Digital trends applied to the vine and wine sector

A comprehensive study on the digitalisation of the sector

OIV Digital Transformation Observatory Hub

November 2021

This report was prepared for the International Organisation of Vine and Wine by Minsait Business Consulting in the framework of the implementation of the OIV Digital Transformation Plan.

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Elected on 23 November 2018.
1992-2018 Secretary General of the Spanish Wine Federation (FEV).
He combines a scientific academic background with a degree in Biology, a career in the private business sector and a wide experience of public and administrative activities in the wine sector.

Foreword

"The OIV shall be an intergovernmental organisation of a scientific and technical nature"

Agreement of 3rd April 2001, establishing the International Organisation of Vine and Wine, Article 1.2.

From its foundation in 1924 the scientific and technical mission of the OIV has always been at the core of its activity. The research in chemistry and microbiology in wine, first started by Pasteur, the father of modern oenology, was continued by his successors, which led to the creation of its strong foundations. The evolution of this, lead to a biochemical approach that has been applied to many of the observations relevant to wine and plant physiology in vine.

In the second part of the 20th century, new disciplines of life sciences entered in the scope of knowledge for the work of the OIV, and genetics took its turn into the classification of vine varieties and the study of yeasts and other relevant microbes.

By the end of the nineties, some observations moved the eye back from the microscope and amplified the focus to understand the vineyard and oenology in terms of balance of the systems and self-regulation which brought to light ecology and economy and the perspective of sustainability.

The approach of the OIV has always been one of taking advantage of the most recent evolution of all scientific knowledge and using the most innovating tools offered by technology to mankind. As a consequence, this research leads to the identification of standards or orientations, when necessary. Science and its implementation being universal, provide a common language for humanity.

At present, digital tools and data science are driving the most innovative evolution of our society, in our lives and the economy. We are at a point in time where man has created new capacities and has even been able to transfer these human capacities to machines, thereby making artificial intelligence possible.

The speed of digital transformation is so high that disciplines unknown a few years ago have been appearing and new discoveries may arise.

Vitiviniculture may be adapting at a different rhythm and at different stages, in some cases the sector may be subject to profound disruption. In a changing environment, the reactions of the sector may be fearful and hence even conservative, but at the same time it is important to be mindful that these new technologies and capacities that we obtain, will offer invaluable opportunities, analytical and prediction tools and will accelerate all procedures.

If we want to continue being relevant to the producers and consumers, the OIV needs to expand its influence, reach new horizons, continue to analyse procedures and enhance cooperation amongst actors. For this, the OIV needs to acquire expertise in all relevant digital sciences and technologies, like we have done in the past, from our experts and delegates of our Member States. Creating a paradigm shift through the proposal of digital innovations in the vine and wine sector shall enable the OIV to extend its impact and scope to new geographical territories, such as Asia.

Given the characteristics of the wine sector and the interest of the consumers on the integrity and choice of distinctive information, particular attention should be paid to distributed ledger technologies (DLT). Given its enormous capacity for traceability and transparency regarding the origin and processing of wine, this system can be perceived as truly revolutionary. In theory, if a digital footprint can be initiated from the vineyard, consumers would be able to search for all available information related to the identity of the product and its processing from “grape to glass”.

New concepts like big data and artificial intelligence need to be internalized and quickly transferred to a new generation of OIV experts. To elaborate, one of the most pressing issues of current times is climate change, and the challenges it poses can be addressed more effectively if we incorporate these scientific disciplines in our attempt to analyse and forecast volatilities and provide improved services to our Member States.

When new opportunities arise, temptation for new regulatory interference may appear. In the OIV, we need to anticipate these situations by increasing our support in ensuring fluidity in information exchange and promoting understanding and expert capacity to attain transformative outcomes from research in this area of digital knowledge.

With this purpose in mind, we are working as decided in our strategic plan 2020-2024, where digital transformation appears as a catalyst - more properly an enzyme - to accelerate the kinetics that will allow the vitivinicultural sector, its producers and consumers, to adapt to a world threatened by the climate change crisis.

2 Executive summary

The International Organisation of Vine and Wine (OIV) has launched a new digital observatory hub aimed at identifying the main trends in digitalisation and how new technologies can be applied in the vine and wine sector. The initiative aims to provide updates on the digital/technological trends taking place in the vine and wine sector, and seeks to engage scientists by providing them with more insights. This is aligned with the OIV's strategic plan for the period 2020 – 2024, which is built around six main axes, of which Axis V is "facilitating the digital transition of the sector".

This report is a study of the current state of development of new technologies in the vine and wine sector and of new digital trends. It is based on expert interviews and on a quantitative survey on digital trends completed by experts from OIV Member States.

The report analyses different technologies used across the stages of the value chain: vineyard, winery and distribution. Artificial intelligence, robotics, satellite imagery, Internet of Things (IoT) and blockchain are some of the technologies included.

For each one a definition has been included, as well as its application in the sector and their future prospects.

From these experts' interviews and questionnaires, it can be concluded that digitalisation has already started transforming the sector, while adoption across all stages of the value chain is different but continues at high rate. However, there are a number of challenges to overcome before reaching a higher maturity level (i.e. lack of public initiatives support, high implementation costs for small producers and low end-user commitment).

Digital transformation offers an opportunity for the sector to gain efficiency, transparency, productivity, open itself to new business models/value propositions and improve in sustainability. However, it requires large investments in terms of skills, capital and time hence the slow transition. It is yet to be seen how this transformation will shape the vine and wine sector, but this report gives an overview on how the main digital trends throughout the whole value chain are transforming the status quo.

3 Purpose and methodological approach

This publication provides an overview of the status of a set of technologies identified by different experts:

Internet of Things, Artificial Intelligence(*), Robotics, Satellite Imagery, LIDAR(*), Blockchain(*), E-Label, E-Certificate and Smart Storing.

To this end, research has been carried out to broaden knowledge on the most advanced digital trends and technologies(*) in the sector.

This report has been prepared through interviews with leading experts in each field and a survey on digital trends that has been completed by the experts from OIV Member States:

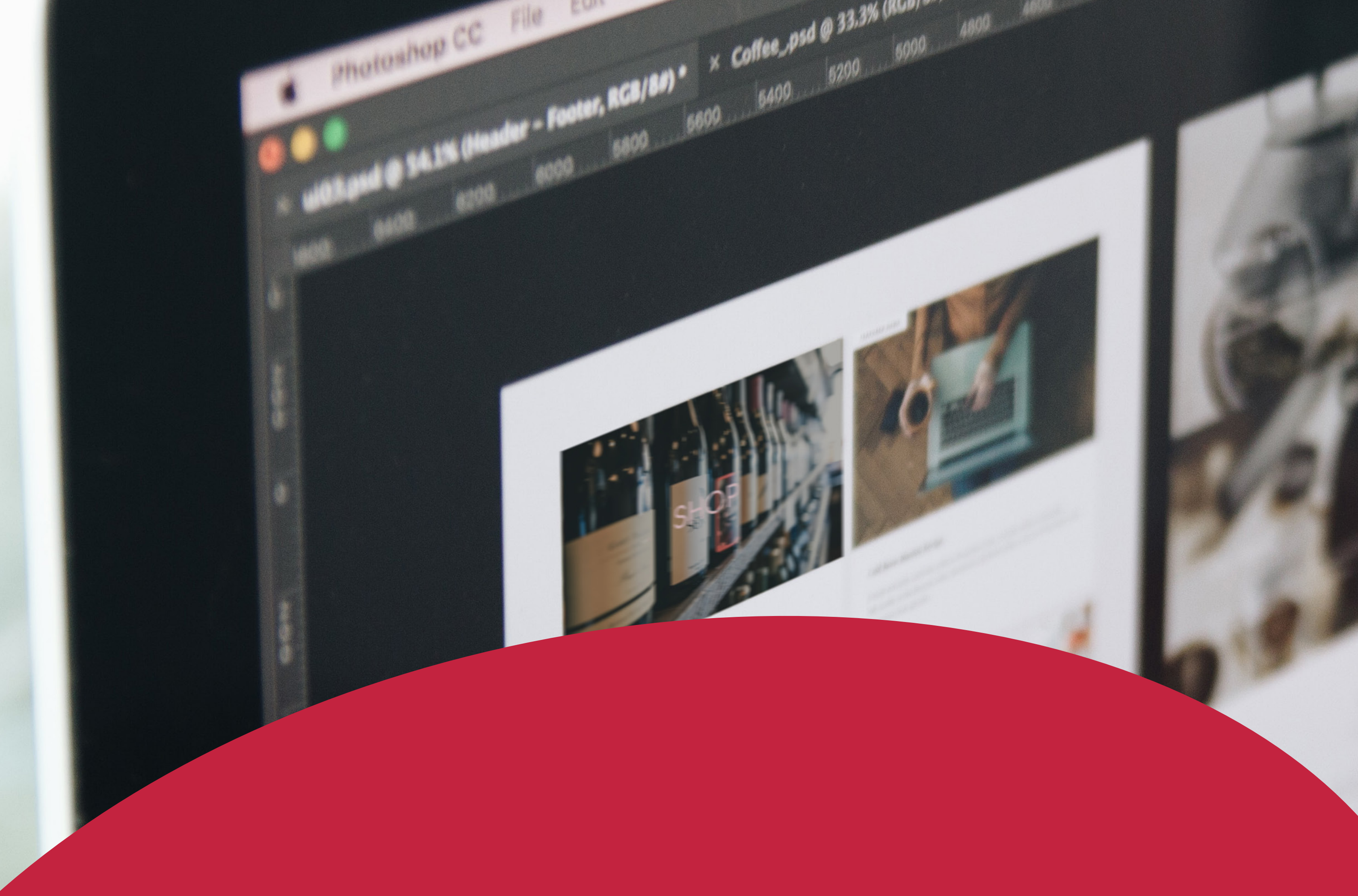
1. Expert interviews

A selection of experts on digital trends in the vine and wine sector were interviewed to find out the maturity level of their specific technological field of expertise, the main challenges that the technologies are facing in their implementation in the vine and wine sector and all the benefits that they bring today and those that will bring in the coming years. The information gathered served as the basis for this comprehensive report.

2. Questionnaire to experts from OIV Member States

A survey was sent to experts belonging to the OIV Member States to gather first-hand information on prevalent digital trends in the vine and wine sector in their country. The results of this questionnaire yielded interesting conclusions about the benefits, the maturity level and future of each technology at each stage of the value chain, and served as the basis for an overall study of the progress and impact of digital trends and technologies in the sector.

(*) Glossary



4 An introduction to the digital revolution

The XXI century is characterised by the continuous development of technologies, the emergence of digitalisation and the definitive take-off of the internet. All these factors have created a new socio-economic and business context—the digital revolution.

Digitalisation has been identified as one of the major trends that will reshape society and the global economic system in the near and long-term future. Today, economic growth goes hand-in-hand with the exploitation of technologies and information, while digitalisation is increasingly covering more and more fields of business activities and creating new opportunities for the social and economic development of organisations.

John Sviokla, a well-known author and US advisory innovation leader, said: "the Internet is one of the most complex things ever created. It takes human organisation to another level. Thus, the digital transformation[*] will trigger a completely new revolution that will transform organisations and governments, and lead to extraordinary wealth creation around the world[1]."

In broad terms, digital transformation is the integration of digital technology into all areas of an organisation to add value to society, change the way it operates and how it delivers value to companies, its products, supply chain, processes, employees and customers. It is a cultural change that requires organisations to continually challenge its status quo and think outside the box, having the ability to act and react to changing conditions and strategies in order to evolve and succeed.

Current trends in digitalisation are bringing big changes that can range from finding new business models, opportunities and making existing processes more efficient or affordable, to pursuing disruptive opportunities to boost the state of an organisation's current operations. In other words, digitalisation is not only about digitalising existing processes, but also about rethinking current operations in light of the new outlook brought about by digital technology.

[*] Glossary
[1] Kravchenko, O., Leshchenko, M., Marushchak, D., Vdovychenko, Y. and Boguslavska S. (2019). The digitalisation as a global trend and growth factor of the modern economy. Ukraine: SHS Web of Conferences

Over the last ten years, agricultural technology has witnessed a dramatic rise in investment, with 6.7 billion dollars invested in the last 5 years and 1.9 billion in the last year alone[2].

Today's agriculture is continuously increasing the standardisation of more sophisticated technologies- which include satellite imagery, GPS technology, robots, and temperature, moisture and other sensors.

All these advances are helping agriculture to be more efficient, safer and more environmentally friendly.

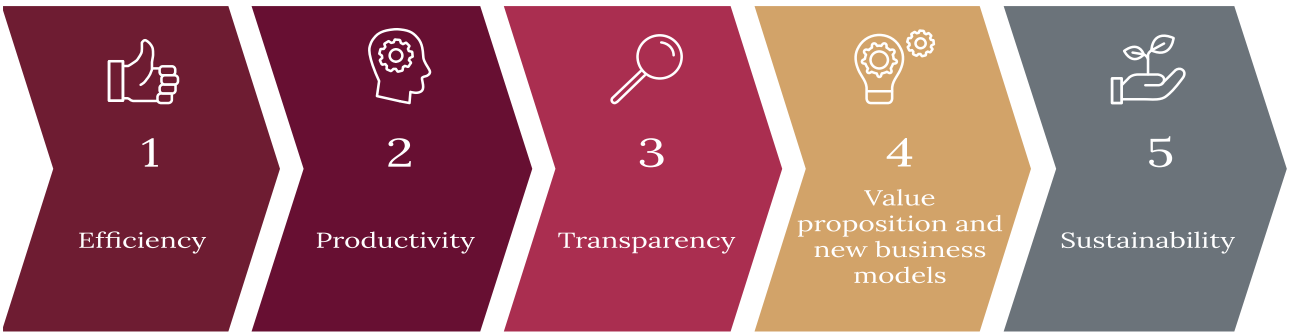
[2] Linly Ju (2021), New Agriculture Technology in Modern Farming. Plug and Play

5 Goals of digitalisation

Some of the main objectives behind the drive for digitalisation are increased efficiency, transparency, productivity, new business models / value propositions and sustainability.

The vine and wine sector as a whole can benefit from advances in technology, but these require significant investments in time, money and new capabilities. This is often the main reason behind its slow uptake.

Main objectives behind the drive for digitalisation



1. Efficiency

Increased efficiency has clear benefits, such as managing and using scarce resources more efficiently, reducing the use of environmentally unfriendly products (these two also promote sustainability), as well as improving an organisation's ability to communicate in a more agile way, hold meetings or share and download documents with ease. Digitalising manual processes has become a key issue for the development and survival of organisations. Today, artificial intelligence and robotics are taking over repetitive tasks, helping organisations reduce operational positions and shifting employees to more value-adding activities and achieving work efficiencies.

In the case of the vine and wine sector, this has been reflected in an improvement in the different stages of the value chain, such as obtaining data in the vineyard on the state and quality of the grapes, increasing production capacity or improving manual distribution processes through technologies such as smart storing.

2. Productivity

Increasing annual production with the same resources is one of the main goals of any sector, and today this is strongly linked to digitalisation. Increasing production has a direct and positive impact on the performance of countries, sectors and organisations. Examples of productivity gains through digitalisation are, the ability to work across organisations from different countries, and time savings on import/export issues (due to the ease of applying for permits and modifying regulations, etc.).

Another example of these digital improvements is the high capacity to collect data for further exploitation leading to improved decision making allowing the vine and wine sector to improve productivity in the winery by reducing costs and, thanks to data collection in the vineyard, to make better decisions when deciding when to harvest the grapes for the next winemaking process in the winery.

3. Transparency

Transparency is a major concern for all governments, organisations and consumers, and digitalisation contributes greatly to its achievement through technologies that play an essential role in improving transparency by making information more accessible to a wider audience. Fraud control can be carried out more efficiently, for example, through greater control over paperwork between customs offices.

End consumers are also able to interact directly with organisations and have direct information about production stages (for e.g. through blockchain), which is a clear benefit for end consumers.

One example of increased transparency for consumers in the vine and wine sector is the e-label, which thanks to a QR code allows a greater inclusion of information that traditional labels allow.

4. Value proposition and new business models

The digital transformation has opened up new opportunities for many sectors. New products and uses emerge every day and technology developments can accelerate the obsolescence of old business models, which can be quickly replaced. One such example of a new business model is digitalisation in retail, where digital transformation is increasingly focused on the customer rather than the product and combines customer experience with operational excellence. To meet these needs, physical stores must tap into their strengths while leveraging digital solutions. Operational excellence is at the core, offering products to customers at affordable prices, at the right time and using fast and cost-effective supply chains.

Thanks to the digitalisation of the sales channels (i.e. online), consumers are now able to buy products more easily. For example, crates of bottles can now be delivered directly to their homes without the customer needing to go to a logistics centre or point of sale.

Finally, another important factor is the improvement of services. With the implementation of digitalisation, organisations will be in a position to provide better services to their members, keeping them better informed, and allowing them to interact more directly and efficiently.

5. Sustainability

Sustainability is another goal of digitalisation and they go hand-to-hand to improve the vine and wine sector. Some visible examples are regenerative agriculture, which helps to improve soil quality while contributing to climate change mitigation, or new water cycles (colleting, using and regenerating the water).

In addition, the circular economy(*) offers many new opportunities to help wine companies shift their business model towards sustainability applying three clear principles: avoid using limited resources and creating waste and other forms of pollution; keep products and materials in use for as long as possible and at their maximum possible value; and regenerate natural systems.

(*) Glossary

Expert

Adela Conchado

Head of environmental missions at The Overview Effect (helps companies innovate and create products and services that generate positive impact and value for the company at the same time), with experience in decarbonisation strategies, active demand management, and circular economy innovation.

1. Challenges for the sector regarding sustainability

- Promoting local products and the local economy.
- Contributing to create economic value in rural areas by fixing population to the territory.
- Guaranteeing rights and good conditions for employees in the value chain.
- Investing in different forms of sustainable mobility in the distribution process.
- Promoting sustainable and efficient production without pesticides and with the minimum use of water.
- Promoting regenerative agriculture.
- Guaranteeing health and value in biodiversity and terrestrial ecosystems.
- Providing new healthy alternatives to the consumers.
- New forms of sustainable energy as biofuels.
- Reducing waste throughout the value chain.
- Considering the climate risk and the impact of rising temperatures in the production process.

2. Challenges for the sector regarding sustainability

- Regenerative agriculture: improving soil quality and contributing to climate change mitigation.
- Maximum use of biological production: winery as a biorefinery. There is already a tradition of reuse in the sector that could be largely extended by identifying high-value applications: natural dyes, extracts for the food sector, biomaterials including bioplastics, biofoams or biotextiles, etc.,
- Product eco-design and marketing model: New packaging formats (reusable, returnable, compostable, recyclable) and new product access formats that promote circularity: subscription, “bulk”, “milk-man” model...
- Optimising the life cycle of facilities, infrastructure, machinery and equipment.
- Water cycle: collection, use and regeneration of water.
- Minimising energy consumption and renewable supply.

“In the vine and wine sector, we are seeing very interesting lines of innovation that have to do with regenerative agriculture, which improves the quality of the soil and therefore the productivity of the vineyard and in turn helps to mitigate climate change”

Adela Conchado

6 Main digital trends in the vine & wine Sector

6. Main digital trends in the vine & wine Sector

6.1. Internet of Things (IoT) / Sensorisation

6.2. Artificial Intelligence

6.3. Robotics

6.4. Satellite Imagery / Geographical Information Systems (GIS)

6.5. LIDAR (Laser Imaging Detection And Ranging)

6.6. Blockchain

6.7. E-Label

6.8. E-Certificate

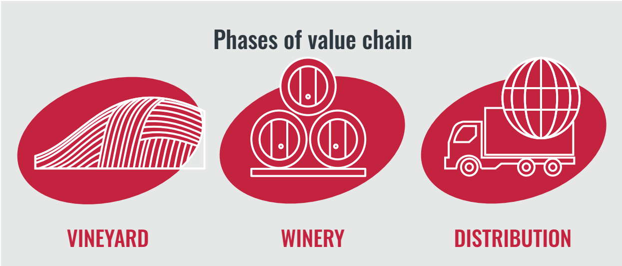
6.9. Smart Storing

6.1 Internet of Things (IoT) / Sensorisation

Experts

Daniel Seseña

He leads the Industry 4.0 digital offering at Minsait from Indra (one of the world's leading global technology and consulting companies), including the development of solutions in this area. He accrues over 20 years of international experience in technology, business and operations consulting, leading digital, strategic and operational transformation projects, with a focus on operations, supply chain and processes.



A. The technology

The Internet of Things (hereinafter, IoT) describes the network of physical objects (things) that incorporate sensors, software and other technologies in order to connect and exchange data with other devices and systems over the Internet. These devices range from common household objects to sophisticated industrial tools[3].

In recent years, IoT has become one of the most important technologies of the 21st century. Everyday objects can now be connected to the Internet using devices, enabling communication between people, processes and objects through mobile technologies and exploit big data aided by low-cost computing, advanced analytics and cloud. In a hyper-connected world, digital systems can record, monitor and adjust every interaction between connected things. The physical and the digital areas work hand in hand and cooperate with each other.

The development of sensor technology offers the possibility to a large number of devices to coexist and work together exchanging information (e.g. soil and water conditions for efficient use of water, irrigation management, etc.). However, there is still no automated control of the entire winemaking process. Today, the concept of smart vineyards refers to new measurement tools based on the collection of a multitude of data by using wireless sensors (eventually combined with satellite or drone images and powered by Artificial Intelligence).

Wireless sensors — that are very important for smart vineyards — are used to collect different measures within an area. With regard to vineyards and wineries, they can be implemented directly in the soil, embedded in vine trunks or placed among leaves, depending on the data to measure, to help improve productivity and climate prediction.

The IoT applications can be classified according to their place in the value chain:

Vineyard

One of the main reasons for using technological solutions in vineyards is to reduce risks during harvesting. Most of the sensors and satellite imagery currently used in vineyards focus on vine quality control and meteorological aspects: monitoring soil and water conditions for efficient water use, irrigation management and weather forecasting. It also allows monitoring key parameters such as ambient temperature, wind speed, relative humidity, leaf wetness, soil moisture and rainfall.

There are also many applications thanks to the combination of technologies such as drones and infrared and multispectral images for pest control in the vineyard. For example, many wineries already combine sensor data (humidity, temperature, soil conductivity and vine quality) and satellite imagery to monitor key environmental factors for the harvest in real time.

Another application of the Internet of Things is to make the sector more sustainable and regenerative by optimising water use, eliminating pesticides and measuring soil quality.

All of this technology helps mitigate the adverse impact that environmental conditions have on plants.

Winery

The main objective of using sensors in the winery is to control all the relevant parameters for a correct winemaking process and to guarantee a quality product. Due to changing weather conditions, each year the product, even though it is made in the same way, has certain differences. Sensorisation enables monitoring the winemaking process in real time. Small modifications can be made to achieve a product that is as close as possible to what is desired.

[3] Oracle (2021). *Supply Chain Management / Internet of Things*. Spain, Official Oracle Website

"One of the use cases of the first stage of the value chain would be the image recognition technologies, which have a fundamental role in the production process to reduce waste. IoT sensorisation technology plays an important role in the first stage of the value chain. It deals with aspects of water and irrigation efficiencies, as it exploits big data and climatic variables and their integration in the production processes to improve water efficiency and the provision of the nutrients needed by the vineyard. The idea is that IoT can play a very important role in improving efficiency and reducing the negative impact on the production process. It can enable the data collection and aggregation of information and the development of dashboards for improved decision-making. It can improve efficiency to improve the quality and regeneration of the soil and can demonstrate how the agricultural sector has a key role in the absorption of CO2 into the soil"

Nacho Rivera

Current methods mostly involve testing in wineries outdoors. However, what wine makers are demanding nowadays are sensor-based online systems to carry out the evaluation of the fermentation process without needing laboratory facilities.

There are sensor technologies and methods for monitoring the process with the potential to improve wine quality and reduce costs. Machine vision systems are used in the bottling, capping and labelling process to meet quality standards—as are production order planning systems, systems for integration and control of the number of bottles passing through a production line and machine error control systems.

Sensors can be used in wine cellars to monitor the ageing of wine, including the key factors of temperature, light and humidity. Temperature is particularly important as even the slightest fluctuations can alter the oxidation of the wine and therefore significantly affect the quality.

Distribution

In the distribution phase, IoT also has considerable advantages when it comes to improving logistics to boost efficiency and reduce costs. Examples include transport management systems to control and optimise all the company's logistics flows or computer vision solutions to control the incoming flows and in-plant movements of raw material and finished product transporters.

Nacho Rivera

Co-founder and CEO of The Overview Effect, a company that uses technology and innovation to promote the sustainability of all types of companies in a multitude of sectors.

B. Application in the sector

- IoT platforms for data collection, monitoring and analysis in the wine production environment are digital platforms capable of handling big data in an agile way to accelerate advanced analytical solutions:
    - o Integration: massive data standardisation (ontology and semantics), connection of entities with the physical and virtual world, open publication (via API and OpenData).
    - o Analytics: definition and execution of advanced analytics algorithms via notebooks, centralised data lake to optimise operations and exploitation among others.
    - o Visibility: simple and user-friendly generation of analytical dashboards to support the construction of models and the analysis of results.

    IoT platforms can feature dashboards for the monitoring of harvest and KPIs, the fermentation process and tanks, and the bottling process. It also allows the possible development of advanced analytical models to allow the prediction of the impact of weather conditions on the harvest, development of predictive maintenance models on assets and the analysis of manufacturing data (pH, alcohol volume, potassium) and thus prevent quality risks and cost increases.

- Full traceability of the value chain: visibility on processes, generation of early alarms in case of deviations and traceability of materials (in-process product traceability within the plant, unit traceability of the final product by RFID and quality assurance of wine to customers with blockchain technologies). Advanced solutions that integrate physical (sensors) and logical (IT systems) information to improve the visibility of operations in vineyards and wine production plants:
    - o Real-time collection and visualisation of key production process metrics
    - o Processes.
    - o Supply chain detail monitoring.
    - o Warehouses: detection of actual and expected stock-outs using computer vision and based on production orders.
    - o Transportation: status of shipments from vineyard to winery and from winery to distribution.
    - o Dashboards and generation of alarms in case of deviations.
- Some examples of real cases that are being seen in wineries in Europe are the combination of sensor data (humidity, temperature, soil conductivity and quality of the vines) and satellite images to monitor in real time environmental factors key to harvest. Another example is the introduction of various technologies to improve the production cycle in the field: combine drones and infrared imaging and multispectral data for information on the maturity and quality of the grapes and use artificial vision for the selection process.

C. Technology in the future

The vine and wine sector is looking towards IoT. The technological revolution is in all sectors and it was not going to be left out of something as traditional and avant-garde as the world of wine.

Different wineries are applying new technologies to improve the quality of their products, creating within this world smart wine.

Some of the different components, which a few years ago were too expensive for many small and medium-sized wineries, have now become more affordable, while the systems are easier to install, manage and maintain.

This is the perfect combination for sensors and advanced robotics to be used to control wine quality.

As previously mentioned, sensor systems are already an important part of the digitalisation process in the vine and wine sector. They will continue to be important after the implementation of other new technologies that rely on collected data—such as artificial intelligence or robotics— and will make the information gathering process even more critical. The main question is how to handle and make all this information useful. Data alone is worthless, unless it can be properly managed and interpreted.

"I believe that the adoption of digital technologies will be asymmetric in the three key areas (field, plant, distribution) depending on the profile of the company. In smaller companies focused on the value of the product, the adoption of digital technologies will focus on those that favour traceability (guarantee of origin of their product) or quality (prediction of harvests, time of harvest, etc.). For their part, larger companies will combine the above with technologies that make the production process (maturation and bottling) of their wines more efficient." Daniel Seseña.

"Wineries will continue to maintain their classic appearance (tradition), but they will implicitly integrate digitalisation, incorporating advanced sensory and analytical elements that will enhance control of the quality and efficiency of the entire wine process "

Daniel Seseña

6.2 Artificial intelligence

Experts

Dr Karly Burch

She is a Research Fellow at the University of Otago's Centre for Sustainability in Dunedin, Aotearoa New Zealand. She holds an MSc in agroecology from the Norwegian University of Life Sciences and ISARA-Lyon (an Erasmus Mundus double degree programme), and a PhD in sociology from the University of Otago.

José Luis Flórez

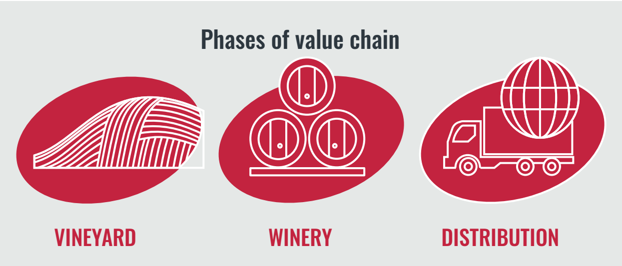
AI leader at Minsait from Indra (one of the world's leading global technology and consulting companies) and Chairman of Dive, has had a dual career, combining entrepreneurship and executive roles in big-sized corporations. In his entrepreneurial activity, he founded companies such as Neo Metrics, , Dive –formerly Touchvie or more recently Plaiground, all of them with significant contributions in the application of AI and ML to make companies smarter; while at the same time assuming global advisory and executive roles in AI in large international corporations such as Accenture and Minsait.

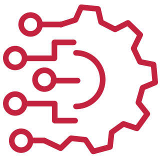
Ganesh Padmanabhan

He is an accomplished technology and business executive with a strong track record of bringing disruptive technologies like cloud, big data & Artificial Intelligence (AI) in Fortune 500 companies and startups. He is currently involved with several AI startups and the host of Stories in AI show, where he interviews 50+ innovators and practitioners on AI every year.

Dr. Bernard Chen

He is a Professor of Computer Science Department at the University of Central Arkansas, USA. He received his PhD. Degree from the Georgia State University in Computer Science with Bioinformatics concentration in 2008. His research is mainly focused on interdisciplinary data science projects, such as Bioinformatics and Wineinformatics. He has authored over 80 peer reviewed research papers.





A. The technology

Artificial Intelligence (hereinafter, AI) is a branch of computer science concerned with building smart machines capable of performing tasks that typically require human intelligence. AI is an interdisciplinary science with a wide range of applications. Through its use of machine learning and deep learning, AI is creating paradigm shifts in many sectors of the economy. Similar to human brains, AI learns from experience by using advanced algorithms and software to identify patterns or features contained within large amounts of data. AI is strongly dependent on sensor technology as the information used to identify patterns and make predictions.

Artificial Intelligence (AI) plays a central role in the digital transformation of society and is now a priority. Its future applications are expected to involve major changes, but AI is already used for a number of tasks on vineyards, in wineries and for distribution.

Vineyard

As far as the application of AI in vineyards is concerned, AI software provides valuable insights into "quantifiable aspects (e.g., size, yield) and other conditions on vineyards. Machine intelligence, along with data received from sensors and imagery, enables winegrowers to improve many aspects involved in vineyard management.

For example classifying vineyards according to grape variety (distinguishing the grape variety by observing the characteristics of the fruit, the grape. The shape of the bunch; the stalk; the size, shape and colour of the grape, the seed, the type of skin, the taste, etc...); the care and optimisation of crops through sensors and images that can provide information to support the adjustment of treatments by helping winegrowers to control yield and measure grape type, pinpointing the optimum time to harvest grapes and guarantee quality.

This technology, if properly merged with other technologies such as sensorization, can bring many benefits. It can gather, interpret and learn from collected data, helping farmers to make decisions based on facts and predictions.

Winery

In wineries, AI collects data received from sensors and uses it to improve production. Having real-time control of inventory and barrel conditions allows for optimal production scheduling based on the analysis performed. This can help wineries to maximise their productivity and can contribute to more sustainable production.

Thanks to the information received about barrel conditions, AI is able to determine or predict wine quality based on the distribution of its components, track the maturation process in the barrels and perform a sensory analysis of fermentation products (acids). This can directly affect the productivity of the winery by saving time and money.

Distribution

In the last stage of the value chain, wine marketers use AI to reach the end customer, changing the way consumers buy wine, understanding product preferences and generating disintermediated direct channels to the end customer that will ultimately benefit productivity.

One interesting use in the marketing phase is that of virtual reality applications and devices. Wine tourism can be promoted through these applications. Consumers can participate in virtual reality wine tastings, where, for example, by wearing virtual reality glasses, they can be immersed in the vineyard or winery while tasting different wines in the comfort of their own homes. This could generate new opportunities for the vine and wine sector. Potentially, it could attract investors interested in the development of this technology, as well as new customers open to having this kind of experience. Another example of potentially interesting AI technology is the "virtual sommelier", which makes recommendations according to individual consumer preferences.

"What's really driving AI to the forefront today, is an intelligence revolution we are in. The world has become far more complex than it was even a few centuries ago, and making sense of it, thriving in it, will require humans to seek ways to expand our intelligence spectrum to do more with what we have. We now have the tools and the infrastructure to codify that human knowledge and intelligence that are uniquely human into non-living things with software and that is what this is all about"

Ganesh Padmanabhan

B. Application in the sector

Given the many sources and the sheer amount of data collected through different technologies, artificial intelligence is required to manage and process all the data collected before it is managed and displayed in a way that is useful for decision making.

- Complete crop monitoring and management application to optimise production and consumption of resources for wine growing, using various techniques (computer vision, predictive models) and data from various sources for: control of the ripening cycle and harvest planning, pest control, adequacy of actions and minimisation of their consumption (irrigation, fertilisation,etc.) with the following functionalities:
    - Crop life cycle management: crop sensing for monitoring with machine vision (pest detection, break-ins, fruit ripening, etc.) traceability of materials and objects using machine vision or blockchain.
    - Predictive models: results of actions according to action history and previous context, prediction of harvest date, prediction of pest spread, etc. to make decisions on crop care, avoiding unnecessary consumption, or harvesting.
    - Dashboard: control interface with graphics and alerts, interactive and customisable.
    - Data collection: based on IoT (sensor system in the crop), manual input or by voice with speech to text technique.
- Process monitoring to increase the efficiency of the company's own assets and production processes and the quality, using sensor technology and artificial intelligence, providing: process visibility, intelligent alerts for immediate action, traceability of materials and objects, security, optimised storage:
    - Tank control: real-time temperature control with sensor technology; predictive tank maintenance and leakage control by using computer vision; algorithms for real-time alerts and warnings.
    - Warehouse and inventory management: storage optimisation with a variety of techniques:
        - Computer vision with alerts in case of shortages, space optimisation with dimensioning of openings and products, warehouse security, object and label recognition (individual products).
        - Alert engine for warehouse or procurement actions.
        - Integration between warehousing systems, database inventory and purchasing systems.
- Traceability of the production process in the wineries and of products (food health), with global vision for production and cost efficiency, and anticipation of incidents:
    - Physical security in plants and warehouses with computer vision: detection of PPE, inclination of machines and objects, proximity to machines, smoke, fire, leakages, floods, anomalous behaviour (aggressions, theft), accidents,...
    - Traceability of materials with computer vision, blockchain or graphs.
    - Predictive maintenance with computer vision: detection of surface defects, uncoupling, changes of state etc.

- Bernard Chen is conducting ongoing research in the field of viticulture that focuses on using the computational wine wheel to process wine reviews in human language format from professional wine reviewers. Once the reviews are processed into computer recognizable format, tens of thousands of wines can be analysed all together by artificial intelligence algorithms to discover the correlation of wine sensory components with grade and price; the difference of soil of wine region or country; the weather impacts on wine. The future goal of this research is to combine wine sensory reviews from different sources with chemical analysis data on the reviewed wine to discover the connections between two wine evaluation methods. In this way, different professional wine reviewers' review logic and reasoning can be analysed and summarized through AI so that the wine review process can be done automatically through the input of the chemical analysis of a wine. This would remove all subjective information and make the wine review process objective allowing the consumer to have more objective information about the wine he/she is going to consume.

"We expect a major change in this industry. Furthermore, within the European plans, the agricultural sector is strategic and we want to make extensive use of AI. With technological applications and solid management, it will be one of the sectors with the greatest impact in the coming years"

José Luis Flórez

C. Technology in the future

AI is rapidly evolving today and is expected to transform industrial processes and value chains in ways yet to be imagined. However, in general, AI is still at an early stage of development and adoption in many sectors. Thus, it is not that the vine and wine sector is lagging behind, but rather that, in general, most industries are in the embryonic phase of AI. Therefore, the potential for future growth is high.

"In the future, we will be able to obtain objective wine reviews and grades from AI and machine learning"

Dr. Bernard Chen

Karly Burch's In-Depth Interview

She is a Research Fellow at the University of Otago's Centre for Sustainability in Dunedin, Aotearoa New Zealand.

1. What are you currently working on? What are the implications of artificial intelligence technology and its applications in your research?

I am currently working on the MaaraTech Project—a large-scale, transdisciplinary project collaboratively designing (co-designing) robotic and human assist technologies with AI capabilities for wine-grape vineyards, apple orchards and blueberry orchards in Aotearoa New Zealand. The project is based out of the University of Auckland under the leadership of Professor Bruce MacDonald. It is funded primarily by the New Zealand Ministry of Business, Innovation and Employment (MBIE), with co-funding from industry partners.

I am currently team co-lead (alongside Professor Hugh Campbell) and research lead of the project's Community Technology Adoption Team. Our team is responsible for supporting co-design processes and providing critical sociological and science and technology studies (STS) insights into the drivers and barriers to technology adoption.

Our project is designing technologies to assist with three labour-intensive tasks that include decision-making: wine-grape vine pruning, apple fruitlet thinning and blueberry harvesting. These technologies include a virtual reality (VR) training headset (e.g., to train agricultural workers in pruning wine-grape vines and thinning apple fruitlets), an augmented reality (AR) headset to assist work (e.g., to make pruning decisions on behalf of agricultural workers, supporting their work out in the field), and fully automated robotic technologies that can complete these tasks on their own. While the three case studies and tasks help to focus technology development within the project, the technologies are also being designed to support growers with other tasks of interest (e.g., identifying disease, estimating yield) which have been identified within co-design workshops with growers and industry partners.

2. What is the state of development/implementation of this technology, especially in the wine sector?

While the fully autonomous robotic technologies are a few years away, the VR training tool our team is developing is getting close to the stage of commercialization, particularly for use in the wine-grape industry.

3. What are the main benefits that this technology can bring to the sector?

Wine-grape pruning is a hugely laborious task that needs to be completed annually within a particular seasonal timeframe. Each vineyard may have its own ways of pruning, meaning that training workers on the particular pruning strategy of a particular vineyard is extremely important. The purpose of the VR headset is to support with training agricultural workers to complete these tasks. One of the most difficult aspects of training workers is that training takes place using real wine-grape vines, meaning that mistakes made during the training process have actual material consequences on vineyards. The VR training tool would allow workers to make mistakes within a virtual world before making real cuts on vines, something that is very important to growers. We have received a lot of interest from industry partners, growers and agricultural trainers who would like support with streamlining and standardizing their training processes and, thus, see value in this technology.

4. Do you see any possible/clear drawback to the application of this technology?

At this point, we have yet to conduct usability studies on the VR training tool, but we are hoping that the training tool will be both usable and useful for all end users, particularly on-the-ground end users who may be using the tool in their everyday work: agricultural trainers, supervisors and workers. One aspect that we have to keep in mind is that there can be bias designed into technologies, so we need to use VR headsets that can accommodate all people without discrimination. For example, some VR headsets are designed particularly for men, and can result in women suffering higher rates of cybersickness, which would not be ideal for vineyards with a commitment to gender equity. As cybersickness could result from using VR technologies, our project team members are also thinking of other ways to conduct the training without the headset (e.g., through a touchscreen device).

As social scientists, our team wants to better understand how the VR training tool might transform everyday work on vineyards and orchards, and have begun conducting interviews with possible on-the-ground end users of this technology: agricultural trainers, supervisors and workers (seasonal and regular) involved in wine-grape pruning. We think these interviews with possible on-the-ground end users are extremely important to better understand the nuances involved in the everyday use and possible adoption of the VR training tool. In thinking about possible drawbacks, vineyard managers and trainers will need to train the VR training tool to ensure their desired pruning techniques are being taught to workers. This may involve a time investment at the outset. These are all things that we continue to consider and hope to improve as the technologies are being developed with input from industry partners, growers, trainers, supervisors and workers.

5. What could be the bottlenecks faced in the implementation of this technology in the sector?

Moving from proof of concept to commercialization seems to be a struggle. The desire to capture IP in order to successfully commercialize a technology can also cause disruptions within co-design processes. For example, if IP needs to be protected, it is difficult to discuss particular aspects of technologies with possible end users who have not signed non-disclosure agreements. This can hinder the ability of technology producers to remain responsive to the needs and desires of possible end users and wider societal actors. Therefore, technology developers engaged in co-design need to be skilful in how they protect IP, while also remaining responsive to the needs of research collaborators. I am also personally interested in questions of data governance, and how to ensure new technologies (particularly those developed with public funding) respect the data sovereignty of possible end users (there is currently a lot of abuse around data mining and data grabbing in AgTech).

6. Is there a sector in which it has been already successfully implemented? Which one? Why do you think it has been successful there?

VR has been used for training in fields such as healthcare and construction. These kinds of trainings allow workers to engage in pre-training before going out and learning/making mistakes in the real world.

7. What are the main applications of this technology in the vine and wine sector? What tools and resources would be needed for these applications?

Use case 1: VR training headset

- How does it work?

  It is a tool to train agricultural workers on how to prune wine-grape vines according to the specific style/instructions of the vineyard they will be working on.

- What is the operational model: who uses it and how?

  The technology would be used to train agricultural workers who will prune wine-grape vines.

- Who would bear the investment and what is the return on investment?

  Individual vineyard owners, or agricultural training or recruitment organisations would potentially purchase these technologies.

Use case 2: AR human assist headset

- How does it work?

  It uses machine learning to assist agricultural workers in pruning wine-grape vines: the headset would determine pruning cut points and let agricultural workers know where to make cuts on a vine.

- What is the operational model: who uses it and how?

  It would be used by agricultural workers out in the field.

- Who would bear the investment and what is the return on investment?

  Individual vineyards owners, or agricultural training or recruitment organisations would potentially purchase these technologies.

8. To what extent do you think this technology will be implemented and embraced by the wine sector in the next 5 years?

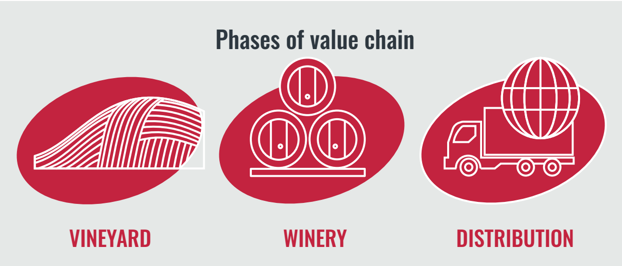
According to my colleagues, the VR training tool and potentially the AR headset could be commercialized and adopted within the wine sector in the next five years. The fully autonomous pruning robot will need more time to develop.

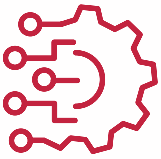
6.3 Robotics

Expert

Albert Strever

He is working as a Senior Lecturer in Viticulture at the Department of Viticulture and Oenology, Stellenbosch University. He also coordinates the Agricultural Faculty's Innovation and Informatics initiatives and previously did research in Grapevine Cultivation and Remote Sensing.





A. The technology

Cambridge defines a robot as a "machine controlled by a computer that is used to perform jobs automatically". Robots are able to assist humans or replicate human actions. In the beginning, they were used to perform monotonous tasks, but have evolved to perform more complicated actions that ease different types of work. All robots have different levels of autonomy, from human-controlled bots that carry out routine tasks that a human has full control over, to fully autonomous bots that perform tasks without any external influences.

In the wine industry, high-tech robots equipped with artificial intelligence are becoming an essential part in minimising, for example, the effects of drought, fluctuating temperatures and changes in harvest schedules. They are more precise and quicker than any human winegrower is.

When talking about the applications and benefits of robotics in the vine and wine sector, a series of applications can be developed according to its position in the value chain:

Vineyard

With regard to planting (traditionally a two-man process), robots punch a hole in the ground with a hollow metal tube and deposit the seeds using a compressed air mechanism. Once planted, robots can monitor factors such as grape yield, vegetative growth and grape composition in vineyards.

By doing this, a map showing the quality of the crop in specific zones can be created and, when it comes to increasing yield, preventing disease or controlling excess growth, vines can be pruned and pesticides can be applied efficiently using robotics. To perform these tasks, a 3D image of the plant must be computed, allowing machines to move along the vines, pruning and fertilizing.

Just as planting, monitoring, pruning and fertilizing vines can be automated; the task of harvesting grapes can be also carried out by robotics, by shaking the vines and collecting the grapes as they fall from the vine.

The IoT applications can be classified according to their place in the value chain.

Winery & Distribution

In the final stages of the value chain, the use of robots is common in many warehouses, and for some logistics centres, it is necessary to efficiently track inventory within many warehouses in different locations helping to increase the productivity of the distribution stage. Through smart storing—which refers to the automation of warehouses through robotics and AI, and smart shops—the final stage of the wine life cycle is considerably improved. As distribution and commercialisation are more efficient due to time savings and automation of operational work making tasks run autonomously due to the integration with artificial intelligence, increased task security, control and optimise all the company's logistics flows, improved inventory control capability, etc.

"With the latest advancements in this technology and improved energy efficiency as well as lowered cost in recent years, it is believed that in the next three to five years these systems will become more viable and will have a far greater impact on the vine and wine sector"

Albert Strever

B. Application in the sector

In recent years, the use of drones and robots, two increasingly common technologies in the vine and wine sector, have become commonplace. For the past two years, a Spanish winery has been using drones in its vineyards to create a vigour map to determine the maturity and quality of the grapes and identify the optimal time for harvesting.

Elsewhere, the Polytechnic Unit of Valencia (Spain) presented an autonomous vineyard-monitoring robot as part of the Vinescout project. The device is a model that assists wine producers in measuring key vineyard parameters such as the water status of the vine, leaf/canopy temperature and plant vigour. This new robot combines 3D vision with ultrasound sensors and artificial intelligence, resulting in more precise driving.

Another example from a winery in southern Europe is the implementation of transport management systems to control and optimise all the company's logistic flows of the company, also has implemented artificial vision and robotics solutions to control the incoming flows and movements in the plant of raw material and finished product transporters.

Interactive use case

Drones and image recognition technologies to reduce losses and guarantee the quality of the product. Example: **Ponte da Boga**

C. Technology in the future

In some sectors, such as the automotive industry, this technology is highly developed and plays a crucial role. However, this technology is at an early stage in the vine and wine sector, as until now there have been several challenges in applying this technology. These include the high costs, the lack of technological culture in the sector and a lack of professionals trained in the technology. Another issue is the high-energy consumption of the robots, which means they do not have a long autonomy of use. Also, the practicality of use and maintenance may favour the use of i.e. autonomous electric tractors, which may gradually automate more and more to become more like robots.

6.4 Satellite Imagery / Geographical Information Systems (GIS)

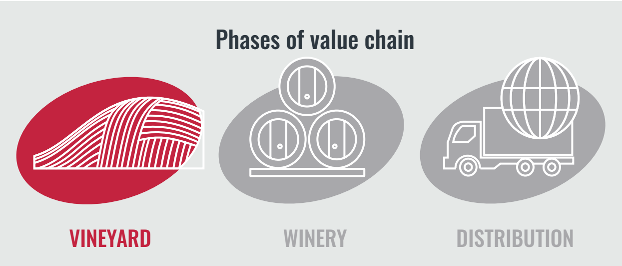
Experts

Benjamin Bois

He is an assistant professor at the University of Bourgogne-Franche-Comté, in Dijon, France. He teaches viticulture, GIS, terroir and climatology at the Institut Universitaire de la Vigne et du Vin (IUVV). His research, carried out at the Climate Research Center (Biogeosciences Laboratory of the University of Burgundy), focuses on the relationship between climate and viticulture, with particular interest in climate change impact on viticulture, climate zoning methods and the role of climate in the terroir effect.

Julian Chambouleyron

Julian is the President of Gisworking SA Owner of AMANDES SAS. Master of science (MSc) Geoinformation systems at Faculty of Geo-Information Science and Earth Observation (ITC) of the University Twente.



Satellite imagery in the field of agriculture, and more specifically in the vineyard and wine, have many applications and benefits. These benefits are not only passed on to producers, but also provide great benefits to governments, consortia, cooperatives and the whole sector in general.

A. The technology

Images taken by satellites (or satellite imagery) are used for a wide range of purposes such as cartography, geo-positioning, studying climate change, geographic surveys, etc.

In recent years, the use of wide-spectrum satellite imagery for the benefit of the agricultural sector has become increasingly widespread. This has been particularly boosted since the start of the European Union's Copernicus Earth observation project- a project where a series of Sentinel satellites have been launched into space tasked with generating a vast amount of information on growing conditions and plant health used to improve farm efficiency.

Satellite imaging technology has improved significantly. Radar images of land and sea can now be captured — day and night, and in all types of weather conditions— using the new technologies and the various cameras fitted to these satellites. Thermal images and infrared images overlaid with the other images can provide a comprehensive picture that yields a vast amount of accurate information on the state of the terrain, crops, etc.

Images obtained from these satellites can be displayed with combinations of bands or spectral indices. The most common index is the NDVI, also known as the green or vigour index. Another lesser known but equally useful index, especially when the green index is over-saturated, is the GNDVI (chlorophyll index). These indices can provide a lot of information about the state of the crops, how ripe the crops are, and what type of crops are being grown on each plot of land.

"Digital cartography, together with robotics, drones and GNSS (global navigation satellite systems such as GPS and Galileo) time and space precision improvement have opened a new era for viticulture"

Benjamin Bois

"We are no longer talking about precision agriculture, we now discuss digital Agriculture. We believed we could cope with digital by the extensive use of satellite imagery at beginning and drones nowadays...Now we are adding robotics and even IOT. Still not enough. My interpretation is that we are missing something crucial on adding all those technologies together. And that is that, we forget to put all the pieces of data we collect here and there together into one place, to make valuable decisions"

Julian Chambouleyron

For producers, having accurate images of the field that are renewed in a short period of time represents a considerable advantage, as it allows them to know the state of their crops, diseases, lack of water, or ripeness in real time.

"It allows to reduce inputs in the vineyard (pesticides, fertilizers and herbicides) through an optimized spreading of products. Combination of these technologies with the generalization of "easy-to-use" devices such as smartphones makes it possible for grape growers to set up traceability systems for following up management practices, as well as grape quality, grapevine growth and diseases development. Besides, progress in robotics together GNSS and digital cartography has led to the production of autonomous trailers. Theses light machines limit soil compaction and reduce labour intensive tasks for vineyard workers." - Benjamin Bois

The progress in satellite imaging technology now makes it possible to see what lies beneath the canopy layer, even the ripeness of the fruit under the leaves, as is the case with vineyards, coffee or fruit plantations.

When combined with artificial intelligence and the Internet of Things, this technology can create predictive models, which farmers can use to predict annual harvests, anticipate severe weather, quickly and accurately detect diseases or pests, and learn from the history of previous years to increase or improve harvests.

For governments and institutions, this technology facilitates and favours the control and delimitation of land, and precise and autonomous knowledge of the type of crops in a given territory. It is a very useful tool to improve environmental and rural management, especially if national or state subsidies for agriculture are available.

Satellite imagery is an established technology that has significantly evolved and improved over the last few years, greatly increasing its applications and accuracy.

B. Application in the sector

An example of a real case of the use of satellite imagery in the agricultural sector is the Corine Land Cover (Coordination of Information on the Environment or CLC) project. 39 countries participate in this project as of today.

Since the mid-1980s, digital satellite images of the European Union Member States have been collected and evaluated uniformly according to land use, with special focus placed on land use changes and environmental issues.

These images are subsequently made accessible to the public for use and interpretation in different areas.

However, although it relies on remote sensing imagery as a data source, it is in fact a photointerpretation project (i.e. not an automated classification project). Its main purpose is to facilitate decision-making on territorial policy within the European Union.

Another example is the case of MED-GOLD. Climate change is causing new patterns in global meteorological conditions, which are already greatly affecting many aspects of our society. Although it is a global phenomenon, nowhere in the world is climate change expected to have such dramatic ecological, economic and social consequences as in the Mediterranean basin, where climate projection scenarios indicate that they will be higher than the expected average values, putting biodiversity and anthropogenic activities such as agriculture at risk. Against this background, the agricultural sector in particular is especially vulnerable, as it is highly dependent on climate and therefore very sensitive to any variation. The most likely scenario will increase the risk of crop failure and pest damage, as well as extreme weather events such as storms, floods or heat waves. Immediate action is therefore needed to deal with these uncertain forecasts. MED-GOLD's challenge is to develop tools capable of managing more resilient, efficient and sustainable agri-food systems. This requires the development of climate services to support decision-making and the implementation of good agricultural practices. MED-GOLD aims to translate all the accumulated knowledge on climate data and forecasting - on a seasonal scale and beyond - into accessible and high added-value information for a wide range of end-users in the agricultural sector.

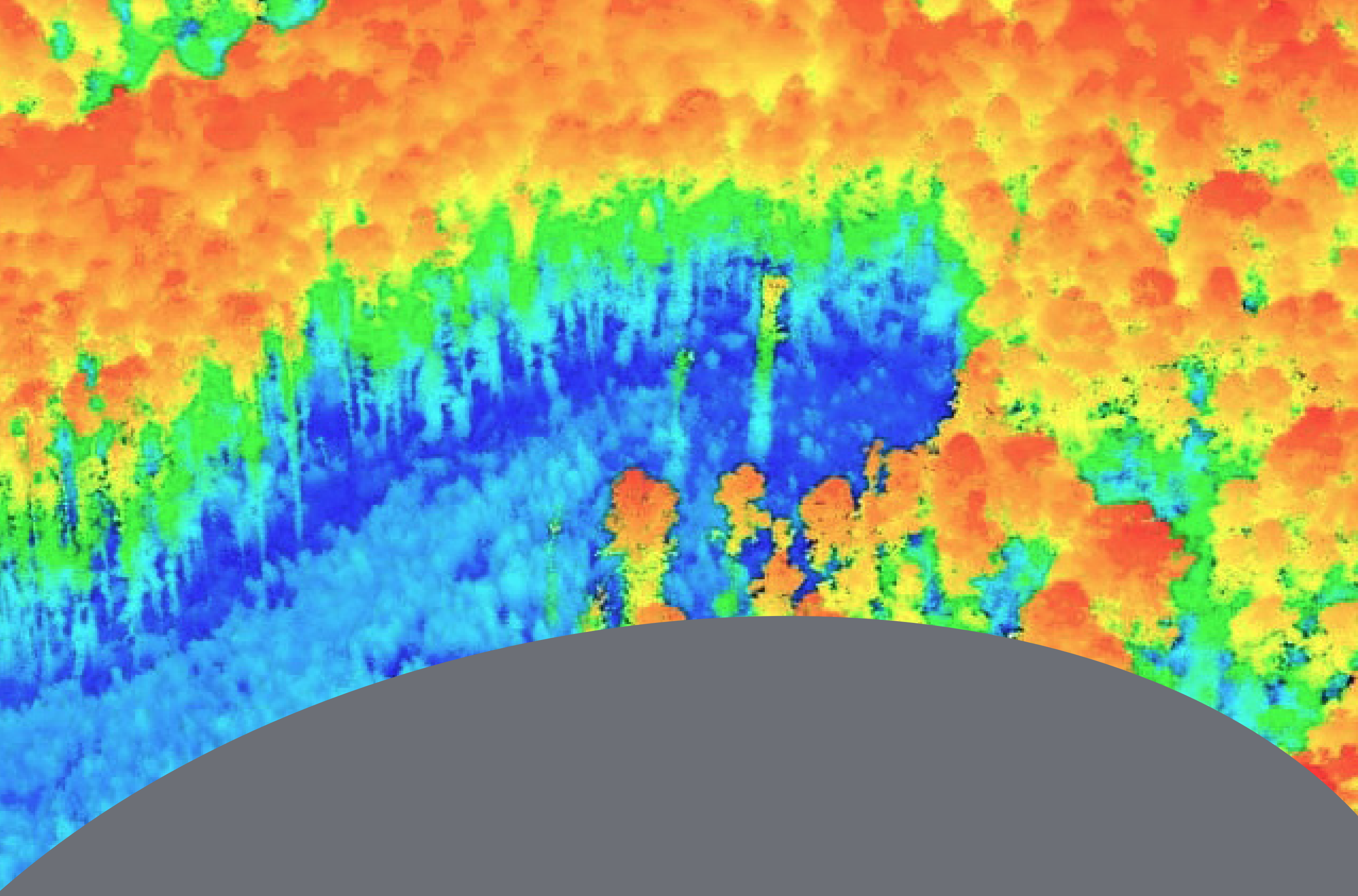
A Geographical Information System (GIS) is a very intuitive tool for modelling digitally agricultural fields. The fields, crops and plants are defined in a geographic inventory data model. Then, it can be connected to external systems by means of WMS -WFS standard geographic protocols where you can get tons of existing data from satellite, soils, water, etc. Then watering systems and meteo stations can be connected by means of IoT and you can see how your GIS polygons and point's KPIs become valuable.

C. Technology in the future

Satellite imaging technology, unlike many of the technologies mentioned throughout the report, is a technology that is already at an advanced stage of maturity.

In the coming years images will be captured with higher resolution or using technically superior cameras or different spectrums, and this technology is not expected to undergo any radical changes in the short/medium term.

The evolution and development of this technology is certain to become widespread, as will the integration with other different technologies (IoT, artificial intelligence, etc.) and new applications and uses.

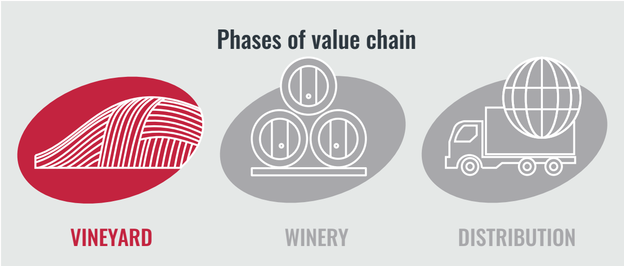


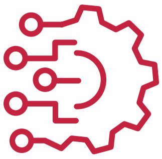
6.5 LIDAR (Laser Imaging Detection and Ranging)

Expert

Alexandre Bastard

He is the head of Research, Development and Innovation of EtOH. After a PhD in Enology/Biology, he cofounded EtOH, specialised in the digital transformation for the wine, beer and spirits industry. He leads the department of innovative projects and R&D projects with a focus on new technologies and data.





A. The technology

LiDAR (Light Detection and Ranging) is a remote sensing method that can be used to map the structure including height, density and other characteristics of vegetation in a region. This makes it the ideal tool to study the characteristics of a particular area in detail (e.g. terrain, vegetation, obstacles, slope, etc.[4]).

LiDAR is an "active" remote sensing system, which means that the system itself generates energy (light) to measure objects on the ground.

The system emits light in the form of a rapidly firing laser, which travels to the ground and reflects off objects such as buildings and tree branches. The reflected light energy then returns to the LiDAR sensor where it is recorded. Remote sensing captures information -without physically measuring it- about a terrain and records data, which are subsequently used to measure conditions and characteristics.

Where this technology is primarily being used in autonomous vehicles, as it can accurately map the vehicle's surroundings.

In the world of vine and wine, this tool can be used to map the vineyard in three dimensions, from the topography of the land to the fruit of each vine. The "3D cloud points" that are recorded provide an accurate 3D model of a representation of the vineyard. The light emitted by the technology is reflected on the objects it encounters in its path, returns to the sensor and creates the 3D map.

LiDAR was initially used in aircraft. Now it can be installed on drones, tractors and autonomous vehicles. When attached to any of these "vehicles", it can map the terrain perfectly and see in detail the characteristics of the surrounding environment.

Some benefits of this technology include a better understanding of soil properties, improved accuracy of autonomous robots, and improved vineyard technologies with autonomous decision-making models.

[4] Wasser, L. (2020). *The Basics of LiDAR – Light Detection and Ranging – Remote Sensing*. Neonscience

B. Application in the sector

The technology has proven to be effective and many development studies are underway, although it is still not very widespread in the vine and wine sector. Some of the different uses for vineyards include:

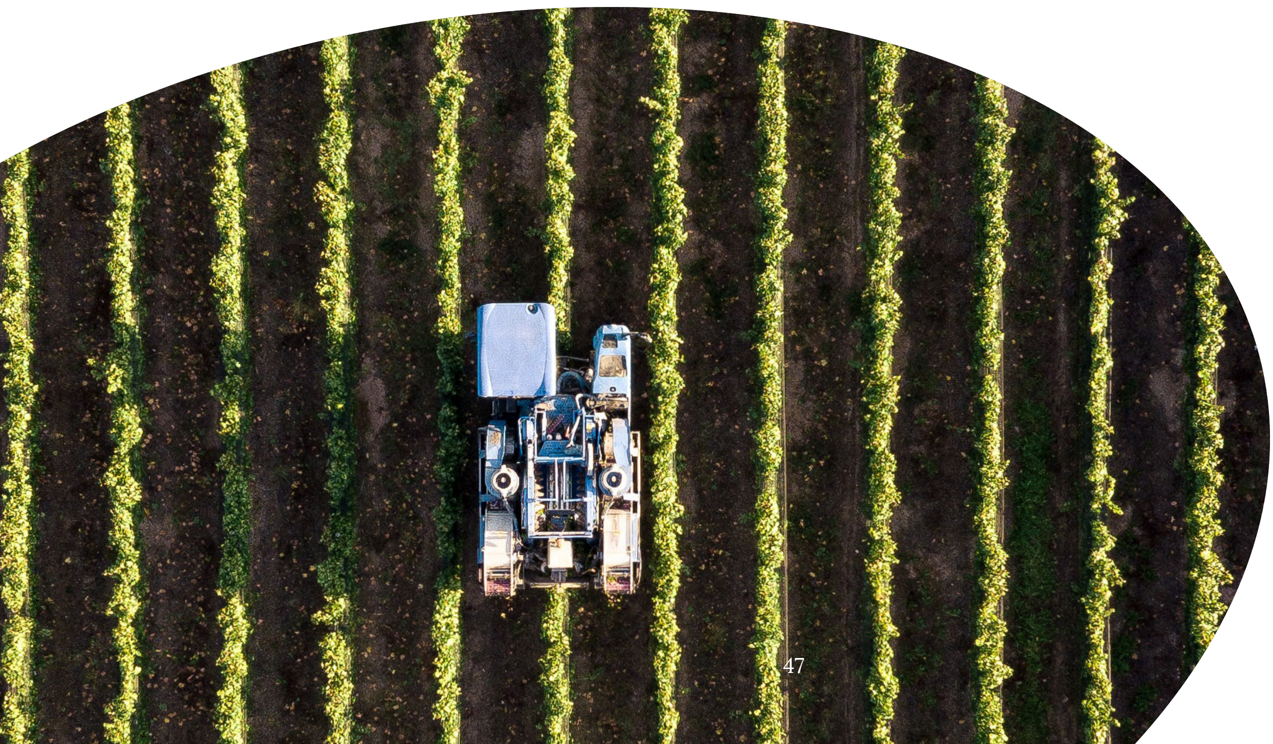
- Harvesting Yield Assessment: as the technology moves through the vineyard, it analyses the areas where there is more fruit and identifies where there is not so much so that other tools, such as fertilisers, can be used to stimulate growth. This way fertilizers and water are used more efficiently.
- Site Specific Spraying: to know precisely which areas have the highest leaf and fruit density. This information can be used to improve precision in the use of pesticides and reduce pollution and costs for the producers.
- Reduce accidents in the vineyard: by having a detailed 3D map of the terrain, the safety of tractors and autonomous vehicles can be improved as the terrain is perfectly mapped with slopes, holes and other kinds of hazards.

C. Technology in the future

In the future, the main user of this technology is expected to be tractor and autonomous vehicle manufacturers for use in agriculture, and so reach the vineyards aboard these vehicles. The technology is expected to be used extensively in crop farming (including vineyards) in the coming years, as it becomes more accessible in terms of cost and adaptability (drones and tractors). As autonomous vehicles continue to develop, the demand for LiDAR tools will rise, resulting in an increase in supply and more competitive prices.

“With LiDAR, agricultural robotics takes a step forward in thoroughness and adaptability. Thanks to its precision, this technology allows robots to better locate themselves and interact with any environment such as vineyards, vines or grapes”

Alexandre Bastard



Smart vineyards

Experts

Antonio Graça

He is scientific-secretary of the Sustainable Development and Climate Change (ENVIRO) expert group of the OIV. He heads the R&D department of SOGRAPE, a Portuguese family-owned wine company, with a strong international presence and unique diversity.

Adriaan Oelofse

He is the Research, Development & Innovation Manager of WINETECH (Wine Industry Network of Expertise and Technology NPC), the South African Industry body that funds and drive research and innovation. He represents South Africa at the OIV Commission II – Oenology group of experts and is also a member of FIVS-STC (Scientific and technical committee).

Mario de la Fuente

He is the manager of the Spanish Wine Technology Platform (PTV), the institution that boots the R&D projects in the viticulture sector at the national or international level.
He also is a researcher in viticulture and oenology at the Polytechnic University of Madrid (UPM) and member of the Spanish delegation of the OIV (MAPA) within the Viticulture Commission, being the Chairman of the OIV Group of experts in vine protection and viticulture techniques (PROTEC) at international level.

Smart vineyards is an agronomic concept that defines the management of agricultural plots based on observation, measurement and action under situations of environmental variability.

This methodology requires a set of technologies that include global navigation satellite systems (GNSS), drones, sensors, satellite and airborne imagery—together with geographic information systems (GIS) and machine learning—to estimate or evaluate and understand these variations. The information collected can be used to not only conduct an accurate assessment of the optimal planting density, but also estimate the right amount of fertiliser or other inputs needed and more accurately predict crop yields and production. This information can also be used by variable-rate technologies (VRTs) to optimise the distribution of seeds, fertilisers, crop protection products and segmented harvest.

Smart vineyards is a type of crop management strategy in which decisions can be made dynamically thanks to the vast amounts of information obtained directly from the field through technologies such as sensor technology or aerial imagery. Farmers are able to improve their decision-making and act proactively on crops by receiving first-hand information directly and in real-time.

These systems provide highly accurate knowledge of the needs and behaviour of crops for a more efficient management of resources and production that can save operational costs and aid producer profitability if applied correctly.

This technology (or new crop management strategy) is now available and is currently being used by farmers and growers in many countries such as Spain, France, Portugal, South Africa, Chile, etc. If properly integrated, this technology can bring numerous benefits and improvements to crops.

The use of resources can be fully optimised owing to extensive knowledge of the soil conditions, plants, luminosity, humidity and other indicators, resulting in significant cost savings.

By knowing the amount of water the plant needs and receives, optimal irrigation can be achieved, saving not only water, but also maximising the productivity of each plant to obtain a higher yield and improved quality.

Smart vineyards bring many benefits such as:

- To aid informed decision making.
- Establish early warning / detection systems.
- Provide suitability tools for climate change readiness.
- Improve sustainable and profitable crop production.

“In the scope of digital transition, and in the grape and wine sector more than in any other sector, one should never forget the principle that technology should serve people and not the other way around”

Antonio Graça

“The only thing that is constant is change, so be open-minded, adapt and learn”

Adriaan Oelofse

“The wine sector has always combined tradition with innovation, and has been a pioneer in implementing a number of technological innovations in the agro-food sector. However, for innovation to be successfully implemented in the sector, R&D&I must be championed and financed by both the public and private sectors. This is the only way to rigorously test the wide range of innovations on offer”

Mario de la Fuente

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6.6 Blockchain

Experts

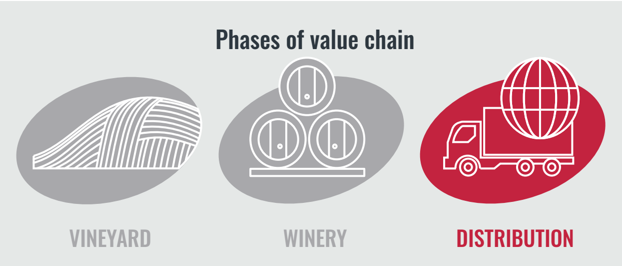
Javier Ibañez

Prof. Dr. Javier Ibáñez, Chaired Professor of Commercial Law from Comillas Pontifical University, head of its FinTech Legal Observatory and co-founder of Alastria Consortium, first (2017) national public-permissioned blockchain DLT network public-private consortium in the world.

Dr. Ibáñez is currently working in the field of DLT networks: Governance of public-permissioned distributed ledgers, token taxonomy, alternative DLT systems for permissioning, and blockchain international legal framework.

Oliver Oram

Oliver's background in financial technology opened his eyes to the potential of Blockchain & distributed ledger technology, which led him to study an MSc of International Management, focusing on fiscal decentralisation, at the School of Oriental Studies. As CEO, he leads Chainvine's team of experts. He acts as a thought leader/smart partner at the Commonwealth Partnership for Technology Management and is an expert advisor at the OECD for the Rural Innovation Group through his work with the wine industry.



A. The technology

As the name suggests, Blockchain is a chain of blocks, which contain encrypted information sent in form of data transactions on the network[(8)]. Because they are interlinked (hence the word chain), they allow the transfer of data (or value) with fairly secure encryption through the use of double asymmetric-key (public and private) cryptographic encryption, with the notes of automatic replicated data sharing (distribution), ecosytemic consensus, disintermediation, peer-to-peer (P2P) node participation, data privacy and immutability[(9)].

One of the truly innovative characteristics of Distributed-Ledger Technology (hereinafter DLT) upon which blockchains are based, is that the transfer does not necessarily require a third party to certify the information, through trusted-third parties could be enabled in permissioned blockchains[(10)] to satisfy legal-compliance requirements. It is instead distributed among multiple independent and equal nodes that examine and validate it without the need for them to know each other. Once information is entered, it cannot be deleted.

Only new information can be added, as the blocks are connected to each other through cryptographic encryption, so it is impossible to modify data from a previous block in the chain, as the information from the previous blocks would have to be modified(11).

Its operation can be complex to understand when explaining the internal details of its implementation, but the basic idea can be easily explained[(12)].

Each block stores:

- A number of valid records or transactions
- Information about that block
- Its link to the previous block and the next block through the hash of each block—a unique code that can be thought of as the block's fingerprint.

Therefore, each block has a specific and immovable place within the chain, as each block contains information from the hash of the previous block. The entire chain is stored on each node of the network that makes up the blockchain, so an exact copy of the chain is stored by all network participants.

As new records are created, they are first verified and validated by the network nodes and then added to a new block that is linked to the chain. Such chain is replicated in all nodes (node ecosystem), composing the ledger itself (distributed or shared ledger).

As a distributed-ledger technology, where each network node stores an exact copy of the chain, the availability of the information is guaranteed at all times. If an attacker wanted to provoke a denial of service, all the nodes in the network would have to be overridden, since it is sufficient for at least one to be operational for the information to be available.

On the other hand, being a consensual registry, where all nodes contain the same information, it is almost impossible to alter it, guaranteeing its integrity. If an attacker wanted to modify the information in the blockchain, the entire chain would have to be modified in at least 51% of the nodes.

[(8)] A "transaction" is defined by the International Telecommunications Union (2019), ITU FG DLT,Technical Specification D1.1 *Distributed Ledger Technology Terms and Definitions*, August, Geneva, 6.61, as the "whole of the exchange of information between nodes…uniquely identified by a transaction identifier". In a wider sense, transaction encompasses some kinds of data Exchange composing a contractual agreement executed by Smart contracts (cf. Javier Ibáñez (2018), *Derecho de Blockchain y de la tecnología de registros distribuidos*, Cizur Menor, Aranzadi, 54-64

[(9)] Ibáñez, ibid., 31-43; cf. Andrea Molano (2019), *Keys to understanding blockchain technology*, BBVA

[(10)] In accordance with the standards of ITU-T (FG DLT D.1.1, cit., 6.42) and International Standards Organisation (ISO), ISO/CD 22739, Blockchain and distributed ledger technologies –Terminology, "permissioned" means "requiring authorization to perform a particular activity or Activities". Such authorization requires complex offliner or offchain governance and legal policies, approved by the node ecosystem (cf. Javier Ibáñez, Alastria Governance Policies and Ethics, in Ibáñez -coord.- (2020), Alastria Mission and Vision. A multidisciplinary research, Madrid, Reus, 61-76; David Contreras et al. (2020), Validation and Governance in an Alastrian Testnet Node, in Alastria Mission…, cit., 47-60; and incentives for node validation (cf. Pietro Marchionni (2020), Rewarding Honest Validators, ibid. 81-96

[(11)] *OECD Blockchain Primer*, OECD (2018)

[(12)] *Blockchain: what it is, how it works and how it is being used in the marketplace*, Cecilia Pastorino, Eset, (2018) Finally, since each block is mathematically linked to the next block, once a new block is added to the chain, it becomes unalterable. If a block is modified, its relationship to the chain is broken. In other words, all the information recorded in the blocks is immutable and perpetual. In this way, blockchain technology allows us to store information that can never be lost, modified or deleted.

B. Application in the sector

Blockchain technology has a multitude of generic applications. The most common ones, for which most industries or sectors are implementing proofs of concept and decentralised applications and platforms (DApp), are: traceability based upon self-sovereign identity (SSI), smart contracts for legal and economic transactions and tokenisation to create new markets on assets.

Traceability with full sovereign digital identity. It entails the ability to verify or check all the steps that a product has followed throughout its useful life, with in dubious identification of traced objects (i.e. wine bottle, grapes from a vineyard)[13]. This technology allows traceability to be visible and verifiable for everyone, without the possibility of being altered or modified, integrating the ledger as a database wherein agri-food data can be shared by all the participants in the value chain, integrating smart contracts to seek traceability of commercial trade of agricultural assets, and also solutions from IoT on production, to create indelible timestamped proof of current status of the production[14]. Specifically, as far as the vine and wine sector is concerned, this technology allows anyone involved in the life cycle of the product (grape producers, cooperatives, vine farmers, viticulturists, integrated wineries, storage companies and market intermediaries, amongst others) to make all the steps taken by the wine from the vineyard to the marketing stage public. Blockchain records each stage (grape harvesting, production, distribution, etc.), verifying the authenticity of the previous steps each time[15].

- Smart contracts[16] is another of the applications that blockchain technology enables on the corresponding layer of permissioned blockchains. A smart contract is a computer code that allows a contract to be verified and enforced automatically, making it legally valid. People do not need to intervene to check or execute such contracts as they operate on a blockchain, the same mechanism on which cryptocurrencies are based.

  The content of the contract is converted into a code, which is stored in a blockchain. In practice, the terms of the contract are translated into a series of statements and commands that work autonomously thanks to blockchain technology. The code uses the logical rules of programming to ensure that, if certain conditions in the contract are met, the corresponding clause is executed.

  In some cases, it is necessary to involve "oracles" or external agents that verify whether a contract condition has been fulfilled. These IT tools validate the conditions foreseen in the smart contract by using external information to decide whether a clause has been fulfilled or not. When the oracle obtains this information and verifies it, the contract is executed and the planned transaction takes place.

  In fore coming wine-industry integrated digitised solutions, delivery and payments by smart contracts increase the efficiency in credit collection from

[13] Aymo, M. Bellón, C. y Sáenz-Díaz, R. (2020), Smart contracts and decentralized applications in Alastria: the case of Spanish wine, in *Alastria* ence (IEMCON). 335–340. IEEE. DOI: 10.1109/IEMCON. 2018.8615007

[14] Zhao, G., Liu, S., Lopez, C., Lu, H., Elgueta, S., Chen, H., et al. (2019), Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions. *Computers in Industry*, 109, 83–99; Kim, M., Hilton, B., Burks, Z., Reyes, J. (2018), *Integrating blockchain, smart contracttokens, and IoT to design a food traceability solution.* 9th annual information technology, electronics and mobile communication conference (IEMCON). 335–340. IEEE. DOI: 10.1109/ IEMCON. 2018.8615007

[15] *How smart tech could put a stop to wine fraud?* Matthew Vincent, Financial Times (2019)

[16] Defined by ITU-T FG DLT D1.1, 6.51, as program written on the distributed ledger system which encodes the rules for specific types of distributed ledger system transactions in a way that can be validated, and triggered by specific conditions"; on the concept and enforceability of legal Smart contract see ITU-FG DLT. Technical Report D4.1 Distributed ledger technology regulatory framework, 5.2.3.1, as incorporated (ibid..) by J. Ibáñez as "contract with contract-law structure". While the SC code can self-enforce transactions on DLT-managed assets, other contract terms require traditional enforcement, in particular when its breach requires restitution, when SCs are used pseudonymously or in an international contexts (like wine exports) wherein conventional enforcement is costly and slow

clients and in credit payment to wine suppliers, provided that logistic partners and banks are incorporated by nodes, substantially reducing working capital requirements. Where the terms are payable upon receipt, proof of delivery from a carrier automatically triggers digital invoicing and banking payments [17].

- Another up-and-coming application of blockchain is Non Fungible Tokenisation (NFT). A non-fungible token is a unique token that is generated and legally represents the ownership of a unique product (e.g. a specific bottle of wine, an art peace, a house, etc.) A good example of how NFT works is if I want to sell a bottle, a box, a pallet, or a container of wine. A specific token is created that virtually represents the ownership of that specific good, that is unique, and can be sold, bought or transferred. For example, distributed ledger technology or Blockchain, as it is often referred to, provides suppliers and those within the supply chain better data to track the wine as well as its properties i.e. the source of the wine, its journey and its processing. Having this type of technology implemented within the supply chain means that buyers can instantly obtain this data on the source of wine, its journey, and most crucially of all, its legitimacy. With this intelligent solution implemented on platforms there can be no more doubts on whether the wine is what it says it is. Blockchain gives buyers the power to know that it is. By being able to track the health, wealth, and happiness of the wine, this technology and data tracking has provided a safe means to transport wine and can make this industry one of the safest and most transparent in the world. This can lead to the elimination of paperwork for compliance purposes and the import and export of wine by allowing government inspectors at ports and borders to easily access the data they require for the movement export and import of goods.

C. Technology in the future

When addressing the possible drawbacks and obstacles that this technology is currently facing Mr. Oram pointed out: “*The main draw back at the moment is slow user adoption but I believe this is down to a lack of clear education and perhaps a perception that technology is expensive for vineyards and SMEs involved in the wine trade I believe this will be over come sooner than we believe as more data from companies become available.*”

Mr. Oram also addresses that “*The technology will breakthrough in the next five years and there will be much more engagement or the same as in the early days of the internet. I see we are at the tip of the iceberg and that in the next five years significant scaling of this technology in the wine industry will take place.*” Oliver Oram.

> *“With the help of blockchain, I would like every producer to know where their bottles are at every moment. The technology is applicable to all kind of wines (no matter its price), and it is just as accessible as all will need access to compliance data”*
>
> Oliver Oram

[17] Aymo et al., Smart contracts and decentralized applications...cit., 143

Dr. Javier Ibañez's In-Depth Interview

Prof. Dr. Javier Ibáñez, Chaired Professor of Commercial Law from Comillas Pontifical University, head of its FinTech Legal Observatory and co-founder of Alastria Consortium.

1. What are the main benefits that this technology can bring to the sector?

- Full transaction traceability for consumers
- Fraud prevention in wine commercialisation and distribution
- Enhanced marketability for relevant actors, mainly producers and cooperatives, with effective cross-border cost reduction of wine exchanges
- Material and virtual combined security for transactions on wine and its tokens or digital representations of value
- Speed of legal compliance with administrative burdens
- Fast and secured commercialisation of wine in worldwide token markets

2. Do you see any possible/clear drawback to the application of this technology?

- Political and public-administrative suspicions and/or indecisions; lack of confidence on the resilience or security of DLT architecture or related devices
- Lack of interest of major dominant intermediaries, brokers and distributors, and other monopolistic forces, in public and in private sector as well
- Producers and intermediaries interested in opaque transactions or market abuse (price strangling, informative manipulation, and insider trading...)
- Market factual powers of fraud promoters with respect to wine quality, geographic origin or grape authenticity

3. What could be the bottlenecks faced in the implementation of this technology in the sector?

- Smart contract code implementation
- IoT oracles implementation
- Public-node governance
- Full legal compliance in different jurisdictions with respect to several concerned legal areas
- Private distribution of DLT benefits among relevant stakeholders

4. Is there a sector where it has been already successfully implemented? If so, which one? Why do you think it has been successful there?

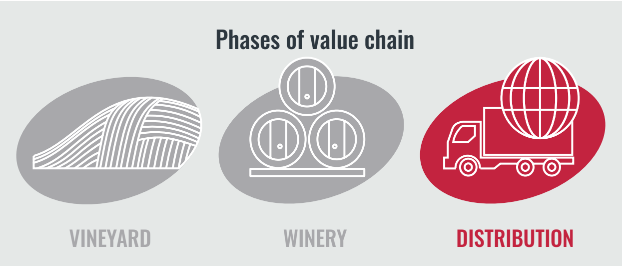
There is not yet a sector wherein DLT is fully implemented, exception made of the financial sector in the field of primary and secondary market experiences in sandboxes, tied to the facilitation of use cases in the framework of the EU financial digital strategy. However, DLT is progressing in parallel within the realm of all main industrial sectors. Bottlenecks do not differ substantially in such sectors.

6.7 E-label

Expert

Fabian Torres

He is Principal Business Consultant in SICPA - Expert in Digital Transformation - Guidance Consulting and Advice to Clients in their IT-Strategy, over the last 10 years, implementing the latest cutting-edge technologies.



A. The technology

Electronic labelling (e-labelling) is an alternative and voluntary way for manufacturers to provide a greater amount of information. It has typically been displayed with a physical label that is stamped, attached, or etched on a product. E-labelling means this compliance information is created electronically and displayed on a screen.

Over the past few years, countries, regulatory bodies and local authorities have tended to require manufacturers to display an increasing amount of information on the labels of products. Such information can range from warnings and cautions on the types of materials used and even clinical data, which then also needs to be translated into other languages. Stickers are becoming thicker, text is becoming smaller, and more and more labels are being added. With the introduction of e-labels, the distribution of information within labels has become quicker and more practical.

On the other hand, labels have started to play an increasingly important role in terms of product traceability and security against fraud. On certain products, such as alcoholic beverages, some governments are imposing increasingly stringent measures.

The use of certain certificates of authenticity, invisible or thermal inks, and other mechanisms to identify when a product has been altered or tampered with fraudulently are becoming ever more important and standardised in the sector.

E-labelling affects the last stage of the value chain of wine, namely distribution, providing benefits to manufacturers, regulators and final consumers.

For manufacturers and regulators, e-labelling offers a powerful alternative to the traditional methods of displaying compliance information. This is especially helpful as it enables product design innovation, benefits the environment and protects natural resources. It avoids unnecessary paper consumption and reduces the waste created in the process of producing and updating physical labels.

E-labelling—through QR codes, for example—provides easy access to information and also allows more information to be displayed than on a physical label, and contains all information required by regulatory bodies, while always maintaining security and reliability. QR codes are ideal for the consumer to access from the place of purchase or a restaurant. They are not only able to compile all the product information that is available, but they can also link to videos on experiences related to that specific bottle and grape.

Operational since 2010, several wineries in Spain have accepted the anti-fraud system of the "Centro Técnico Operativo del Vino (CTOV) 5" as a formula to safeguard the prestige of their brand and to offer a safer product. The purpose of the CTOV, powered by SICPA, is to protect the product against possible fraud or manipulation, as well as to improve its traceability. The encrypted and sequential code linked to each bottle is activated when the wine is bottled.

B. Application in the sector

Recent studies[5] show that illicit trade and fraud in the wine and spirits sector is on the rise. That destroys the integrity of supply chains and hard-won customer trust. For more than 90 years, a global provider of security inks as well as secure identification, traceability and authentication solution is helping the industry and governments to battle illicit trade worldwide. In that journey we discovered that it is essential, especially for the wine industry, to merge in one unique solution the material and security features, combined with powerful secure systems to help to control the full value chain to avoid illicit trade and to open a direct communication channel with the client to increase their loyalty.

The use of electronic tags is now becoming widespread. These labels have QR codes that allow the product to be traced from its origin, verifying the product that is being purchased by using a specific type of ink and holograms to prevent counterfeiting and thus achieve greater reliability for the end consumer and avoid illicit trade.

A secure QR code for electronic labels has been developed, shielded with 4 digital layers, one of them based on blockchain, which even allows the tokenisation of wine with bottle-specific NFT (non-fungible token).

C. Technology in the future

E-labels are a technology that, despite already being developed and affordable, still offers room for growth, especially in terms of potential applications and uses. The vast amount of data and information supported by this technology, coupled with its easy access, suggests that it is set to become a mainstream technology in the future. As the use of this technology becomes more widespread, its usability will increase and new functions will emerge. Traceability, cross-selling, and compliance are some of the areas where investment in this technology is being made. Great strides are expected to be made in the short/medium term.

"Thanks to the implementation of E-Label our customers can include more information in their bottles, including media content and this has helped to increase transparency"

Fabián Torres

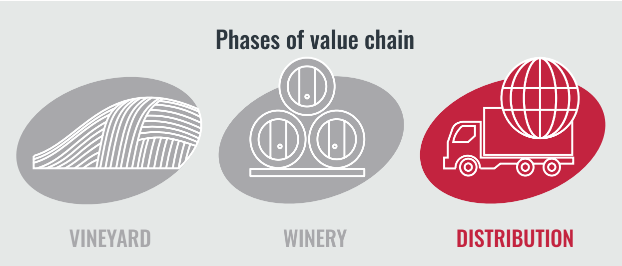
[5] (2021). *E-Label* 4.0. Spain: SICPA SPAIN SLU

6.8 E-certificate

Expert

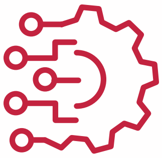
Glauco Bertoldo

Agronomist graduated from at Federal University of Paraná (UFPR), specialist in fertilizer production and technology at University from São Paulo (Esalq/USP) and specialist in data science from Mackenzie University (MACKENZIE). Federal Inspector of the Ministry of Agriculture, Livestock and Supply (MAPA) of Brazil since 2002.



An e-certificate does not necessarily imply creating a new certificate but it is rather a safer and more efficient way to exchange data throughout the whole life cycle of a product. Exchanging information electronically can offer plenty of benefits compared to the traditional certification system.

Find an illustrative example of the operational model of an Electronic certificate used for international trade.



A. The technology

An Electronic Certificate (hereinafter, E-Certificate) is a set of data that enables (i) the identification of the holder of the certificate, (ii) a secure exchange of information with other persons and institutions, and (iii) the electronic signing of data sent in a way as to allow verification of its integrity and origin.

An e-certificate contains specific information about a product to prove that it meets some requirements and certifies some of its aspects (origin, sanitary, import-export, tax, etc.). The main difference resides in that the certificate is digital, which means that the information is stored in the cloud, cannot be lost or counterfeited and can be accessed from many electronic devices.

Another major differentiating fact is that one e-certificate can contain the information of many different certificates. The same e-certificate can acknowledge the origin of a product, the quality, producer, health certificate, and any other requirement a country or counterpart needs.

Click here to see the video

Currently, the vine and wine sector has no commonly agreed standards for e-certificates, nor does it have any global certificates to simplify the trade of wine between countries or regions.

In the vine and wine sector, some of the most commonly used certificates are the organic certificate, certificate of origin, quality certificate, free sale certificate and environmental certification. At present, all these certifications are managed in the traditional way (i.e. paper certifications that must be passed along from hand to hand just like the products they certify).

Examples of certificates

E-certificates bring numerous benefits to the sector (public or private) they are implemented in. These benefits are spread throughout the entire production chain, from obtaining raw materials to marketing and exporting the finished product. The main benefits for the vine and wine sector are:

- Reduce time issuing certificates
- Improved flow of information
- Improve certificate integrity and security
- Environmentally friendly
- Reduce barriers to trade
- Regulatory modernisation

B. Application in the sector

A successful use case of an e-certificate implemented recently in the sector of fresh goods (plants and flowers) is ePhyto Certificate (an abbreviation for "electronic phytosanitary certificate"). ePhyto is the electronic version of a phytosanitary certificate in XML format.

Since 2011, the Commission on Phytosanitary Measures (CPM[6]) has encouraged the advancement of electronic certification. The CPM-9 adopted the Appendix 1 to ISPM 12. The appendix describes the format and content of electronic phytosanitary certificates and their exchange between NPPOs and refers to harmonised codes and schemes[7].

All the information contained in a paper-based phytosanitary certificate is also contained in an ePhyto. It can be exchanged electronically between countries and the data can be printed out on paper, if needed.

An ePhyto is an umbrella certificate that holds many certificates required in the trading of plants and plant-related products.

As mentioned above, the integration with a central hub helps to organize and classify all the information to streamline and facilitate the trade of these products.

It is even more important in the case of flowers and plants, as they are perishable products and can often carry pests and plagues. By reducing customs clearance times, losses due to product spoilage are minimized and all phytosanitary requirements can be grouped together in an efficient way, thus preventing the spread of pests.

Click here to see the video

[6] The Commission on Phytosanitary Measures (CPM) is the governing body of the International Plant Protection Convention (IPPC)
[7] Food and Agriculture Organisation of the United Nations

C. Technology in the future

Below is an example of how an e-certificate could be created for use in the world of wine. Before creating and implementing a digital certificate, it is essential to have a clear understanding of its intended purpose. Some things to take into consideration prior to the creation of the e-certificate are: the most common or demanded certificates by countries as of day, the sort of information to be included, how to be flexible in the information contained, etc.

To create an e-certificate for the vine and wine sector, three main aspects must first be defined, the functional, technological and financial models.

"Electronic certificates already play a prominent role in facilitating international trade. Wines must follow this innovation"

Glauco Bertoldo

1. Functional model: What certifications to include

One of the first things to determine is the information contained and what current certificates are going to be included in this e-certificate.

It is worth keeping in mind that the e-certificate does not intend to harmonise the criteria under which the countries manage their imports/exports (that is a matter determined by the legislation of each country). It will cover all the information that any country requires, and will set out what documentation needs to be submitted in order to be able to trade with such country.

There are currently many different certificates containing a wealth of information. This makes exporting a complex process, which very often leads to delays, a lack of transparency and problems with the flow of information.

The main difficulty in creating the digital certificate is defining how much information it needs to contain, and the flexibility to integrate all the information required by each of the countries. All this can only be achieved if the information is organised in a predefined and systematic way so that it can be found and accessed quickly and easily.

For exports in the vine and wine sector, some of the most important certificates are:

The fact that the e-certificate can contain all certifications does not mean that all of them are to be fulfilled. It is possible to include only the information necessary to export to a specific country, with the option of adding more information later.

In addition to all the certificates it contains, it will be necessary to add several categories of information relevant to the trade of the products.

2. Proposal to categorize information

- **General information, which contains relevant data of the trade operation**: the producer, importer, exporter, brand name, country of origin, country of destination, quantity, etc.
- **Product details, with information on product specifications**: classification, WCO code, packing information, batch...
- **GI data, which contains info regarding**: Country, national type, international type, product category, name, Geographical indication/appellation of origin (GI/AO)...
- **Analysis results**: This category includes all information related with lab work, product tests, analysis, and chemical specificities of the product: Report of analysis ref. name of laboratory, density, total alcoholic strength,
- **Additional declarations**: This is a slot reserved for all the information that countries may request and which are not included in any other specific category previously mentioned. It also covers any certification or reassurance any official body has granted the product, for example: The <official body> of <country> certifies that the above listed product was produced following the production methods approved in <Country> and is fit for export.

3. Technological model

As mentioned before, a hub stores and classifies all information and certificates, allowing all users to consult any information that has been stored.

There are plenty of ways countries or users can exchange and access the information contained in the hub. Some of the most common technologies used for this are:

- **Application programming interface (API)**: An API(7) is a software intermediary that allows two applications to interact with one another. When an application is used, it connects to the Internet and sends data to a server. The server then retrieves that data, interprets it, performs the necessary actions and sends it back to the user. The application then interprets that data and presents the information in a readable way.
- **It is a standard connection between systems that allows the information to be transmitted instantly.**
- **Point to point communication (P2P)**: In modern computer networking, the term point-to-point telecommunications means a wireless data link between two fixed points. The telecommunications signal is typically bi-directional and either time division multiple access (TDMA) or channelized. The most prominent example of point-to-point communication is a simple telephone call, where one phone is connected with another, and both nodes can send and receive audio.
- **E-mail**: This is a regular system in which the user can share the certification and plenty of other information via standard e-mail. A fast and easy solution does not carry any specific requirements hardware wise. The information is stored and organised in a Hub, and is then digitised in e-mail format to make it easily accessible, shared and interpreted.

In terms of the technological model and information delivery, the countries/users can decide which format suits them best, allowing them to have different formats throughout the whole export process, choosing the most convenient one each time.

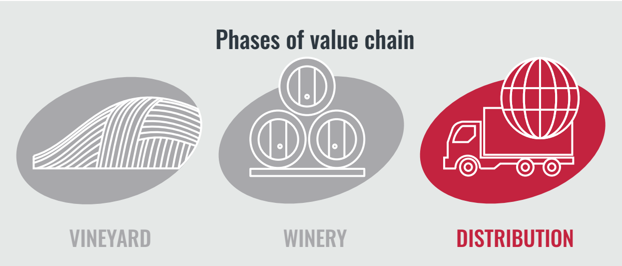
(7) For a simple explanation, **click here**

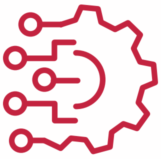
6.9 Smart Storing

Expert

Sergi Almar

Sergi is a partner at Minsait Business Consulting from Indra (one of the world's leading global technology and consulting companies). He is an engineer with an MBA and international experience in business consultancy, focusing mainly on Supply Chain.





A. The technology

Smart warehouses (smart storing) aim to provide efficiency to logistics, helping companies reduce costs and increase product input and output cycles. This is the latest technology used in logistics centres to increase efficiency in processes such as the reception of goods, order preparation and product storage.

With this technology, smart warehouses operate under the control of warehouse management software (WMS). This system directs operators and handling equipment in processes such as receiving or order picking (among many others), to optimise warehouse resources.

The implementation of logistics software is essential to guarantee full control of warehouse stock and, above all, to ensure product traceability in a facility (a logistics attribute increasingly demanded by companies).

This type of warehouse is made up of four key technologies: Warehouse automation; Warehouse management software (WMS) and other applications, such as ERP, SCA/WCS or MES; Radio frequency identification systems (RFID); and Disruptive technologies: blockchain, big data, AI, IoT, etc.

Companies find many benefits with the implementation of intelligent warehouses, as they improve logistics efficiency and allow them to have greater adaptability in the preparation and delivery of orders to the customer:

- Optimisation of warehouse resources
- Increased productivity (increase in picking cycles and storage of goods)
- Availability of a permanent inventory
- Efficiency in order preparation (optimised picking routes)
- Increased fluidity in logistics processes
- Improved safety for employees, storage systems and goods
- Increased storage capacity of the facility
- Logistic KPIs updated in real time
- Total control of the status of the goods
- More accurate demand forecasting
- Automated and comprehensive product traceability

B. Application in the sector

There are multiple applications that, synchronised with the company's ERP, make all processes more efficient.

- The Warehouse Management System (WMS) acts as the brain of the warehouse. It is responsible for coordinating all the processes that take place inside it, from the reception of inputs to the output of orders. By way of example, easy WMS (the Mecalux WMS) incorporates more than 80 advanced functionalities ranging from the management of dispatch routes to cross-docking or wave picking.
- The Warehouse Control System (WCS) is the application that coordinates the tasks of the multiple automatic handling equipment with the WMS orders. It is, therefore, a basic component of intelligent warehouses, as it ensures the correct operation of the entire installation.
- The Manufacturing Execution System (MES) in intelligent warehouses with production lines is the computer system that facilitates the sequencing of production activities, the assignment of tasks to each operator or quality control (of both raw materials and end products).

For example, in a winery in northern Spain, a finished product warehouse automation project was undertaken with robotics. The aims were to: gain flexibility in warehouse operations, improve the service quality for customers, increase the capacity for picking and dispatch of the finished product and boost warehouse productivity by automating tasks and reducing the need for manpower.

To achieve this, the management of the finished product storage areas was automated by deploying AGVs. A robotic palletiser was implemented for the preparation of consignments and SAP's EWM was installed as a management tool for warehouse operations. SAP Fiori provided mobility solutions to simplify the work (use of a camera to read labels, portable printers for operators and sending instructions to the AGV).

Since 1991, a well-known Italian cooperative has invested 42 million euros in technology. A large part of this investment has been allocated to the implementation of intelligent warehouses to increase efficiency in the distribution of its products:

- Warehouse System 4.0 (2018). 14 metres underground to facilitate integration with the territory.
- New fully automated bottling lines in 2018 and 2020.
- 20 new environmentally friendly stainless steel vats, underground (2020).
- Photovoltaic system (2020). 500 KW/hour to power the automated warehouse.

From the empty bottle to packaging and palletising, everything is automated. The way the bottled wines are stored is via trolleys that transport the pallets of boxed wines to a central storage system where a separate mechanical picker is responsible for storing and picking the orders from the various customers and drivers.

This is a large system where the pallets are transported by mechanical trolleys and stored in a large warehouse capable of holding an impressive 7,000 pallets and four million bottles. This warehouse is very large and is one of those innovative storage centres where everything is fully automated, including order picking.

> *"The main objective that companies seek with robotisation of warehouses is gains in efficiency, resulting in a reduction of costs and greater accuracy in the delivery of products to the customer"*
>
> Sergi Almar

[18] Mecalux Esmena (2020), *Smart warehouses: from automation to big data*

C. Technology in the future

This technology is at an early stage of adoption in all sectors, but it is worth noting that a higher level of maturity is reflected in sectors/organisations where there is a high volume of storage and a large number of product references. “*Until today, this type of technology has not yet reached a high level of development in the distribution phase of the value chain of the vineyard and wine sector, but it is true that the demand for these technologies by companies in the sector is increasing and, therefore, we will see a greater impact in the coming years.*” Sergi Almar.

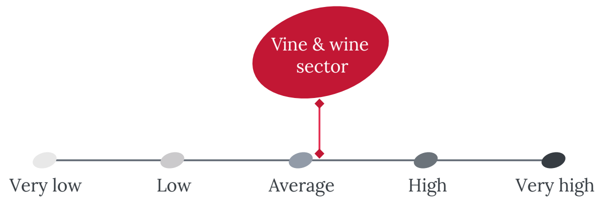
7 Country insights on vine and wine sector digitalisation

This section provides a deeper insight into the state of digitalisation in the vine and wine sector according to experts from OIV Member States. The aim is to know what technologies are more prevalent today, their benefits, maturity level and future of each technology at each stage of the value chain. In other words, this chapter focuses on the progress and impact of digital trends and technologies in the vine and wine sector.

To this end, a digital survey consisting of 8 questions was conducted among experts belonging to 18 OIV Member States. Most of the respondents reported that digitalisation in the sector is at an early stage of adoption. The contrast between the rapid pace of technological development in today's society, and the fact that the vine and wine sector has not yet reached digital maturity, has logically led respondents to expect a strong push towards digitalisation in the short and medium term.

A detailed summary of the answers to the questions concerning digitalisation in the vine and wine sector is given below.

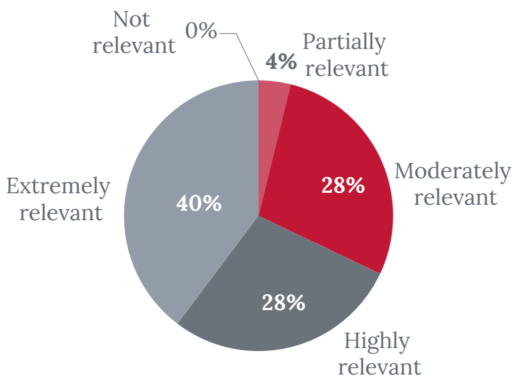
1. **In comparison with the other agro sectors (coffee, cocoa, olive oil...), what is the current extent of adoption of digital technologies in the vine and wine sector?**



The graph above shows that the vast majority of the experts surveyed think that the degree of adoption of these technologies is "average" in the vine and wine sector when compared with other agro sectors. The vine and wine sector does not seem to lag behind other agro-food sectors in general in terms of its extent of digital adoption.

2. How significant do you think the impact of digitalisation will be in the next 5-10 years in the vine and wine sector?

Impact of digitalisation in the next 5 - 10 years / Digitalisation benefits expected in each step of the value chain



It is clear that the respondents acknowledged the relevance of technological developments in the sector in the coming years. According to the data collected, as can be seen from the graph above, 68% of the respondents believe that digitalisation will have a major impact on the sector in the next 5-10 years. Only 4% believe that it will have little or no impact.

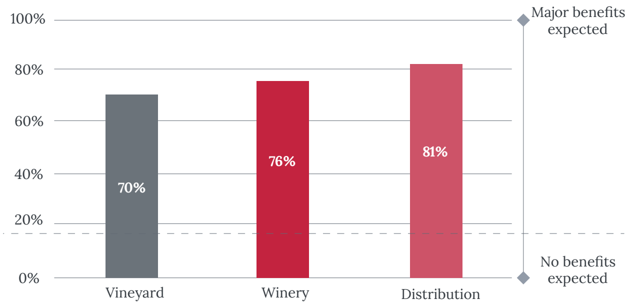
3. Currently in your country, how digitalised is the vine and wine sector in each stage of the value chain?

Degree of digitalisation at each stage of the value chain

Most experts indicated that the most digitalised stages in the value chain are the distribution and winery stages. Technological progress has given rise to numerous opportunities in winery and distribution stages of the value chain, which have been possible by technological applications already referred to in this report. The distribution stage shares technological solutions with other sectors, which could explain the higher degree of development. Nevertheless, in the vineyard improvements have been made thanks to technologies such as drones, robotics and autonomous machinery, broad spectrum satellite images, sensorization and other technologies related to smart vineyards.

4. To what extent can each step of the value chain benefit from digitalisation in the next 5 to 10 years?

Digitalization benefits expected in each step of the value chain



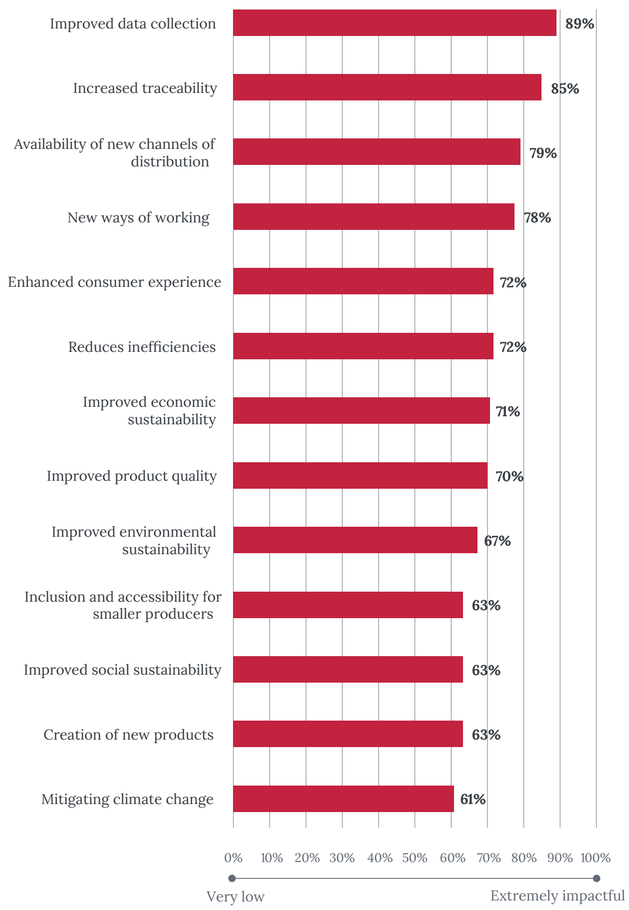
The answers of the experts give an idea on how the vine and wine sector can benefit from digitalisation in the three main stages of the value chain. The distribution stage can continue to increase efficiency and reduce supply costs through the implementation of smart storing facilities capable of automating manual or repetitive tasks.

In the wineries, the application of artificial intelligence and the exploitation of data obtained from sensors placed across production process are expected to increase productivity and provide real-time control over the inventory and the state of barrels.

Robotics and image processing will also contribute to improving vineyard productivity and yield.

5. What fields will be impacted by digitalisation of the vine and wine sector the most?

Future impact of digitalisation on the vine and wine sector

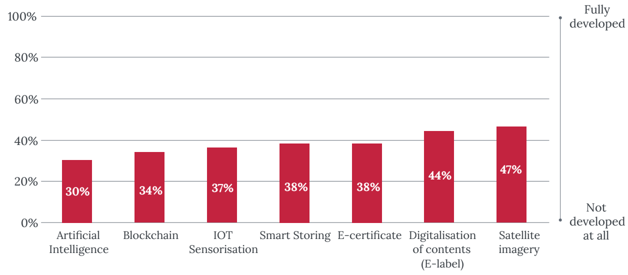


The results reveal that countries expect major benefits from the development of technologies in all aspects of the sector overall. 89% of respondents believe digitalisation will be beneficial in terms of improved data collection (data on quality, weight, grape acidity, etc.) while 85% think it will enhance traceability.

Other effects will include the emergence of new distribution channels, the implementation of new ways of working and the enhancement of the end-consumer experience.

6. What is the degree of development of the following technologies in your country's vine and wine sector?

Digitalisation degree
Degree of development of the following technologies



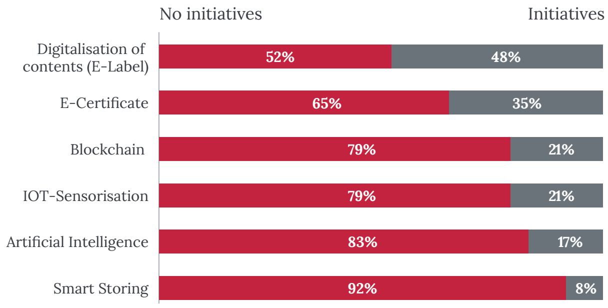
** The score shown in the graph only includes data from regions for which information is available.*

As pointed out in previous questions, respondents consider that technologies still have a relatively low degree of maturity in the sector (an average adoption rate of around 40%). This seems to indicate that the sector's digitalisation process has already started and has the potential for further development in the coming years.

The result of the graph reveals that the technology with the highest degree of development in the respondent countries today is general cartography (satellite imagery/drones...).

7. **Are there any public initiatives (schemes/ support programmes/policies) currently in place in your country to promote the following digital tools in the vine and wine sector?**

Existence of current public initiatives to promote the following digital tools in the vine and wine sector



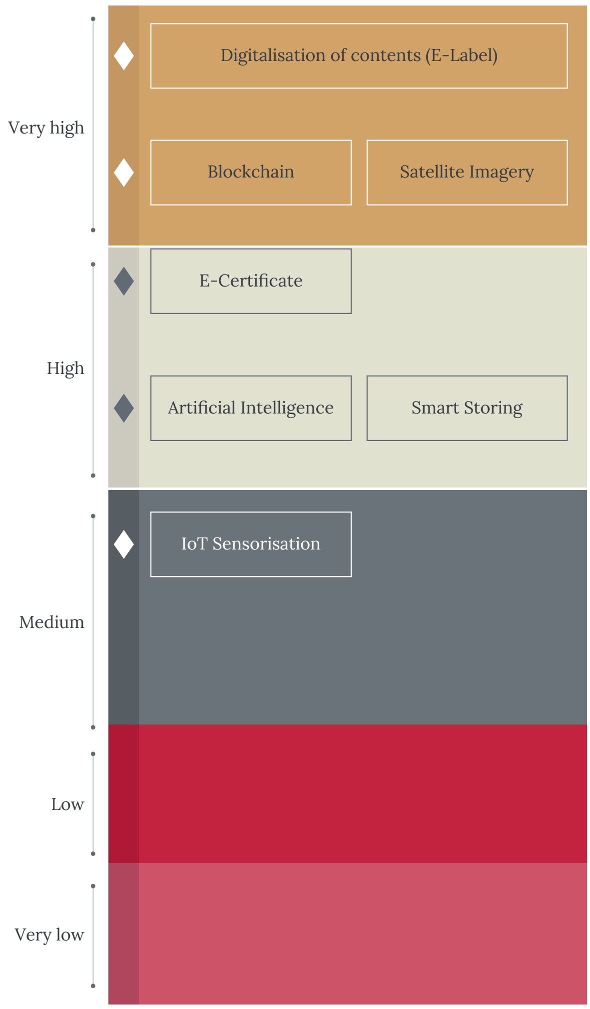
The answers reveal that so far there has been little support in the form of public initiatives to promote digitalisation in the sector. The focus of public institutions seems to have been limited to the digitalisation of contents, regulatory information and processes such as, for example, QR-code labelling (indicating the ingredients and origin of the wine).

According to the respondents, the public sector in some of the member countries promote other initiatives such as:

- The use of artificial intelligence to control insect traps in fields
- The digitalisation of documentation/certifications
- The use of sensors in the vineyard to anticipate possible weather problems (e.g. frost or hail) and optimise the use of phytosanitary products
- Wine producers associations or regional bodies supervising the quality of local wines, who apply a label of quality on wines along with a holographic sticker certifying origin and authenticity.

8. **Which of these technologies should be prioritised for the digital transformation of your country's vine and wine sector?**

Priority Level



The respondents consider that the technologies that must be prioritised first are those capable of increasing efficiency, productivity and regulatory improvements. This is the case of technologies related to the digitalisation of production-related processes or the processing of images obtained from drones or satellites (general cartography). Blockchain is also regarded as a high-priority technology that can improve the traceability of wine from its origin in the vineyard to its consumption by the end consumer.

Other technologies of priority include the e-certificate, artificial intelligence or smart storing, despite of them being at an early stage of development. Other more established technologies such as sensorisation / IoT are held as a medium priority, despite their growth potential.

The survey participants consider that none of the technologies identified should be given low or very low priority.

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8 Conclusions

The vine and wine sector has now entered into an age of modern digitalisation. Before it lies many opportunities for innovation and a myriad of benefits to take advantage of, such as improved vineyard yields; increased productivity through the exploitation of data using technologies such as artificial intelligence; or the reduction of supply costs by implementing smart storing.

Faced with the opportunities that digitalisation of the sector offers, there are still a number of uncertainties (which technologies to invest in, the difficulty and resources required to implement them and certain risks when making decisions, etc.) that hinder the evangelisation and generalisation of these technologies. This makes it difficult to become a leading sector in the use of these technologies and to adapt to an increasingly technological world.

It can be concluded that the adoption of digitalisation in the vine and wine sector is still at a low maturity level but with a high rate of growth and potential. A significant impact on the sector is expected in the short to medium term (5-10 years). The experts surveyed believe that the level of adoption of these technologies is “medium” when compared to other sectors. While the vine and wine sector is not the most technologically advanced, it does not appear to be lagging behind other agro-food sectors such as coffee, olive oil, cocoa, etc.

There are a number of challenges to be addressed for digitalisation in this sector to reach a high degree of maturity. Some have been identified such as the lack of public initiatives support, the high implementation costs for small producers or the low commitment of end-users.

Nevertheless, as most experts interviewed believe, digitalisation will bring major benefits throughout the different stages of the value chain. These include improved data collection at source (acidity, quality, weight, etc.), aimed at improving vineyard productivity and yield, product traceability, a more efficient use of data to increase productivity, and improvements leading to the introduction of new distribution and marketing channels.

Glossary

1. Artificial Intelligence (AI): machine-based system that can, for a given set of human defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. (OECD)
2. Blockchain: a blockchain is a shared ledger of transactions between parties in a network, not controlled by a single central authority. You can think of a ledger like a record book: it records and stores all transactions between users in chronological order. Instead of one authority controlling this ledger (like a bank), an identical copy of the ledger is held by all users on the network, called nodes. (OECD)
3. Circular Economy: maintaining the value of products, materials and resources in the economy for as long as possible and minimising waste. (European Commission)
4. Digitisation: the process of changing data into a digital form that can be easily read and processed by a computer. (Oxford)
5. Digital transformation / Digitalisation: refers to a process of adoption of digital tools and methods by an organisation, typically those that have either not been including the digital factor as part of their core activities or have not kept up with the pace of change in digital technologies. (OECD-OPSI)
6. Internet of Things (IoT): the connection of devices within everyday objects via the internet, enabling them to share data. (Oxford)
7. Light Detection and Ranging (LiDAR): is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses – combined with other data recorded by the airborne system – generates precise, three-dimensional information about the shape of the Earth and its surface characteristics. (National Oceanic and Atmospheric Administration – U.S. Department of Commerce).
8. Technology: scientific knowledge used in practical ways in industry, for example in designing new machines. (Oxford)

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