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Advanced Technologies for Industry – Product Watch

Satellites and drones for less intensive farming and arable crops

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EUROPEAN COMMISSION

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Section 1

1. Background and objectives of the report

Background

The Product Watch Reports have been developed in the framework of the 'Advanced Technologies for Industry' project and serve to identify and analyse 15 promising ATI-based products and their value chains, with an assessment of the strengths and weaknesses of the EU positioning.

Promising ATI-based products can be defined as "*enabling products for the development of goods and services enhancing their overall commercial and social value; embedded by constituent parts that are based on AR/VR, Big Data & Analytics, Blockchain, Cloud, Artificial Intelligence, IoT, Mobility, Robotics, Security & Connectivity, Nanotechnology, Micro-nanoelectronics, Industrial Biotechnology, Advanced Materials and/or Photonics; and, but not limited to, produced by Advanced Manufacturing Technologies*".

1.1 Background of this report

Food security. As the global population continues to rise, there is increasing pressure on the agricultural sector to ensure the provision of sufficient food. With a current estimated population of 7.8 billion inhabitants[1], and an expected growth of roughly another 2 billion by 2050, this global challenge is imminent.[2] A recent report highlights that, despite efforts to ensure food security and address the Sustainable Development Goals[3], the number of persons globally affected by hunger is on the rise.[4] The agri-food sector is further threatened by impacts to productivity and harvest as a consequence of climate change. Natural hazards such as drought, pest and disease outbreak and flooding are among the challenges the sector faces, further risking food security.

A growing need for resource efficiency in agriculture. Increasing yield per hectare is an important element in ensuring that sufficient food is prepared to feed the growing population. A key part of this is also the reduction of food losses from the sector, e.g. due to poorly timed harvest.[5] At the same time, the agricultural sector is pressured to reduce its environmental impact, seeking increased resources efficiency in the inputs, as well as the emissions coming from the sector. The agricultural sector accounts for 70% of freshwater consumption globally, which has increased six-fold over the past 100 years. Through the use of technologies, there is a potential to limit food losses in production, and in turn increase the amount of food yield per hectare, as well as monitor the evapotranspiration which is key for a sustainable agricultural sector and water resource management and the related Sustainable Development Goals.[6]

A move towards precision agriculture, smart farming and digital farming. Hand in hand with a transition to an Industry 4.0, is also the transition to an agri-food 4.0, also referred to as precision agriculture. Precision agriculture includes the use of digital techniques to monitor and optimise farming practices and output.[7] In addition, smart farming involves all farming operations, and not only the

[1] Worldometer. (2020, September 28). Current World Population, https://www.worldometers.info/world-population/
[2] FAO. (2018). The future of food and agriculture: Alternative pathways to 2050, http://www.fao.org/3/I8429EN/i8429en.pdf
[3] The report refers specifically to SDG Target 2.1 'by 2030 end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round' and Target 2.2 'by 2030 end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons'

[4] FAO, IFAD, UNICEF, WFP and WHO. 2020. In Brief to The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Obtained via: https://doi.org/10.4060/ca9699en
[5] Fruit Logistica. (2020). Do the right thing (right). https://www.fruitlogistica.com/media/fl/fl_dl_all/fl_dl_all_fachbesucher/Fruit_Logistica_Trend_Report_2020.pdf
[6] The European Space Agency. (2020). Satellite and machine learning for water management. http://www.esa.int/Applications/Observing_the_Earth/Satellites_and_machine_learning_for_water_management
[7] European Parliament. (2019). Precision agriculture and the future of farming in Europe. https://op.europa.eu/en/publication-detail/-/publication/40fe549e-cb49-11e7-a5d5-01aa75ed71a1/language-en

machines of the farm. Together, smart farming and precision agriculture, are referred to as digital agriculture.[8] Specifically relevant digital technologies include the Internet of Things (IoT), Big Data and Artificial Intelligence as they facilitate the application of technologies across value chains, while targeting increased resource efficiency and higher yields per hectare. The precision farming market is currently valued at €6 bn in 2020[9] and is estimated to grow to a value of €11 bn by 2025, based on a Compound Annual Growth Rate of 12.7%.[10] This growth can be attributed to the increasing importance of IoT, predictive analytics and improved farm management opportunities.

The role for drones and satellites. Recent initiatives such as the Copernicus project, but also private projects, have advanced the availability and quality of remote sensing data for applications in the agricultural sector. These include both data that are captured via satellites, as well as drones. **Satellites** are able to capture agricultural information through the use of sensors that are mounted onto them, taking images of the earth surface at regular intervals corresponding the moments when a satellite passes over a certain geographic area. The Satellite Data Services Market, which refers to applications in various sectors, including agriculture, was valued at €6.5 bn in 2019, and is projected to grow up to a value of €20.1 bn by 2025 at a Compound Annual Growth Rate of 21% over that period.

Figure 1: Satellite data services market – projected growth between 2019 and 2025

Source: Markets and Markets, 2019

The amount of this type of data available for the agri-food sector has substantially increased in recent years and the trend is on the rise.[11] **Drones** are able to provide insights to a multitude of sectors[12] and are able to offer the same information as satellites on land use and related to the land surface in a transparent and objective way, as they use the same spectral resolution and have the same usefulness for farmers.[13] The main benefit of drones compared to satellites is the flexibility (different sensors are

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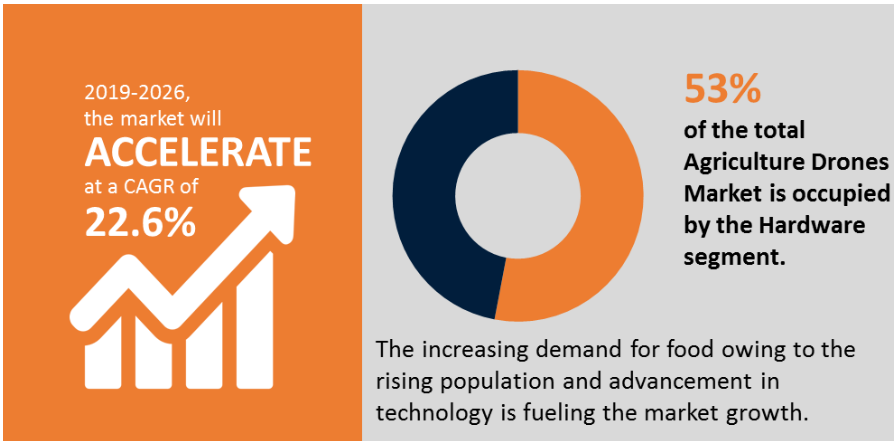
[8] AgroCares. (n.d.). What is the difference between precision, digital and smart farming? https://www.agrocares.com/en/news/precision-digital-smart-farming/
[9] Based on current exchange rate 28 September 2020, 1 EUR = 1.16279 USD
[10] Markets and Markets. (2020). Precision Farming Market by Technology (Guidance, VRT, Remote Sensing), Application (Crop Scouting, Field Mapping, Variable Rate Application), Offering (Hardware—Sensors, GPS, Yield Monitors; Software; Services) and Geography - Global Forecast to 2025 https://www.marketsandmarkets.com/Market-Reports/precision-farming-market-1243.html?gclid=Cj0KCQjwk8b7BRCaARIsAARRTL4HSgy1tYWUnAcoY17b5Jtw7PsTTwjKrMWjFHnfFcNF-G1x_C3n7M4aAgy5EALw_wcB
[11] OECD. (2018). How digital technologies are impacting the way we grow and distribute food. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/CA/GF(2018)1&docLanguage=En
[12] European Commission. (2018). Drones in agriculture. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Drones_vf.pdf
[13] The European Space Agency. (2020). Satellites provide crucial data on crops during COVID-19. https://www.esa.int/Applications/Observing_the_Earth/Satellites_provide_crucial_data_on_crops_during_COVID-19

possible, and imagery is available wherever and whenever needed) and the increased spatial resolution. While satellites offer information at specific moments related to their position, drones can be integrated into farming and agricultural advice on an as-needed basis. The use of drones is also subject to the drone legislation of each country or region. A recent report from the Food and Agriculture Organisation (FAO) highlights that harnessing the information from drones is vital in addressing the sustainability challenges that agriculture is faced with, both in relation to climate change, as well as the Sustainable Development Goals.[14] The Global Agriculture Drone Market is forecast to reach €5.75 bn by 2027, an increase from roughly €1.1 bn in 2019.[15] Market reports highlight that COVID-19 has impacted the sector, mostly due to government restrictions, however it is forecast to pick up in 2021.

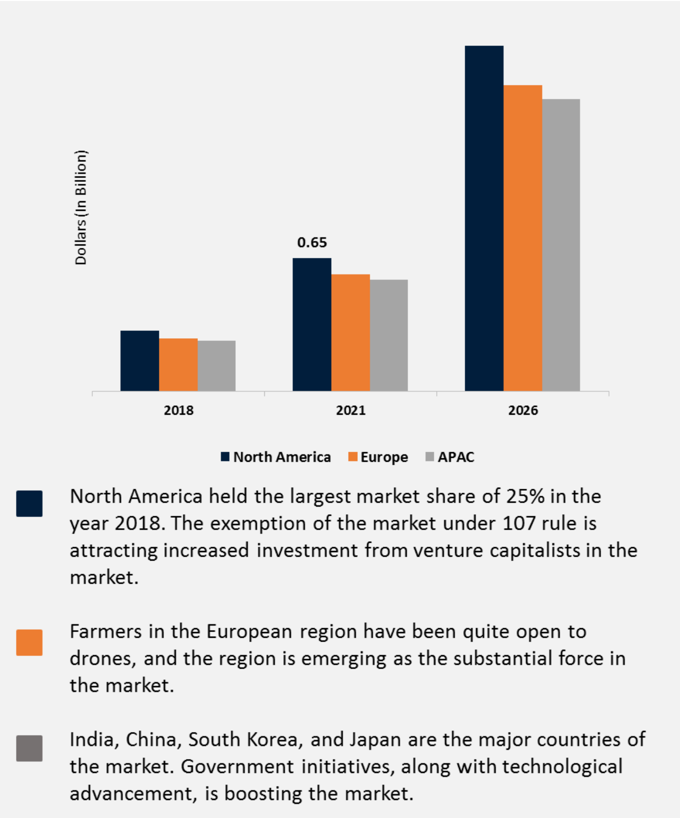
Figure 2: Developments for the agricultural drone market: projected Compound Annual Growth Rate (CAGR) and market share in the hardware segment



Source: Reports and Data, 2020

[14] FAO. (2018). E-agriculture in action: drones for agriculture. http://www.fao.org/3/I8494EN/i8494en.pdf
[15] Reports and Data. (2020). Agriculture Drones Market By Component (Hardware, Software & Services), By Integration (Pharmaceutical Grade, Food Grade), and By Application (Crop Scouting, Field Mapping, Livestock Monitoring, Smart Greenhouse, Crop Spraying, Others), Forecasts To 2027. https://www.reportsanddata.com/report-detail/agriculture-drone-market

Figure 3: Developments for the agricultural drone market: Market size in major world regions and expected growth between 2018, 2021 and 2026.[16]

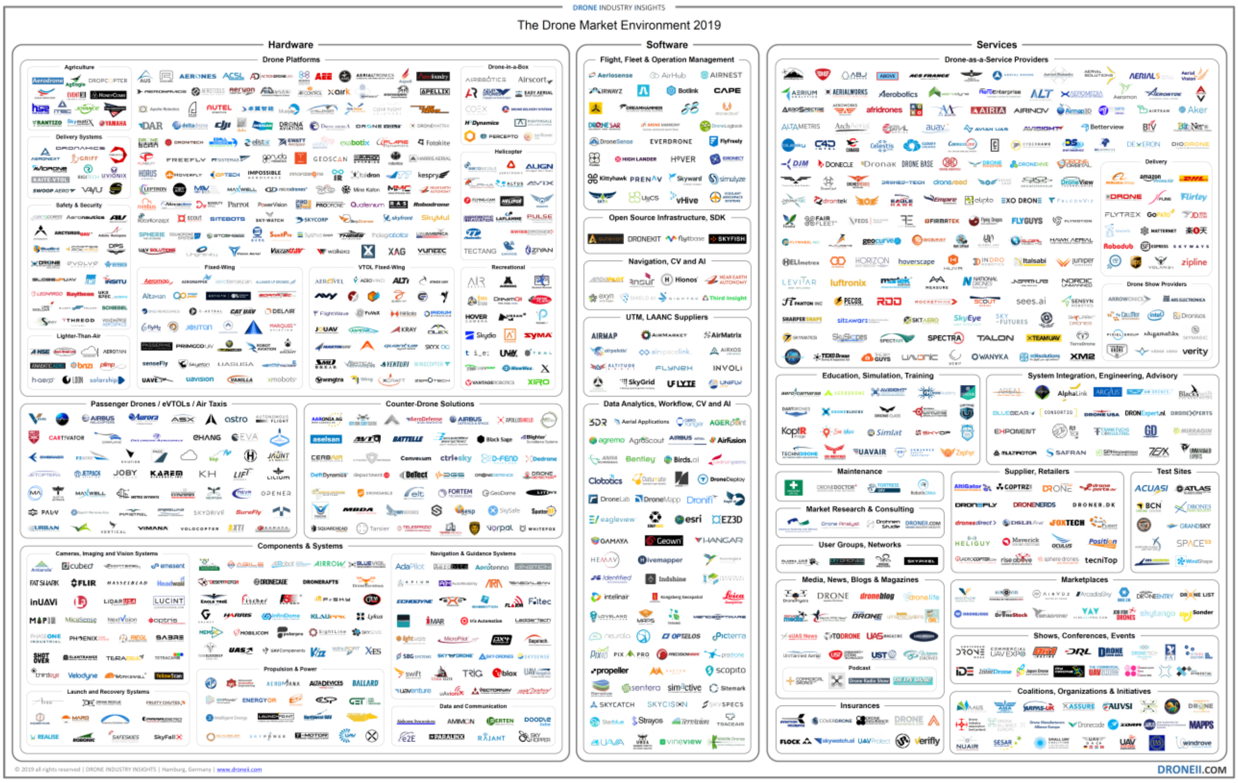


Source: Reports and Data, 2020

Figure 4 gives an overview of the drone market environment based on Drone Industry Insights. While the figure does not focus on drones for agricultural applications alone it gives an impression of the fragmented nature of the market.

[16] The 107 rule refers to legislation in the United States that allows business to fly drones without applying for authorisation from the Federal Aviation Administration while still being in compliance with Federal Law. For more details see: https://skyward.io/part-107-basics-commercial-drone-regulations-in-the-u-s/

Figure 4: Overview of the fragmented drone landscape - The drone market environment 2019



Source: Drone Industry Insights, 2020

1.2 Objectives of this report

Digital technologies are rapidly changing agricultural practices today. Farmers still struggle to adopt the technologies that are suitable for their specific practices, often due to high investment cost, both financially and in terms of skills. Specific evidence for all types of arable crops are needed to sufficiently encourage farmers to take up the practices in their specific field, where further customisation is frequently needed.

The report specifically zooms in on the use of satellite and drone technologies for arable crop farming, providing an overview of the context, value chain and relevant stakeholders. The objective is to map the key players in the satellite and drone technology for arable crops value chain, as well as to identify their strengths and weaknesses, also in comparison with international players. Analyses were based on desk-research, interviews as well as on the internal expertise of IDEA Consult on the subject.

Section 2

2. Value chain analysis

2.1 Value chain structure

The proposed value chain focuses on the 'Satellites and drones for less intensive farming and arable crops' value chain. For the purpose of this report, we focus on less intensive farming. Less intensive farming is understood to focus on outdoor and less intensive crops such as arable and staple crops, cereals and vegetables.

The value chain is depicted in Figure 5 with indications on the general value chain structure in grey, followed by specific value chain in green. Both the general and specific value chains are primarily supported by Internet of Things, Big Data and Artificial Intelligence.

Inputs. This segment of the value chain focuses on the inputs to the agricultural production as well as the data collection related to precision farming using satellite and drone data. Advanced technologies such as drones, satellites, but especially also sensors, cameras, and data gathering, and processing infrastructure are needed in order to carry out these activities.

Data interpretation for applications. Between the inputs and primary production there is data interpretation that feeds into the primary production process. The value chain focuses on satellite and drone data interpretation for the following application areas:[17]

- Topographic survey
- Crop area mapping
- Phenotyping
- Monitoring yield, biomass and soil condition
- Crop inspection
- Crop water status (early detection of water deficit or crop water stress)
- Soil characteristics (texture, soil fertility)
- Heterogeneity of crop development in different farm zones
- Early detection of disease
- Variable rate application (fertilisers, seeds, chemicals, water, etc.)
- Farm machinery guidance / automatic steering
- Farm machinery monitoring and asset management
- Geo-traceability

Primary production. In the primary production segment of the value chain, the inputs as well as the data interpretation come together to support the overall production activities to achieve, among others, optimal harvest. The agricultural products that are produced will ideally have a higher yield and better quality and thus allow for appropriate margins to be obtained by the stakeholder active in this value chain segment.

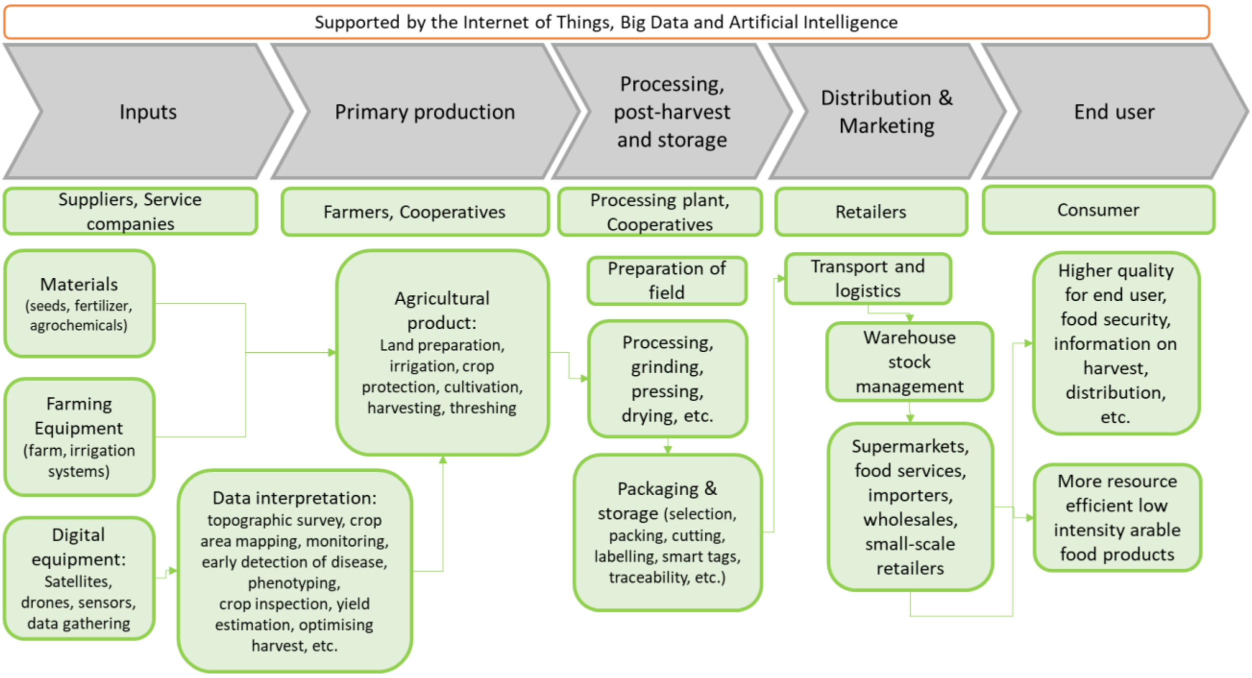
Processing, post-harvest and storage. This value chain segment features processing plants, but also increasingly includes other stakeholders such as cooperatives active in processing but also packaging foods. Increasingly traceability is becoming more and more important for consumers, and hence also smart tags and big data are involved in this value chain segment.

Distribution and marketing. Retailers but also transport and logistics companies are active in this segment. Here it is important to note that retailers play a vital role in choosing which products to give shelf life to, but also in determining the price for indicated products.

[17] European Commission. (2018). Drones in agriculture. https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/Drones_vf.pdf

End user. End users are increasingly interested in high quality products, but also demand food security and traceability of their products.

Figure 5: Satellites and drone technology for less intensive farming and arable crops



Source: based on Pesce et al., 2019 and Sims et al., 2015

2.2 Key actors in the value chain

Along the value chain, a series of key actors can be identified. A non-exhaustive list of key actors includes:

- Farmers
- Drone and drone component manufacturers
- Satellite and satellite data providers
- Integrated service providers
- Intermediaries, cooperatives and research and technology organisations

Farmers. The proposed value chain focuses on farmers that are active in growing less-intensive crops, such as arable crops. Farmers are faced with the decision about which technologies to adopt to support their decision making and are increasingly interested in the possibilities that drones and satellites can offer.

Drone and drone component manufacturers. The drone manufacturing market is very fragmented, with certain players focussing specifically on applications for the agricultural sector. These are highlighted in Table 1, with an indication of the specific application area (if relevant) this manufacturer is active in.

Table 1: Non-exhaustive list of drone and drone component manufacturers for arable crop applications

Drone and drone component manufacturer	Application areas	Country	Website
DJI	Drone manufacturer	South Korea	https://www.dji.com/

Drone and drone component manufacturer	Application areas	Country	Website
Droneseed	Seed distribution	United States	https://www.droneseed.com/
DRONExpert	Custom developments for integration of sensors in drones	Netherlands	https://dronexpert.nl
FLIR	Thermal Camera	United States	www.flir.es
Hyphen - Airphen	Phenotyping	France	https://www.hiphen-plant.com/our-solutions/airphen/
Maia	Multispectral camera	Italy	https://www.spectralcam.com/
MicaSense	Sensor technology for drones	United States	https://micasense.com/
Parrot[18]	Drone manufacturer	France	https://www.parrot.com/en
Precision hawk	Drone manufacturer	United States	https://www.precisionhawk.com/
PX4Dsurvey	4D drone mapping software	Switzerland	https://www.pix4d.com/
Range rotors	Crop protection	Germany	https://rangerotors.de/
Rauch	Spreader	Germany	https://rauch.de/en/
SenseFly	Fixed wing and rotary drones with multispectral, thermal and single-band cameras	Switzerland	https://www.sensefly.com/solution/ag-360-agricultural-drone/
Skydronex	Drone manufacturer	Spain	https://www.skydronex.com/
Trimble	Drone manufacturer	United States	https://www.trimble.com/

Source: Compiled by IDEA Consult based on PwC 2016, interviews

Satellite data providers. Satellite data can arise from both public and private satellites, where Table 2 presents a non-exhaustive list of these stakeholders.

Table 2: Non-exhaustive list of satellite and satellite data providers (public and private)

Satellite data provider	Country	Website
Apollo mapping	United States	https://apollomapping.com/
Copernicus – Sentinel 1	European Union	https://sentinel.esa.int/web/sentinel/missions/sentinel-1
Copernicus – Sentinel 2	European Union	https://sentinel.esa.int/web/sentinel/missions/sentinel-2

[18] Acquired Sequoia

Satellite data provider	Country	Website
Copernicus- Sentinel 3	European Union	https://sentinel.esa.int/web/sentinel/missions/sentinel-3
Digital Globe / Maxar	United States	https://www.digitalglobe.com/
NASA	United States	https://worldview.earthdata.nasa.gov/
NOAA	United Stats	https://www.noaa.gov/satellites
One Atlas - Airbus	European Union	https://www.intelligence-airbusds.com/oneatlas/
Planet	United States	https://www.planet.com/
RapidEye / Blackbridge /Planetlabs[19]	Germany, Canada, United States	https://earth.esa.int/web/eoportal/satellite-missions/r/rapideye
SPOT 5/6/7	France	https://oneatlas.airbus.com/
Telespazio	France	https://www.telespazio.fr/fr/nos-solutions/environnement-agriculture-forets
Terrasat- Airbus	European Union	https://www.intelligence-airbusds.com/en/8694-terrasar-x-tandem-x
UrtheCast / GEOSYS	Canada	https://www.urthecast.com/geosys/

Source: Compiled by IDEA Consult based on interviews

Integrated service providers. Service providers play a vital role in adding value to the data collected through interpretation and decision support for farmers. A non-exhaustive list of stakeholders is presented in Table 3, with indications of the application areas for each integrated service provider as well as their country and website.

Table 3: Non-exhaustive list of integrated service providers

Integrated service providers	Application areas	Country	Website
365 Farmnet	Farm management software	Germany	https://www.365farmnet.com/en/
Agrisat	Time series for agriculture based on satellite data	Spain	https://www.agrisat.es/en/
Agrodrone 360	Drone based monitoring	Italy	https://www.agrodrone360.it/
Agrosat	Satellite data-based monitoring	Italy	https://www.agrosat.it/it
Airbus	Monitoring services based on satellite data	France	https://www.intelligence-airbusds.com/monitoring-services-for-agriculture/
Auravant	Digital agriculture platform, satellite-based	Argentina	https://www.auravant.com/en/home/
Boer en Bunder	Satellite based parcel information	Belgium	https://boerenbunder.be/
Climate corporation – fieldview	Integrated data platform, using satellite or other data sources	United States	https://climate.com/
Cropio[20]	Crop health management and vegetation control platform	Cyprus	https://about.cropio.com/
Dacom	Software for agri-business	Netherlands	https://www.dacom.nl/
Delair	Drone based multi and hyperspectral data	France	https://delair.aero/agriculture-forestry-business-solutions/

[19] No longer actively collecting data, but impressive historical records are available: https://www.planet.com/pulse/historic-rapideye-constellation-captures-last-light/

[20] Acquired by Syngenta https://www.bizjournals.com/triad/news/2019/09/02/syngenta-acquires-agri-business-software-company.html

Integrated service providers	Application areas	Country	Website
Didex	Drone based	Belgium	https://didex.be/en/
Dronebee	Satellite and drone-based maps and decision support	Italy	https://www.dronebee.it/
DroneDeploy	Software and platform for drone use	United States	https://www.dronedeploy.com/solutions/agriculture/
Dronewerkers	Drone based advice for precision agriculture	Netherlands	https://www.dronewerkers.nl/
Farmshots	Variable rate application based on satellite imagery	United States	http://farmshots.com/
FarmStar	Satellite based advice, variable rate application	France	https://www.myfarmstar.com/en/technology/
Greenfield	An agronomic advisor based on satellite and drone data directly to farmers and agro industries	Spain	https://greenfield.farm/en/home/
ISAGRI	Agricultural software	France	https://www.isagri.com/Ressources/Pages/Accueil.aspx
Landviewer	Digital agro-platform with satellite-based monitoring	United States	https://eos.com/
MyJohnDeere	Information platform	United States	https://myjohndeere.deere.com/mjd/my/login
Sentinel hub[21]	Satellite based data exploration	Slovenia	https://www.sentinel-hub.com/
Slantrange	Data analysis tool, multispectral imagery	United States	https://slantrange.com/
SNAP	Satellite image software	European Union	https://step.esa.int/main/download/
Taakkaart	Precision agriculture platform	Netherlands	https://www.taakkaart.be/
Taranis	Agronomic service provider based on drone and satellite information	United States	https://taranis.ag/
Visual nacert	Software application	Spain	https://www.visualnacert.com/
WatchItGrow	Platform / farm management system using satellite images	Belgium	https://watchitgrow.be/en
Xarvio[22]	Digital farming solutions	Germany	https://www.xarvio.com/be/fr.html

Source: Compiled by IDEA Consult based on interviews

Intermediaries, cooperatives and research and technology organisations. These stakeholders play a key role in advising farmers on the use of technologies and uptake of solutions as a part of the wider precision farming landscape. While research and technology organisations are more focussed on developing new techniques such as for disease detection, cooperatives are increasingly involved in testing solutions and advising farmers on interesting options for adoption. Cooperatives are also seen to become more active in post-harvest activities. Additional stakeholders active in this stakeholder group also include field technicians and consultancy companies as well as irrigation communities.

2.3 Linkages along the value chain

The value chain actors in the area of satellite and drone applications for arable crops contains various stakeholders along the value chain. The following section presents observations about the linkages between actors across this specific value chain.

[21] Featuring Sentinel hub playground, EOB Browser tools
[22] Part of BASF

Fragmented landscape with acquisition. The landscape of, especially, drone manufacturers is considered fragmented, and features a lot of startups.[23] This leads to a lot of competition on a small scale. In recent years this has also included acquisition of smalls companies by larger dominant players, seeing a lot of takeovers taking place. The drone manufacturer DJI from South Korea has bought out many competitive smaller players to have a leading position in the drone market. Typically, large players such as Bayer with Monsanto, as well as BASF and John Deere apply satellite and drone data in their solutions and are also active in acquiring expertise to support these activities and their overall portfolio.

Information asymmetries and the role of intermediaries. Farmers and other stakeholders along the value chain are faced with information asymmetries about what is possible to achieve with the data. This is due in part to ongoing research activities to determine further techniques and uses of data for agricultural applications. It remains important to have value chain stakeholders that can bridge between the technology providers and the farmers in order to support the uptake of these technologies. Especially cooperatives also play a key role in supporting the uptake of technologies. At the same time cooperatives are more and more active on further positions of the value chain, also taking up greater roles in post-harvest activities.

[23] See Figure 3 on drone fragmentation across the market, based on Drone Industry Insights, 2020

Section 3

3. Analysis of EU competitive positioning

Figure 6: Overview of the strengths, opportunities, challenges and risks for satellites and drones in less intensive farming and arable crops

• EU Copernicus programme • Technological strengths	**Strengths**	**Challenges**	• Legislative framework • Explaining the use of drone and satellite technologies • Data interpretation and modelling
• Increasing yield per hectare • Disease detection and outbreak management	**Opportunities**	**Risks**	• International positioning towards Asia and the United States • Fear of unwanted monitoring and crop damage

Source:IDEA Consult

3.1 Strengths

EU Copernicus programme. The EU Copernicus programme and especially the Sentinel-1 and Sentinel-2 satellites provide regular coverage, with an appropriate spatial resolution for agricultural applications, and data that are freely available. Service providers are able to build on this collected data and add value to it, providing interpretation that is valuable for the agricultural sector. The programme thus enables farmers to have access to more complete information about the crops and plants that they are growing, including information on yield, and potential harvest dates, but also to allocate resources (such as water) adequately. In addition, Sentinel-1 allows the use of medium-high resolution radar satellite images that are not affected by clouds. Further satellites will continue to strengthen the existing basis of information provided through the Copernicus programme, which can be considered the European equivalent of the Landsat programme of the United States. That being said, the Copernicus programme, has enhanced sensors (especially through Sentinel-2) with greater spatial and temporal resolution as compared to similar, freely available satellite programmes in Asia and the United States. The political commitment for this programme to continue to deliver reliable and impartial information on the productivity of the agricultural sector is seen as a true and future oriented European strength.

Technological strengths. The technology itself is considered valuable for not only its ability to cover spatial scales uniformly, but its ability to transparently and objectively capture and transmit information. While the data collected require the application of certain processing techniques and interpretation, it remains easy to download and incorporate. For example, satellite imagery-based platforms such as Taakkaart.be, WatchItGrow and FarmStar are tools that are highly valued by farmers. As a result, the ability of the data to support decision making is key to its current and future adoption in the sector.

3.2 Opportunities

Increasing yield per hectare. The techniques applied through drone and satellite measurements have a considerable potential to improve the yield per hectare of farms adopting it through closer monitoring and optimal harvest times. As the uptake and application of the technologies by the agricultural sector are still undergoing, the adoption can still improve margins further. The biggest gains in yield are more likely with increasing field size. The true potential for increasing yield also depends on the national context as well as the specific crop produced. Companies include FARMSTAR, who offer a multistep approach to generate crop recommendations for farmers, including variable rate application with the aim of improving management of the crop and increasing yield per hectare with a gain of up to €45/ hectare.[24] Greenfield Technologies also offer crop monitoring in the form of yield prediction and quality monitoring to allow for the negotiation of prices, planning of timed harvests and organisation of

[24] FarmStar (n.d.) Variable Rate Application. https://www.myfarmstar.com/en/our-offer/variable-rate-application/

machinery and transport around this.[25] In addition, in tomato harvesting, data can provide indications on where to begin the harvest, such as in areas where there is the most sun damage to the plants. Another example is related to flood likelihood, where data can highlight which areas of the parcel are most likely to be affected by flood damage. This can be related to the overall productivity of certain parts of the parcel vs others – all of which is detectable by imagery.

Disease detection and outbreak management. Though still currently in development, techniques are being researched in order to be able to detect specific disease outbreaks using satellite and drone data. The research needs to be carried out for specific crops and diseases individually in order to calibrate techniques, however the potential to use these solutions to detect diseases is highly sought after. Especially also insurance companies (such as Munich Re[26] or Swiss Re[27]) are active in the agricultural sector and are interested to understand the application of remote sensing techniques through satellites and drones in order to monitor the impacts of climate changes, droughts and disease outbreaks on the agricultural sector, also in the hope of improving response to impacts.

3.3 Risks

International positioning towards Asia and the United States. Especially in drone manufacturing, Asian companies are well placed and considered very competitive as compared to European manufacturers. For example, large players in drone manufacturing from Asia include DJI. At the same time large companies such as John Deere are dominating the market from the perspective of the United States. Sensefly is the homologous of DJI in Asia or 3DR and Precisionhawk in the United States. However, Sensefly is develops professional drones, thus it is generally less known by the hobby and leisure consumers. While there are many companies that manufacture custom-made drones in Europe, the main problem is the electronic components and the integration of sensors in the drones, which takes place largely outside of Europe.

Fear of unwanted monitoring and crop damage. While improved monitoring benefits a farmer, there is also a fear associated with too much transparency and perhaps unwanted monitoring taking place via satellite and drone data. In addition, the use of drones also risks damaging crops through its actions and movements. This is a trade off towards the benefits of the technologies. It is important to work with the agricultural sectors and farmers to understand the importance of precision farming and the overall benefits of the techniques such as satellite or drone based monitoring for the overall sustainability of the farm and agricultural sector.

3.4 Challenges

Legislative framework. At present, the legislative framework in Europe differs on the use of drone technology for agriculture. Current drone regulation does not permit a drone pilot from the Netherlands to fly a drone in Belgium and vice versa. This means that markets are developing at national scale. At the same time, the applications for which drones may be applied also differ. Countries such as Germany permit the use of drones for spraying from the air, which allows for the use of drones for crop protection, or fertilisation. However, e.g., in Belgium, drones may only be used for monitoring techniques. With a new drone legislation in development, it may be possible to tackle some of these differences with a harmonised set of European rules.

Explaining the use of drone and satellite technologies. Techniques of using satellite and drone data for agriculture are able to offer a multitude of information to farmers. It is important that the techniques are well explained in order to foster the further uptake and adoption. At present information about the possibilities are not clearly communicated to the farmers and are also not translated into immediate economic gains for a farm. Hence, a number of service providers offers training to their clients e.g. Dronebee offer training in the area of precision farming, pix4D software, data analysis and processing and technology transfer. It is important that the business model for applying drone and satellite techniques is well developed and clear. In addition, it should be ensured that the information that is needed to support decision making is available when needed (e.g. with the right frequency of images).

Data interpretation and modelling. Once data are collected, there remains the necessity to process and interpret the data in a meaningful way. Greenfield for example has developed several services like

[25] Greenfield Technologies (2020) Crop Monitoring. https://greenfield.farm/en/crop-monitoring/

[26] See https://www.munichre.com/en.html

[27] See https://www.swissre.com/

Smart4Farmer, to support farmers in the interpretation of data. While certain interpretations are well understood, further interpretation needs to be developed, where research and development are still ongoing. In some cases, the information may not be granular enough (low spatial resolution) to be able to address the questions or issues at hand. This could be the case e.g. for diseases on plants, which start out in a small area. Here a higher spatial resolution would allow to detect the smaller scale developments. At the same time, certain data signals from the plants can be best captured by hyperspectral data, however it remains important to detect which spectral information is the most pertinent for the specific plant or disease in order to accurately be able to interpret the results and in turn convey this information to the farmer to be able to support their decision making.

Section 4

4. Conclusions & outlook

4.1 Conclusions

Better monitoring and informed decision making. Satellite indicators enable the monitoring of planting, growing and harvesting of staple crops such as cereals and rice at national level. In addition, through satellite and/or drone imagery, farmers can switch from managing between field differences to within field differences. The collection of impartial data at regular intervals and at a high spatial resolution enables this monitoring and can support farmers decision making about their crops. Agricultural crop farmers have a great potential use of this information and there is a growing community that report enhancements to the Copernicus Programme to improve the service to farmers and agronomists.

More support for deployment of drone and satellite-based solutions. Certain applications are highly developed with commercial solutions being offered (e.g. FarmStar developed in collaboration with Airbus). However further techniques for the interpretation of data, such as those based on the interpretation of hyperspectral bands, remain in the R&D phase. These include, for example, applications related to disease detection, which are being developed by research and technology organisations. In addition, the measurement of crop canopy temperature through the thermal band also requires further technical advancement. Currently, there are satellites with thermal bands that are able to detect crop water stress but with low spatial resolution of 100m (Landsat 8) and 1000m (Sentinel-3) per pixel. Thermal bands are a very useful measure for detecting situations of water stress in crops, however, further improvement for applications in agriculture is needed. Thus, further support targeting the deployment and demonstration of these solutions is needed for these wider application areas to be deployed.

Training and awareness-raising remain key. While the potential for satellite and drone data to support farmers in their decision making is high, adoption rates can be further helped through continued awareness raising and training of farmers. Due to the technical nature of the data and application, the advantages of the use of these techniques as well as the business model need to be clearly communicated to farmers to support uptake. Training and awareness raising can particularly target the different farm needs, based on size, crop and application areas.

4.2 Outlook

Great potential for the Copernicus programme to inform the agri-food sector. Data provided by Copernicus and the Sentinel satellites are vital in providing timely and transparent information on agricultural production. As the programme gains in reputation, and the awareness of farmers and other agri-food value chain stakeholders increases, the uptake has potential to further improve the efficiency of the agri-food sector. Improvements can include improved harvest times, resource efficiency in irrigation, crop protection and fertiliser use, as well as disease detection. Data can also be used in modelling for determining optimal sowing times, detecting early development of plants and subsequent modelling-based harvest estimations.

Drone legislation. A new drone legislation will allow for greater potential for the use of drones throughout the EU for agricultural applications. Uniform regulation across the EU will enable the landscape to be less fragmented and become more consolidated. Current European players will have the potential to expand their solutions and services to other EU countries and markets. Farmers in countries where current services are not yet available, will benefit from new opportunities in the adoption of drone technologies, also for further applications, such as planting of seeds, crop protection, among others. The latest updates on the Drone Legislation Framework are available via the European Union Aviation Safety Agency (EASA).[28]

[28] EASA. (n.d.). Drones – regulatory framework timeline. https://www.easa.europa.eu/drones-regulatory-framework-timeline

4.3 COVID-19

The Product Watch report 'Sensors for farm management of livestock value chain' presents the COVID-19 impact on the agri-food sector. Here below we present an update on the latest developments and developments specific to the use of drone and satellite data in the value chain.

Most of the COVID-19 impact on the agri-food sector was related to supply chain or labour shortages. The agri-food sector has faced a unique situation in the face of COVID-19. COVID-19 impacted the sector, but also showed the innovativeness of the agri-food sector in finding solutions. The supply chain is a complex interaction among farmers, agricultural inputs, processing plants, shipping, retailers, and more. Elderly persons and vulnerable groups also struggled to obtain food in times where their health and safety were at risk. New digital platforms were and are key in supporting the interaction between stakeholders in improving supply chain management and food delivery. Social distancing and travel restrictions resulted in major labour shortages, especially impacting harvest. Technical solutions have provided opportunities in the increased application of robotics, or the use of satellite or drone data to better inform and manage fields remotely.[29]

Satellites have provided crucial data on crops during COVID-19. While the situation did not increase the demand for solutions based on satellite and drone data as such, the use of satellite and drone data eased the pressure on farmers in the form of time efficiency gains. For example, less time could be spent by farmers in going to their fields to inspect their crop especially if the images do not show any problem. Rapid analysis products were developed by solution providers to establish so-called 'checkpoints', detecting sites that required a visit for closer inspection to determine possible issues. The aim was that this information would be an added value to the services of the distributor to their costumers (farmer, technicians, etc.). Where during the lockdown, flax growers with fields in France and the Netherlands were not always allowed to visit their fields freely, the satellite imagery allowed them to monitor their fields remotely. Data also supported in estimating correct harvest times. COVID-19 was and is an opportunity for satellite and drone manufacturers and data providers to showcase their services and innovate, developing new solutions and services in response to the pressures created by the outbreak.[30]

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[29] SmartAgriHubs. (2020). Analysis of Covid-19: solutions on the forum. https://www.smartagrihubs.eu/docs/COVID-19/ANALYSIS-OF-COVID-19-SOLUTIONS-ON-THE-FORUM_v3.pdf

[30] The European Space Agency. (2020). Satellites provide crucial data on crops during COVID-19 https://www.esa.int/Applications/Observing_the_Earth/Satellites_provide_crucial_data_on_crops_during_COVID-19

Section 5

5. Annex

5.1 List of interviewees

Interviewee	Company	Country
Jonathan Van Beek	Research Institute for Agriculture, Fisheries and Food (ILVO)	Belgium
Thierry Chapuis	National Centre for Space Studies (CNES)	France
Mayte Gallego Garrido	Fundacion Fundecyt-Parque Cientifico Y Tecnologico De Extremadura (Fundecyt-Pctex)	Spain
Ignacio M. Cano Rodilla	SKYDRONEX - DRONEX (R)	Spain
Jorge Blanco	Greenfield	Spain
Miguel Córdoba	Greenfield	Spain
Carlos Campillo	Cicytex	Spain

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About the 'Advanced Technologies for Industry' project

The EU's industrial policy strategy promotes the creation of a competitive European industry. In order to properly support the implementation of policies and initiatives, **a systematic monitoring of technological trends and reliable, up-to-date data on advanced technologies is needed**. To this end, the Advanced Technologies for Industry (ATI) project has been set up. It will provide policymakers, industry representatives and academia with

- Statistical data on the **production and use of advanced technologies** including enabling conditions such as skills, investment or entrepreneurship;
- Analytical reports such as on technological trends, sectoral insights and products;
- Analyses of policy measures and policy tools related to the uptake of advanced technologies;
- Analysis of technological trends in competing economies such as in the US, China or Japan;
- Access to technology centres and innovation hubs across EU countries.

You may find more information about the 16 technologies here: https://ati.ec.europa.eu.

The project is undertaken on behalf of the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the Executive Agency for Small and Medium-sized Enterprises (EASME) by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

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