies in this field, the adaption phase is quite long. This slows down the shift towards a new dominant design.

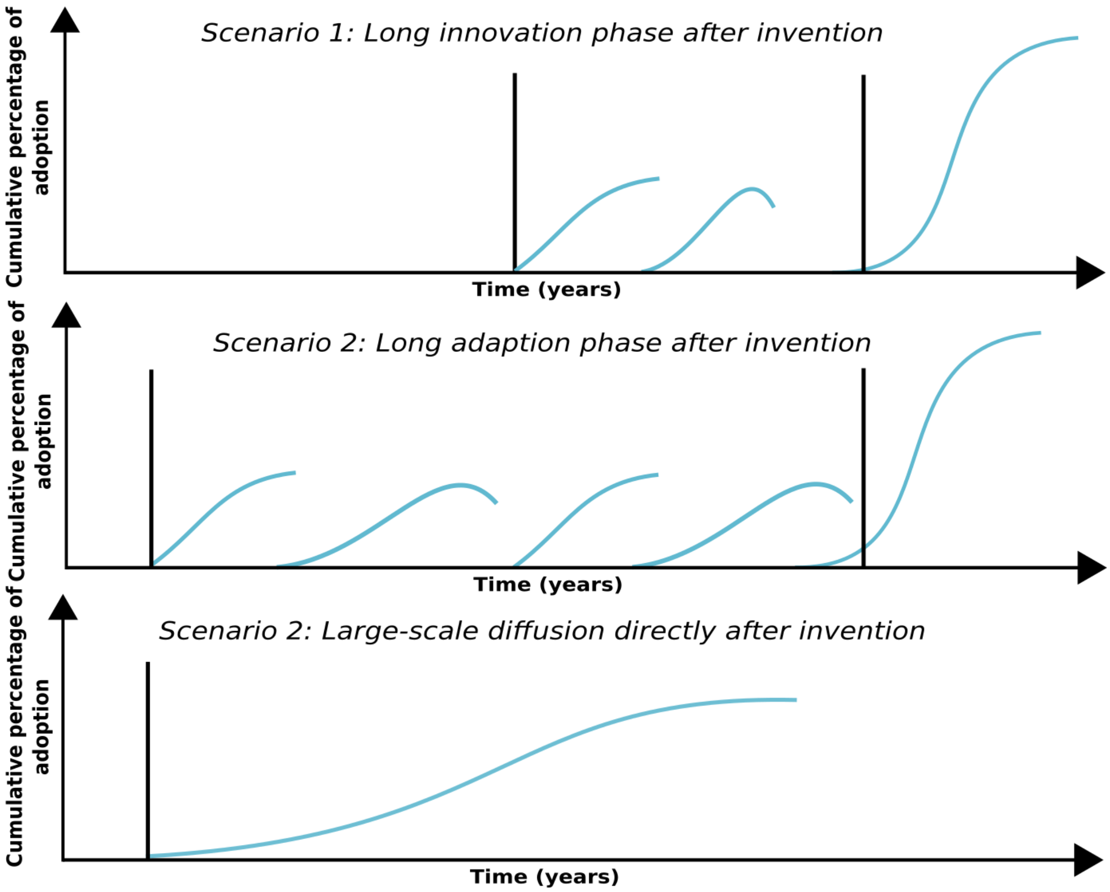


Figure 11: Three scenarios after the invention of breakthrough technology, (Ortt 2010)

3.2.2. Gartner Hype-Cycle in the AgTech field

An alternative model that describes the adoption process over time is represented by the "Gartner Hype-Cycle" that describes the key stages of product utilization in a market (Lamb, Frazier et al. 2008).

This model takes into account the s-curve, thus depicting the technology maturity. It also adds an important element, being the human-centric perspective in terms of human expectations described by peaks or hype levels on the curve (Dedehayir and Steinert 2016). "The first rise in hype is the primarily unsubstantial hype that occurs when a technology is first discussed in the media. Some technologies experience multiple rounds of vacuous hype before beginning a more-serious growth path. The second stage of hype is associated with the beginning of real adoption growth" (Linden and Fenn 2003). After the 'innovation trigger', a high peak is registered ('peak of inflated expectations'). Three major elements are responsible for it: "attraction to novelty (and the love for sharing), social contagion, and heuristic attitude in decision-making" (Dedehayir and Steinert 2016). The media support these trends, increasing even further the development of the peak. However, quite often the sharp peak of enthusiasm for the new technology ends up in disappointing early results. This causes the hype to suddenly drop in what it is called the 'trough of disillusionment'. It is right at this point that the take-off phase of the discussed s-curve starts to take place, as a second equation of the bigger picture given by the hype-cycle (see *Figure 12*).

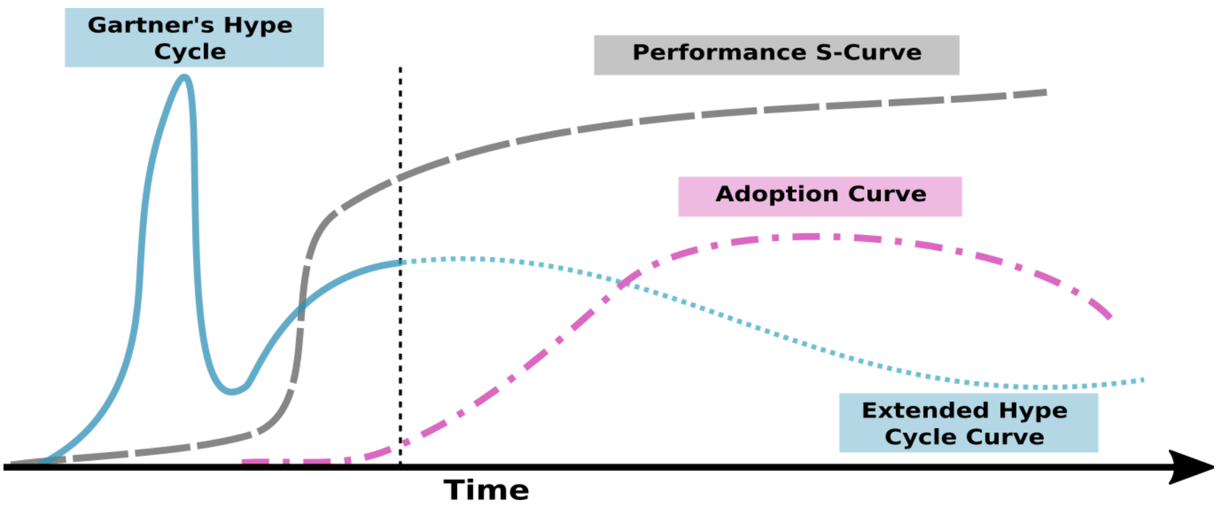


Figure 12: Different life-cycle models merged

A re-examination of the Gartner hype-cycle has been done by Chatzikostas (2017). In this model (*Figure 13*) it is possible to observe more in-depth the development and diffusion stage of some of the main AgTech technologies previously discussed. Technologies such as plant sensors, deep learning, IoT, soil sensors, machine learning, drones, etc. are still crossing the peak of inflated expectation. Some of them are still in the innovation initial phase. Other technologies like Big Data, aerial imagery, AI, etc. are starting now to grow and develop through the slope, being still into a transitional phase towards the adoption.

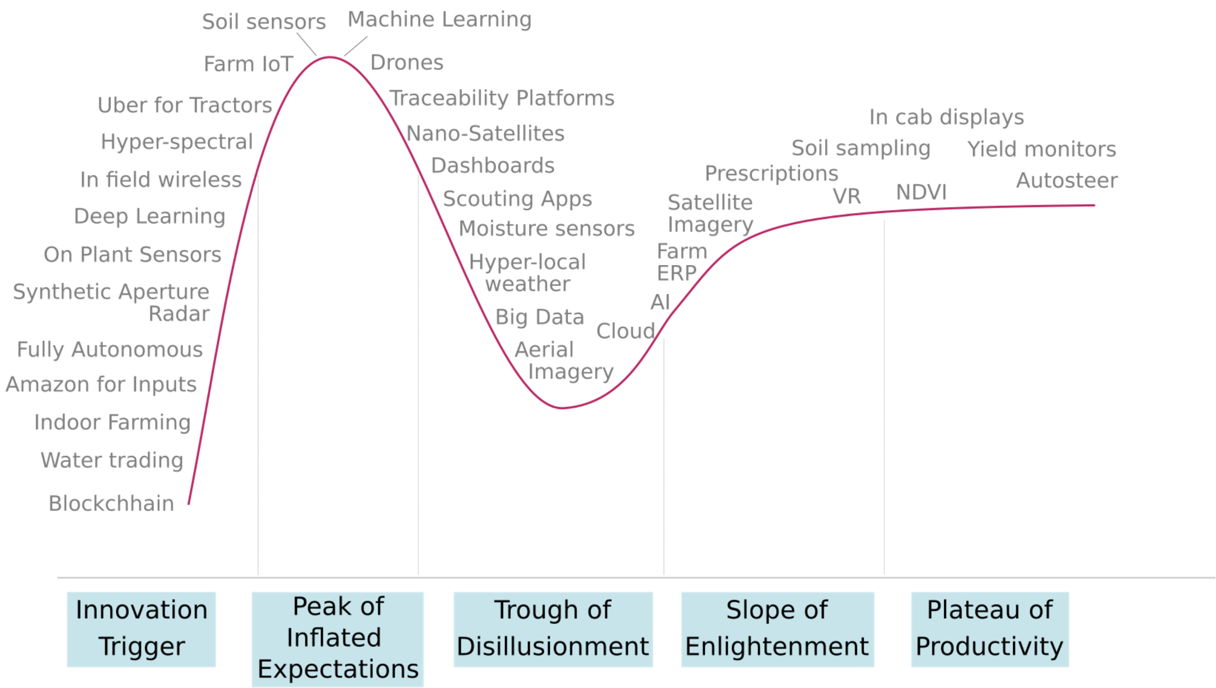


Figure 13: Ryan Rakestraw, Venture Principal at Monsanto Growth Ventures, PrecisionAg Vision event, October 2016, (Chatzikostas 2017)

After the use of different models, the picture of the new technologies development and diffusion in comparison with the traditional farming methodologies looks now clearer. However, the question concerning the main motivation of the long adoption cycle remains. Since the technologies discussed are already highly developed and commonly utilized in different industries, the main concern regards therefore the difficulties to adopt them in the agriculture field.

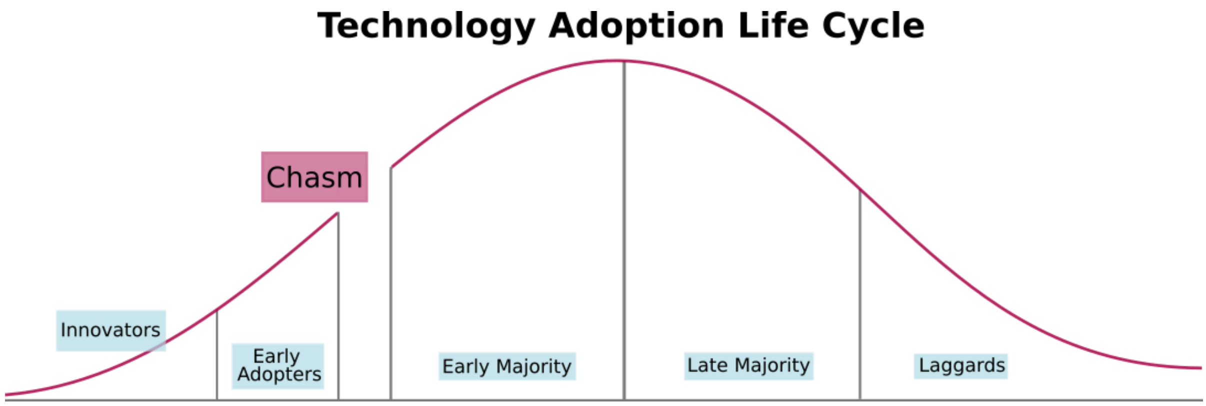


Figure 14: The chasm between early adopters and early majority

A possible motivation of this long adoption cycle lies in the difficulty to reduce the gap between early adopters and the early majority – 'the chasm' (*Figure 14*).

"Early adopters are respected by their peers and know that to retain that respect they must make sound innovation adoption decisions", while the early majority is identified as a group of adopters that "adopts the innovation slightly before the average member of a social system" (Schilling and Shankar 2019). Whenever an innovation fails to cross the chasm, the diffusion path will not take place and new players, innovations, and substitutes will replace it in the market. From a development point of view, one of the reasons at the base of this problem might lie into the difficulty in crossing the 'valley of death' – that is defined as the "space between opportunity discovery and product development" (Markham, Ward et al. 2010). See *Figure 15*.

"The valley of death is the gap between formal roles, activities, and resources poured into research and the existing formal new product development roles, activities, processes, and resources that lead toward commercialization" (Markham, Ward et al. 2010). The problems to tackle to reduce or eliminate this gap is about the reduction of the technology immaturity (both in terms of performance and competitive system), the creation of a shared vision and the development of a network of actors that are willing to learn and build up the missing vision.

The interaction between actors able to conceptualize the idea, adopting and advocating the project (champions), providing resources (sponsors) and setting the goals and criteria (gatekeeper) assure the passage from new product development to the final commercialization and diffusion (Markham, Ward et al. 2010).

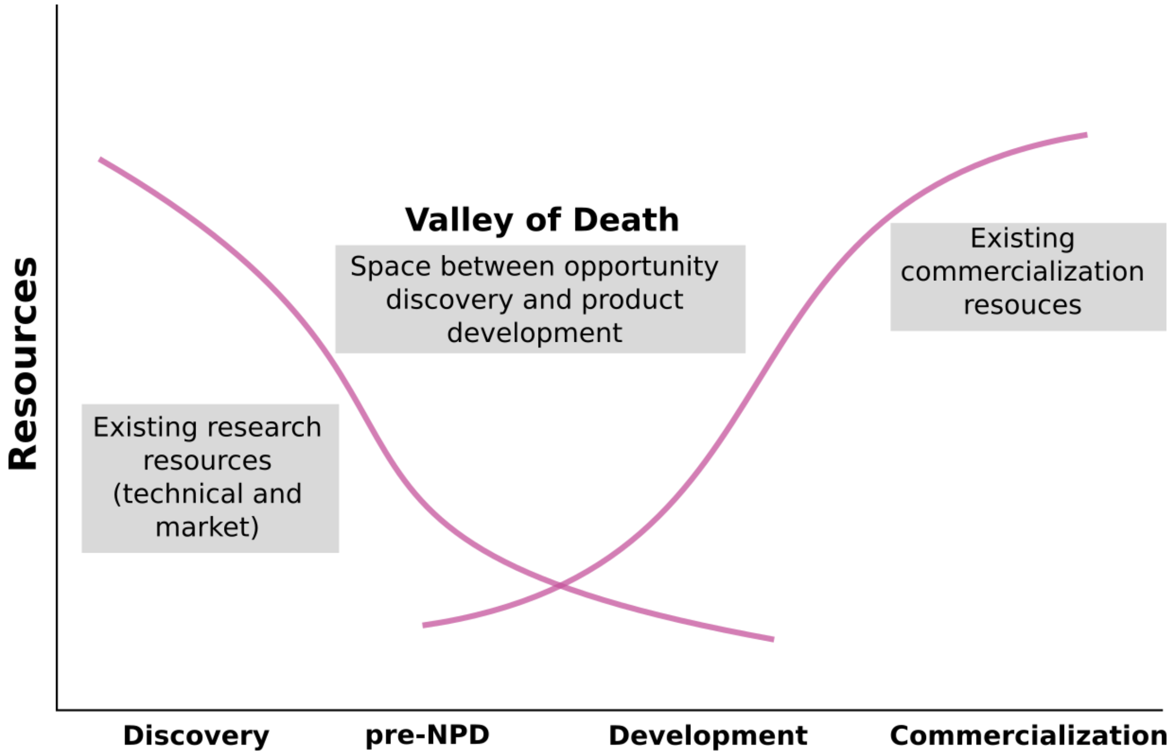


Figure 15: Valley of Death, (Markham, Ward et al. 2010)

3.2.3. One way to commercialize the technologies: the use of a niche strategy

"Radical technologies are relatively crude at the time of their invention and need to be improved and better adapted to user needs. They are only able to compete in specialized markets. These early market niches are important for the further development of the new technology" (Kemp 1994). Once a technology has been discovered and implemented it needs to be commercialized on the market. The rate of adoption can vary depending upon different factors. To commercialize a technology however is not that simple, especially when the market is saturated and the incumbent technologies are highly diffused. This is why radical technologies may benefit from accumulated experience in other sectors, and more importantly from the presence of a network in which it can be easily introduced (Kemp 1994). A possible strategy to create this network and deploy specific marketing and distribution technologies is the niche market strategy. Thus, "the pioneer invests in small production facilities allowing the production of a specific product, tailored to the niche" (Ortt, Zegveld et al. 2007). This strategy has been proven very successful especially in the case of innovative products. Once the innovation is then present in the niche market can overcome other technologies, shifting towards the mass market and gaining the majority of adopters, becoming then the dominant design.

Also, a niche market strategy seems to be the best strategy fit in scenario 2 (*Figure 16*). It, indeed, takes a long period of exploration and adaptation before the diffusion takes off (Ortt, Zegveld et al. 2007).

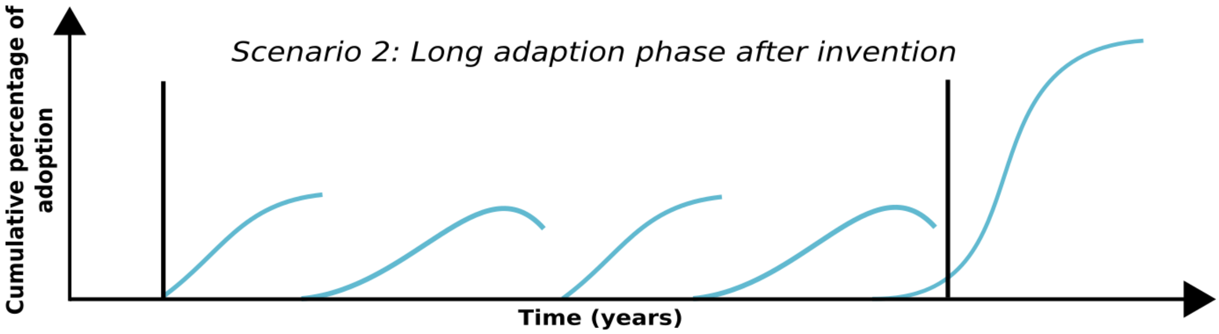


Figure 16: Pre-diffusion scenario 2 and niche market strategy

3.3. Definition of regime, niche and landscape

A transition can be defined as a "process of change from one system state to another via a period of nonlinear disruptive change" (Loorbach, Frantzeskaki et al. 2017). The transition-niche perspective considers that innovation dynamics are driven by both internal forces as well as external factors. This perspective uses a multi-level perspective (MLP) approach to study different configurations in the societal system. In the context of the MLP, the system is divided into three levels: a macro level, represented by the socio-technical landscape, a meso level, that is the regime, and a micro-level - the previously discussed niche (Loorbach, Frantzeskaki et al. 2017).

The landscape comprises slow-changing external factors and is the level with the slowest dynamics. This level entails a wide range of factors that can be taken into account, such as macro-economic factors, corruption, power differences, or cultural aspects. The meso-level or socio-technical regime describes the current trajectories in the existent stable patchwork as well as the existing technologies in use. These technologies are generally mature and highly diffused, and this is also a reason why there is more resistance to new technologies. Finally, the micro-level, the niche, is the level prone to generate and develop radical innovations. It is characterized by low stability and dynamism (Geels 2002).

What is important to consider is that the transition process is characterized by a very iterative and interweaved behavior. A possible outcome will arise from the coevolution of the three levels together instead of a linear, vertical process (Raven 2005). The different three levels are represented in *Figure 17*. The different changes in the regime pathway and the overall nonlinearity in the interaction between the different levels are also presented. The last one creates the 'opportunity window' for possible changes due to either new arising opening within the niche system, the pressure operated by the landscape, or the coevolution of both.

To make it possible for the transition to happen, innovations arising in the niche level, or micro-level, need to be able to scale up and diffuse in the market, expanding later on to the other two levels. Therefore, once an innovation grows as a niche market, it needs to take place in the regime simultaneously with the actual incumbent regime. Once the opportunity window is present, also caused by the pressure of the landscape, the niche will be able to overcome the old regime and establish a new one. The transition is characterized by three important elements: non-linearity, multilevel, and coevolution. Thus, changes do not take place in gradual or incremental changes; the changes come across the whole system. Also, technological innovation interacts with other aspects such as institutional changes in an evolutionary way (Loorbach, Frantzeskaki et al. 2017).

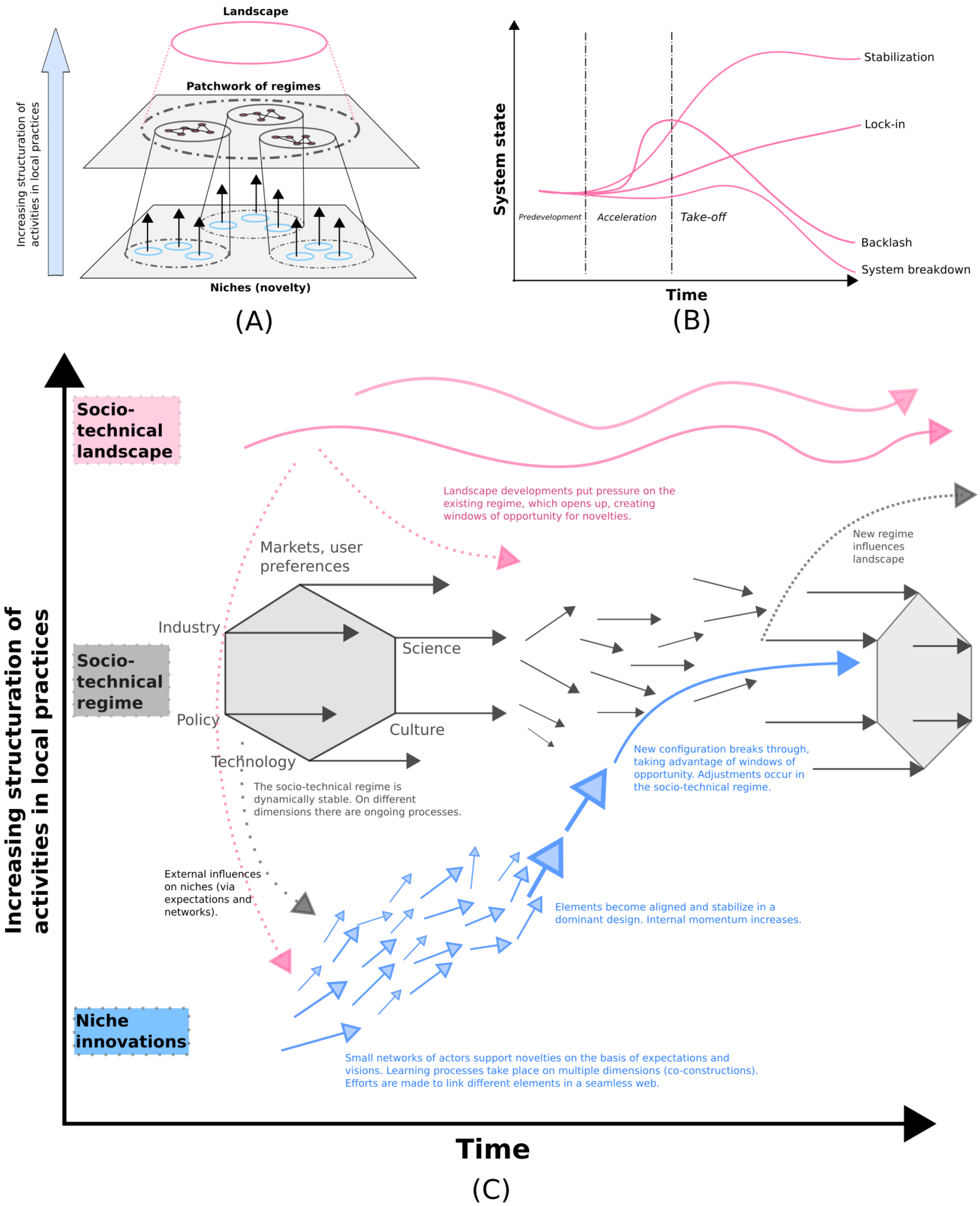


Figure 17: Multi-level perspective model. Coevolution between the three dimensions (a); regime changes due to the coevolving landscape pressure and niche emergence (b); nonlinearity of the transition and different type of pathways (c); (Loorbach, Frantzeskaki et al. 2017)

In the specific context of the agriculture sector, the actual regime is represented by the use of traditional farming practices such as agroforestry, intercropping, crop rotation, cover cropping, traditional organic composting, and integrated crop-animal farming (Singh and Singh 2017). On the niche level lies the use of the new agriculture 4.0 practices, consisting of applied use of technologies to improve farming efficiency. Examples are given by the use of AI, ML, precision agriculture, etc.

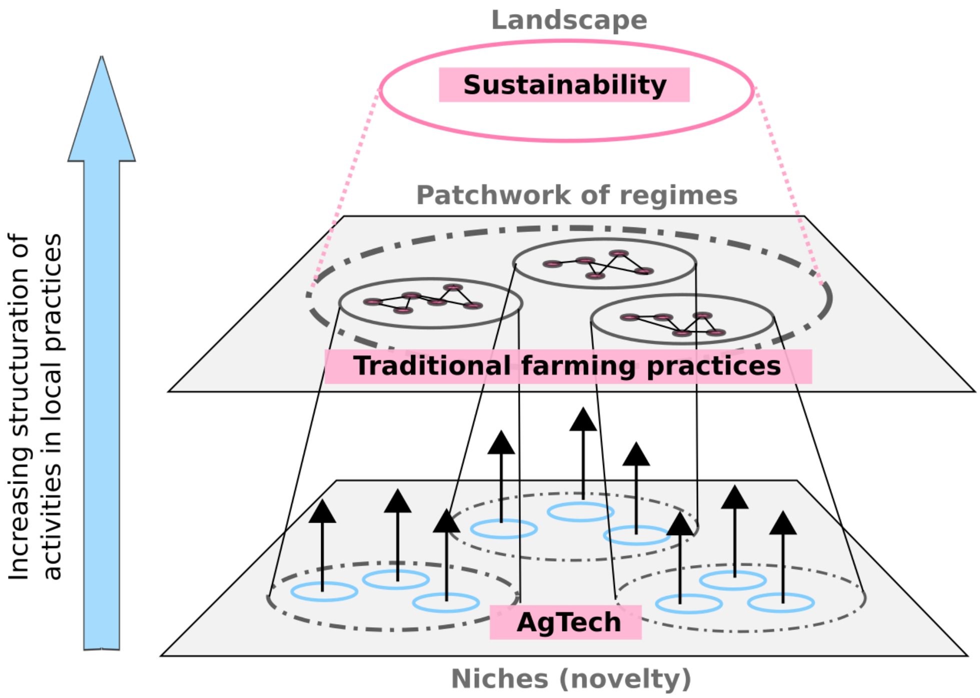


Figure 18: MLP in the agriculture industry

The industry is exploring the shift from the incumbent regime to a potential new one, dictated by the further development and better acknowledgment of the niche. However, to make the transition possible, the landscape must play a central role, depicted in *Figure 18*. "As the broader societal context changes and new radical alternatives develop and emerge, regimes inevitably will enter a process of increased stress, internal crises, destabilization, and shock-wise systemic reconfiguration" (Loorbach, Frantzeskaki et al. 2017). Several factors are enabling the transition towards a new regime. Many of them can be categorized under the concept of sustainability.

Indeed, factors such as climate change, increase in population, new diet behaviors, food safety, etc. are the main triggers towards a new dominant regime. The agriculture industry is therefore right in the central phase of shifting towards a dominant regime: a sustainable digitalized agriculture that is more efficient and more sustainable. This is possible due to the window of opportunity that is now open thanks to the impact of these factors towards the other levels. Some linking mechanisms can also include that niches receive support from the actual regime actors. A practical example is given by the care farming niche, which in The Netherlands was supported by both the Ministry of Agriculture (agriculture regime) and the Ministry of Health Care (care regime) (El Bilali 2019).

As studied by El Bilali (2019), some of the factors addressing external trends and exogenous factors affecting the transition towards a sustainable agro-food system are "globalization and agro-food market internationalization, population growth, global financial crisis, changes in diets and lifestyles, (neo)-liberalization, international treaties and conventions, the Common Agricultural Policy in the context of the European Union, increasing concerns about animal welfare and the environment, and climate change".

In *Table 3*, Wolfert, Ge et al. (2017) offer a more detailed picture of the pushing and pulling factors driving the transition.

Table 3: Factors driving the development of Big Data and Smart Farming, (Wolfert, Ge et al. 2017)

Push factors	Pull factors
General technological developments	**Business drivers**
Internet of Things and data-driven technologies	Efficiency increase by lower cost price or better market price
Precision Agriculture	Improved management control and decision making
Rise of ag-tech companies	Better local-specific management support
	Better cope with legislation and paper work
	Deal with volatility in weather conditions
Sophisticated technology	**Public drivers**
Global Navigation Satellite Systems	Food and nutrition security
Satellite imaging	Food safety
Advanced (remote) sensing	Sustainability
Robots	
Unmanned Aerial Vehicles (UAVs)	
Data generation and storage	**General need for more and better information**
Process-, machine- and human--generated	
Interpretation of unstructured data	
Advanced data analytics	
Digital connectivity	
Increased availability to ag practitioners	
Computational power increase	
Innovation possibilities	
Open farm management systems with specific apps	
Remote/computer-aided advice and decisions	
Regionally pooled data for scientific research and advise	
On-line farmers' shops	

3.4. The concept of sustainability

3.4.1. Definition of sustainability

The term 'sustainability' is increasingly achieving importance in all industries. Driven by the necessity to tackle numerous insurgent concerns, especially from the social, organizational, and environmental point of view. It is nowadays a term that every company, independently by the industry, is adopting. Examples of how the term is treated within corporates are for instance the right of the workers, the use of fewer resources during the production processes, or the preservation of a natural landscape. However, a clear single definition has not yet be given in the literature. On the other hand, there are the more common definitions of "sustainable development", "sustainable production" or "sustainable economy". Missimer, Robèrt et al. (2017) defined the concept of sustainability as the "elimination of mechanisms of systematic degradation of essential aspects of both the ecological and the social system". However, the authors also claimed that in terms of the concept of sustainability itself, and more specifically concerning social sustainability, 'vagueness and pluralism' of definitions are more 'appropriate and preferable'. This is due to the complexity behind the existence of the concept, and therefore "a common definition is impossible or undesirable" (Missimer, Robèrt et al. 2017).

Concerning the concept of 'sustainable development', the most significant definition has been given during the World Commission on Environment and Development in 1987 by Cassen. The notion has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Cassen 1987). The key element in the author designation is given by the concept of 'needs' and more specifically by the idea of "limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (Cassen 1987).

Close definitions towards the idea of sustainability have been proposed by authors such as Kemp (2011), who, with the intent to pair the concept of sustainability with the innovative element, proposed the concept of eco-innovations.

> "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp 2011).

An important element in this definition is given by the need to reduce the resources used and to decrease the release of harmful substances through the whole life-cycle (Kemp 2011).

On top of this definition lies the one of 'sustainable innovation' – "a process where sustainability considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialization. This applies to products, services, and technologies, as well as new business and organization models" (Clark and Charter 2007).

The agriculture sector is rapidly adopting the concepts of sustainability innovation and sustainable development within the farming practices and more generally along with the different phases of the supply chain. However, shifts in complex technological systems do not only involve technological changes but changes in production, organization, and people's lifestyles too (Kemp 1994).

Nowadays, a common practice to measure the concept of sustainability within industries is also given by the measurement of the 17 Sustainable Development Goals (SDGs) developed by the United Nations Member States in 2015 with a roadmap towards the year 2030. They are described as "a shared blueprint for peace and prosperity for people and the planet, now and into the future" (SDGs 2015). Smart agriculture, or Agriculture 4.0/Agtech, can be related with at least five sustainable development goals: "Goal 8: Decent Work and Economic Growth, Goal 9: Industry, Innovation, and Infrastructure, Goal 11: Sustainable Cities and Communities, Goal 12: Responsible Consumption and Production, and Goal 13: Climate Action" (Ciruela-Lorenzo, Del-Aguila-Obra et al. 2020).

As quite often discussed in the literature and affirmed by many different authors, sustainable development has three main objectives: economic efficiency, environmental sustainability, and social fairness. Since this concept involves changes concerning the way resources are used, consumption and production configurations, as well entire social structures reconfigurations, a new business model is required deriving it from new approaches that take the full life-cycle of the agricultural supply chain into account (Belaud, Prioux et al. 2019).

3.4.2. Sustainable business model and the sustainable business model archetypes

As was discussed before, the main three dimensions of sustainability are the social, environmental, and economic dimensions. This holistic view also goes by the name of 'sustainable business thinking', balancing or aligning the value creation for all the stakeholders involved in the process at different levels of the business activities (Bocken, Rana et al. 2015). Even though the concept of 'sustainable business thinking' is quite diffused, the tools that have been created during the past years in literature still don't fully reflect the conceptualization of this holistic perspective that takes into account the social dimension too. Examples can be given, such as the use of the 'Life Cycle Assessment' (LCA) tool and the 'Business model canvas' (BMC). While the first narrowly focus on parameters such as energy and carbon reduction - excluding the social dimension and the embracement of the stakeholders' considerations, - the second tool gives insights on the specific elements of a business model, without necessarily providing good insights on a sustainability level (Bocken, Rana et al. 2015).

Business model innovation is more than simply changing the product/service offered to the customers. "Business model innovation involves changing 'the way you do business', rather than 'what you do' and hence must go beyond process and products" (Bocken, Short et al. 2014); it lays the foundations towards the creation of an innovation system. Thus, business model innovations for sustainability are defined as "innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organization and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions" (Bocken, Short et al. 2014). They are the key to business success.

A business model innovation is characterized by three elements (*Figure 19*): the value proposition – highlighting a product/service offering for the customer that can generate economic, ecological and social value; value creation – i.e. the identification of new markets, opportunities and the modalities to gain a revenue stream; and delivery and value capture – identified through the different ways to earn revenues (i.e. "provision of good, services or information to users and customers") (Bocken, Short et al. 2014).

Figure 19: Conceptual business model framework (Bocken, Short et al. 2014)

To provide a more comprehensive model, able to properly include the sustainable aspects as well, Bocken, Short et al. (2014) developed the 'sustainable business model archetypes' – a categorization of clusters of solutions that contribute towards the realization of a sustainable business model, creating new development paths and innovation (see *Figure 20*).

According to the authors' explanation, the selection criteria for the model development include elements concerning "innovations that generate environmental and/or social benefits in business operations" (Bocken, Short et al. 2014), either through negative impacts reduction or new value generation. However, the simple application of the model in the agriculture industry doesn't come without implications. Indeed, even if one of the underlying factors is the environmental dimension – that in the Agtech field plays a fundamental role – the model does not sufficiently push towards that direction. The environmental dimension is indeed considered through the use of two archetypes mainly:

- 'repurpose for society/environment', defined as the prioritization of "social and environmental benefits rather than economic profit (i.e. shareholder value) maximization";
- and 'maximize material an energy efficiency' – "Do more with fewer resources, generating less waste, emissions, and pollution".

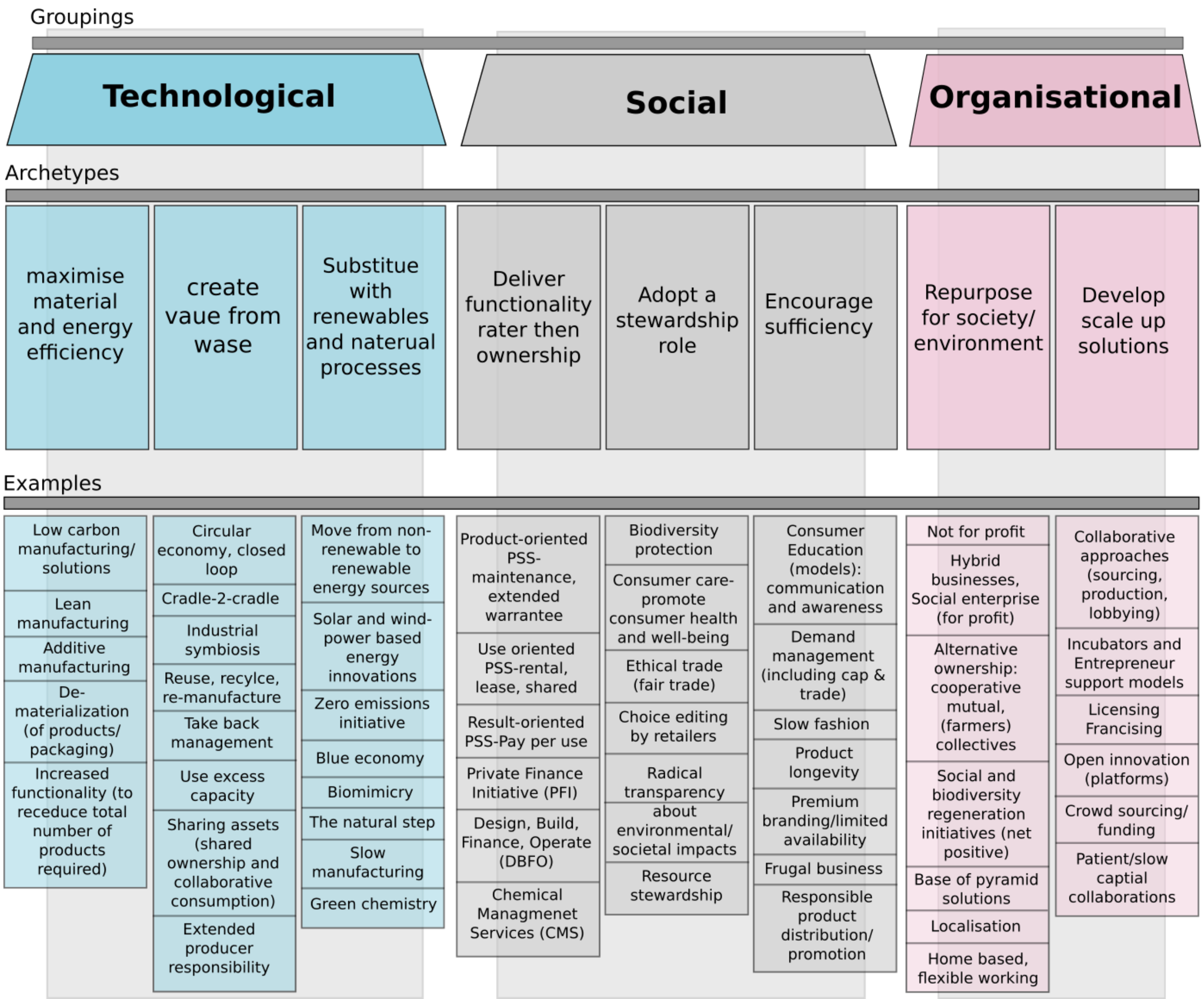


Figure 20: Sustainable Business Model Archetypes (Bocken, Short et al. 2014)

While these dimensions take briefly into account the social and environmental aspects, given the wide array of researches towards environmental/sustainability indicators in the literature, in the model more space should be given to these dimensions. Also, given the multiple examples proposed by the authors as well, it appears that even though the model can be generalized at a higher level towards all the industries, the use of it within manufacturing, energy, and mobility prevails. This is also demonstrated by the empirical use of the model found in the literature. Applications were discussed in the following sectors, but material concerning the application in the agriculture field was lacking. A potential elaboration of the model, as an improved fit concerning the agriculture field, will then further on be elaborated starting from a different groupings categorization and the identification of archetypes/set of criteria, that more specifically apply in the agriculture sector context. This will, therefore, result in the final outcome of the report.

3.4.3. Environmental/sustainability indicators in the literature

In literature, it is possible to retrieve some information concerning the environmental parameters or indicators for sustainable agriculture. On the base of this information, a few hypotheses to be verified during the project will be developed. This information, however, result to be very useful in the understanding of the need to readopt the model of sustainable business model archetypes previously discussed. From the starting point that in the agriculture sector the environmental factors have a central role, and the verification of some of the hypotheses made possible through the use of these factors, a re-elaboration of the model will be developed.

In the previous sections, different types of applications of the 4.0 technologies for smart agriculture have been considered. Some of these are smart irrigation and input delivery; agriculture drones or Unmanned Aerial Vehicles (UAVs); soil and plant monitoring systems; Yield Monitoring Systems; Farm Management Software (FMSs) and Predictive Data Analytics (Annosi, Brunetta et al. 2019). It has been proven through literature that these technologies can transform the production system in a more “sustainable, efficient and resilient one”, enabling and increasing “crop yield, an early detection of diseases, pests or weeds for a timely and site-specific control, an optimization of crop irrigation” (Annosi, Brunetta et al. 2019).

However, what has not been discussed is the motivation behind the use of these technologies. This one is answered by the environmental indicators measured in agriculture. On the base of the studies conducted by Czyżewski, Matuszczak et al. (2018), OECD (2001) and Zhen and Routray (2003) these indicators can be summarized as follow:

- Amount of fertilizer/pesticides per unit of land;
- Amount of irrigation water per unit of land;
- Soil nutrient content and quality;
- Water use efficiency;
- The nitrate content of groundwater and crops;
- Biodiversity and wildlife habitat;
- Greenhouse gas emission;
- Land conservation;
- Landscape.

It is also important to highlight that these have been chosen as a representation of the most important ones out of a major number. These will lay the foundation for some preliminary hypotheses that will be verified thanks to the interviews with the farmers.

4. Methodology: interviews, desk research, and qualitative analyses

In this section, the methodology used for the analysis, as well as the preparation of the material for gathering insights are presented. To answer the main research question of the study, different types of qualitative data have been gathered. Firstly, the company Kubota Holdings Europe, in which the study has been conducted, organized a workshop during which the general open discussion gave initial motivations for the creation of the project. More detailed questions have been identified and asked to a total number of 11 interviewees. Afterward, a start-up database for comparing start-ups and growers was created. Thanks to the insights gathered during the interviews, a categorization of this database depending on grower needs and by the four technology types of business analytics was performed. An analysis using these tools allowed the creation of meaningful results and insights.

These will be discussed in the next section (C*hapter 5*).

4.1. Interviews with the growers

4.1.1. Workshop

On 05/03/2020, an initial exploration of the field was conducted. The company Kubota Holdings Europe directed a workshop in order to explore the main key points concerning farming practices in the orchard domain. The workshop was later on re-elaborated within the company, to understand how these key points are applicable in the vineyards domain as well. The re-elaboration has been made possible thanks to the expertise of several researchers within the company, understanding the differences, if existing, between the domains for each question of the workshop. The two domains (orchard and vineyard), even though they present few differences, are quite similar. Indeed, the main differences are given by some phases during the production life cycle (i.e. in the orchard, one talks about fruit/flowering thinning while in vineyards is about leaf thinning) and the technology adoption. The vineyard domain appears to be more conservative than the orchard one, being more attached to the traditional farming practices used in the past.

The main concept behind the creation of the workshop for this study is the creation of general base knowledge to lay the foundations for the identification of the right questions to be asked during the interviews. Indeed, the workshop gave a general understanding about notions such as the most developing technology trends; consumer tastes' trends; the connection between the technology adoption and the increase in sustainability; the key barriers for the technology adoption and the role of the governments and/or organizations in the technology adoption and sustainability improvements. Moreover, another important aspect of the workshop is the aim to identify potential pain points from the grower side.

Growers, researchers, agronomists, and agro managers participated in the workshop, for a total amount of 9 participants. The participants belong to the following countries: French, Spain, Belgium, and The Netherlands.

The main insights derived from the revised workshop can be found in *Appendix A*.

4.1.2. Identification of the questions

After the workshop session, I identified some questions for the growers' interviews. These questions were aimed at investigating specific hypotheses gained from literature. The four questions are as follows:

1. How would you define the concept of sustainable farming and how does this play a role for you?

2. Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?
3. Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?
4. How do you measure these parameters? Do you make any use of technology to perform these measurements?

As has been briefly mentioned in the literature review (C*hapter 2*), the first hypothesis concerns the presence of a gap in the understanding of the concept of sustainability, considered from the different perspectives of the growers and the start-ups. After different investigating literature, very limited sources were identified. Also, the concept of sustainability, especially from the start-ups' point of view, is only marginally present. Therefore, the following hypotheses were formed:

A. 'sustainable farming' for farmers is a concept mainly involving environmental, economic, and social issues. The first category, environmental, appears to have a major weight on their general concept of sustainability, where the business becomes sustainable whenever fewer resources are used. Thus, the environment is not polluted and the use of land maximized;
B. The same concept for start-ups is more oriented towards the achievement of competitive advantage, meaning through reduction of costs, development of newer technologies, and acquisition of bigger market shares.

These hypotheses, therefore, were at the base of the first question: "How would you define the concept of sustainable farming, and how does this play a role for you?".

Following, a question concerning the possible trends developing in the farming practices and the impact of these on sustainable farming was ideated. It investigated the use of technology during these trends development as well. This second question is meant to understand if there is any correlation between the current market/social/economic trends and the concept of sustainability. Also, the question has been already more deeply investigated during the workshop. However, the re-proposition of the question here allows us to perform the first evaluation, understanding if there are incongruences between the insights previously gathered and the ones given by this question.

The questions: "which parameters need to be monitored during the growth of the crops in order to achieve a sustainable production?" and "how do you measure these parameters? Do you make any use of technology to perform these measurements?" follow. These questions are fundamental for understanding some of the main passages that will lead to an answer to the main research question. The idea behind this investigation is that the identification of the main parameters needed to be measured in the field, as well as the understanding of the role of technology in this process, can determine, together with the start-ups' database (later presented), where the mismatch, if any, between market demand and market products is. The identification of this gap will allow then to proceed further in the identification of criteria. The criteria could then be used for the creation of the start-ups sustainable business model to match the growers' needs.

Concerning these last questions, some information was already identified in the literature, and thus used as a possible assumption of the final outcome of the answer. Some of these indicators have been presented in *Chapter 3* (*Section 3.4.3*). Between the main indicators, one can consider the use of pesticides/fertilizers, landscape conservation, water use efficiency, and quantity/quality of nutrients in the soil.

4.1.3. Conduction of the interviews

Starting from the end of April, and during the whole month of May, I have been conducting interviews with growers. The questions for the interviews have been inserted within a bigger questionnaire created by Kubota Holding Europe. The company too indeed was interested in investigating different growers' perceptions. Thus, because the four questions were part of the company general questionnaire, there was no need for the stipulation of any Human Research Ethics committee modules in accordance with the Delft University of Technology.

In total 11 interviewees were interviewed. The main parameters for the identification of the interviewees were mainly related to the crop type, the geographical area, and the size of the farm.

The main crop type produced was grapes (for wine production, not table grapes). In line with the study parameters, the interviewees were all belonging to European countries. The interviewees were working in, or owning a farming company with an average farm size between 100 and 400 hectares and appeared to have a propensity for innovation. The size of the farm, as well as the degree of innovation they showed, allowed to identify possible market early adopters. Indeed, early adopters are the main target for a clearer understanding of the potential technology use in farming practices and the sustainability concept behind their production.

Unluckily, due to time constraints during interviews, it was not possible to ask all the four questions to all interviewees. Therefore, in some cases, the questions concerning the trends in farming practices and the relative use of technology (question 2) were cut. Still, a sufficient number of responses were obtained, with a total of 6 full interviews conducted. In the remaining 5 interviews, question 2 was removed. However, the analysis has still been possible thanks to the information gathered with the previous workshop results. A full transcript of the interviews conducted can be found in *Appendix B*.

4.2. Start-ups database preparation

4.2.1. Database creation

In order to investigate the business perception, I created a database of innovative start-ups in the AgTech world. The resources used for the start-ups' database creation are offered by Kubota Holdings Europe company and indirectly by the TU Delft University, due to the established partnership of the company with the research organization.

The database has been developed in five main passages. Firstly, the Kubota database was processed from an initial database of 125 start-ups. The number of start-ups was funneled down, removing all start-ups whose crop domain was not within the specialty crops (meaning orchard, vegetables and vineyards domain). Only start-ups operating in crop care management have been considered. More specifically, this means that all the start-ups operating towards Farm Management Systems (FMS), vertical farming, livestock farming, e-commerce/platforms online, or greenhouses technologies were removed. This resulted in only 27 out of the 125 initial start-ups being considered.

A similar process has been applied to the database originally created by the TU Delft University for the company. All the duplicates were removed resulting in 259 start-ups out of the initial 315. Afterward, a funneling process depending on the geographical area was executed. Only the start-ups with their main headquarter within a European country have been considered (being 169 out of 259). Once again, the database was then scaled down depending on the type of crop (specialty crops) and the crop application (crop care management). Once the two initial revised databases were cleaned, they were merged into a combined integrated database of 69 start-ups.

Initially, this project was thought to be for specialty crops in general. However, after deeper analyses, the focus shifted to vineyards only. The available interviewees pointed mainly towards this domain. Therefore, the last step was once again to funnel crop type, excluding all the start-ups that were not oriented towards the vineyard domain, obtaining a final database set of 42 start-ups.

4.2.2. The technology readiness level (TRL)

Following, I assigned a technology readiness level (TRL) to each start-up in the final database. The technology readiness level was originally developed by NASA in the US in 1974 and revised in 1989. The TRL is developed and adopted in different industries to measure and describe the level of technology maturity. Especially concerning hardware, software-intensive, and practice-based technologies, the TRL results to be a useful tool to determine at which stage of development and commercialization the technology is (Nolte, Roger J. Dziegiel et al. n.d.).

Below a representation of the 9 levels to classify the technology maturity (*Table 4*) is depicted. The table represented is an adjustment of the original NASA 9 levels with more specific hardware and software descriptions operated by the Air Force Research Laboratory (AFRL).

Table 4: Technology readiness level (TRL) hardware and software descriptions, (Nolte, Roger J. Dziegiel et al. n.d.)

TRL 1	Lowest level of technology readiness. Research begins to be translated into applied research and development. Examples might include papers studies of a technology's basic properties.
TRL 2	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
TRL 3	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
TRL 4	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
TRL 5	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment.
TRL 6	Representative model or prototype system, which is well beyond that of TRL5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness.
TRL 7	Prototype near or at planned operational system. Represents a major step up from TRL6, requiring demonstration of an actual system prototype in an operational environment, such as in aircraft, vehicle or space.
TRL 8	Technology proven to work in its final form and under expected conditions. In most cases, this TRL represents the end of true system development. Examples include developmental test and evaluation.
TRL 9	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

The level of maturity of each start-up has been determined on the base of the prototype readiness (presence of a patented technology vs fully functioning prototype), and the commercialization phase (testing phase vs stable clients). To do this, each start-up website and/or news event related to the launch of the technology or possible partnerships/new clients has been evaluated.

4.2.3. Four types of Business Analytics

I also performed a first categorization of the database, on the base of the four types of business analytics. "Business analytics refers to the extensive use of data, acquired by diverse sources, statistical and quantitative analysis, explanatory and predictive models, and fact-based management to drive decisions and actions to proper stakeholders" (Lepenioti, Bousdekis et al. 2020). Therefore, the process of iterative exploration of past business performance and insights gathering to drive business planning can be descriptive, diagnostic, predictive, and prescriptive (Banerjee, Bandyopadhyay et al. 2013):

- Descriptive analytics answers the question "What has happened?". It describes a phenomenon through the use of different measures in a simply descriptive way.
- Diagnostic analytics is an extension of descriptive analytics and tends to explain 'why' something happened. It is thus obtained through the use of explorative data analysis, identifying the root causes of a problem.
- Predictive analytics is the stage answering the questions "What will happen?" and "Why will it happen?" in the future. Thus, it predicts future outcomes and uses data mining techniques to explain the main drivers of a future outcome.
- Prescriptive analytics, finally answers questions such as "What should I do and why should I do it?". It goes behind all the previous stages proposing decision-making techniques and suggesting actions to be taken in the future for optimizing the processes. "It associates decision alternatives with the prediction of outcomes" (Banerjee, Bandyopadhyay et al. 2013).

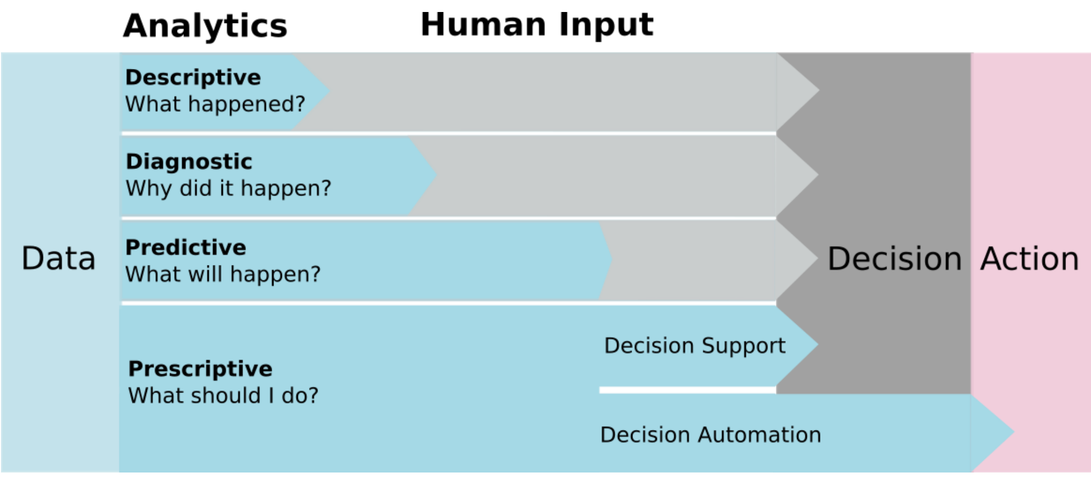


Figure 21: Four types of business analytics, Gartner (2013)

The level of difficulty, value, and intelligence of the business analytics increase from descriptive towards prescriptive. In *Figure 21*, a graphical representation of the four business analytics is given for a deeper understanding.

On the ground of the information given, I categorized the start-ups present in the database following the explained model. Therefore, for each start-up, a business analytical level has been given to start-up technology (product/service). Of the 42 total start-ups, 1 has been categorized as diagnostic analytics, 18 predictive analytics, and 23 prescriptive analytics.

4.2.4. Database categorization

Finally, I performed an additional categorization on the base of the main activities that growers need to perform during the product life cycle to perform farming practices that develop towards the concept of sustainability. This categorization is provided to understand if there is a good match in the type of solutions provided and the market needs, understanding, if present, where the gap between these two realities is. These categorizations have been made possible due to some initial insights gathered from the concept of sustainability, main actions performed by growers, and the type of parameters needed to be measured during wine production. Following the target of the main study, the categories are all related to crop care management, more specifically vineyard care management. The 5 main categories identified are listed and explained below.

- Biodiversity management. This category starts from the need of the growers of recreating the lost variability among living organisms from all sources; this is a factor mentioned in order to farm towards more sustainable practices. A concrete example is given by the use of bees for pollination, and reproduction of different varieties.
- Environment management. This category includes all the software able to give information about environmental conditions (i.e. weather monitoring and predictions, heatwaves, frost, etc.). During the interviews, the growers showed a considerable need for better environmental understanding, due to the unpredictability of the weather on product losses.
- Nutrition management. This category appears to be the broadest and it includes all the activities regarding the nutrition of the soil and plants. Thus, some concrete examples are given by the water stress monitoring on plants/soil, measurements of the nitrogen levels, the vegetation index, as well as activities such as irrigation or fertilization.
- Pest and disease management. This category is between the most important ones due to the strongly expressed need from the growers' side to tackle this problem sustainably. Activities linked to this category are for example spraying chemicals, monitoring insects, pests, and viruses on the plant; biological controls, etc.
- Weed management. Last but not least, this category is meant to group all the technologies able to tackle another problem expressed by the growers, being weeds removal. Concrete examples lie in robotics, through the use of weeding robots.

A full overview of the start-ups' database is visible in *Appendix C*. Few start-ups' names have been covered, being sensitive data in the interest of Kubota Holdings Europe.

5. Preliminary results: the concept of sustainability and an understanding of the parameters

On the base of the analysis conducted, it has been possible to derive some insights slowly leading towards the answer to the final research question: "*How could the sustainable business model archetypes be re-adapted for future sustainable innovations in AgTech?*".

In this chapter, the concept of sustainability from the growers' point of view will be discussed, answering the sub-question: "What is the main concept of sustainability and how does this differ from the grower and start-up point of view?". The analysis will continue throughout the exploration of which main parameters are needed to be measured by the growers to optimize the production. The degree of technology use in the parameters' measurements is also explored. This analysis will, therefore, answer the sub-questions: "Which parameters need to be monitored during the crop production in order to achieve a sustainable implementation in the smart crop management field?" and "How can these parameters be measured? Is there any technology able to measure these parameters within the technologies already developed in the AgTech sector?".

For the analysis creation and data derivation, the data analytics software ATLAS.ti has been used, allowing the creation of explanatory maps on the base of the qualitative data used as input.

5.1. The concept of sustainability: a better understanding

In order to answer the final research question, I performed some preliminary analyses. Through the investigation of the growers' perception, a clear understanding of the main concept of sustainability from their point of view arose.

Firstly, the growers have been asked to rate specific statements following a Likert scale approach based on 5 modalities. Scale "1" was representing strong disagreement with the statement proposed, "2" a simple disagreement, "3" neither agree nor disagree, "4" an agreement, and finally "5" a strong agreement with the type of statement. The results of the first analysis are shown here below (*Table 5*), where the data have been analyzed through Microsoft Excel.

Of the proposed statements, particular attention needs to be given to the first three statements:

1. New technology is exciting and I often implement new unproven technology.
2. Sustainability practices such as cover crops, water management, etc., don't pay any of the bills today.
3. Sustainability is a current buzzword and a fad that will pass.

Table 5: Growers' statements

Statements				
New technology is exciting and I often implement new, unproven technology.	Sustainability practices such as cover crops, water management, etc., don't pay any of the bills today.	Sustainability is a current buzzword and a fad that will pass.	I don't use the data I collect. I manage my business based on past experience.	Quality data is almost as important as the fieldwork.
4	4	1	1	5
5	2	1	2	4
4	2	1	2	4
4	2	1	1	5
4	5	1	1	1
4	4	1	4	4
5	4	2	2	3
5	2	3	2	4
4	1	1	2	2
4,33	**2,89**	**1,33**	**1,89**	**3,56**

Through the first statement, the growers' propensity towards the use of new technology and the embracement of technology adoption is tested. The general result seems to be quite positive, with an average of 4,33. The third statement depicts the concept of sustainability merely as a buzzword, a trend that will quickly disappear. The average answer falls towards a disagreement, with a score of 1,33. This result shows the general propensity of growers towards the importance of the adoption of sustainability practices to keep the business fruitful.

The second statement concerns the adoption of some sustainability practices with the economical dimension linked to the productivity of the fields. Cover crops are a possible “effective soil conservation practice to reduce runoff and water erosion” while improving soil productivity. They do provide a permanent surface cover between growing seasons; following the residues of these crops keep on protecting the soil from the erosion process, increasing soil productivity (Baumhardt and Blanco-Canqui 2014). Other sustainable practices can be water management, crop rotation, etc. The score of this statement alone is not very significant since it is close to the middle. However, when considered together with the other two statements, it shows how the concept of sustainability is highly taken into account, although the economic aspect remains fundamental. The answers given to this statement are indeed very different between each other, varying from 1 to 5, differently from the other statements in which the answers given are more homogeneous. This is mainly driven by the fact that it is indeed true that these practices do not lead to economic benefits in the short term. However, their importance on a long-term scale is recognized, both from an environmental and economical point of view.

These results helped me to create a starting picture for the understanding of the concept of sustainability for growers, deriving the main difference point with the start-ups' view.

However, although the main hypotheses concerned the existence of a big gap between the sustainability concept seen from the two different perspectives, it is more clear that this gap seems to be less wide than initially thought. For start-ups, the concept of sustainability is indeed mainly economically-driven. However, the economic dimension plays a big role for growers too, together with the social, environmental, and technological ones. This is also what mainly emerged from the interviews’ analysis and can be better understood through the graphical representation in *Figure 22*. I found a major gap instead in the use of the technology itself and the understanding of the type of analytics required by the growers versus the start-ups. This concept will be later on explained.

The figure represents a conceptual map that I created through the use of codes in ATLAS.ti. For each specific concept belonging to either a social, economic, technological, or environmental category, I gave a specific code. The codes created through the software represent the concepts expressed in the statements made by the growers and resumed in a few words. An analysis of the interviews’ transcript has indeed been made and the main concept tagged in codes. Through the use of this methodology, I examined all the interview transcripts and created codes for each concept.

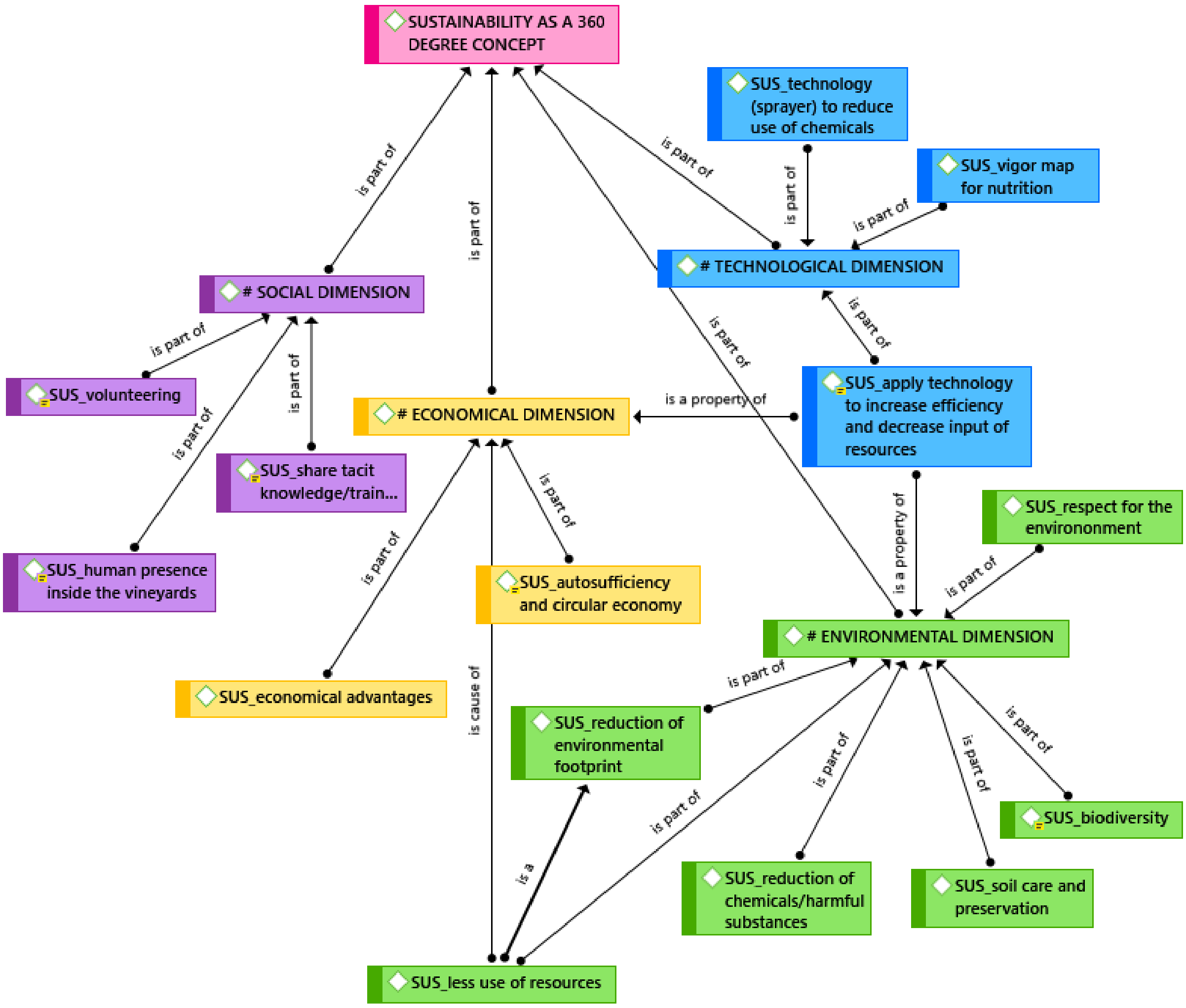


Figure 22: Sustainability as a 360° concept

The following step was understanding of the codes, through a full overview and the grouping of these codes into the categories before mentioned. After it, through the use of the function 'relation manager', I established some relationships and linkages between the codes representing the main sustainability concepts. This process led to the development of a conceptual map representing the concept of sustainability starting from the interviews done with the growers. This methodology will be repeated for the analysis of the main parameters and the technology used for measurements.

From the sustainability conceptual map and the interview transcripts, an important emerging concept is that sustainability is a concept that has to be seen at 360 degrees. Thus, it is important to evaluate it from a different point of view. From it, a more classic triple bottom line (economic, environmental, and social dimension) arose, with an addition of the technological element.

The social dimension is mainly represented by the concepts of volunteering, the human presence inside the vineyards, and the share of tacit knowledge/labor training.

The economical dimension arises due to the growers' expressed needs of gaining economical advantages and self-sufficiency, in terms of circular economy as well.

The environmental dimension appears to be the most complex since it is formed by a higher variety of concepts resumed under the following codes:

- reduction of environmental footprint;
- respect for the environment;
- biodiversity;
- soil care and preservation;
- reduction of chemicals, or more generally harmful substances;
- less use of resources (that is also considered to be comparable to the reduction of environmental footprint, as well as a partial cause of the economical dimension).

Lastly, the technological dimension serves as a bridge between all the other dimensions. Indeed, the majority of codes in this category are linked to the other dimensions as well. The main codes of this dimensions, on the base of the statements done by growers, are the existence of vigor maps for nutrition, the use of technology to reduce the use of chemicals - more specifically in terms of sprayers, and the technology application to increase the efficiency and decrease the input of resources. The role of technology emerging out of this map will be more deeply discussed in *Chapter 5.2*.

In *Appendix D* it is possible to have a look at the complete conceptual map, containing the text reference on which the analyses have been performed and the codes created. In order to deeply understand the codes derivation, an example through the use of the social dimension is here following given (*Figure 23*). Some contents have been covered to maintain the privacy of the interviewees.

As previously argued, the social dimension is composed of the concept of volunteering, the human presence inside the vineyards, and the share of tacit knowledge. In the figure, it is possible to read the precise statements – that can be found in the transcripts of the interviews as well. For example, the 'share of tacit knowledge' concept emerged due to the express need of growers towards a concept of sustainability that takes into account the possibility to work in an easier way for the professionals; a clear education and training given to the labor force; the need to pass the knowledge, in terms of experience mainly, through generations, etc. All these concepts led to the generation of a broader concept, that includes them all under an umbrella code, that is the code 'share tacit knowledge/training'.

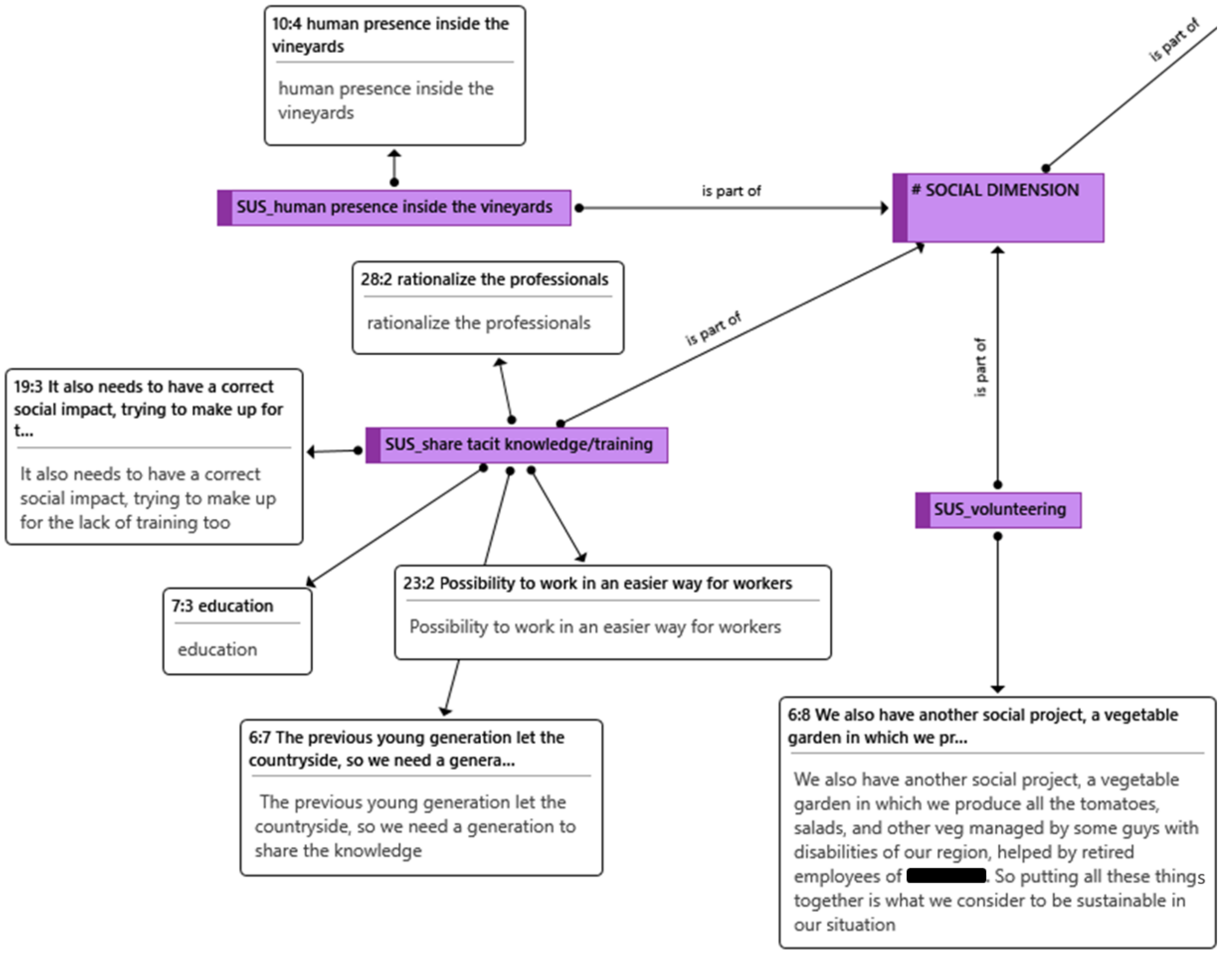


Figure 23: Sustainability map. The social dimension.

5.2. Parameters to be monitored during the production life-cycle and technology use

Following, I applied the same methodology to the discovery of the parameters mainly measured during the crop production life cycle, and more specifically regarding the vineyards field itself. The parameters identified are the ones needed to be monitored in order to achieve a sustainable implementation in the smart vineyard management field.

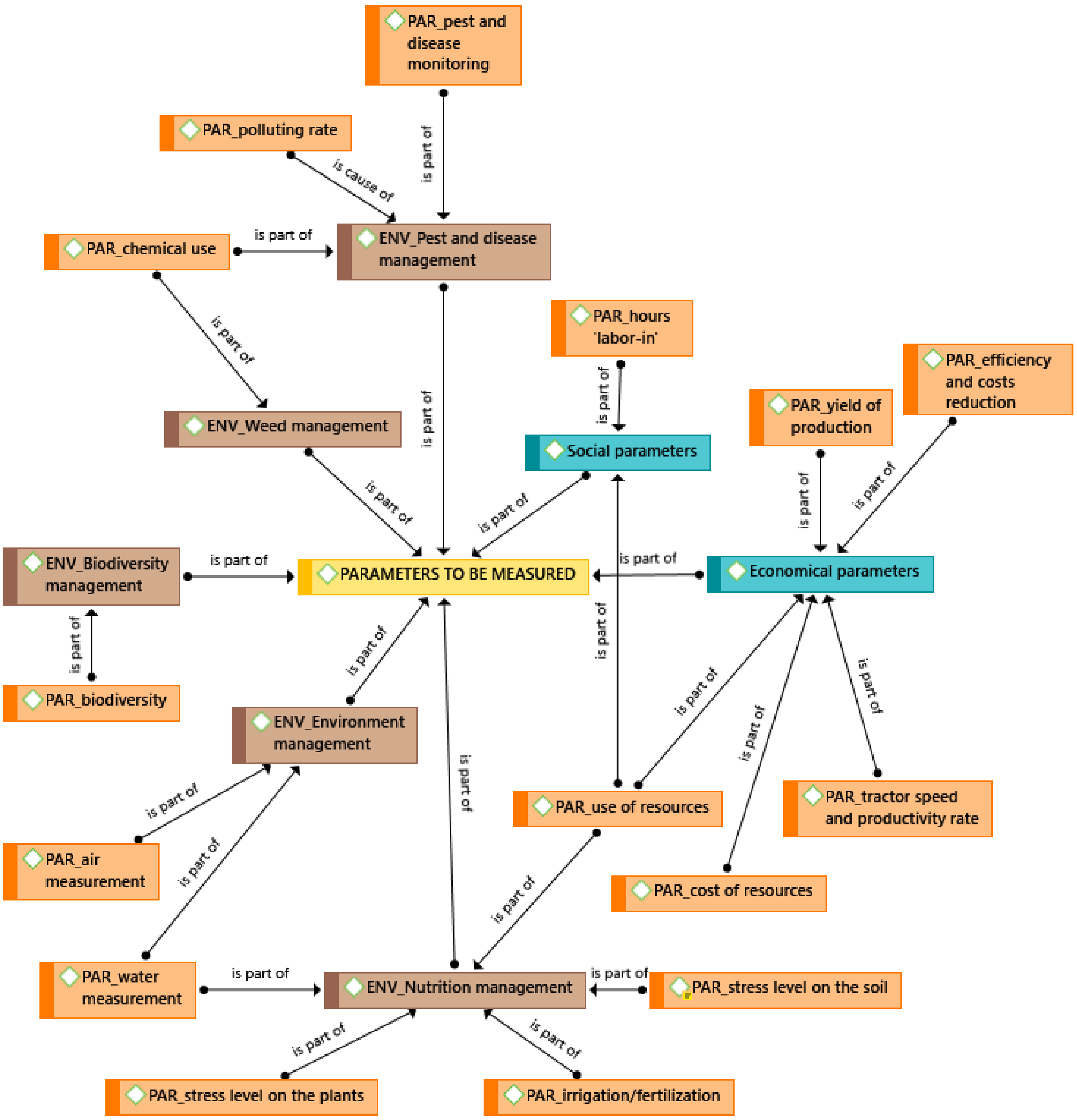


Figure 24: Parameters conceptual map

A graphical representation through the use of a conceptual map is given (*Figure 24*). Once again, from the qualitative data gathered through the interviews, I grouped the main concepts obtained into categories, through the use of codes. In the map, it is possible to distinguish between the more operational codes, linked to the production activity (in brown) and additional parameters, such as the socio-economical ones, that are colored in light-blue. The distinction is done because during this phase the most important parameters concern mainly the wine production itself. Simultaneously, the socio-economical parameters are inserted to reinforce the concept of sustainability as a whole.

The presence of the socio-economical parameters will be discussed again in the next chapter, in which these dimensions will result in the creation of a model. Moreover, the parameters are not static, but interdependent between groupings. Thus, a concept belonging to one of the dimensions of the socio-economical parameter, could apply to one of the production parameters groupings as well. Once all the concepts have been grouped into the parameters codes, it has been possible to group these last ones into the categories that have been used for the start-up database categorization. I performed this analysis simultaneously to a re-evaluation of the database categorization, including eventual adjustments, following a continuous and iterative evaluating process throughout all the project.

The identification of these categories can also be seen as a confirmation of an initial match between the market and the growers' needs in terms of the application towards which the technology should be developed. Although the market is still not fully directed towards these developments, a preliminary assessment between the technologies proposed in the market and the parameters needed to be measured according to the growers' needs, can be observed. Thus, while some categories are still poorly considered, from a market perspective there is a first understanding of the right directions to be explored, and this becomes visible whenever this map is compared with the results from the start-ups' database.

The discovery of these parameters leads to the understanding of the activities and criteria that are mainly taken into account by the growers during the wine production lifecycle. They lay the foundations for the sub-question "which kind of criteria need to be implemented into an AgTech start-up business model in order to develop a sustainable business model that meets the market needs?".

Additionally, the role of the technology in the parameters' measurements is also taken into account. This allows us to explore more deeply the technological dimension and the relation between the technological solution in the market with the growers' needs.

In order to do so, I created a final conceptual map (*Figure 25*). This map is an elaboration of the previous map (*Figure 24*), with an added value: the degree of technology application within the parameters' measurements. The map has been created through the additional information gathered from the final open question performed during the interviews, following the same methodology already described before.

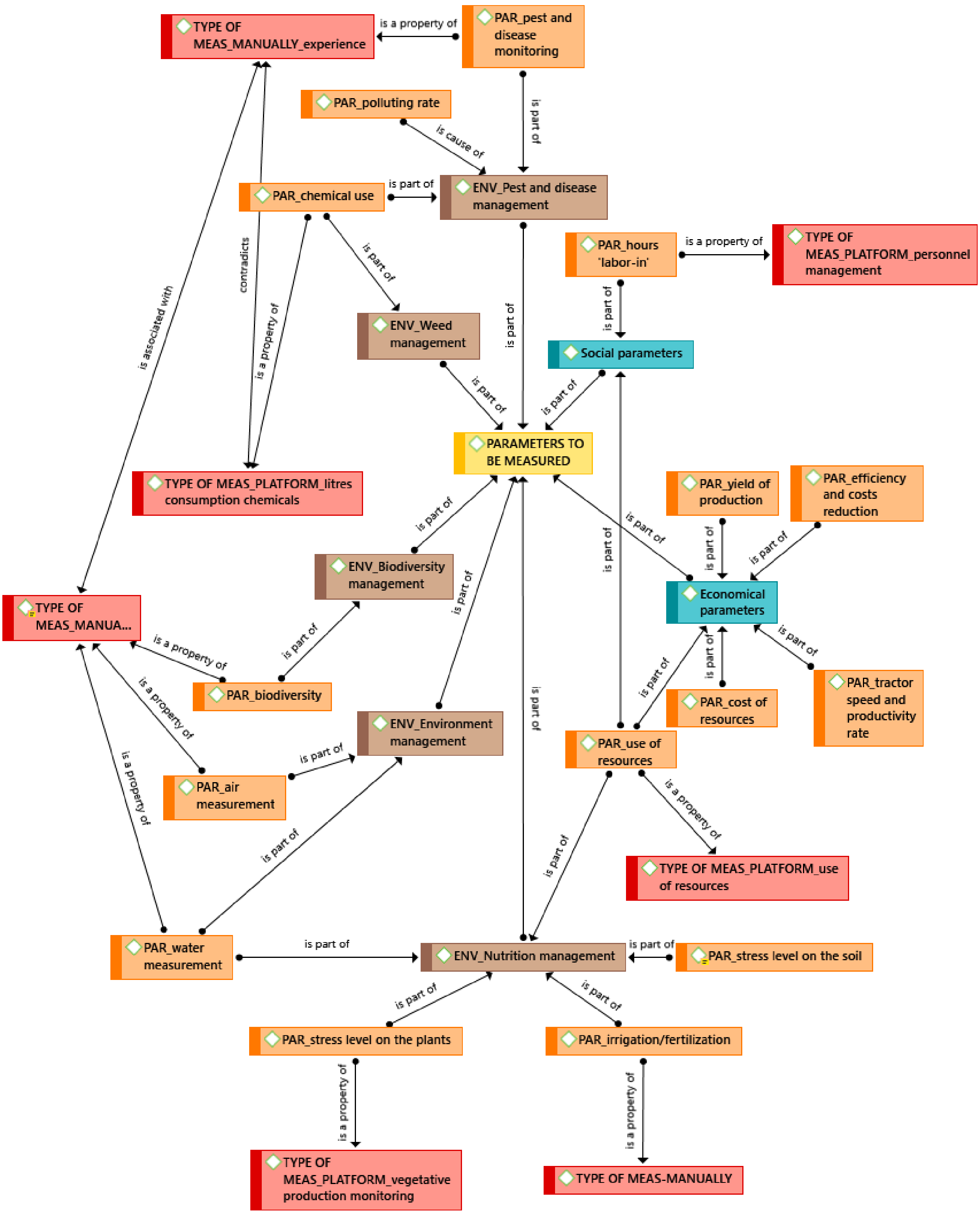


Figure 25: The role of technology in the parameters' measurements

What is interesting to highlight is that even though for the socio-economical parameters more advanced technological systems are used (i.e. the presence of platforms), during the production life cycle, the technologies used in the different phases and for different parameters measurement are still limited or almost absent.

On one hand, this can be explained by the further advancement of systems measuring the socio-economical parameters, such as the Farm Management Systems.

On the other hand, it is still surprising that although there are several solutions proposed in the market, growers prefer to entrust the crops' care to their personal experience and their farm books. Some progressive farmers started to adopt technological systems for certain types of measurements, as shown by the platforms for monitoring the liters of chemical consumption or vegetative production. However, the majority of users still fall in the category of manual measurement and a strong reliance on experience. This discovery leads to the next chapter, in which the main gap existing between market (start-ups) and demand (growers) is discussed.

5.3. The main gap between growers and start-ups

An important finding concerns the presence of a big gap between the type of analytics employed by the growers versus the start-ups. The gap is graphically explained in *Figure 26*.

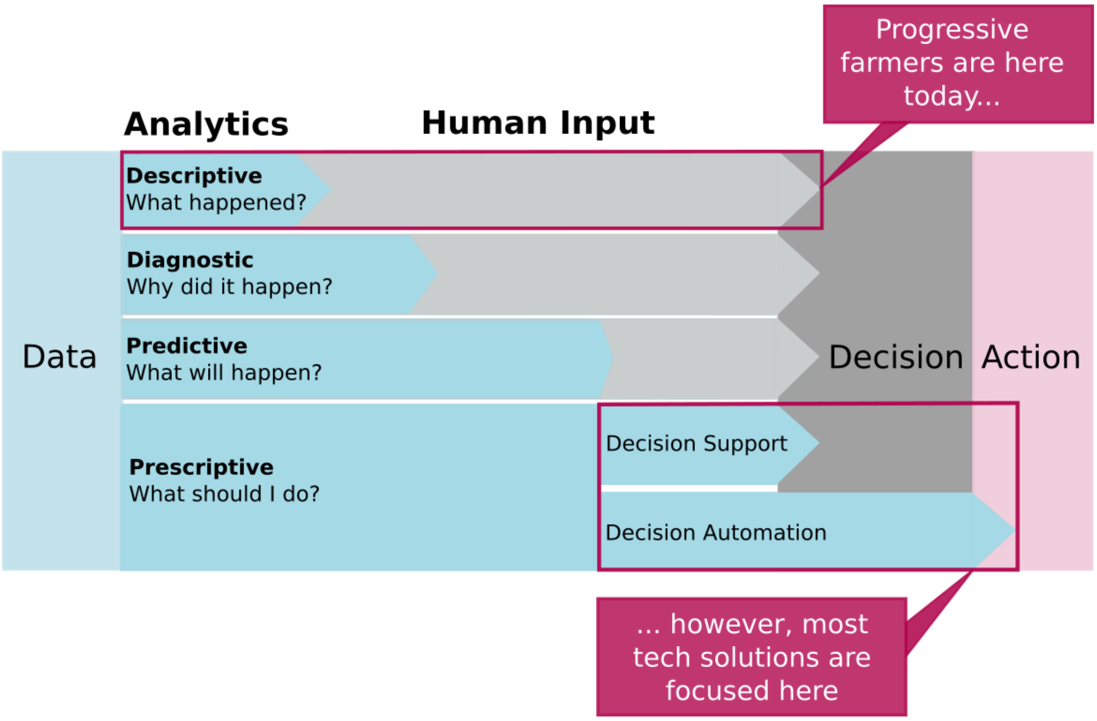


Figure 26: The gap between growers and start-ups. The four analytics.

In *Chapter 4*, the database creation and categorization has been discussed. One of the categorizations used concerned the identification of the type of analytics used by the proposed solution. As already briefly argued, start-ups are generally opting for solutions that favor the most advanced analytics such as the predictive and in most cases the prescriptive ones. This last one answers questions such as 'What should I do?', proposing possible solutions to decision-making type of operations. An example is given by the numerous Decision Support Systems (DSS) launched on the market. On the other hand, as shown by the results of the interviews' analysis through the use of conceptual maps, growers prefer to rely on more basic systems that are giving them descriptive types of analytics. This way, they can decide on the base of the data they gathered (i.e. from sensors) using their experience or consultants'/agronomists' advice, on which they prefer to rely.

6. The identification of a new model

In this chapter, first, a deep understanding of the annual growth cycle of the grapevine is given. This information helps the reader to understand how the issues for the criteria creation have been identified. From there, additional analyses are shown, demonstrating where the main problems lie. These last ones have been derived both through the workshop and the growers' interviews, through the pain points experienced. On the base of the data gathered, the criteria ideated for the model creation are discussed. This point answers the sub-questions "which kind of criteria need to be implemented into an AgTech start-up business model in order to develop a sustainable business model that meets the market needs" and "how do these criteria differ or resemble the sustainable business model archetypes ideated by Bocken et al. (2014)?". Each criterion is discussed, giving to the reader a full understanding of the choices undertaken.

Finally, a new model, derived from the sustainable business model archetypes created by Bocken et al. (2014) is proposed. Explanations for the choices behind the graphical representation of the model are given. The final research question "*How could the sustainable business model archetypes be re-adapted for future sustainable innovations in AgTech?*" is, therefore, answered.

6.1. The vineyard production value chain and main pain points

The vineyards production value chain is composed of different phases, comparable to the annual growth cycle of grapevines. The orchards workshop operated at the beginning of the project within the company Kubota Holdings Europe gave me a full understanding of these phases, that have been discussed with the experts as part of the company interest and domain. These phases are very similar to the ones present in vineyards.

In each of these phases, the main activities and pain points related to these tasks have been discussed. From this initial starting point, more detailed information has been gathered and will be shown. On the base of the criticalities discovered through this process, initial criteria for the creation of a final model have been delineated.

The annual growth cycle of grapevines and the main pain points that emerged during the workshop are here discussed:

- Dormancy. It is the stage of production that coincides with the winter season. During winter, the vines need to store carbohydrate reserves in the trunk and the roots. This is a vital element during the natural cycle that allows the next season’s growth, until the moment in which the leaves will grow and will then be able to provide the plant with the carbohydrates it needs. To increase the strength and vigor of the vine, allowing it to store more energy, activities such as branch and root pruning are very important. More generally, canopy management allows to obtain the perfect tree architecture, preparing it for the next season. One of the main problems noticed during these activities concerns the lack of labor force/skilled labor.

- Flowering. After winter, little brown buds on the vine begin to open up through a process called bud break, from which tiny shoots emerge. This process leads to the flowering of the vine, usually during spring (i.e. around May). It is during this stage of flowering that the pollination and fertilization of the grapevine take place with the resulting product being a grape berry. Important during this stage are also activities such as irrigation and chemicals substances spraying, in order to protect the vines from insects and other pests. The difficulties here emerge due to climate issues (especially frost) and once again the presence of sufficient knowledge to efficiently perform the shoot thinning activity. This last one is needed to increase the possibility of grapes production.

- Fruit set. This stage is between the most critical ones for the wine production, since it determines the potential the crop yield, thus impacting directly on the final output. Fruit set stage follows flowering quite immediately, thus it appears still during the spring period. During this phase weeds monitoring, soil/plant water stress, and type of nutrients, as well as the spraying activity characterize the stage as a very busy one. One of the main pain points shared concerns the difficulty to remove pests and diseases, due to the cost of chemicals and the right timing of the treatments, that determines the final efficiency of these.

- Veraison. This is the name describing the phase in which the grapes start to ripe and change color. This process starts around 40-50 days after the fruit set and it is highly threatened by the water stress and poor canopy management. This means that nutrition management during this stage is fundamental, and consequently, irrigation and soil moisture determine the criticality of the process.

- Harvesting. Finally, during the harvest, the final product is harvested and ready to initiate the wine production cycle. However, this phase results to be the most critical one due to the very small operative window available for this stage performance, as well as the high cost of labor and lack of labor availability during such a warm season.

Given the main pain points shared during the workshop, I proceeded with further investigations, through the growers' interviews. The results are shown in *Table 6*.

Table 6: Critical tasks during the farming process

Critical tasks

Harvesting	Branch Pruning	Spraying	Frost protection	Irrigation	Fertilization	Leaf thinning	Weeding/ Ploughing
3	4	5	5	1	3	4	3
5	4	5	1	4	4	5	4
5	5	4,5	1.5	1	4	3	5
5	2	4	1	1	3	3	3
5	1	4.5	1	1	1	1	3
5	3	5		4	4	2	3,5
4,5	5	5	3,5	2	3	1	3
			5	2,5	2	1	
5	5	5	2,5	1	3	3	4
5	5	3,5	2,5	1	2	3,5	4,5
5	5	5	4	5	4	5	5
3	3	2,5	5	4	1	5	4,5
4	4	5	2	5	3	4	4
1	4	3,5	2	1,5	2,5	1	5
3	5	5	3,5	5	4	5	5
4,18	**3,93**	**4,46**	**2,92**	**2,60**	**2,90**	**3,10**	**4,04**

Firstly, I investigated the main critical tasks again through the use of a Likert scale. Some data are missing wherever an answer has not been given.

From the figure, the main tasks with a higher level of criticality, sorted on decreasing level are spraying, harvesting, weeding, and pruning. Linked to this analysis, an understanding of the most recurrent problems connected to these activities is represented in Table 7.

Table 7: Problems experienced during the farming process

Problems				
Labor shortage/skill	Water shortage (cost & availability)	Chemical regulations	Disease management	Thinning efficiency (controllability)
5	3	4	4	2
2	1	4	4	4
2	4	2	3	4
3	4	2	3	2
5	5	5	5	4
1	4	5	5	4
4	2	4,5	4,5	1
	1	5	2	
4	4	2,5	5	1
4,5	3	4	3	4
5	2	1	5	3,5
3,5	2	1	3	3,5
4	1	3	5	5
3	1	5	4	1
5	5	4	5	5
3,64	**2,80**	**3,47**	**4,03**	**3,14**

Since the biggest problems of the growers are linked to diseases management, chemical regulations, and labor shortages (or lack of skilled laborers), it is possible to state that there is a clear correlation between the criticality of the task and the prevalence of the issue.

Labor shortages and skilled labor lack are indeed strongly impacting on the harvesting and pruning phases. On the same logical line, it is possible to notice the interconnection between pests and disease management, as well as the problematic chemical regulations, with the spraying and weeding tasks mentioned above.

From this starting point, and given the information that I retrieved from the concept of sustainability, the parameters used for the main activities measurements, and the degree of technology employed in the process, the criteria/archetypes that better fit the needs of this field arose. From the statements that emerged from the interviews, commented in *Chapter 5*, an important element to have a look at is the growers' will to adopt the technology. Even though one can notice the gap present in the level of analytics required by the growers vs the one offered by the start-ups, from the statements it is still clear that growers don't agree with both the idea to 'not use data collected' and 'keep on running the business as it was in the past'. They also underline the importance of the quality data, sometimes prevailing the fieldwork itself too (*Table 8*). This shows how, even if they still mainly rely on descriptive data, there is a learning trend towards data-oriented solutions.

This element will result in the main change driving the final model, defining technology as a driver.

Table 8: Growers' statements, part 2

Statements

New technology is exciting and I often implement new, unproven technology.	Sustainability practices such as cover crops, water management, etc., don't pay any of the bills today.	Sustainability is a current buzzword and a fad that will pass.	I don't use the data I collect. I manage my business based on past experience.	Quality data is almost as important as the fieldwork.
4	4	1	1	5
5	2	1	2	4
4	2	1	2	4
4	2	1	1	5
4	5	1	1	1
4	4	1	4	4
5	4	2	2	3
5	2	3	2	4
4	1	1	2	2
4,33	**2,89**	**1,33**	**1,89**	**3,56**

6.2. The criteria

Here, the main differences with the original model ideated by Bocken et al. (2014) are derived. This allows to identify the archetypes between the ones described by the authors that can apply to this field too, the ones that require some change to be applied, and the new archetypes that have been derived by the analysis previously discussed. These last ones are very field-related, targeting the specific problems that have been pointed out in the previous sections.

Archetypes unchanged from the original model

The archetypes that have been considered for the creation of a new model within the ones already existents are:

- *'Create value from waste'*. "The concept of 'waste' is eliminated by turning waste streams into a useful and valuable input to other production and making better use of under-utilized capacity" (Bocken, Short et al. 2014). This criterion is very important within the agriculture field, where the avoidance of waste makes a visible and concrete difference between the operational margins (economically), the preservation of the environment (environmentally), and the possibility to be able to feed the increasing population (socially). The idea behind this concept concerns the reuse of substances within the sector or in other industries as well, avoiding wastes. It can be possible whenever collaborations and partnerships are present between or across different industries players. The technology plays here a role since start-ups have the possibility of creating solutions that meet the concepts embraced by this archetype. A concrete example is given by a 'recycling tunnel sprayer' machine. The machine is substantially a sprayer designed for pesticides application in the vineyards. The sprayer can recover and recycle most of the spray fraction that has not been retained by the canopy, avoiding chemical substances wastes and runoff (Anifantis, Pascuzzi et al. 2017).

- *'Deliver functionality rather than ownership'*. Following the definition by Bocken, Short et al. (2014), this archetype "provides services that satisfy users 'needs without having to own physical products". The authors provided this archetype with the idea that business models are shifting from a manufactured owned product to the offering of a combination of products and services. This is why this criterion is strictly connected with the concepts of Product Service Systems (PSSs) and Servitization. This approach results in a better alignment of the growers' needs (and society as a whole as well) with the start-ups' ones. Through these archetypes, consumers pay for the use of the service instead of the ownership of a physical product. The benefit from a socio-organizational perspective is quite clear. The archetype is indeed meant to change the consumption patterns, reducing the ownership of the product and thus creating incentives for start-ups to develop products that can be compatible with different systems, focusing more on the development of proprietary software. Longevity, upgradability, and reparability of the product are also improved. A possible example concerning the vineyard sector is given by the Integrated pest management systems (IPMs) – software backed on AI and Computer Vision (CV) technologies for the smart recognition of pests and diseases.

- *'Repurpose for society/environment'*. The archetype is considered for the ability of "prioritizing delivery of social and environmental benefits rather than economic profit (i.e. shareholder value) maximization, through close integration between the firm and local communities and other stakeholder groups" (Bocken, Short et al. 2014). This archetype has the strong potential of changing the business mindset towards a real sustainable business, in which the economic benefits are overcome by the environmental and social ones. An example could be given by the introduction of a solution for organic wine production. In general, organic production is less remunerative than the traditional one, but it preserves the environment, more specifically the soil and the landscape, and through the use of less harmful substances it helps in preserving the health of the food consumers as well. This means that the consumers should be willing to pay a premium for it; indeed, one of the main principles of this criterion concerns a shift in the main beneficiary of the business model, where the environment and society are elevated.

<u>Archetypes subjected to changes from the original model</u>

- *'Maximize material productivity and energy efficiency'*. The archetype is originally defined by Bocken, Short et al. (2014) as the ability to "do more with fewer resources, generating less waste, emissions, and pollution". Even though the concept behind the criterion leads towards the creation of a sustainable business model, the criterion itself needs a few changes in order to be more easily adopted in the vineyard production cycle. Firstly, the archetype encompasses a theme that is strictly linked to the manufacturing field and the lean-approach. However, it might not fully fit the purpose of the agriculture sector. The focus of the original archetype is, indeed, on the product and manufacturing process innovation. However, as argued in the archetype 'deliver functionality rather than ownership', in the agriculture field the focus concerns mainly the product as a service. Moreover, energy efficiency and reduction solutions can scarcely be seen other than through the use of renewable solutions. This is because in general, many processes during the crop cycle production are already operated manually – as discussed also during the understanding of the technology role in the parameters' measurements (see chapter 5). For these reasons, the archetype has been divided into two separate archetypes: '*substances reduction and time efficiency*' (discussed further on), and '*maximize the yield of production'*. This last archetype derives mainly from the growers' economic needs. Through the final output maximization, the growers' business can indeed keep on running.

- *'Substitute with renewables and natural processes'*. Defined by the ability to" reduce environmental impacts and increase business resilience by addressing resource constraints 'limits to growth' associated with non-renewable resources and current production systems" Bocken, Short et al. (2014). The archetype is considered partially not applicable due to the consideration of substitution of processes with natural ones. Even though the concept behind suggests the good match of this criterion with the sustainable ideals, it is important to highlight how the processes operated in the agri-sector are already natural. Given also the discussion about energy efficiency in the previous archetype, and the recognized importance of renewables in the field, the archetype has been changed in '*energy efficient-oriented alternatives*'. Many examples can be derived from here. Solar panels working machines, as well as wind energy, are between the most traditional examples.

Archetypes whose application is complex or not possible in the sectorial context

- '*Adopt a stewardship role*'. The archetype, defined as "proactively engaging with all stakeholders to ensure their long-term health and well-being" (Bocken, Short et al. 2014) is correct in the broader concept. However, this criterion should lay the foundations of every business creation and cannot, therefore, be considered as a specific treat leading to sustainability. Without a strong stakeholders' network creation, the pursuit of the other archetypes could not be possible too. This does not concern the creation of a business that goes towards sustainability only, but more generally to every new business in our century, especially where open innovation and collaborations are at the base of every profitable solution. This is why it is not considered as a specific archetype within the model.

- '*Encourage sufficiency*'. This archetype lays the foundation on the creation of "solutions that actively seek to reduce consumption and production" (Bocken, Short et al. 2014). The main reason why this archetype is not considered for the specific sector is strictly related to the concept backing it. It estimated that by 2050 the population will increase by two billion, reaching 9 billion people to be fed. Also, developing countries will have access to a more complete diet. Therefore, population growth and richer diets will require us to roughly double the amount of crops we grow by 2050 (Alreshidi 2019), (Eli-Chukwu 2019), (Dharmaraj and Vijayanand 2018), (Reshma and Pillai 2016). The agri-sector should then not undergo a production reduction, since from the population there will not be any consumption reduction, but the opposite.

- '*Develop scale-up solutions*'. "Delivering sustainable solutions at a large scale to maximize benefits for society and the environment" (Bocken, Short et al. 2014). The idea behind the archetype is that more generally large multinationals own more power to drive sustainability due to their bigger role within the field network of players. Thus, since the most innovative and radical ideas derive from small businesses and start-ups, scaling up could allow to push the sustainability archetypes towards a wider understanding and use. Even though the principle is very correct, one could argue that it is within the objectives of a start-up to grow and scale-up. This way, the start-up increase profits, decreasing costs, and the learning curve. Therefore, this criterion is already implicitly included in the general idea at the base of each business model creation. The archetype is not incorrect or not applicable. However, due to the high generalization of it, other context-specific archetypes are better considered.

New archetypes derived from the analyses

On the base of the analysis I performed throughout the whole project, new criteria have been proposed. Additionally, some of these criteria are also supported by concepts included in the environmental parameters that emerged by the studies conducted by Czyżewski, Matuszczak et al. (2018), OECD (2001), and Zhen and Routray (2003). However, they are here considered under the economical and socio-organizational dimension as well.

- *Sharing of tacit knowledge*. This archetype would play a very important role in the vineyards sector. From the analysis emerged indeed that the labor shortage, as well as the lack of skilled labor, is one of the main issues driving the level of criticality of activities such as pruning or harvesting. Since these activities highly determine the quality and quantity of the final outcome and are therefore strictly related to the maximization of the final yield, start-ups should include this criterion in their business model proposal. The archetype could be defined as the capability of sharing tacit knowledge, thus mainly driven by experience, in a form of explicit knowledge. This would be a useful tool for the growers to train more easily the new workers and create the possibility to derive meaningful insights and be always up to date through open knowledge solutions. The archetype would mainly have a socio-organizational function (creating general knowledge to be shared) and would allow more economically viable solutions. An example could be given by the creation of a mobile app sharing information retrieved from a high number of growers' experience about i.e. the correct way of pruning or the type of insects harming the vines.

- *Encourage Biodiversity*. "Biodiversity refers to all species of plants, animals and microorganisms existing and interacting within an ecosystem" (OIV 2018). Intense farming practices and human activity substantially reduced the presence of biodiversity, in terms of crop varieties, species, and diversity of ecosystems. This led to the increase of soil erosion, degradation of soil structure and fertility, contamination of groundwater, etc. The archetype is therefore meant to restore the environmental benefits. A possibility is through the creation of homogeneous terrain units in the vineyard and their use to design specific viticulture practices for each terrain. This element is important for the application of precision viticulture approaches, whose scope is one of increasing crop sustainability.

- *Substances reduction and time efficiency*. As widely discussed, and strongly emerging from the analysis one of the main problems concerns the use of chemicals and disease and pest management both for activities such as spraying and weeding. The use of chemical substances strongly impacts on the environment. However, more generally here, the reduction of different types of inputs (such as chemicals, but also water, energy, fertilizers, etc.) is taken into account. This not only impacts the preservation of the environment, but it also has economic implications due to the high prices of the treatment solutions. Moreover, the time efficiency is fundamental, since the time window given by nature to operate correctly (to achieve a good final output) is very short. Efficiency is the key here. An example of solutions related to this archetype could be given by monitoring systems on the base of which it is possible to understand when i.e. to fertilize and in which quantity.

- *Preserve the soil and the landscape.* Finally, this archetype is meant to direct the attention towards the soil and landscape preservation. One could argue that the concepts of this archetype are somehow incorporated in the definitions of the previous ones and that, therefore, the existence of this criterion might not be essential. However, this archetype aims to remind to start-ups that the solutions ideated must take into consideration the importance of the soil and the ecosystem around it – embed in the landscape concept. Indeed, every crop production outcome is strictly determined by the quality of the soil, the level of moisture of this, and the type of nutrient in it. If the soil is deteriorated, highly unlikely production will stay efficient. The use of sensors and IoT systems is an example of the type of solutions that might monitor this parameter and increase the level of sustainability.

6.3. A new model

On the base of the original model, I present here a re-elaboration of it for a closer adaptation to the agriculture field. The re-elaboration is needed since the general model is too broad for a direct application into the agriculture field. The model is thought as a tool for the start-ups in the AgTech field to be applied to develop a sustainable business model matching as far as possible the needs of the growers. I derived the following model therefore with a bottom-up approach, directly from the market needs. As discusses, some archetypes have been kept in their original form, others re-elaborated, while new ones have been added. The main dimensions shifted from a more traditional bottom line approach (social, economic, and environmental) while technology is seen more as a driver towards change (*Figure 27*).

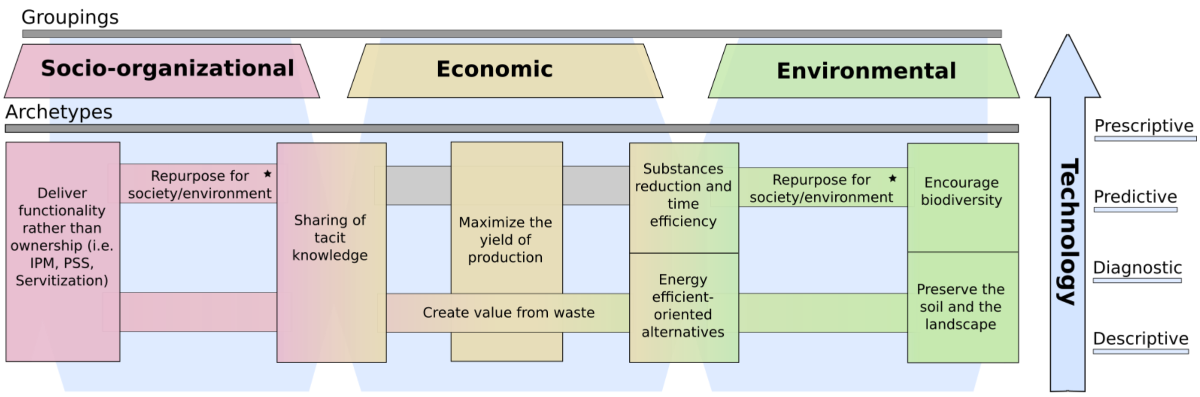


Figure 27: Sustainable Business Model Archetypes in the AgTech sector, more specifically vineyards-related

The first important change concerns the dimensions or groupings used. While in the original model the three main dimensions were the technological, social, and organizational one, in this new model the groupings proposed are the socio-organizational, economic, and environmental. The social and organizational aspects are merged due to the strict relation between them. Indeed, while the general public is considered through the use of the social dimension, the addition of the organizational element allows to include organizations such as governments and research institutes. Since the model takes into account the necessity to collaborate within players and industries, the organizational dimension is mainly considered under an intra-organizational point of view. The economic dimension is fundamental since due to the very low margin of revenues that farmers earn in this sector, a lot of weight is given to this aspect. Even though the environmental dimension was indirectly considered in Bocken et al. model, it is now made explicit given the importance of the environmental aspects within the general concept of sustainability.

I derived these dimensions both from the analyses (clearly identifiable in the main concept of sustainability that arose) and literature. In literature, the social, economic, and environmental dimensions establish a more classic triple bottom line. This can be seen in the works of Brehmer, Podoynitsyna et al. (2018), Díaz-Correa and López-Navarro (2018), and Ribeiro, Sobral et al. (2018). The dimensions are intertwined rather than strictly grouped. This is because each archetype can contribute contemporary to different dimensions. I make it graphically clear through the use of different color shades. The archetype 'repurpose for society/environment' is distinguished by the rest due to the fact that they belong to the grouping 'socio-organizational' and 'environmental', without highly impacting on the economic one. Also, the use of different archetypes at the same time is highly suggested to truly drive the creation of the business model towards sustainability. This is a concept supported by Bocken, Short et al. (2014) too – "real sustainability almost certainly demands combinations of archetypes".

The technological dimension does not disappear. It is rather shifted on the y-axis of the model. This is done because technology can be seen as a driver that applies to each archetype of the three mentioned dimensions. It is, therefore, not enough to limit the applicability and role of technology within a single grouping. Technology is graphically represented by a directional arrow, representing the increasing level of analytics. The four types of business analytics (discussed in *Chapter 4*) can be applied to each archetype.

The main concept behind this graphical representation lies in the necessity for the start-ups of creating incremental solutions that adapt to current market needs. As previously discussed, these solutions need to be firstly descriptive. Once the level of adoption, understanding, and usability o the technology, as well as acceptance of it, grows, it is then possible to gradually ideate more radical solutions. The direction of the arrows points this concept out, shifting from the different levels of analytics. An ideal business model would be given by the realization of it according to as much as possible archetypes and a modular solution that further develops in the market according to the level of adoption readiness of the farmers.

To give more clarity about the explained concept, an example is given through the use of the archetype 'sharing tacit knowledge'. To develop a sustainable business model, an innovative and sustainable product/service form a start-up could be the realization of a mobile application. The app initially could explain, through the use of images and quotes from other farmers or agronomists, how to detect specific types of pests on the vines, with detailed descriptions. On the base of the information, the farmer could take action. This is an example of a descriptive analytic. Following, more advanced solutions such as the use of Augmented Reality could be applied (predictive analytics). On a very high level, the app could evolve through the use of AI and CV, automatically identifying the pests and giving explanations about the type of actions to be undertaken to solve the issue.

7. Evaluation of the model

An evaluation of the usability and reliability of the model explained in the previous chapter is given. The evaluation has been made possible thanks to the collaboration with some experts in agriculture and business models creation. These experts currently work on projects in the field and are situated in different geographical areas, namely The Netherlands, United Kingdom, and Sweden.

The evaluation with the help of the experts is fundamental to the project since, for the time limitation of the project itself, a real-life application for the evaluation is unfeasible.

The evaluation pointed out some model limitations. However, the general feedback is very positive towards the new framework created.

7.1. Experts background presentation

An evaluation is needed to determine model efficacy. The best option would be to undergo a sample of start-ups to the study and see how the development of their business model through the use of the new archetypes would work out. However, due to the short timeframe of the study, this cannot be taken into consideration. An evaluation that does not require a practical application of the model in reality thus needs to be performed.

Table 9: Table of evaluators

Experts chosen for the evaluation of the new sustainable business model archetypes in AgTech		
Name	**Background**	**Publications topic-related**
Carlos Moreno Miranda	Carlos has a background in Food Agroindustry Engineering, after which continued his studies with a Master program in Agricultural and Food Economics. He is currently attending a PhD programme at Agricultural Economics and Rural Policy Group of Wageningen University. Carlos focuses on an evaluating framework with special attention on the role of organizational aspects of supply chains. The goal is to determine how the coordination mechanisms within supply chains are linked to sustainable performance.	Moreno Miranda, Carlos, Dries, Liesbeth, Wesseler, Justus, (active). *A framework for the evaluation of the sustainability performance of agri-food supply chains - Application to strategic agri-food products in the Andean Community of Nation.* Carlos Moreno-miranda, Jeanette Jordán, Raúl Moreno, Pablo Moreno, Jenny Solis (2019). *Protected Designation of Origin and Sustainability Characterization: The Case of PDO Cocoa Arriba.* Agricultural Economics and Rural Policy
Matthew Gorton	Professor Matthew Gorton is joint head of the Marketing, Operations and Systems subject group at Newcastle University and has 20 years of experience in rural development research, acting as a principal investigator on 4 EU projects (COMPETE, FOCUS BALKANS, SCARLED, INNOGROW). He is co-coordinator of Rural Enterprise UK and leads the Pan-European project Strength2Food, looking at short supply chains. He is a trained economist and his PhD considered the growth and performance of rural SMEs. He has undertaken research for DG AGRI, World Bank, FAO and OECD. He recently undertook work with Frontier Economics, for the UK Government, on rural business performance and growth.	Arfini, F., Antonioli, F., Donati, M., Gorton, M., Mancini, M. C., Tocco, B., & Veneziani, M. (2019). *Conceptual Framework.* In Sustainability of European Food Quality Schemes (pp. 3-21). Springer, Cham. Buchenrieder, G., Möllers, J., Happe, K., Davidova, S., Fredriksson, L., Bailey, A., ... & Milczarek, D. *DELIVERABLE 2.1" Conceptual framework for analysing structural change in agriculture and rural livelihoods*. Chaplin, H., Gorton, M., & Davidova, S. (2007). Impediments to the diversification of rural economies in central and eastern europe: evidence from small-scale farms in Poland. Regional studies, 41(3), 361-376. Iraizoz, B., Gorton, M., & Davidova, S. (2007). Segmenting farms for analysing agricultural trajectories: A case study of the Navarra region in Spain. Agricultural systems, 93(1-3), 143-169.
Maya Hoveskog	Maya Hoveskog currently works at the Center for Innovation, Entrepreneurship and Learning research (CIEL), Halmstad University, Sweden. Maya does research in Innovation, Business Models for Sustainability, and Business Administration. One of her current projects is 'Lean Innovation". Its purpose is to: explore and evaluate self-leadership, lean as well as business model innovation in the agricultural sector. Between the numerous projects ongoing, important is the collaboration with numerous engineers and designers in Canada and Belgium (Ghent) for the creation of usability practices for business models.	Tell, Joakim & Hoveskog, Maya & Ulvenblad, Pia & Ulvenblad, Per-Ola & Barth, Henrik & ståhl, Jenny. (2020). *Business Model Innovation in the Agri-Food Sector*. 10.4018/978-1-5225-9615-8.ch050. Karlsson, Niklas & Hoveskog, Maya & Halila, Fawzi & Mattsson, Marie. (2019). *Business modelling in farm-based biogas production: towards network-level business models and stakeholder business cases for sustainability*. Sustainability Science. 14. 1071-1090. Ulvenblad, Pia & Barth, Henrik & Cederholm Björklund, Jennie & Hoveskog, Maya & Ulvenblad, Per-Ola & ståhl, Jenny. (2018). *Barriers to business model innovation in the agri-food industry: A systematic literature review.* Outlook on Agriculture. 47. 308-314. Karlsson, Niklas & Hoveskog, Maya & Halila, Fawzi & Mattsson, Marie. (2018). *Early Phases of the Business Model Innovation Process for Sustainability: Addressing the Status Quo of a Swedish Biogas-Producing Farm Cooperative.* Journal of Cleaner Production. 172. 2759-2772.

To do so, I contacted and interviewed three experts in the field, understanding the strengths and limitations of the model that will be here following discussed.

In *Table 9*, the experts' background and main publications related to the topic under examination are presented. Full transcripts of the interviews performed can be found in Appendix E.

This phase is considered to be fundamental for the project creation. Indeed, "the last step of the designing cycle is to check whether the short and long term effects of utilization of the prototype fit the design goal(s) and satisfy the expectations of the designer and notably of the various stakeholders" (Verschuren and Hartog 2005). However, it is important to underline that the evaluation process is ongoing and iterative and, therefore, takes place continuously throughout the whole process. This is why, after I proceeded with an initial database preparation, I have been making many modifications on the base of the insight gathered through interviews. Also, the combination of the insights gathered both throughout the workshop worked as an additional evaluation of the correct hypothesis assessment. This continuous iteration is visible also through the initial illustrative model in *Chapter 1*, representing the Design Science Research Methodology adopted for the study (*Figure 1*).

Finally, here the last evaluating step is undertaken through the help of some experts' knowledge.

7.2. Model evaluation

7.2.1. The three dimensions

Generally, there is a common agreement towards the three main dimensions identified in the model. It is, indeed, argued in support of the choice that the 'three bottom line' is proper and feasible when assessing businesses because of the access given to a high level of information, and more particularly it fits the agriculture sector. The triple bottom line is indeed a framework ideated by Elkington (1997), recommending that companies commit to focusing on social and environmental concerns just as they do on profits. The economical aspect is strongly suggested in the agri-sector since it is understandable how farmers seek a profit already in the short term before undertaking environmental procedures that will only give monetary benefits in the long term. This is indeed mainly given by the low margins obtained through farming practices, and this is why the dimension needs to be valorized compared to the old model. Moreover, the evaluation pointed out how it can be interesting to merge the social and organizational dimensions, as long as there is clarity towards the understanding of the organizational one. Thus, it has to be clarified whether it is an intra- or inter-organizational dimension.

In this context, the dimension is mainly considered as an inter-organizational one, because it takes into account a broad range of different actors and the relationship within them as well.

7.2.2. The technological dimension

Following, an important aspect to discuss concerns the positioning and creation of the technological dimension. Surely there is a uniform agreement around the concept that technology is seen as a driver, pushing sustainable practices. Moreover, a limitation highlighted towards the starting model (Bocken et al.), is that whenever starting the prototype of a business model from the technological dimension, one might end up figuring out a solution for a non-expressed problem. Thus, the problems and needs of the users should first be addressed, followed by the technology which is once again seen as a driver towards change. So in this sense, it is often better to start with the challenge and then look at the innovation that helps to deal with that challenge.

Another important contributor concerns the positioning of this dimension. If everybody agreed on the identification of technology as a separate element from the classical dimensions/groupings characterizing the development of the archetypes, doubts about the representation of the technology as a directional arrow are presented. On one side, this cohesion between static and dynamism provides a better representation of reality. However, it is thought that the technology should be represented by a more static dimension, thus as a silo as well. At the same time, due to the interrelation of technology with the archetypes present in all the other dimensions, experts suggested to place it at the bottom of the archetypes, including all the above dimensions (see *Figure 28*).

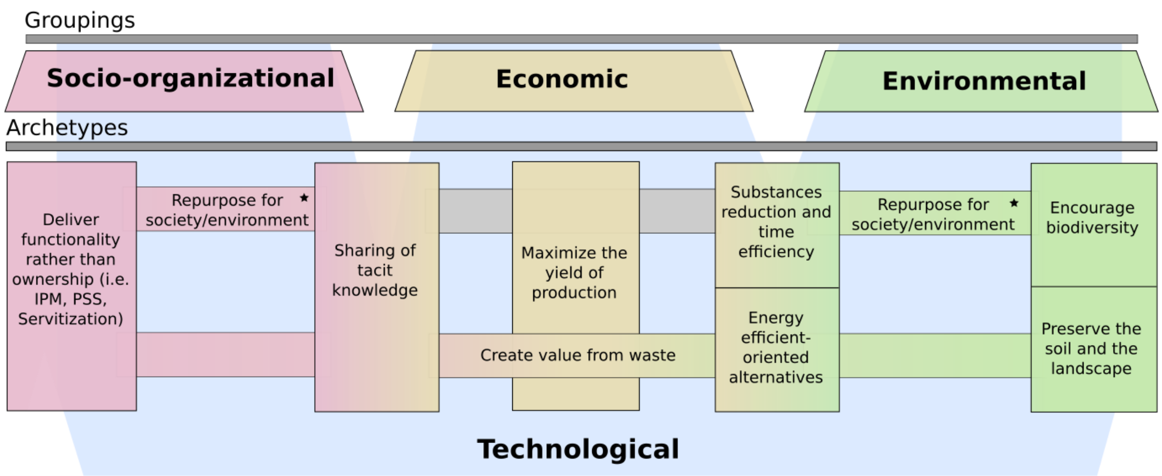


Figure 28: Technology positioning according to evaluators

Even if this graphical representation still can represent the complexity of the model, integrating the whole dimensions within the technological one, an important element is lost. Indeed, the importance of the technology as a directional arrow was one of underlying the progressive incremental steps towards more advanced technological solutions. The four business analytics are, therefore, not represented, even though they are part of the main findings. The technology positioning is indeed one of the main differences derived from the old model; the concept of technology as a driver towards sustainability is fundamental for pushing the sustainability in being the driver of the whole main regime. However, this interesting perspective could be taken into account for further research, trying to integrate the analytics as well in a more comprehensive graphical representation.

7.2.3. Categories intersection

Also, the categorizations are better seen as intertwined instead of strict silos as represented in the original model. In support of this, the evaluators affirmed that "what the innovation literature suggests is that often what you try to do is combining initiatives of technologies from one field to another field to come up with innovative solutions". Also, supporting this choice, an example has been given by the work done by Lüdeke-Freund, Carroux et al. (2018) through the 'sustainability triangle model' in which the archetypes are mixed and very interrelated, going from one in another.

In their paper, the authors elaborated on a sustainable business model pattern taxonomy. Through experts' evaluations, 45 sustainable business model patterns have been classified, grouping them in 11 groups along three dimensions: ecological, social, and economic (*Figure 29*).

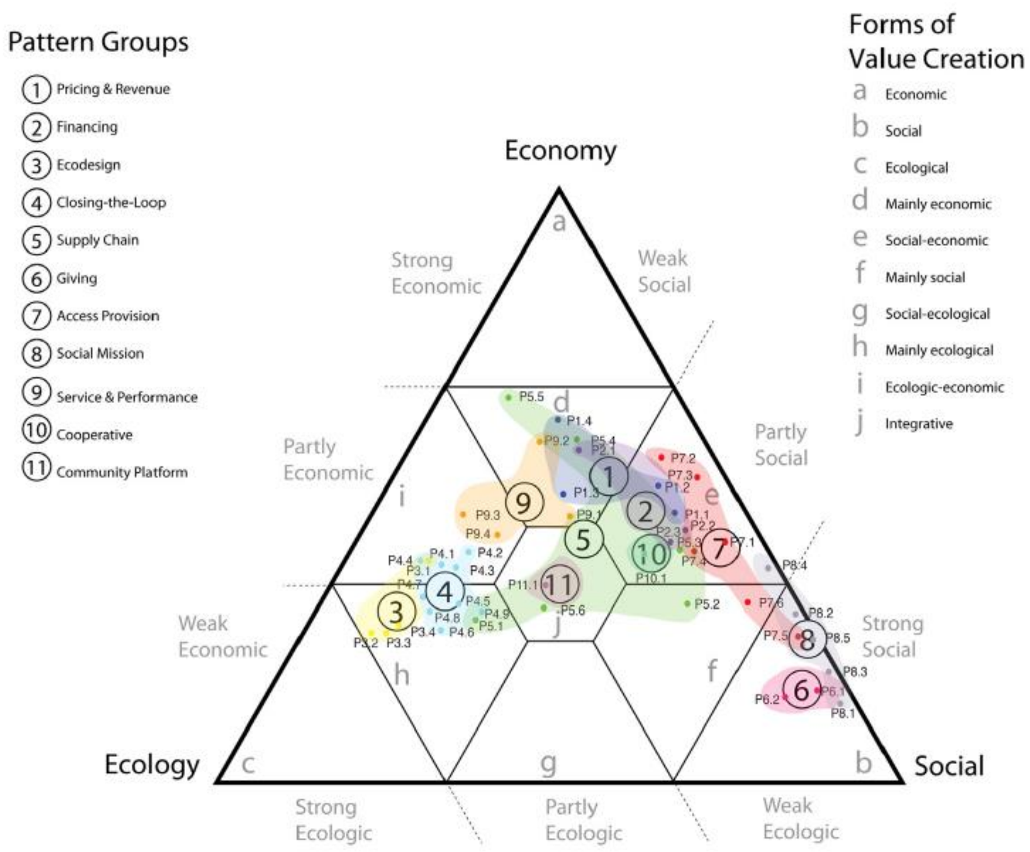


Figure 29: The sustainable business model pattern taxonomy (triangle view) –group and pattern level, (Lüdeke-Freund, Carroux et al. 2018).

As it is observable in *Figure 29*, a strict grouping of the patterns identified within single dimensions is difficult or rather impossible. The interrelation of the categorization is indeed better suitable to mirror the practice of the model in reality.

7.2.4. Model ease of use

One of the main questions that arose during the evaluations concerned the need to identify the ease of use of the framework. It has indeed been expressed how in literature there are many frameworks existent from a theoretical point of view, but when it comes to measuring the efficacy of the framework, there is very little that it has been empirically done. In this sense, it is important to look at the practicality of use. One way could be given by quantitative measurements of the business model sustainability level. Thus, when a start-up ideates a business model, it could start from the ideation of that through the start-up main dimension and a general understanding of the level of sustainability could be given by the number of archetypes taken into account in the business model value.

7.2.5. Archetype 'Adopt a stewardship role'

Another interesting discussion played around the original archetype "adopt a stewardship role". This archetype, as described in the previous chapter, takes into account the role of stakeholders. From the evaluators' point of view, a clear presence of a stakeholders' network is essential for the creation of a business. Stakeholders should seek to increase the empowerment of all actors in the agri-food sector. A start-up needs to be able to get close to the market, thinking carefully about network creation, and collaborating with farmers – in terms of i.e. developing the solution and commercializing it, prototyping, and testing it. However, it is agreed that even though there is visible importance of the concept, the archetype should not be part of the model. There are many tools deeply taking into account the role of multi-stakeholder. Examples are given by the 'value mapping tool for sustainable business thinking' (Bocken, Rana et al. 2015), as well as the 'stakeholder value creation framework for business model analysis' (Freudenreich, Lüdeke-Freund et al. 2019). While these tools are mainly linked to the overall process, through an understanding of the possible value creation or destruction from a stakeholder's point of view, the framework aims at the final product creation, being a sustainable business model. Thus, a good idea would be to combine the use of different tools in order to establish a sustainable business. However, it is good not to include this archetype within the framework.

7.2.6. Archetype 'Encourage sufficiency'

Regarding the archetype 'encourage sufficiency', doubts about the feasibility of this archetype within the model are expressed. Experts indeed affirmed how reducing production goes against food safety principles and thus a review of this archetype should be considered. Moreover, the expert Matthew Gorton affirmed that "it is very difficult to persuade someone to have innovation if they are going to make less money or if they are going to be financially unviable".

7.2.7. New archetypes and final conclusions

Concerning the new archetypes ideated, there is an overall understanding and agreement of these concepts within the framework. However, a simpler solution would be the one to include them within the broader concept of 'ecological ecosystem services', suggested by the expert Maya Hoveskog. Examples of these are pollination, water purification, wetland absorbing carbon dioxide, etc.

To conclude, generally an understanding and agreement towards the model is expressed. However, as widely discussed, the framework has a fully theoretical nature. Thus further research needs to be established in the application of it in real field application. This could also expose eventual rebounds effects during the application of the archetypes. Further empirical studies are required.

8. Discussion and conclusions

In this chapter, first, a clarification of the sub-questions and main research questions are given. These last ones are therefore answered on the base on the analyses performed throughout all the project. Following the challenges encountered during the development of the project are discussed. Moreover, potential improvements, strengths, and limitations of the model are treated, describing what could have been done differently and why.

Some reflections about the general project are undertaken, analyzing the managerial, social, and scientific implications of the project. Follows a personal reflection about the project, as well as more generally the study program that has been undertaken.

Following, the conclusions are presented. Within this section, the main contribution of this project to the general research in the field is clarified. Together, several starting points for potential future research are expressed.

8.1. Discussion

In this paragraph firstly a summary of the main outcomes encountered for each sub-questions and research questions is explained. Following some of the challenges experienced during the development of the outcome are discussed. Moreover, few words are spent on the importance of the managerial, social, and scientific implications of the project. Following, a personal reflection about the project, as well as the process contribution, is given.

8.1.1. Answering the research questions

To answer the final research question, during the project, I created 5 main sub-questions that have been leading the process towards the final outcome. Here following, they are briefly discussed, making more clarity about the general process structure.

1. *What is the main concept of sustainability and how does this differ from the grower and start-up point of view?*

The first step I have undertaken to reach an answer to the final question concerns the exploration of the concept of sustainability. More particularly, there is the need to explore how the concept is perceived from the market side (the start-ups) and the consumers' side (the farmers). Thus, I have been conducting 11 interviews with farmers from different European countries. At the same time, I have been analyzing a start-ups database composed of 42 start-ups in the precision viticulture sector. Thanks to the data gathered, it has been possible to define some insights through the use of the software ATLAS.ti (qualitative data analysis tool). A final conceptual map has been derived. In the map, the main prevailing dimensions are: social, economic, environmental, and technological. An interesting insight is that, differently by the first assumed hypothesis, the economical element plays a very big role for the farmers as well – thus not only from the start-ups' point of view. However, it is important to underline how the environmental aspect still prevails. This aspect is not sufficiently taken into account by the start-ups. A full explanation about the analysis conducted to answer this sub-question can be found in *Section 5.1*.

2. *Which parameters need to be monitored during the crop production in order to achieve a sustainable implementation in the smart crop management field?*

Similarly, using the same methodology, the main parameters that need to be monitored during the grape production to achieve a sustainable implementation in precision viticulture have been investigated. Through the use of the 11 interviews, thanks to one of the questions asked during the interviews, I have been able to retrieve data concerning the type of parameters that most commonly needs to be monitored. The outcome of this sub-question resulted in the following parameters:

- Biodiversity management
- Environment management
- Nutrition management
- Pest and disease management
- Weed management

Also, this study helped to define one of the two categorizations actuated in the start-up database, understanding the gap between market and demand. The full study can be explored in *Section 5.2*.

3. *How can these parameters be measured? Is there any technology able to measure these parameters within the technologies already developed in the AgTech sector?*

Strictly linked to the previous sub-question, an understanding of the degree of technology implied in the process has been explored in S*ection 5.2*. A third conceptual map has been created on the base of the answers given during the interviews. The map identifies the biggest gap between growers and start-ups, driven by the technology level of analytics used by growers vs start-ups. Indeed, even though farmers affirm to be quite inclined to the use of new unproven technologies, it has been quite surprising to discover how little the use of technological tools during the parameters' measurement is.

4. *Which kind of criteria need to be implemented into an AgTech start-up business model in order to develop a sustainable business model that meets the market needs?*

On the base of the discoveries, and through the identification of the most painful tasks that growers perform during the crop production life-cycle, I have been developing some new criteria that better fit the purpose. These new archetypes are the following:

- Sharing of tacit knowledge
- Encourage Biodiversity
- Substances reduction and time efficiency
- Preserve the soil and the landscape

Each of the new criteria is discussed in detail in *Section 6.2*. Examples for clarity are also provided.

5. *How do these criteria differ or resemble the sustainable business model archetypes ideated by Bocken et al. (2014)?*

Some archetypes from Bocken et al. (2014) model have been removed, others have been subject to changes, while most importantly new ones have been introduced (as discovered through the previous sub-question). This last category can be considered as the most interesting one, since it shapes the model on the best fit for the agriculture sector, in viticulture. However, this sub-question mainly focuses on the differences from Bocken et al. (2014) model, explaining them into details. The full criteria description can be found in *Section 6.2*.

The sub-questions lead the way through a gradual logic process that can be seen finalized through the answer to the main research question: "*How could the sustainable business model archetypes be re-adapted for future sustainable innovations in AgTech?*". The answer is given by a proposal of a new model, re-adapted by the model ideated by Bocken et al. (2014). The new model is thought of as a tool that start-ups can use to develop a sustainable business model that meets the requirements of the farmers. All the outcomes from the previous sub-questions can be found within the model, starting from the dimensions proposed; the technology dimension is seen as a driver; the level of analytics proposed, driving incrementally the change towards digitalization; the incorporation of the new archetypes within the framework besides the old archetypes modified and re-organize for the new model. The final answer to the research question can be fully explored in *Section 6.3*.

8.1.2. Limitations during the process

The overall project is highly based on data gathering and analysis. The data has been gathered both through desk research and interviews. However, the majority of data has been retrieved through the use of interviews. Thus, a high number of exogenous variables have been encountered. The biggest one playing a role in this context has been the unfortunate events of the pandemic Covid-19.

Originally, a higher number of interviews were planned to start from mid-March. Also, the interviews were planned as face-to-face interviews through different trips in the home country of the interviewees, as part of the original plan of the company Kubota Holdings Europe as well. However, due to the virus, the interviews have been postponed until the end of April. Therefore, the overall situation impacted on the time frame planned for the development of the project. Moreover, a new methodology for the interviews has been established. These have been then conducted through web calls. This led to a lower number of interviewees both due to the limited familiarity with the web tools, and the general availability given the unfortunate situation. Also, the use of web calls limited the amount of time planned for each interview. This led sometimes to only a partial gathering of information.

Another issue observed concerns the chosen target crop. Initially, the main target of the study was on specialty crops (orchards, vineyards, and vegetables). Different events however led to the decision of focusing on a single crop: vineyards production. The first issue that led to this decision is the difference in the life-cycle production between crops such as vineyards & orchards on one side and vegetables on the other. Following, the issues found during the interview process impacted the type of crop as well. In the absence of enough meaningful data for the study of the orchard crop, the target thus shifted on the vineyard's production only. In this context, fundamental has been the re-elaboration of the data gathered during the orchard workshop into insights applicable to the context of the vineyard.

8.1.3. Review of the conceptual model: strengths and weaknesses

Concerning the model itself, there are several limitations to be discussed.

The first limitation, and perhaps the biggest, is that the model ideated is context-specific. This means that the model arose from an in-depth study concerning the AgTech sector in viticulture. Therefore, it is mainly thought of as a tool that viticulture start-ups can use to develop their business model according to the needs of the vineyard sector. Moreover, the study has been conducted on the base of the main needs of growers in the geographical area of Europe. Thus, even though one could assume the similarity of the insights in other countries, it cannot be stated as a certainty, since different climate issues, social aspects, of type of terrain, could lead to different insights.

Another important limitation regards the usability of the tool in its singularity. As previously stated, the sustainable business model archetypes are, by definition, archetypes. Thus, they are criteria that are meant to lead towards the ideation of a business model according to sustainability specifications. However, when ideating a business model, innovation systems and multi-stakeholders' perspectives are also needed. Therefore, the model is thought of as a tool that if used alone cannot provide as much powerful insights as to the support of it with a broader set of tools (i.e. the value mapping tool).

Concerning the main strengths, it is possible to affirm that this context-specific property allows us to create very detailed business models, given the field-related precise information given. Thus, given the fact that there is a visible and proven gap in the usability of technology in the field, impacting on the shift towards a new regime, the model can support the steps towards the digitalization.

Moreover, even though the model is context-specific, the study represents also full guidance on how to perform the research for the basis of new model creation. Thus this process can be repeated in the field needed to obtain a closer model to the type of crop under evaluation. This means that the process for model creation can also be generalized to different sectors.

8.1.4. Managerial implications

The aim of the general study is quite broad. The study main scope is one of investigating the digitalization of the agriculture sector, studying the transition of AgTech as a new stable regime. However, due to the short window of time, the study conducted focuses on the ideation of a new model of sustainable business model archetypes that can be used for the creation of a sustainable business model. This can be seen as a starting point towards the bigger picture.

The study covers one of the most important topics when talking about the creation of a new product and/or service: the creation of a business model. This is indeed one of the main topics that a company, both as a corporate or a start-up, must face in order to be able to develop and run a business. Companies in the AgTech sector can thus consider this work as a powerful contribution to be taken into account when generating their business model.

The managerial implication is indeed quite intuitive and visible. Any AgTech start-up developing either a product (i.e. sensors, hardware, robotics, drone, etc.) or a service (decision support systems, software, platform, etc.) should start with a good value proposition.

While the value proposition should mainly be driven by a bottom-up approach, starting from the needs of the market (observing and studying the demand), it is noticed through the start-up database, that many of the innovations proposed are launched on the market with a top-down approach. Technologies that are already successfully tested in other fields are brought in the agriculture sector thinking that this could be enough. However, the market studies and the level of readiness of the customers need to be highly taken into consideration as well. This study has been conducting following a bottom-up approach and contains already meaningful insights that can be taken into account while building the value proposition. Moreover, as already explained, the business model should be driven both by technology and sustainability. These elements can be achieved through the development of the business model through the use of the archetypes identified in the final model proposed. Each archetype is defined by the needs of the growers, considering the sustainable element as primarily for the shift towards digitalization. The digitalization is also driven by an incremental approach following the four levels of analytics, helping the company to reach and understand the market.

In a nutshell, the model can be considered by the AgTech companies, and more particularly start-ups, as the primary starting point to develop new products/services that will be successful in the future, given the sustainability issues and changing market demands.

8.1.5. Social implications

Concerning the social implications, the impact of the model on society as a whole is quite strong. Indeed, one of the main issues within the agriculture sector regards the general reputation as a farmer. Farmers are frowned upon by society due to the strong chemical usage and general CO_2 impact on the ecosystems. However, society does not consider how important farmers' actions are for the well-being of the whole of humanity. Through the use of this model, start-ups can provide farmers with the right tools for more sustainable farming practices. Through the shift towards digitalization, farmers will be able to use more sustainable-oriented products within their daily production, delivering a more efficient and clean production to an increasingly growing population. Society will also start to correctly recognize their efforts.

8.1.6. Research implications

The development of this project allowed me to identify an important gap discovered through the analyses and still missing in the literature. Initially, the project arose around the identification of a gap in the different understanding and interpretation of the concept of sustainability, respectively from the growers and start-ups sides. However, with further investigations, it has been discovered, that although existent, this gap is not that wide as expected. More importantly, another gap has been identified. As explained in *Chapter 5.3*, while start-ups are already providing a complex solution with a high level of analytics (predictive and prescriptive), growers are still behind, preferring usage of more descriptive types of technologies. Therefore, there is a very specific gap in the market to be addressed. The model ideated aims at starting the process towards the gap resolution, and, as a further step, the sector digitalization process.

Thus, as previously explained, one of the main outcome's contributions is that through the use of the model, start-ups can guide growers towards the understanding, acceptance, and adoption of the technology, starting from the most remarkable needs expressed, according to the market studies. This thus allows start-ups to get closer to the grower's perspective, aligning the needs of market and customers, and preparing the basis for the shift towards the AgTech regime. At the same time, start-ups can get closer to the growers' point of view, developing solutions that fit their main needs and purposes.

However, this is not the only contribution of the general findings. Indeed, what it is important to underline as a scientific implication and general contribution to the literature and research field, concerns the process itself.

During the numerous researches done for the study development, an interesting founding has been that the sustainable business model archetypes ideated by Bocken et al. (2014) are applied in several fields and practical examples, but no application in the agriculture sector has been found. Moreover, when looking at the general literature concerning the agriculture sector, a classic triple bottom line – social, economic, and environmental dimensions – is preferred. Therefore, in the absence of literature towards this field, the general process used through the study, as well as the final model derived, can be considered as a contribution to the general scientific community. The process is clearly explained in all the phases, so that it can be replicated and re-applied for different agriculture study sectors, besides the viticulture one. Following the steps defined by the methodological approach represented in the Design Science Research Methodology in *Figure 1*, the study can be repeated and re-adapted for the type of crop under observation.

8.1.7. Personal reflection

This project has been for me a source of personal growth, in which the general knowledge gained through my Master's program has taken shape in a concrete form, generating an outcome that can be applied in a real business environment. Indeed, through the ideation and development of this study, many theoretical concepts have been put in practice, discovering the empirical application and effects of them on real-life business cases. This has been possible especially through the support given by the company Kubota Holdings Europe within the study. Concepts of business models and strategy, customer journey map, management, digitalization, sustainability, and market trends have been applied within the project, leading to the generation of a final framework.

More importantly, the development of this project allowed me to discover a field of study that I have never taken into consideration before, and in which the application of the studies gained through the Master program results challenging but satisfactory. The agriculture sector indeed appears to be a very challenging field due to the social consequences of the issues impacting on it. Therefore, a clear strategy and a defined methodology for the digitalization shift are needed. Market understanding is still quite scarce, and this is a limiting factor for general strategy identification. The novelty and the power of the field must be explored to satisfy general future needs, creating new opportunities for a strongly impacting business in the present and most importantly in the future.

Concerning the process, the methodology chosen for the project resulted to be very effective. As briefly discussed already, there are few limitations and major issues that occurred due to the Covid-19 global pandemic. However, alternative methods for continuing the study have been applied, resulting in a final outcome with a short delay compared to the originally planned timing. An initial comprehension of the general literature existing about the topic selected occurred.

Following, empirical studies in the field have been conducted to retrieve information lacking in the literature, fundamental for the creation of the outcome. Once the data have been gathered and analyzed, the creation of new criteria, and following a new product, the model, has been possible. Finally, following the research methodology chosen, a final evaluation has been performed. It is important to underline as the final evaluation has not been the only evaluation performed. Indeed, the evaluation process went through every new finding cycle. This is possible to observe through evaluations performed through the workshop, the interviews, and the analysis of the database. Thus, the evaluation is seen more as an iterative process, going throughout the full study.

Concerning more into detail the discovery and analysis process, possible improvements could have been possible through a more linear process during the interviews, gathering the full data needed. However, the data used for the analysis are useful and reliable thanks to the heterogeneity of the sample, including 3 EU countries and the UK during the detailed interviews (France, Italy, Spain, and United Kingdom) and, additionally, Belgium and The Netherlands during the workshop. An improvement could have also been made by interviewing start-ups as well. In this way, a more precise understanding of both parties could have been obtained. Even though this point of view has partially been retrieved through the presence of several start-ups owners during the orchard workshop, the information concerning the start-ups' point of view has been mainly gathered through the study of the database. The time limitation did not provide sufficient space for this in-depth analysis. However, this is a possible improvement to be considered.

8.2. Conclusions and future research

8.2.1. Conclusions

A full study has been performed, starting with the identification of the main gap between growers and start-ups, the understanding of the concept of sustainability, and, more importantly, the use of technology, mainly AI-related that played a fundamental role in the context. Due to these researches, the need for a new sustainable business model archetype tool arose. Differences between the original model from Bocken, Rana et al. (2015) have been derived and a clear explanation of the main reasons determining the change has been presented.

It is clear that, because the agriculture sector is changing and technology is required to keep the peace with the coming populations' needs, start-ups need to be able to provide products and services in accordance with these developments. On the other hand, it is also required from the growers' side to fully embrace the technology as a powerful tool supporting their daily practices towards an optimization of the production.

On the base of these discoveries, it has been possible to create and develop a new model representing the sustainable business model archetypes in the AgTech sector, viticulture-related.

The model represents the main contribution that the project provides to the literature of the sector. Through the use of this tool, start-ups can develop a sustainable business model that mirrors the use of sustainable archetypes in the precision viticulture field. This allows them to better match the growers' needs, delivering technologies that can be understood and adopted by the actual users. Through different technology incremental steps, the use of the model leads towards the adoption of more complex technologies, providing a first starting point for the digitalization of the sector.

Together with that, as briefly explained, another important contribution is given by the methodology, and thus the process, to obtain such a tool. This is, indeed, very important to re-create a similar tool specifically for the field under study.

Moreover, the model is thought in a wider context. The main scope concerns the capability of pushing the stabilization of a new regime, overcoming traditional agriculture. This is why this initial outcome can be seen as a starting point for numerous future researches.

8.2.2. Future research

Firstly, due to the high theoretical treats of the model, one possible line of research concerns the empirical study of the model. Thus, starting from a sample of start-ups it would be interesting to explore the functioning of the archetypes in a real-life business model creation and the derived outcomes. In such a study, eventual rebound effects could be studied, as well as the suitability of the archetypes in each singular start-up business model.

Following the line of the theoretical study, an interesting future research question would be "*how can these archetypes push the AgTech sector in its transition from niche to the dominant regime, overcoming the traditional agriculture business?*" and thus to do so major studies towards the understanding of how the integration of sustainability into AgTech start-ups business model impact on the industry shift towards digitalization would be needed.

The final outcome of this paper can, therefore, open numerous paths towards new researches and create solutions for the digitalization and empowerment of the sector, giving in the meanwhile an initial tool for the beginning of this process, starting with the creation of a new mentality.

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Appendix

A. Vineyards Workshop

05.03.2020

The insights are gained from the following countries: French, Spain, Belgium, The Netherlands, and England. After this initial information, more detailed interviews with players in French, Italy, Spain, and England have been conducted.

- **What are the key trends in farming practices and structures and which effects will they have on sustainable farming?**

The technology is already present, but alone it's not enough. It requires the presence of meaningful social value for the consumer as well. Creation of an 'innovation system'.

Sustainability is becoming one of the key drivers between the trends impacting on farming practices. An example is given by the reduction in the use of chemical products. "Farmers are considering the benefits on the landscape"; there is higher acceptance towards technology whenever the benefits of a sustainable way of farming are seen. However, one needs to be careful about the profitability factor that is significantly increasing and might lead to unsustainable practices.

Crops with longer cycles give more opportunity for digitalization. In vineyards, the full cycle is around 2 years. This might lead to an increase in digitalization, even if the vineyard sector is still more conservative than others such as the orchard one. However, being a high-quality crop, thus being more profitable, technology adoption is more easily embraced

The labor shortage is another driver. Nowadays, everybody wants to live in the city; there are no people in the field anymore. The trends vary also depending on the countries. One of the main difficulties discovered now in Belgium/NL is the necessity to house growers.

- **What are the key trends in consumer tastes and the agro-food industry? Which effects they will have on sustainable farming?**

Also, the market is explorative, going towards multi-variety and multi-protecting systems. This trend is starting from the farmers, through the use of experimental stations. Big importance is also given to the trend towards organic production. This experimentation is pushed by the collaboration between producers and sellers and mainly driven by the consumer's money.

From the industry's perspective, food security is becoming a problem and with growing demand, farmers need to adapt in order to produce more, which is also consistent with smart farming and organic production.

Another trend is given by the recent increasing interest in applications such as spraying applications and harvester (i.e. NewHolland harvester for wine grapes). Farmers are starting to discover the benefits behind the technologies.

- **Which technology trends do you see in vineyards?**

One of the main applications now concerns weeds removal with robots (automated weeding); they can use fewer quantities of herbicides. However, they are going towards technologies that are lighter and can reduce soil compaction. More generally a possible trend regards the direct work on the soil (meaning soil sensoring, irrigation & weather stations, but also yield monitoring through imaging drone/satellites – even though this is still an underdeveloped trend).

More common are the trends towards the use of sensors and machine learning (i.e. smart algorithms and Computer Vision). Common is also the research of new ways of arranging the canopy to be able to use future technologies on it.

It is however important to underline that even though there are several improvements especially towards the use of hardware usage (with subscription models), farmers are still far away from using Decision Support Systems (DSS). For major benefits derived by the use of those, first of all, a big amount of data is required for implementations and improvements. From the growers' side, agriculture consultants still have a primary role. They do prefer to rely on human knowledge.

- **What are some country experiences and approaches in developing and encouraging the adoption of appropriate technologies for particular farming systems in Europe?**

Concerning the approaches and the way to encourage technology adoption, from the participants' stories emerged that the end-user is fundamental. An example regarding The Netherlands concerns the use of a very small robot operating in the cutting and picking phase. R&D has been accurately conducted. Thus, following the developer took on very risky investments with the use of their own resources. Since they talked a lot with the growers and they understood their final target, the innovation was then proven successful. In France, the social sphere is encouraging for technology use that promotes sustainability.

More generally the technology adoption is pushed through subsidies (from the government) and the share of knowledge to the farmers. Subsidies can be applied through either tax cuts (NL) or new technology investments (i.e. new machinery).

- **How to stimulate the adoption of technologies that can improve sustainability at the farm level?**

A possible way to stimulate the adoption from the government side concerns for example the creation of incentives such as "first-mover advantages" in terms of for example achievement of a specific brand title or similar initiatives. This would encourage growers to adopt the technology. Indeed, this way the first adopter would not incur only in costs for the technology development and commercialization - that would later on spread on the market, providing similar advantages for all the users. Moreover, the use of subsidies can trigger the adoption (i.e. organic farm is increasingly receiving EU funding).

Another suggestion is the one to change the investment model. Now for the technology growers pay upfront (needing to borrow money) - while for the manual labor they pay at job done.

The technology adoption can also be stimulated by showing the positive outcomes derived by the use of it and obtained by the early adopters (maybe through the use of collaborations). More generally, there is a need for ‘social innovation’. This means that farmers need to be 'educated' about the usage and benefits of the technology. A change of mindsets needs to occur and this can happen through training or information sessions.

It is also important for the customer experience. For this, the timing is critical. The technology needs to be deployed as soon as it is ready and mature enough. It needs to be, however, proven useful (by the market) and easy to use. Personal financial matters play also a role.

- **What are the key barriers to technology adoption amongst growers?**

There are several key barriers to technology adoption. Some of them are strictly correlated with the geographical area and the country regulation, while some others can be generalized to a bigger number of growers. One of the technology adoption barriers in The Netherlands concerns for example the water usage (the soil is always quite moisturized, therefore systems linked to smart irrigation systems or similar would not be needed) and the water salinity (especially in areas close to the see, such as Zeeland).

Another reason is given by the 'ecosystem changes' - meaning the way companies support each other and push the technology - between regions. Indeed, there are changes also within the same country (i.e. NL between Zeeland and other areas). A clearer standardization or stability would incentivize the adoption. The consumers' perception plays an important role too. For example, there is the social perception that if the sprayers are bigger than it means that growers are spraying more and it is not socially accepted.

The government could also be a barrier to adoption (both actively or passively). The lack of regulations concerning the type of spray to use is a (passive) example. Another example (active) concerns the regulations about the use of chemicals in production. The use of incentives, such as subsidies, could facilitate the adoption. Another important barrier is given by the quite important upfront investment needed for the technology. Indeed, whenever growers invest in technology, they are able to exploit the positive outcome of technology usage only at the end of the year. The fear to jump in a failing investment is a barrier too.

- **Which trends on the consumers' side are changing the face of orchards / will change the face of orchards in the future? How?**

Organic products, traceability along the whole supply chain, and highly demanding quality.

- **What are the costliest tasks that growers deal with? Why?**

Pest diseases, weed control, and harvesting. They are all very expensive. Concerning harvesting for example the cost is around €2000/hectare. However, it depends on the country (and the weather). I.e. The Netherlands needs to do it more often because of the frequent rain.

- **What are the key subsidiaries that growers are getting from the government? How does this differ from country to country?**

Tax base subsidy. For example, if they have a data-driven system and the use of GPS they do have advantages related to the depreciation (75% machines) in The Netherlands.

In Belgium, if they invest funds for GPS or machines they get 30% of the investment back. This is similar in the NL too (obtaining 40% subsidy) if you are a start-up.

Concerning Spain and France, the interviewees are not acknowledged about the presence of specific subsidies. In general, in EU the subsidies depend mainly on the green eco-friendly policies; so EU policy on agriculture depends on the sustainable impact of your production.

- **What is the role of governments and markets in stimulating the adoption of appropriate technologies that can improve sustainability at the farm level?**

The government is not sufficiently stimulating the adoption of technologies since it doesn't create long-term stable regulations. Indeed, many growers don't want to invest because policies change every year. Concerning the market regulations, sometimes (i.e. UK case) they are even tougher than the governmental policies, ending up pushing the adoption more than the government itself.

Indeed, more generally, concerning topics such as pest disease, the government is a bit passive, letting the retail mainly regulate them. Considering the new trend towards 'individual treatments' the government should push regulations towards precision farming (instead of for example organic farming). Precision farming is argued to be safer and greener than organic farming (since this last one uses sulfites and vinegar that negatively impacts on the environment).

- **Do we face failing government support for the farm economy? Why?**

Even though the governments are supporting the farmers some incentives would be needed - for example about the type of spray to use or rewards for first-mover adoption.

- **How to make farm production cost/price-driven?**

It already is! And it helps with management decisions such as whether to increase labor costs and decrease water management costs. However, it is not necessarily a good system. A value-driven approach would be more beneficial and profitable for farmers.

- **Where does the knowledge for pruning come from?**

There is no standardized knowledge about it. Skilled laborers look at the tree's architecture and with experience learn how to prune it. They simply know how to do it "based on the gut feeling". The way laborer prune changes also from country to country (or regions as well). There is not a common consensus about it. Inexistence of any data-driven model for it due to lack of data and insights. More generally there is no system for a knowledge base on how to prune, irrigation, root cutting, general agronomic advice. In Belgium, some independent advisors are doing it. However, every country has a different vision/perception.

- **Information source for frost detection?**

When the temperature drops under 1 degree they get an alert and they start the installation of i.e. sprinklers. The best method against frost in the NL and Belgium is to spray water. This is why water management might be a touchpoint. However, they do it only when strictly needed (temperature below zero) to avoid soaked soil. An opportunity would also then be weather forecast and frost prediction since the systems they are having now are not really precise. Perfect conditions are needed for a correct functioning (i.e. whenever it is too cold the system might not work properly).

- **Why netting, trapping? Different targets for different species?**

Netting can have the double purpose of protecting from insects and hail. Also in Italy, France, and generally in warm countries, they are used to protect the crops from sunburn. On this last point, they are now starting to experiment with the use of solar panels instead. These are easier to use because don't require the effort linked to installation and removal and produce energy at the same time. In France, they are also testing multispectral nets (thermic signal) and the signal appears to be still receivable from under the net. Trapping is to identify insects' diseases and eliminate them.

- **How to decide about pest control?**

They make use of manual traps checking. In France, it is done by advisors (with the use of surveys). In NL and Belgium, they do simply manually count them. Insect pest detection is more difficult than other pest diseases since you don't see the insects that easily and you see the negative outcome on the crop when it's already too late. Some of them for example make eggs and then they are more easily recognizable, but the method is still quite underdeveloped. Evaluation of last insect treatment however results to be quite difficult. You don't know if it has had efficacy or not.

- **Are there costs for advisors on pest detection?**

Yes. For example, in Belgium, they come five times during the year spreading knowledge of what they encountered in other fields and sharing information.

- **How is the need for irrigation defined?**

It depends by country. I.e. In the NL and Belgium not that needed because the soil is always quite moisturized. As said before it is mainly used to avoid frost. Concerning the countries where it is done (i.e. France) there are usually sensors (analog sensors) in the soil/plant monitoring the water requirements; they are quite cheap so almost everybody has them and you get wireless info directly on your phone (app/website) about the water stress. Now there is a trend towards fertigation (irrigation and fertilization together).

- **Where is the need for summer pruning?**

Pruning strengthens the tree (pruning and root pruning). You can remove already some of the shoots to balance the production when the tree is too vigorous and it is done manually.

- **Where does the general knowledge for decisions come from?** Experience.

B. Growers' interviews

UK – Tony

22.04.2020

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

I think it is key that any food product now has a setting from which the primary producer makes it as sustainable as he possibly can. It comes down to a lot of good practices that have been used for years and the ones that are still working are usually the ones that are the most innovative in the vineyards and have the best return. There are a lot of products that have been used in the past that are on the way out. And I am quite glad about some of these products going. That means that people are now looking at alternative ways of producing the same products with limited use of chemicals or artificial products. To me every step has to be more sustainable; we all know what is happening with global warming, and especially it is quite a high input industry that did a lot of chemical inputs into commercial viticulture. So I think that the more we can do, the better - since we have been using technology to do that sensibly, using education and a lot of science to back up what we are doing. Essentially the ethos of why we are doing this, the idea of ideally having a pure, green natural vineyard, used to be the norm. It used to be more of a monoculture and we are now trying to introduce more biodiversity. The key, the one that I have been pushing to my staff, you are here working all day, then make it a healthy place where to work. So if everybody has a little bit of feel for your own personal health while working in the vineyards, working in that scene, we are going to use a little bit of product less.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

The big one is herbicide use; it is declining. And people are putting more emphasis on good soil persistence. Trying to maintain a good healthy soil bio substance. Also, I think another one is the use of fossil fuels. Because weeders are probably less invasive on fossil fuels use than mechanical weeding farm situations which are a bit more hitting on fossil fuels use. So you are trying to hit a nice balance with the use of cover crops. In precision agriculture, precision farming technology is naturally playing a fundamental role. It also changes the bottom line for businesses. In our business the margins are quite tight, in a very demanding global market; so, you need the best quality product you possibly can to compete, you need to make sure the product you are making is the best you possibly can. The way to do that is to have a well thought out designed farm. For instance, tractors, compared to when I was starting, are now more superior. They are more fuel-efficient and compatible with more equipment; you can indeed now use the equipment on the back and the front. So really technology has changed massively.

IT – Giacomo

04.05.2020

(Original language of the interview)

1. **Come definiresti il concetto di agricoltura sostenibile e come quest'ultimo svolge un ruolo nella tua azienda agricola?**

La presenza umana all'interno del vigneto. Utilizzare ciò che c'è realmente bisogno di utilizzare, perché l'agricoltore spesso e volentieri vuole troppo bene alla sua vigna e fa delle cose di cui non c'è più il bisogno di farle (tipo troppi trattamenti). Poi sicuramente c'è anche la parte di sostenibilità economica che ti porta ad essere più parsimonioso. Include anche le aree verdi attorno all'azienda, le aree attorno ai vigneti. É una visione a 360 gradi.

2. **Quali sono i principali trend che si stanno lentamente sviluppando nel mondo agricolo? Come pensi che impattano sul concetto di agricoltura sostenibile? Quanto e come svolge un ruolo la tecnologia nello sviluppo di questi trend?**

Nessuna informazione.

3. **Quali sono i principali parametri (le principali misure o criteri) che vanno misurati sul campo durante la produzione agricola per far sì che si possa ottenere una produzione sostenibile per l'ambiente e a livello economico?**

Utilizzare alcune molecole (e alcune non sono ammesse, per esempio il diserbo chimico non é ammesso). L'emissione di CO2 emessa durante la produzione. Il numero di personale in giornate impiegato per ettaro. (*Quindi le area affette sono quelle dei parassiti/malattie delle piante e manodopera*).

4. **Come misuri questi parametri? É la tecnologia uno strumento chiave per la misurazione di questi dati, di questi criteri?**

Non utilizziamo la tecnologia ma facciamo dei calcoli specifici di sostenibilità previsti da un progetto ministeriale. Si tratta del progetto ministeriale VIVA E SOSTEGNO. Quindi questi calcoli sono frutto del mio quaderno di campagna, delle registrazioni di passaggi, di quale trattore abbiamo utilizzato o non. Non viene fatto nessun Life Cycle Assessment (LCA).

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

Through the use of the human presence inside the vineyards. The use of what it is really needed, since the grower quite often, being too close to his vineyards, performs some tasks that are not necessarily needed (i.e. too many pest and disease treatments). The economical sustainability is also a side to not under evaluate, thus the need to be careful with money expenditures. It is a 360 degrees' vision; the green areas around the vineyards fields need to be protected too.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

No data.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

The use of specific molecules since some type of chemical substances are not allowed (i.e. the chemical weeding). CO2 emissions during production. The number of workers/ha needed for a day of work. The areas mainly monitored concerns, therefore, pests and disease management and labor.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

We don't use any form of technology for this but we calculate them following specific sustainability parameters defined by a ministerial project. This project is called VIVA E SOSTEGNO. Therefore, these calculations are the product of my farming notebook, step recordings, which tractors have been used, and which not, etc. There is no Life Cycle Assessment (LCA).

IT – Leonardo

05.05.2020

(Original language of the interview)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

What we are doing, I wouldn't say it is sustainable farming, but rather a sustainable estate; and for us, the most important thing is economical sustainability; if you can invest in all the different fields, you can do it only if you have enough money to invest. And talking about the farming strictly is the precision agriculture is our driver/path, so using vigor map for nutrition and using the new machinery for reducing the quantity of chemical spraying for disease and pest control. Then we have 2 social projects: one that regards the school of pruning. More than 10 years that approximately 20/25 people come for a full immersion of 3/4 days for the winter pruning and 2/3 days for the spring pruning, so it is something that I think it is very important to save a kind of a job that is going to be lost. The previous young generation let the countryside, so we need a generation to share knowledge. We also have another social project, a vegetable garden in which we produce all the tomatoes, salads, and other veg managed by some guys with disabilities of our region, helped by retired employees of San Felice. So putting all these things together is what we consider to be sustainable in our situation. Naturally, the goal is to reduce as much as we can the chemical usage. The issue I think with sustainability compared to biological agriculture is the simple name: bio is a little word explain, and in the mind of the consumer is much more related to nature. Sustainability is much more developed, in 360 degrees. Not only a matter of bio-organic for the soil, but it has many more aspects to develop. It is much less known and it needs a stricter protocol. We are thinking to accept to try to do the EQUALITAS protocol. I think for the consumer is not enough clear what sustainable means.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

I don't know if, for sure not in the next future, but maybe what I see is the organic farming will be developed. In one part of the vineyards, we are already operating organically, also if we are not certified organic, but we are already managing the vineyard with organic.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

What we are trying to check is first of all the quality and the number of insects and bugs and kind of grass we have in our vineyards. Then I also check regularly the quality of the water, of the little springs during the season of the spring just to see in the superficial water you have chemical residuals. At this stage, we don't do anything else.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

We don't use technology for this. It is done in a very simple way. We put a table in the vineyards and after a certain number of days, we check how many worms or other bugs we find under it. Or how many kinds of grass we find in the vineyards where we don't do cover crop naturally. We also put a little pipe just to see if they are colonized by wasps or bees or other bugs.

IT – Alberto

05.05.2020

(Original language of the interview)

1. **Come definiresti il concetto di agricoltura sostenibile e come quest'ultimo svolge un ruolo nella tua azienda agricola?**

Per noi il concetto di agricoltura sostenibile è un concetto che si è evoluto nel tempo. Oggi fare agricoltura sostenibile significa fare agricoltura sostenibile a 360 gradi. Quindi che abbia un basso impatto sull'ambiente. Che sia economicamente sostenibile, dunque che abbia una redditività; che abbia anche il giusto impatto sociale, cercando anche di sopperire a quella che è la mancanza di formazione. Noi la facciamo ai nostri dipendenti ma anche agli agricoltori che ci conferiscono le uve, quindi ci portano il loro prodotto tutti gli anni. Li formiamo sulla sostenibilità dell'agricoltura, su come si fa l'agricoltura oggi rispettando l'ambiente e così via. Quindi oggi è un concetto a 360 gradi. Non si può pensare di fare agricoltura sostenibile pensando solo di migliorare l'uso dei prodotti parassitari. C'é tutta una serie di aspetti che vanno seguiti e gestiti, non ultima la gestione del suolo e quindi la sostenibilità della risorsa suolo diventa fondamentale e lo sta diventando sempre di più.

2. **Quali sono i principali trend che si stanno lentamente sviluppando nel mondo agricolo? Come pensi che impattano sul concetto di agricoltura sostenibile? Quanto e come svolge un ruolo la tecnologia nello sviluppo di questi trend?**

Nessuna informazione.

3. **Quali sono i principali parametri (le principali misure o criteri) che vanno misurati sul campo durante la produzione agricola per far sì che si possa ottenere una produzione sostenibile per l'ambiente e a livello economico?**

Allora.. tutto! No nel senso che è complessa la cosa. Immagini che noi gestiamo e monitoriamo le attività manuali perché è fondamentale sapere dove gli operatori sono e che cosa stanno facendo e in che momento lo stanno facendo, proprio per evitare che abbiano delle esposizioni non corrette ai prodotti parassitari, quando li utilizziamo; e che quindi rispettino i tempi di rientro e tutta una serie di cose che ad oggi sono necessarie. Poi monitoriamo tutta la parte vegeto-produttiva. Esiste un mio collega che fa tutti i monitoraggi a partire dall'inizio della stagione fino alla raccolta e quindi valutiamo lo sviluppo delle piante, se hanno delle patologie o fisiopatologie e interveniamo di conseguenza. Ma questo è un aspetto fondamentale perché si interviene soltanto laddove esiste una necessità evidente e importante. E laddove questa necessità non può essere risolta con soluzioni preventive. Quindi il monitoraggio e la raccolta dei dati è fondamentale, anche in merito all'attività dell'anno successivo. Laddove c'è una problematica sorta in maniera imprevista quest'anno; ma il prossimo anno può essere risolta in maniera preventiva. Se no si è sempre alla rincorsa dei problemi, e come agricoltore biologico non si va da nessuna parte.

4. **Come misuri questi parametri? É la tecnologia uno strumento chiave per la misurazione di questi dati, di questi criteri?**

Ad oggi utilizziamo un'app che ci permette di fare tutti questi monitoraggi, raccogliere i dati e poi valutarli da remoto. L'app si chiama *4Grapes*, utilizzata per tutta la parte vegeto-produttiva. Invece per la parte legata alla gestione del personale e la gestione delle attività che vengono fatte sia manualmente che dagli operatori che usano i trattori usiamo un software che si chiama *Isaculture* ed è francese.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

For us, the concept of sustainable agriculture is a concept that has evolved over time. Today, making sustainable agriculture means making sustainable agriculture at 360 degrees. So it needs to have a low impact on the environment. It needs to be economically sustainable - thus creating profitability. It also needs to have a correct social impact, trying to make up for the lack of training too. We indeed train our employees, but not only. We do train also the farmers who give us the grapes, bringing us their product every year, so that it is a good product. We train them on the sustainability of agriculture, on how agriculture is done today respecting the environment, and so on. So nowadays it is a 360 degrees' concept. One cannot think of doing sustainable agriculture thinking only of improving pest and disease management. There is a whole series of aspects that must be followed and managed, not least the management of the soil. Indeed, the sustainability of the soil, as a fundamental resource, is becoming more and more central.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

No data.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

Well, we have to think about the fact that we manage and monitor manual activities because it is essential to know where the operators are and what they are doing at a specific point in time to avoid incorrect exposures to chemical substances for example. Thus, we need to understand if, for example, they are respecting the re-entry period and a whole series of things that today are necessary. Then we monitor all the vegetal-productive parts. There is a colleague of mine who does all the monitoring from the beginning of the season until the harvest. We, therefore, evaluate the development of the plants, the eventual presence of pathologies, or physio-pathologies and we act accordingly. But this is a fundamental aspect because we only intervene where there is an evident and important need for doing it. Especially in situations in which this need cannot be solved with preventive solutions. So to monitor and collect data is fundamental, also with regard to the potential benefits linked to the following year. Where there is a problem that arose unexpectedly this year, we develop the knowledge to be better prepared for the coming year and, if possible, prevent it.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

Nowadays, we use an app that allows us to do all these monitoring; collect data, and then evaluate them remotely. The app is called *4Grapes*, and it is used for all the vegetative-productive parts. For the part related to personnel management and the management of the activities that are done both manually and by the operators who use tractors, we use a software called *Isaculture* that is French.

IT – Carlo

08.05.2020

(Original language of the interview)

1. **Come definiresti il concetto di agricoltura sostenibile e come quest'ultimo svolge un ruolo nella tua azienda agricola?**

L'agricoltura sostenibile è un concetto importantissimo e io lo sintetizzerei in 4 parole: "Noi dobbiamo custodire il nostro terreno!". Noi non siamo i proprietari del nostro terreno; siamo semplicemente dei custodi e lo custodiamo 30/40 anni per poi consegnarlo ad altre mani, che possono essere di una famiglia o di altre persone. Quindi dobbiamo fare in modo che le nostre azioni vengano messe in opera per una corretta coltivazione, che sia vite o che sia grano, e che dunque non vadano a ledere la nostra risorsa più importante: il terreno. Quindi bisogna ragionare in questi termini, sia che io faccia biologico o agricoltura convenzionale; in entrambi i casi va usato il buon senso, adottando tutto quello che si può per poter coltivare delle piante sane, ottenere un prodotto sano per poi vendere un prodotto altrettanto sano. Allo stesso tempo è importante cercare di ridurre le sostanze inquinanti. Devo inquinare il meno possibile i miei vigneti ed il mio territorio. Questa é la base per lavorar bene ed allo stesso tempo ottenere un profitto, infatti quando lavori bene e fai tutto quello che devi fare in maniera etica e sostenibile, ne trai anche più profitto. Diventi più preciso e performante. Penso si debba quindi portare il massimo rispetto per il nostro territorio e le nostre colline. Quando sia adotta questo 'modus operandi' ti rimane addosso dal punto di vista lavorativo ma anche personale.

2. **Quali sono i principali trend che si stanno lentamente sviluppando nel mondo agricolo? Come pensi che impattano sul concetto di agricoltura sostenibile? Quanto e come svolge un ruolo la tecnologia nello sviluppo di questi trend?**

Secondo me, i principali trend sono: la scomparsa di dilettanti o comunque scompariranno nei prossimi anni. Quindi ci sarà una forma di aggregazione maggiore nelle aziende. E in un certo senso le aziende diventeranno sempre più estese perché le piccole imprese saranno destinate a scomparire dal momento che hanno possibilità di investimenti limitate e difficoltà nell'ammortizzare i costi. L'altro trend riguarda il maggior utilizzo della tecnologia fondamentalmente. Vanno di pari passo. Le aziende che potranno permettersi le tecnologie saranno aziende che avranno sempre la possibilità di ammortizzare questi costi su più ettari di estensione. É un trend che è ormai segnato da tanto tempo e non può che portare benefici.

3. **Quali sono i principali parametri che vanno misurati sul campo durante la produzione agricola per far sì che si possa ottenere una produzione sostenibile per l'ambiente e a livello economico?**

Questo argomento rientra più nell'ottica economica. Se posso fare un lavoro in un'ora bene. Se lo faccio l'anno prossimo devo vedere se riesco a farlo in 50 minuti ma allo stesso tempo sempre fatto bene. É da qui che nasce il bisogno di acquistare macchinari agricoli al passo coi tempi. Un esempio più pratico: quando noi cimiamo con le cimatrici (potatura primaverile) adottiamo l'ultimo modello del macchinario per operare nel modo migliore, perché sappiamo che più il macchinario è nuovo, più ti permette di ottenere una velocità maggiore ed un taglio più netto. Se io faccio il conto di quanti km ci sono in un ettaro per misurare la vigna in termini di velocità del trattore (in km/ettaro) noto la differenza di velocità in termine di maggior efficienza nelle tempistiche e quindi anche economica. Quindi se vado a 6 km/h, rispetto ai 5 km/h originari, aumento la mia produttività del 20%. Quindi io misuro da quello. Ovviamente va misurata anche in termini qualitativi, ma quello è più complicato.

4. **Come misuri questi parametri? É la tecnologia uno strumento chiave per la misurazione di questi dati, di questi criteri?**

Principalmente manualmente.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

Sustainable agriculture is a very important concept and I would summarize it in 4 words: "We must protect our land!". We are not the owners of our land; we are simply caretakers. We take care of the farm for 30/40 years and then we have to hand it over to the other hands, which may be from a family or other people. So we must make sure that our actions are translated into acts for proper cultivation, whether it is vine or wheat. Especially we need to make sure to not harm our most important resource: the soil. So you have to think in these terms, whether I'm an organic or conventional agriculture grower, common sense must be used, adopting all the possible solutions to grow healthy plants, obtain a healthy product and thus sell an equally healthy product. At the same time, it is important to try to reduce pollutants. I must try to pollute my vineyards and my territory as the least as possible. This is the basis for working well and at the same time make a profit. Indeed, when you work well and do everything you need to ethically and sustainably farm, you also get more profit. You become more precise and performing. I think, therefore, we should bring the utmost respect for our territory and our hills. When this 'modus operandi' (this way of proceeding) is adopted, you will keep on using it both from a working and a personal perspective.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

In my opinion, the main trends are the disappearance of amateurs (that eventually will fully disappear in the coming years) and an increase in technology use. So there will be a greater form of aggregation in companies. Companies will become increasingly large since small businesses are destined to disappear. Small farms have indeed limited investment economical availability as well as increasing difficulties in the amortization of the costs. The other trend concerns more generally the greater use of technology. They go hand in hand. The companies that can afford the technologies will be companies that will always have the possibility of amortizing these costs over several hectares of extension. It is a trend that has been marked for a long time and can only bring benefits.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

This argument falls more on the economic perspective. If I can do a job in an hour, I am happy well. However, if I do it next year I want to do it in 50 minutes but at the same time still well-done. This is where the need to buy agricultural machinery that is up to date comes from. I will give a more practical example: when we prune with the trimmers (green pruning) we adopt the latest model of the machinery to operate in the best way because we know that the newer the machine, the more it allows you to obtain a higher speed and a cleaner cut. If I take into account how many km there are in one hectare to measure the vineyard in terms of tractor speed (in km/hectare) I notice the difference in speed in terms of greater efficiency in timing and therefore also economic. So if I go to 6 km/h, compared to the original 5 km/h, I increase my productivity by 20%. So I measure by that. Obviously, it must also be measured in qualitative terms, but that is more complicated.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

No, it is done all manually.

FR – Baptiste & Xavier

11.05.2020

(The original language of the interview was in French. Thanks to the company resources, in terms of French-speaking personnel this interview has been possible)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

Some people speak about the positive footprint. I think it's an ambitious, very long-term goal. For me, sustainable farming is 'trying to reduce at the maximum footprint on the nature and the usage of chemical products'. It's a way of farming that works on the total respect of biodiversity, in terms of biodiversity of the ground too. In our company, we have developed a concept to crystalize the idea of sustainable farming: 'it is living soil'. Your soil is the result of your actions and is your wealth, your richness. If you have a living soil, then that is a good indicator that you are working in cooperation with nature. It's a concept recently defined by our group. Another long-term concept is a positive footprint - how our activities can have a positive impact on the environment.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

No data.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

First of all, you should start monitoring your KPIs. We use the IFT (Indice de Frequence de Traitement/ Frequency Treatment Indicator). It identifies whether some toxic products, such as carcinogenic products, are used for example. Also when you test the technology, an important parameter is the fuel footprint, dioxide, CO2 rejections, etc. Another parameter is the derivation percentage, thus the residue in the environment and more generically the biological activity in the ground (i.e. residue in pesticide product). All of these indicators are studied and taken care of in our group.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

They are measured all manually. For example, you can see that you spend 200L of chemicals in the following year instead of 300L. But technology doesn't play a role in this context for us.

FR – Sebastien

12.05.2020

(Original language of the interview)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

Less energy. More environmental protection. Possibility to work in an easier way for workers. Cheaper.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

Perhaps, pesticide management (IPO) and weeding management. Also, sensors and algorithms to predict diseases. So you make the treatment with the right timing.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**
   - Quantity of pesticides used;
   - Quantity of fossil fuels used;
   - Quantity of water used;
   - Number of hours 'labor-in';
   - Biodiversity (even if it is very difficult to calculate and monitor this);
   - The yield of production.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

We are in standards of quality systems, and we do measure the number of pesticides used. We do use the Indicators of Frequency of Treatment (IFT) in France. We count the number of trees, the quantity, the areas of grass with no pesticides inside, and so on. But everything is done manually. There is not technology applied for this.

They did not adopt any of these technologies because in their company at the moment the most important factor is the organization of tasks inside the company itself. Also, they do have free consultants that can help the growers. Two big limitations in the technology adoption for their company are the cost and the time that the workers can spend on learning the technology.

IT – Luigi

14.05.2020

(Original language of the interview)

1. **Come definiresti il concetto di agricoltura sostenibile e come quest'ultimo svolge un ruolo nella tua azienda agricola?**

Diciamo che il concetto di sostenibilità per noi riguarda il minor utilizzo di prodotti che nuocciono alla salute, sia per gli operatori che per il vino di per sé. Dunque il minor utilizzo possibile di sostanze nocive per l'uva. Con sostenibile intendo anche finanziariamente sostenibile. Questo è dato dal fatto che sebbene la sostenibilità porta talvolta a costi maggiori - dati i numerosi passaggi in più nella vigna durante il processo di produzione - i benefici finali sono visibili. Dunque l'importante è che i costi siano sostenibili, nel senso che si riesca a sopportare il costo e che sia anche una sostenibilità finanziaria. Noi stiamo cercando di fare il massimo in questo, soprattutto cercando di non utilizzare prodotti chimici che nuocciono alla salute.

2. **Quali sono i principali trend che si stanno lentamente sviluppando nel mondo agricolo? Come pensi che impattano sul concetto di agricoltura sostenibile? Quanto e come svolge un ruolo la tecnologia nello sviluppo di questi trend?**

Nessuna informazione.

3. **Quali sono i principali parametri (le principali misure o criteri) che vanno misurati sul campo durante la produzione agricola per far si che si possa ottenere una produzione sostenibile per l'ambiente e a livello economico?**

Prima di tutto è possibile misurare una produzione sostenibile dalla produzione di una qualità e quantità giusta, in modo da poter ottenere un vino di qualità. Cercare dunque di ottenere il massimo dalla produzione del vino, utilizzando tutta la nostra capacità e la nostra tecnologia, sia in campagna che in cantina. Così è possibile arrivare alla produzione di una bottiglia che si avvicini a quello che è un prodotto più perfetto possibile, più integro possibile e di valore. In questo modo è poi possibile chiedere al consumatore finale una cifra che sia anche per lui sostenibile in maniera proporzionata alla qualità.

4. **Come misuri questi parametri? É la tecnologia uno strumento chiave per la misurazione di questi dati, di questi criteri?**

Sono tutti i parametri che si vedono con l'esperienza e con i risultati ottenuti negli anni. Sono dunque parametri che continuiamo ad ottenere con la nostra esperienza ed il nostro lavoro e con il nostro modo di fare.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

Let's say that the concept of sustainability for us concerns the reduction in the use of products that are harmful to health, both for operators and for the wine itself. Therefore, the least possible use of substances harmful to grapes for example. By sustainable I also mean financially/economically sustainable. This is because although sustainability sometimes leads to higher costs - given the numerous extra steps during the production process in the vineyard - the final benefits are visible. So the important element is that the costs are sustainable, in the sense that you can bear the cost and thus is financially sustainable. We are trying to do our best in this, above all trying not to use chemicals that are harmful to health.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

No data.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

First of all, it is possible to measure sustainable production by the production of the right quality and quantity, in order to obtain a quality wine. Thus, trying to get the most out of wine production, using all our ability and technology, both in the countryside and in the cellar. In this way, it is possible to get to the production of a bottle that comes close to the product perfection, as intact as possible and valuable. In this way, it is then possible to ask the end consumer for a figure that is also sustainable for him in proportion to the quality.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

These are all the parameters that can be seen with experience and with the results obtained over the years. They are, therefore, parameters that we continue to obtain with our experience and our work and with our way of doing.

IT – Marco

14.05.2020

(Original language of the interview)

1. **Come definiresti il concetto di agricoltura sostenibile e come quest'ultimo svolge un ruolo nella tua azienda agricola?**

Secondo me il concetto di sostenibilità non deve essere un concetto di marketing ma una reale presa di coscienza; dobbiamo fare qualche cosa per il nostro pianeta. Questo è il primo punto. Io voglio poter entrare nei vigneti senza avere dei problemi. Ecco perché noi siamo legati a questo metodo in cui facciamo trattamenti con alghe, facciamo trattamenti con diverse cose, andando incontro ad un percorso sempre più naturale. Prima ho menzionato che abbiamo iniziato il percorso biologico ma poi l'abbiamo lasciato perché nel biologico c'è presenza di rame, che è un metallo pesante. Noi cerchiamo di andare oltre a quello che è il biologico. Quindi abbiamo fatto delle prove, delle esperienze, e stiamo facendo tuttora delle esperienze con l'ozono, e siamo stati l'unica azienda in Italia, insieme ad una francese in Provenza, che ha iniziato a fare delle esperienze due anni fa e poi da lì abbiamo sensibilizzato la tematica. Dunque stiamo continuando questi esperimenti con dei risultati positivi e abbiamo delle idee di poter anche andare avanti con i trattamenti all'ozono. Dunque ne parlano tutti ma la sostenibilità deve essere a 360°. Purtroppo ci ritroviamo in una società nella quale molte volte il profitto viene prima di tutto, mentre io direi che sicuramente ci vuole del profitto per concludere in modo positivo il proprio bilancio ma non deve essere solo quello. Io, così come tutti i miei collaboratori, mio padre, ed in generale la generazione prima di me, siamo dell'idea che bisogna produrre con coscienza. E sicuramente per questo motivo stiamo mettendo in campo delle pratiche e la sostenibilità la vedo anche nei confronti dei miei collaboratori e deve essere anche sociale. Noi cerchiamo di fare qualche cosa anche per il territorio Insomma a 360°.

2. **Quali sono i principali trend che si stanno lentamente sviluppando nel mondo agricolo? Come pensi che impattano sul concetto di agricoltura sostenibile? Quanto e come svolge un ruolo la tecnologia nello sviluppo di questi trend?**

Direi che la tecnologia sarà sempre più importante, ma ciò che va sottolineato è che dovrà essere una tecnologia facile e fruibile. Si pensi anche solamente a quante persone ci saranno poi sul nostro pianeta tra 30/50 anni. La tecnologia sarà dunque necessaria per il futuro e per aiutarci ed essere più mirati, più tempestivi; e questo significa che ci può aiutare anche ad economizzare le risorse. Per esempio, riguardo ai trattamenti sui vigneti, se si ha il supporto della tecnologia c'è sicuramente una riduzione di costi, una maggiore tempestività ed un minore utilizzo di prodotti per la lotta antiparassitaria.

3. **Quali sono i principali parametri (le principali misure o criteri) che vanno misurati sul campo durante la produzione agricola per far si che si possa ottenere una produzione sostenibile per l'ambiente e a livello economico?**

Noi abbiamo aderito ad un progetto del Ministero dell'Ambiente che si chiama Viva, che va a considerare certi indicatori che sono per esempio aria, acqua, ecc. e che considerano le varie fasi dal campo al consumatore finale. Per esempio la misurazione dell'energia andando a capire dove andare a risparmiare. Dunque noi seguiamo questo protocollo e siamo certificati "VIVA".

4. **Come misuri questi parametri? É la tecnologia uno strumento chiave per la misurazione di questi dati, di questi criteri?**

La misurazione avviene soprattutto in modalità manuale. Poi ci sono delle situazioni in cui vengono utilizzati anche degli strumenti ma soprattutto in modo manuale.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

In my opinion, the concept of sustainability should not be a marketing concept but real awareness. We must do something to preserve our planet. This is the first point. I want to be able to enter the vineyards without having problems. That's why we are trying this method in which we do treatments with algae, we do treatments with different things, going towards an increasingly natural path. Before I mentioned that we started the biological path but then we gave it up. This is because during the biological growth the metal copper, which is a heavy metal, is used. We try to go beyond what is organic. So we did some tests, experiences, and we are still doing experiences with ozone. We were the only company in Italy, together with a French company in Provence, which started to experience with ozone two years ag. So we are continuing these experiments with positive results and we have ideas that we can keep on experimenting with ozone treatments. So everyone talks about this hot topic, but sustainability truly must be seen with a 360 degrees perspective. Unfortunately, we find ourselves in a society in which profit often comes first. While I would say that surely the profit is central to end the year with a positive balance sheet, that shouldn't be the only element to consider. Myself, all my collaborators, my father, and in general the whole generation before me, are of the idea that we must produce with a conscience. In our little, we try to do something for the territory as well.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

I would say that technology will become more and more important, as long as it will be an easy and usable technology. Just think of how many people there will be on our planet in 30/50 years. Technology will, therefore, be fundamental in the future; it will help to better identify the target and the right timing. This also means that technology will help us in saving resources. For example, with regard to spraying treatments on vineyards, if you have the support of technology there is certainly a reduction in costs, greater timing, and chemical reduction.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

We endorsed a project promoted by the Ministry of the Environment. This project is called VIVA. It allows us to consider certain indicators such as air, water, etc. It considers various stages from the field to the final consumer. For example, the measurement of energy provides information concerning where to save money. So we follow this protocol and are certified "VIVA".

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

The measurement takes place mainly manually. There are situations in which some tools are used, but more generally is manual.

SP – Ruben

19/05/2020

(Original language of the interview)

1. **¿Cómo definirías el concepto de agricultura sostenible y que impacto juega para ti?**

Deberíamos empezar a pensar que es la única agricultura. La en aquella no desperdiciemos ningún tipo de recursos por el menos hecho de tener a nuestros campos. De racionalizar a los profesionales y de solo quedarse con lo aquello menor impacto tenga en nuestro entorno. Además, hay que producir un contexto económico, no hay que desarrollarse económicamente por el menos hecho de poder hacerlo.

2. **¿Cuáles son las principales tendencias que se desarrollan actualmente en las prácticas agrícolas? ¿Cómo impactan el concepto de agricultura sostenible y cómo juega un papel la tecnología en el desarrollo de estas tendencias?**

Prácticas agrícolas que se están tendiendo hacia el desarrollo de la biodiversidad, biodinámica, etc. La tecnología tiene un papel fundamental, nos ayuda a gestionar los recursos que se tienen que utilizar, y hacerlo de la manera más eficiente posible, con el menos consumo posible.

3. **¿Qué parámetros necesitan ser monitoreados durante el crecimiento del cultivo para lograr una producción sostenible?**

Deberíamos estar hablando desde la mano de obra que estamos utilizando, las materias activas que estamos utilizando, el tipo de material, de madera etc. Son todas cosas que ce tienen que tomar en cuenta.

4. **¿Cómo se miden estos parámetros? ¿Utiliza tecnología para hacer estas mediciones?**

Pues depende de lo que estamos hablando, pero por ejemplo pues litros cuando hablamos de productos químicos o cuantos kilogramos de cierto material etc. Nosotros si tenemos de estas plataformas en donde se puede integrar estos resultados.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

We should start thinking that it is the only type of agriculture. In that, we do not waste any type of resources, at least for the sake of our fields. We should also rationalize the professionals and to keep only whatever has the least impact on our environment. Besides, an economic context must be created. We should think about the fact that sometimes it is not necessary to economically grow without thinking at the impact of this action.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

Agricultural practices that are developing towards the creation of biodiversity, biodynamics, etc. Technology plays a fundamental role; it helps us to manage the resources that we use in the most efficient possible way, with the least possible consumption.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

We should be speaking about the labor force, the active materials that we are using especially in terms of the type of material (wood, etc.). They are all things that have to be taken into account.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

Well, it depends on what we are talking about. I think, for example, that the liters consumption, especially when we talk about chemical products it is important. Another element is the quantity (i.e. in kilograms) of certain materials. We do have these platforms where these results can be integrated.

SP – Jose

25/05/2020

(Original language of the interview)

1. **¿Cómo definirías el concepto de agricultura sostenible y que impacto juega para ti?**

La definiría como aquella que utiliza sus propios recursos, que no tiene que estar con recursos terceros, que se sierra el circulo de producción y no tiene que estar dependiendo de los recursos terceros. La agricultura que no acaba con los recursos que la naturaleza te da, sino que vuelve a reproducir estos recursos. En pocas palabras que no se debe robar a la naturaleza.

2. **¿Cuáles son las principales tendencias que se desarrollan actualmente en las prácticas agrícolas? ¿Cómo impactan el concepto de agricultura sostenible y cómo juega un papel la tecnología en el desarrollo de estas tendencias?**

Sin información.

3. **¿Qué parámetros necesitan ser monitoreados durante el crecimiento del cultivo para lograr una producción sostenible?**

Pues ahí hay que monitorear sobre todo gasto de fertilizante, de agua de productos fitosanitarios, etc. Y ajustando y disminuir toda la utilización de estos tipos de productos, eso se debe de monitorear.

4. **¿Cómo se miden estos parámetros? ¿Utiliza tecnología para hacer estas mediciones?**

Trabajamos mucho con los datos anteriores de las parcelas y siempre vamos ajustando dependientemente de los datos que tenemos. Y si, trabajamos con una a empresa a aquella mandamos los datos para poder desarrollar estadísticas y mejorar nuestro proceso.

(Translation)

1. **How would you define the concept of sustainable farming and how does this play a role for you?**

I would define it as one that uses its own resources, that does not have to be with third-party resources, that closes the circle of production and does not have to be depending on third-party resources. Agriculture that does not destroy the resources that nature gives you, but reproduces these resources again. In short, you should not steal from nature.

2. **Which are the key trends developing now in farming practices? How do they impact on the concept of sustainable farming? And how does technology play a role in the development of these trends?**

No data.

3. **Which parameters need to be monitored during the growth of the crops in order to achieve sustainable production?**

Well, there you have to monitor, above all, the cost of fertilizer, the water of phytosanitary products, etc. And adjusting and decreasing all the use of these types of products, that must be monitored.

4. **How do you measure these parameters? Do you make any use of technology to perform these measurements?**

We work a lot with the previous data of the plots and we are always adjusting depending on the data we have. And yes, we work with a company to which we send the data to be able to develop statistics and improve our process.

C. Start-ups database

Company Name	Technology	Year Founded	HQ Country	Description	TRL	Functionality categorization	Type of analytics
AgriCircle	DSS, Saas	2012	Switzerland	AgriCircle is one of the leading providers of field management solutions.	8	Pest and disease management	Prescriptive
Agriw	AI, ML	2017	Portugal	Agriculture 4.0 Smart Farming Solution based on AI and ML with Virtual Assistant recommendations. TOSCAN is a decision making Virtual Assistant assured by an AI system. It establishes a relationship between all the operators of an agricultural holding through an assisted prescription, simplifying, and making the work more efficient.	2	Pest and disease management; Nutrition management	Prescriptive
AgroFly SA	Drones	2017	Switzerland	Agricultural UAV manufacturer (SpUAV)	8	Pest and disease management	Prescriptive
Agroinsider	DSS, SaaS	2015	Portugal	AgroInsider provides technology tools for tracking farm data.	8	Nutrition management	Predictive
Agrologies	Sensor, Software	2014	Greece	Agrologies helps farmers manage irrigation via their smartphones, anyplace, anytime!	7	Nutrition management	Prescriptive
AgroPestAlert	DSS, SaaS	n/d	Spain	Developer of monitoring solution aimed at farmers to prevent irreparable damage to the harvests caused by pests. The company offers an interconnected network of electronic and intelligent trap devices assisted by cloud data analytics applications that can identify the pests at the species level and transmit the warning of their presence at the moment they appear, thereby enabling farmers to control infestation on time before the populations get out of control.	7	Pest and disease management	Predictive

AgsenZe	AI, IoT	2016	United Kingdom	AgsenZe‚Äôs aims to be the world-leading ‚ÄòIoT‚Äô company for smart agriculture.	8	Nutrition management	Predictive
ApisProtect	Big Data, IT	2017	Ireland	ApisProtect develops an agricultural technology designed for the management and care of bees.	9	Biodiversity management	Predictive
aQysta	CleanTech	2013	The Netherlands	We are a developer of hydro-powered pumps that do not require any fuel or electricity to be operated. Our flagship product “Barsha Pump” is an award-winning innovative pump, which has, so far, been rolled out across 13 countries. We dream of being a global leader in hydro-powered pumping solutions and with it create a sustainable impact.	8	Nutrition management	Diagnostic
Brioagro	DSS, Saas	2014	Spain	Brioagro is a mobile intelligence for growing crops.	7	Nutrition management	Prescriptive
Ceptu	Image Recognition	2014	Denmark	Ceptu creates satellite-based software applications for farmers.	6	Nutrition management	Predictive
[redacted]	Drones	2015	France	It is an innovative start-up specialized in the analysis of vines.	7	Pest and disease management; Nutrition management	Predictive
CropSafe	Image Recognition	2018	United Kingdom	The simple alternative to allow any landowner to survey their land with the touch of a button using satellite ML techniques	5	Pest and disease management; Nutrition management	Predictive
Drone Ag	Drones	2015	United Kingdom	Practical, hassle-free drone automation and AI for Agriculture	7	Pest and disease management	Prescriptive
[redacted]	DSS, Saas	2007	Slovenia	The start-up automated pest monitoring system is utilizing proprietary IoT + AI to revolutionize crop protection decision making	8	Pest and disease management	Prescriptive
[redacted]	IoT	2016	Italy	Developer of a precision farming device designed to preserve olive trees. The company's device monitors the status of the olive farm and reports data to the platform through algorithms based on agronomic studies, enabling olive oil producers to receive the necessary information and efficiently intervene to fight diseases, improving fertilizer application and irrigation.	8	Pest and disease management	Prescriptive

Force-A	Sensor, Software	2004	France	FORCE-A designs, produces, and sells optical sensors for the assessment of physiological and health status of crops.	8	Nutrition management	Predictive
Frontec	Image Recognition	2006	Spain	Frontec is a technology used for geospatial and agricultural science with ICT.	9	Nutrition management	Prescriptive
Geabit	AI, ML	2016	Greece	Geabit is the first AI-based monitoring system for agriculture dedicated to crop yield enhancement.	7	Nutrition management; Environmental management	Prescriptive
[redacted]	IoT	2017	Italy	Developer and provider of intelligent sensors intended for managing agricultural irrigation. The company product monitors the most important parameters of the soil through a low cost, reliable and scalable network of nodes, to ensure correct irrigation and provides actionable insights based on a ML engine, enabling farmers to take decisions on their daily activities with valuable insights based on factual data.	8	Nutrition management	Prescriptive
IRRILAND SRL	Machinery	n/d	Italy	Irriland is specialized in the design, development, manufacture, and assistance of automatic irrigators, booms, pivot, separators.	8	Nutrition management	Prescriptive
[redacted]	IoT	2003	France	It is a company specializing in the creation of decision support tools for agricultural production.	7	Nutrition management	Predictive
Just Common Sense	Machinery	2010	Sweden	Just Common Sense has developed and sells an innovative agricultural machine for weed control.	8	Weed management	Prescriptive
[redacted]	Robotics & Automation	2013	Spain	Developer of software designed to know the real state of vineyards, the environmental parameters, and vineyard diseases. The company's software tracks farm and crop-related data including sanitary quality of grapes, chemical residues, and basic environmental factors affecting cultivation from vineyards and communicate those to cultivators, enabling vineyard managers to know the sanitary condition of the vineyard from any device connected to the Internet.	7	Pest and disease management; Nutrition management	Predictive
[redacted]	Robotics & Automation	2011	France	Developer of agricultural robots designed to weed, hoe, and assist in harvesting. The company develops and markets agricultural, wine-growing robots and electric tools to help operators to weed, hoe, and harvest the fruits of their labor with complete peace of mind, enabling farmers to reduce the workload and optimize the profitability of farms while limiting the environmental impact.	8	Weed management	Prescriptive

One Drop One Solutions	Sensor, Software	2015	Switzerland	A mission to reduce the impact of human activities on potable water reserves providing the most advanced, efficient, sustainable.	6	Nutrition management	Prescriptive
Phenospex	Sensor, Software	2011	The Netherlands	Phenospex designs sensors and imagery analytics to extract quantitative metrics about shape, health and yield potential of crops	7	Nutrition management	Predictive
PlantCT	DSS, Saas	2005	Hungary	An Agro- tech start-up working on the PlantCT which a CT scanner for plants. It monitors crop-health and predicts plant diseases.	8	Pest and disease management; Nutrition management	Predictive
[redacted]	Image Recognition	2015	Germany	Mobile app, IR, AgTech, plant disease diagnostic	7	Pest and disease management	Prescriptive
[redacted]	Image Recognition	2016	The Netherlands	Developer of hyperspectral imaging technology designed for agricultural activities. The company's technology is a non-invasive crop monitoring and management system which uses hyperspectral cameras for precision agriculture analysis, enabling farmers to do better harvest planning, increased efficiency in resources, early detection of diseases and reduces inspection costs.	6	Nutrition management	Predictive
[redacted]	Robotics & Automation	2016	Switzerland	Developer of drones designed to monitor vineyards. The company's drones support aerial decisions and drone mapping, scout vineyards with multi-spectral imaging techniques, and also analyses and interpret the data collected, enabling winemakers to develop precise, cost-effective, in-field plans for optimizing quality and yield.	6	Nutrition management	Predictive
Revotree	AI, IoT	2017	Italy	Revotree develops an IoT system with AI to predict soil's moisture and help farmers saving water.	7	Nutrition management	Prescriptive
RootWave	Machinery	2012	United Kingdom	RootWave is an electronic company that develops tools that kill weeds using electricity.	7	Weed management	Prescriptive
SENCROP	DSS, Saas	2016	France	Sencrop is an ag-tech start-up that empowers farmers to make better decisions in their daily agricultural activities.	8	Nutrition management; Environmental management	Predictive

SenseFly	Drones	2009	Switzerland	SenseFly develops and produces aerial imaging drones for professional applications.	8	Nutrition management	Predictive
Smart Biosystem	Sensor, Software	2012	Spain	Smart Biosystem focuses on the agrotech sector that automates a regulated irrigation system.	5	Nutrition management	Prescriptive
[redacted]	DSS, Saas	2010	Hungary	Developer of precision viticulture systems. The company develops sensor systems that capture the weather parameters to provide support for precision vineyard monitoring.	8	Nutrition management; Environmental management	Predictive
Spacenus	AI, ML	2015	Germany	Spacenus offers AI platforms that use smartphone cameras and satellite imagery for agriculture.	5	Nutrition management	Predictive
Tamic	Big Data, IT	2014	Spain	TAMIC, Big Data to serve the viticulture from Pened√®s	6	Nutrition management; Environmental management	Prescriptive
TEYME	Machinery	n/d	Spain	TEYME manufacturers, develops and produces machines for the protection of crops and others.	8	Pest and disease management	Prescriptive
Visio-Green Agriculture	IoT	2016	France	IOT for agriculture	6	Nutrition management; Environmental management	Prescriptive
[redacted]	Robotics & Automation	2015	France	It is a French industrial start-up, on the market of autonomous and electric wine robots, it supports winegrowers in improving their vineyards with the latest technological solutions. The start-up reconciles contemporary environmental and economic issues by offering a driverless solution. It ensures greater hygiene and safety for wine workers.	7	Weed management	Prescriptive

D. Sustainability conceptual map

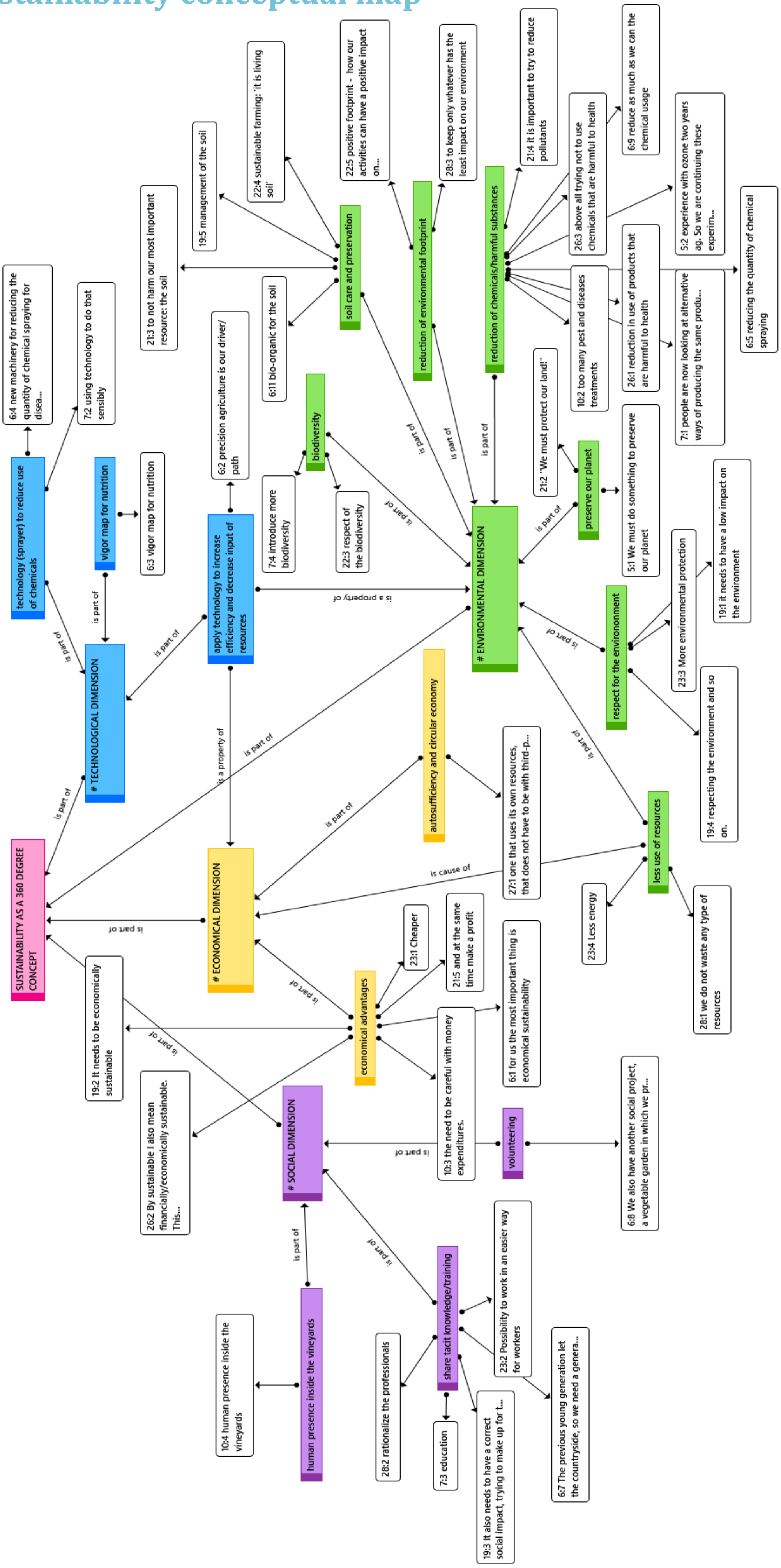

Figure 30: Sustainability full conceptual map

E. Model's evaluations

Carlos Moreno Miranda

Background: Carlos has a background in Food Agroindustry Engineering, after which continued his studies with a Master's program in Agricultural and Food Economics. He is currently attending a Ph.D. program at Agricultural Economics and Rural Policy Group of Wageningen University. More specifically Carlos focuses on an evaluating framework with special attention on the role of organizational aspects of supply chains. The goal is to determine how the coordination mechanisms within supply chains are linked to sustainable performance.

1. *Do you agree with the original model dimensions' identification? Do you consider the triple bottom line used in the second model to be an improvement? Why?*

I agree with the model initiative. The 3BL is a useful baseline for assessing sustainability in agri-food scenarios. As you know, the scientific community differs in ways to evaluate sustainability dimensions. Some examples are the existing methods such as LCA, S-LCA, DEA (they differ in perspectives). Also, the vast list of indicators. In other words, I would say there is always a systematic bias towards a single or a couple of dimensions, and this aspect is inescapable. However, based on my experience, 3BL is proper and feasible (relatively) when we assess businesses (e.g., firms, companies) because you have access to a high level of information or more variables are under your control. Regarding the organizational dimension, I see it is still unclear (this happens quite frequently in publications), some authors put this dimension with the economic one (economic-organizational), some of them as a single one (organizational). Also, the organizational perspective should be clear; therefore, you should consider whether you refer to an intra-organizational dimension or an inter-organizational one.

2. *How do you see the use of technology in this picture? Can it be considered as a driver pushing sustainable practices towards innovation?*

Yes, I agree. It is a driver pushing sustainable practices. However, from my point of view and by considering the sustainability context, no all technological advances aim to promote sustainable practices; therefore, it is necessary to target them, for instance, biotechnology.

3. *Do you see this categorization as strict groupings rather than intertwined ones?*

I see them as an intertwined one rather than strict groups.

4. *How do you think it is possible to create value from waste in the agriculture field?*

First, from my point of view, it is necessary to prioritize subsystems. I have experience in agri-food chains. In my country, Ecuador, I can tell you that first, it has been sought to prioritize chains that urgently require the implementation of circular economy models that allow revaluation of waste. This priority has been based on contribution to GDP, the complexity of the chain, and the level of waste generation (mainly organic). The cocoa and derivatives chain is an example. I do not have specific amounts of biomass generated as a waste, but I can assure you that amounts are very high.

On the other hand, look at a market perspective and alternatives for the use of the identified biomass. The intervention of the academic sector has been vital in this regard. Subsequently, propose a business or service portfolio where the initial biomass is the protagonist and design a parallel value chain (cocoa biomass) to the conventional one (cocoa).

5. *Could you make an example, if possible, of a renewable resource/technology introduced to cope with the scarcity of resources?*

Cocoa biomass to produce biofuel.

6. *Do you think that to encourage sufficiency through solutions that actively seek to reduce consumption and production can encourage sustainability in the agriculture field?*

I have my doubts because reducing production, and more if it is food, goes against food safety principles. I think that this should be reviewed and contextualized to clarify it.

7. *As a start-up, do you think it is possible to deliver sustainable solutions at a large scale for maximizing benefits for society and the environment in the agriculture field?*

Yes, it is. Look at the example of the cocoa bean sector that I mentioned above. With this initiative, we have increased, for instance, job vacancies in cacao production locations.

8. *How do stakeholders play a role in the creation of a sustainable business?*

Linked and transdisciplinary work. Stakeholders should seek to increase the empowerment of all actors in the agri-food sector.

9. *From your point of view what could lead start-ups in the agriculture field to really develop a sustainable business model that meets the market requirements?*

My answer will always be on Value creation on biomass, which is based on the experience of Latin-America countries.

Matthew Gorton

Background: Professor Matthew Gorton is a joint head of the Marketing, Operations, and Systems subject group at Newcastle University and has 20 years of experience in rural development research, acting as a principal investigator on 4 EU projects (COMPETE, FOCUS BALKANS, SCARLED, INNOGROW). He is co-coordinator of Rural Enterprise UK and currently leads the Pan-European project Strength2Food, looking at short supply chains. He is a trained economist and his Ph.D. considered the growth and performance of rural SMEs. He has researched DG AGRI, World Bank, FAO, and OECD. He recently undertook work with Frontier Economics, for the UK Government, on rural business performance and growth.

1. *Do you agree with the original model dimensions' identification? Do you consider the triple bottom line used in the second model to be an improvement? Why?*

I think it depends on how you want to look at sustainability. You could say that the sustainability of a business model also means that will be financially self-supporting. And to what extent that needs to be part of a business model. Importance of including then the financial dimension as well.

2. *How do you see the use of technology in this picture? Can it be considered as a driver pushing sustainable practices towards innovation?*

It depends on how you want to set it up. You could start with the technology, that is effectively what Bocken et al. (2014) model does, or you could start with one of the main challenges and then you look at the development of a business model that meets those challenges. So, for example, it may be about sustainable food sources, sustainable diets as a challenge and then you look at sustainable solutions to that challenge. Or maybe the challenge of green energy or cleaner energy and you look at solutions for these challenges. I think that the danger sometimes with the original model is that you end up with a solution without really saying first what the problem is. What you are trying to address. So in this sense is always often to start with the challenge and then you look at the innovation that helps to deal with that challenge. And sometimes the innovation is technological, but in other cases, it may be more of a socio-organizational challenge, or solutions, or other recombination of these dimensions.

The main critique of Bocken et al. (2014) model: push approach in the market instead of a pull approach, starting from needs.

3. *Do you see this categorization as strict groupings rather than intertwined ones?*

I don't think they should be strict silos. What the innovation literature suggests is that often what you try to do is often to combine initiative of technologies from one field to another field to come up with innovative solutions.

4. *How do you think it is possible to create value from waste in the agriculture field?*

Some examples There are different ways to look at that. The strict wise are so some of them can be related to energy, so anaerobic digestion, there might be other cases where the waste is a byproduct that can be reused in other production processes i.e. fish oil.

About farming practices: it is quite interesting in terms of waste in the agri-food sector. The major part of food waste occurs at the consumer level of free processing. It is either the retailers, until a much more increasing pace to the consumer level. I think there is a lot of the circular economy in literature, and that is great, but they are often looking at it from an industry perspective. But it is actually the consumer level the level in which the waste is occurring. And often the consumer is not included in those industries' perspectives.

5. *Could you make an example, if possible, of a renewable resource/technology introduced to cope with the scarcity of resources?*

I am not sure about it. Wind energy would be a classic example in which you have farmers in remote places can access to the national grid. That would be a renewable resource that would generate income. The critical element in the agriculture industry is land use. This sector takes approximately 75% of the land use globally. So it is really about the management of these land resources and the additional sources of revenue or business that is related to that land in addition to agriculture.

6. *Do you think that to encourage sufficiency through solutions that actively seek to reduce consumption and production can encourage sustainability in the agriculture field?*

You probably have to think about what would be the enabler towards the transition to that. So what you are describing could often be seen through the conversion to organic. Where we talk about the lower yield of production and the ration input/output would typically be lower than through a conventional production system. Now the movement towards that depends over the per-unit price that can be achieved with the lower output system, which has to be significantly greater than the one that can be achieved traditionally. If you look at the transformation in alternative food production systems, you need that financial perspective in terms of whether that is going to be sustainable or not. It is very difficult to persuade someone to have innovation if they are going to make less money or they are going to be financially unviable.

7. *As a start-up, do you think it is possible to deliver sustainable solutions at a large scale for maximizing benefits for society and the environment in the agriculture field?*

I think it is still possible and you see that through precision agriculture. And the benefits that you can have significant environmental improvements and a lot of that is quite rapidly disseminating. So yeah I think it is possible, definitely! But there has to be a good rationale for people adopting that mentality. And also in terms of performances, it has to be easy to use, adaptable, with a lot of services in place for servicing and training if that is required.

8. *Do you think criteria such as "encouraging biodiversity", "substances reduction (i.e. water, chemicals, etc.) and time efficiency (operating in the time window)", and "sharing of tacit knowledge" could play a role? If not what could? Explain.*

Well, surely tacit knowledge is really important, as well as all the innovation that you just said as well. But especially tacit knowledge exchange is very important. The other thing to think about with farmers' innovations is the question of credibility, so who is actually behind the innovation and whether they are trusted by farmers or not. So in my experience somebody that is a farmer themselves and who is got farmers' operations, if they go in and put the solution they are much more to get hearing and take up compared to someone with exactly the same solution but who got no background in farming. This is sort of a credibility issue that it is quite important and tacit knowledge sort of lies behind that. So start-ups need to think about their network and eventually collaborate with farmers if still they are not doing it, in terms of developing the solution and commercialize it, prototype it and test it. They need to get close to the market and once again it is related to the business model.

From a farmer's perspective, farmers would be looking to minimize the input use. From a cost basis but also an environmental basis, in terms of like pesticides or fertilizers sprayed. Input minimization and reducing runoff would give both environmental and financial benefits.

Biodiversity is important and everything, especially related to crop care, would surely raise questions about biodiversity. I am not sure if every solution should improve biodiversity, but it would become a problem if they would make it worse.

9. *How do stakeholders play a role in the creation of a sustainable business?*

This goes back to the network perspective within a business model. So it is trying to assure that you got the right people in the initiative, especially in terms of knowledge and credibility as well as the ability to interact with potential bias.

10. *From your point of view what could lead start-ups in the agriculture field to really develop a sustainable business model that meets the market requirements?*

What primarily they need to do is to come up with a solution to the problems that the current market is truly facing. Part of that is product related, in terms of for example sustainable fruit diets; and then there are process-related questions to do with how food is produced. And current problems in terms of the environmental carbon footprint for food.

Maya Hoveskog

Background: Maya Hoveskog currently works at the Center for Innovation, Entrepreneurship, and Learning Research (CIEL), Halmstad University, Sweden. Maya researches Innovation, Business Models for Sustainability, and Business Administration. One of her current projects is 'Lean Innovation". Its purpose is to: explore and evaluate self-leadership, lean as well as business model innovation in the agricultural sector. Between the numerous projects ongoing, important is the collaboration with numerous engineers and designers in Canada and Belgium (Ghent) for the creation of usability practices for business models.

1. *Do you agree with the original model dimensions' identification? Do you consider the triple bottom line used in the second model to be an improvement? Why?*

The general dimensions that you opted for, make actually quite a lot of sense, especially considering the field. The economic aspect is indeed very important. It is a general mindset driven by society. The profit somehow always overcome environmental issues. It is understandable how farmers seek a profit already in the short term before to undertake environmental procedures that will only give monetary benefits in the long term.

And of course, you could put a lot of dimensions into a model. But in your, I see the presence of both a dynamic and static concept. The patent archetypes are static; they are a sort of outcome. So you could take one for example, and start from there, basing your business model on it. But at the same time, your technological pillar introduces dynamic in it, because you go through different pillars. This force goes towards more complex technologies.

2. *How do you see the use of technology in this picture? Can it be considered as a driver pushing sustainable practices towards innovation?*

Maybe technology can also be introduced as a patent/archetype. I agree that it can be introduced throughout all the model in the different dimensions. It goes across. But I think that somehow it should also be a patent because the patent has a way of representing a static perspective. It gives you an idea, triggers you and you try to make it yours in the business model. At the same time, I understand that the idea that you are trying to give is one of the interrelations between the technology and the different archetypes. So I am also not sure of where it could be placed. Maybe as a fourth grouping. But then of course the limitation is that it becomes a bit of a silo thinking. Or maybe including the technology pillar as a grouping but that goes across the other three as well, so that you have a distinct pillar but showing the interrelation with the archetypes of the other groupings too. And all the archetypes should make use of the technology going from a more descriptive towards a prescriptive one. Thus, it could be put as a grouping under the archetypes, including all the other groupings as well. In the original model, you have the groupings, archetypes, and examples. Here instead of the examples, just below the archetypes, you could insert the technology as a big groping including all that is above.

3. *Do you see this categorization as strict groupings rather than intertwined ones?*

You have a point there. When you talk about patents you expected that there will be different models distinguish from each other. Meaning that for example in the creation of your business model, you opt for one of these dimensions and you go for it. But this is not how it works in reality. And this is why all the work that has been done in literature on these archetypes is mainly on the ideation of collaboration between these. An example is given by the work done by Florian Lüdeke-Freund et al. (2018) through the 'sustainability triangle model' in which the archetypes are mixed and very interrelated, going one in another. There is no clear distinction because such a thing would not be feasible in reality. This paper also strengthens your proposition towards the creation of the model.

Something that I would like to underline here is also about the practicality of the frame. How good is it and more generally what about the ease of use of the framework?

If you give this framework to a start-up, how can they make sense of it and practically use it? Because there are in literature many frameworks from a theoretical point of view, but then when it comes to measuring the efficacy of the framework, there is very little that it has been empirically done. Especially because, many archetypes in the short term could work, but after a while there could be some sort of rebound effect, obtaining the exactly opposite output than the desired one. So this is something that needs to be taken into account, especially for further research and application. And this is especially important when it comes to technology and its life-cycle. So maybe it could be affirmed that this tool is still experimental and an empirical evaluation is needed to verify the correctness of it and the feasibility in practice. Also, the use in the short term and long term can create changes in the framework.

4. *Do you think criteria such as "encouraging biodiversity", "substances reduction (i.e. water, chemicals, etc.) and time efficiency (operating in the time window)", and "sharing of tacit knowledge" could play a role? If not what could? Explain.*

I think they do work pretty well. They agree with the concept of ecological ecosystem services. Every farmer is the manager of an ecological ecosystem service. There have been studies here in

Sweden, especially in the group I have been working with about farmers that consider themselves as managers of these ecological ecosystem services. Pollination, water purification, wetland absorbing carbon dioxide, etc. are all examples of ecological ecosystem services. I think this is a central point, especially if you consider the environmental part as the core. And indeed, this is the core of the agricultural sector. The problem is that the work that has been done on ecological ecosystem services is more on a macro-level. So one of the problems concerns how to evaluate these services since they are free. Also, the discussion is around the fact that humans, due to their artificial activity have reduced the capacity of these systems. A good question would be how to restore the ecological ecosystem services. And the trade-off for farmers is also towards environmental sustainability vs profitability. So for example if my soil is deteriorating, and I decide to go for a choice such as the wetland, it will not be possible to grow something there for a while, decreasing the immediate profitability, but improving the efficiency of the soil in the long-term, thus restoring partially the ecological ecosystem.

So I think some of these concepts could more generally be included in a broader archetype, i.e. 'protection/restore of ecological ecosystem services'.

5. *How do stakeholders play a role in the creation of a sustainable business?*

This is essential. It is one of the pillars of business model sustainability. In order to speak of sustainable business model perspective. It is somehow part of the definition of the concept itself. In a classic business, you mainly consider two types of stakeholders: customers and suppliers. In business modes for sustainability, however, we are adopting a multi-stakeholder perspective. A good reference towards this topic is given Freudenreich et al. (2019), or by the 'value mapping tool' of Bocken et al.

However, you cannot really include everything in the model. Also, the value mapping tool is mainly linked to processes, understanding which kind of value could be created or destroyed from a stakeholder's point of view., The framework instead is considered mainly for the final product creation. However, a good idea would be one of combining the use of different tools towards a common goal, the one of creating a sustainable business. More generally, the use of a single framework alone is not that powerful.

6. *From your point of view what could lead start-ups in the agriculture field to really develop a sustainable business model that meets the market requirements?*

Once again, listen to stakeholders. Have the archetypes as a start, but then look into the perspective of the stakeholder. It is not only about the product/service that is put on the market but also about the ecosystem around it.