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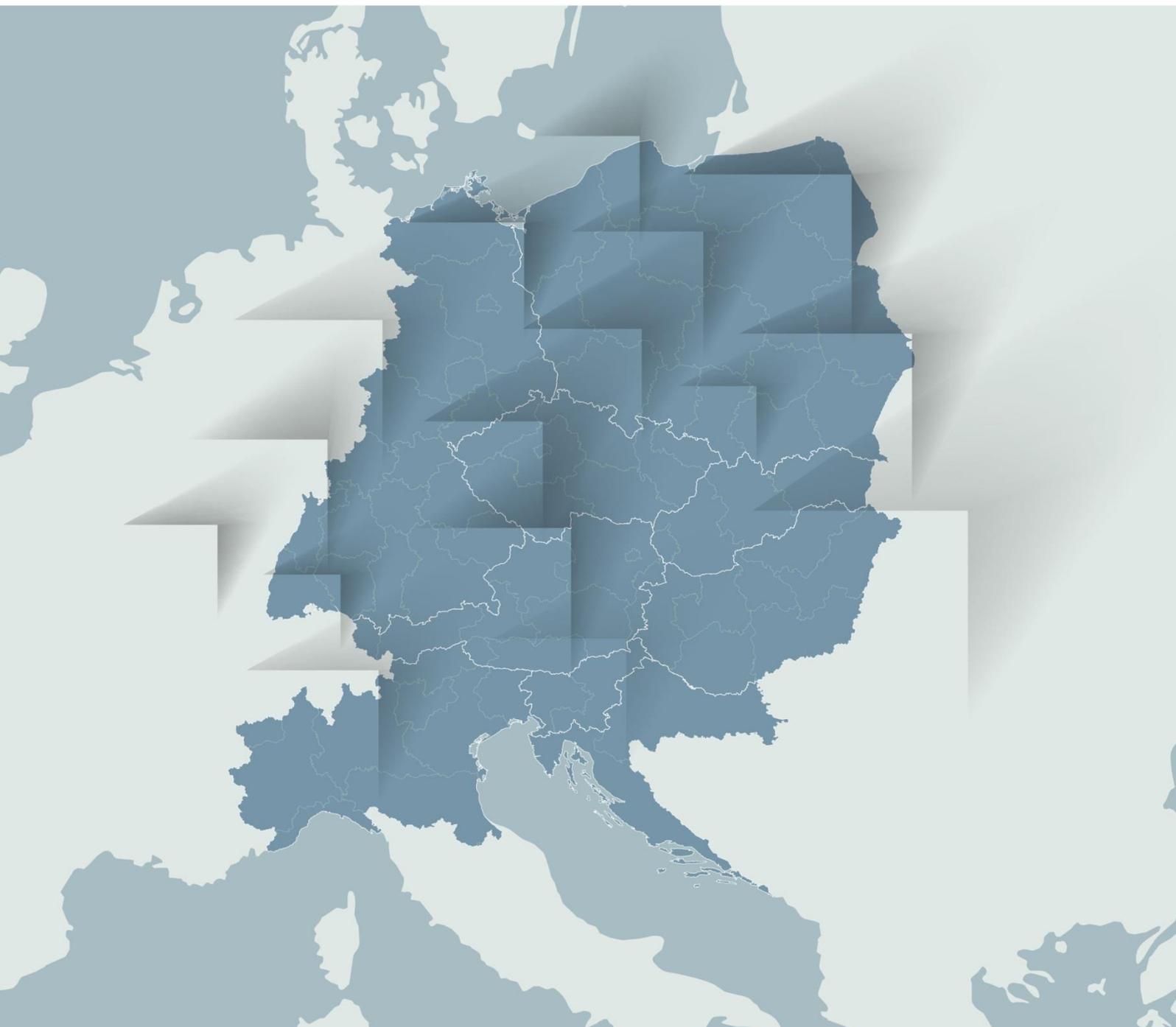Development Fund

## Transfarm4.0

# POINT-ZERO REPORT OF CE EMERGING CLUSTERS & SPECIALISATIONS IN PF

**D.T1.2.3 (PP 3 HBLFA-FJ)**       **Version 10**

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# Contents

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# A. Introduction

This point-zero report of Central Europe emerging clusters & specialisations in Precision Farming (PF), demonstrate tech/industrial readiness of regional excellences in PF.

- Based on the results of the previous AT.1.2. deliverables
    - D.T1.2.1: Regional report on existing regional industrial excellence nodes in PF
    - D.T1.2.2: 1 transnational capitalization seminar with innovation performers

# B. State of the art report for benchmark[1]

Precision farming (PF) is a farming management concept based on doing the right thing, at the right time, in the right place, in order to increase farming yield and to save inputs, ensuring environmental sustainability.

From this concept, a scientific topic is born in the last 20 years, with a constant increasing interest in the last 15 years (Figure 1).

The main factor of the PF diffusion is linked to the technological development that has characterized human lifespan in the last decades. Informatics, sensing, satellite technologies, mechatronic, IoT etc., which are the most important tools to enable PF, are became easier and cheaper, entering also in the industrial agricultural manufactures supply chain. This has given the pulse to develop new tools useful for agricultural practices, such as guidance systems based on GPS technology, automatic controls of implements/machineries, robots, cloud computing, variable rate application (VRA) of agricultural inputs, plant health sensors (optic measurements), soil analysis, yield measurements, decision support systems (DSS), etc.

All these tools nowadays are more available to the farmers, providing them methods for the renew of their farms and farming practices.

The advantages in the adoption of these tools in Europe is also already demonstrated by several studies and experiences, such as in Sartori et al. (2017)[2] in the AGRICARE project, where conservative agriculture, integrated with precision farming, was able to increase farm yields and reduce the environmental impacts, or in the experience of the European Project VinBOT[3], where a robot for viticulture has been developed to measure grapevine yields with success.

However, the potential applications of PF is it does not end here, because animal farming or greenhouses can benefit from the integration of digital tools able to monitor the production process. It is the example of Internet of Food and Farm project (2020)[4], which has evaluated several study-cases in different agricultural fields to improve performances with the integration of digitalization.

In all of these projects the feasibility and sustainability of PF was demonstrated, confirming the important step up that could be achieved with PF.

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[1] provided from: CREA – Researcher *Davide Boscaro*, *Diego Tomasi* (2020)

[2] Source: Cillis, D.; Pezzuolo, A.; Marinello, F.; Basso, B.; Colonna, N.; Furlan, L.; Sartori, L. Adv. Anim. Biosci. 2017, 8 (2), 439–443.

[3] Source: http://vinbot.eu/?lang=it

[4] Source: https://www.iof2020.eu/

Conversely, the full adoption of PF practices in their farms has been less than expected. For example, farmers are more interested in guidance systems than VRA systems, and many times they don't know the real advantages that could be derived from these tools. USA is the country with the highest adoption of PF systems, where 80% of the farmers use GPS guidance systems and only 30% use VRA technologies, and where the principal technological tools come from. In fact, the biggest companies that provides PF solutions come from this country, where, as just seen, there is the most important market. A good diffusion is also present in Australia, Brazil and Argentina.

On the other hand, in Europe the adoption of these practices is still dammed, with the Northern Country, such as Germany, UK, France or Scandinavian countries with the higher percentages (about the 20% of farms). In central Europe countries instead, the adoption of PF is still a challenge because the rate of farms with this technologies is low. This fact in a first time have slowed the industrial progress for the venture in the production of PF tools.

However, in the last years, Europe and some EU countries, have decided to favour the investments by the farms in PF solutions, giving benefits throw investment founds (such as EIP programs).

This have given input for the development of industrial nodes to provide PF solutions to the farmers. In the next paragraphs it will be illustrated the emerging industrial clusters that are rising in the Central Europe countries.
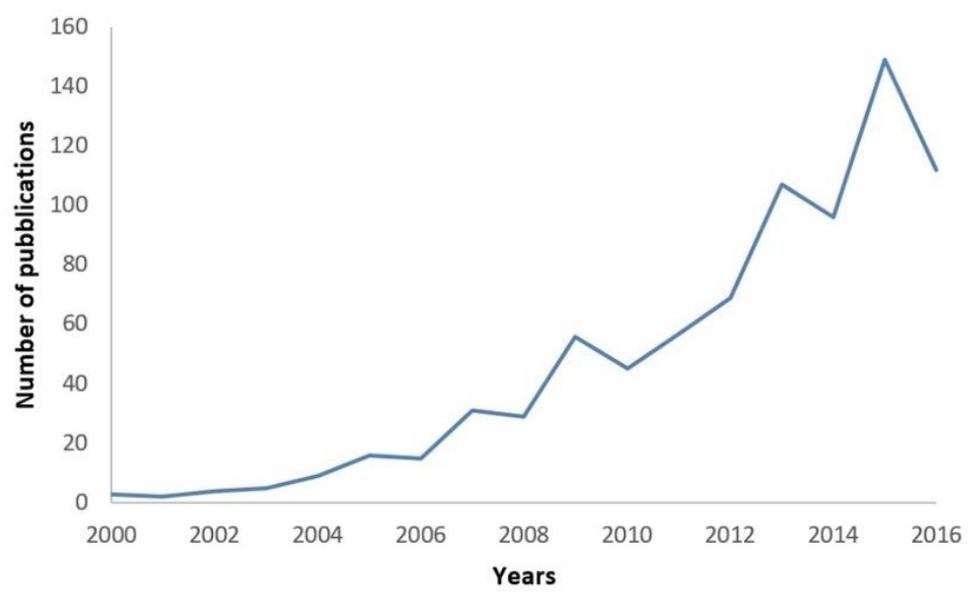


**Figure 1:** Number of scientific publications related to the term "Precision Farming"

# C. Regional report on existing regional industrial excellence nodes in PF (D.T1.2.1)

## 1. Italy[2]

### 1.1 Overview of regional PA status

**National Level Overview**

According to Eurostat[3], Italy is today the second major agricultural producer in Europe after France, with a 56,9 billion € total agricultural output produced in 2018. Nevertheless, Italy stays a step behind the European standard for what concerns PA diffusion: indeed, at the moment less than 1% of Italian cultivated soil is managed with PA systems[4]. These numbers suggest that, despite the rich amount of research and the wide offer of PA technologies produced at national level (sensors, GIS, GPS and GSNN, production mapping, automatic guidance systems, etc.), Italian agriculture is still not able to sufficiently exploit PA when it comes to its practical implementation. The main reason for this lays in the nature of Italian agricultural sector: a fragmented market composed by many small (often family run) farms that lack, in most cases, the onerous capitals and the digital skills needed to adopt PA practices.

Though, agri-food tech is increasing in Italy[5]: 1.890 start-ups over a total of 18.853 considered (10%) operate in the "agri-food tech extended", that is to say, they develop technologies that are virtually applicable to the agri-food sector but have not been applied yet (an example: drones). 617 of them are instead defined as "agri-food tech core", since they produce and already implement techonologies in the agri-food sector.

According to a recent study by Simbiosity, a consulting company in the field of digital innovation, agri-food tech core start-ups increased by 74% in one year: Lombardy (127), Emilia-Romagna (69) and Veneto (54) are the cutting edge regions, bringing together about 50% of the total amount of agri-tech enterprises in Italy developing PA technologies and other agri-food

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[2] provided from: FEDERUNACOMA – Giuseppe Saija (2020); CREA

[3]  https://ec.europa.eu/eurostat/documents/2995521/10217315/5-14112019-BP-EN.pdf/9d55702f-e9f8-dd7e-56c0-50d1b54feb59

[4]  https://www.osservatori.net/it_it/osservatori/comunicati-stampa/coltiva-dati-raccogli-valore-la-trasformazione-digitale-della-agroalimentare

[5] https://www.ilsole24ore.com/art/start-up-cresce-l-agrifood-tech-AEGTIhjE

related services. Northern Italy is indeed by far the most innovative area of the country for what concerns Digital Agriculture, with an annual increment in the number of new start-ups of +80%, followed by Central and Southern/Insular Italy at +58% and +78% respectively.

**Regional Level Ovierview[6]**

**Lombardy:** Lombardy is the first Italian region for number of smart agri-food start-ups (33%) as well as for received funds: 53% of the total 25,3 million euros granted at a national level[7]. After a socio-economic and environmental analysis of this area, the Ministry of Agriculture aims at financing the promotion of new technologies particularly in the field of bioeconomy. Indeed, Lombardy's farms need to adopt new and innovative technologies and mechanization in order to reduce production costs, optimize production inputs and natural resources, and improve the organization and managing of activities at an economic and environmental level. All this is considered necessary to keep Lombardy's agriculture competitive and profitable. In particular, some of the expected innovations are:

- Facilities ensuring a higher energetic efficiency and lower emission of pollutants in the atmosphere

- Structural interventions aimed at rationalizating the use of water and at controlling the distribution of fertilizers

- Facilities ensuring a more effective utilization of phitosanitary products, fertilizers and zootechnic manures

**Emilia-Romagna:** Emilia-Romagna is one of the first Italian regions for regional budget dedicated to scientific research and technological experimentation, as well as for technical assistance and dissemination. Nevertheless, such effort is not always capable of effectively reaching the production side: a relevant number of local farmers and lands are indeed not properly integrated in the PA network. Hence, for Emilia-Romagna the Ministry of Agriculture aims mainly at:

- Spreading a better knowledge of Digital Agriculture among local farmers

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[6] Most information reported in this section comes from the paper *Report sullo stato dell'arte dell'Agricoltura di Precisione in Italia (Mipaaf, 2015)*

[7] https://www.ilsole24ore.com/art/droni-sensori-algoritmi-ecco-rivoluzione-dell-agricoltura-italiana-AEaCUzoG

- increasing farmers' participation in PA practices in order to create a network between farmers, research institutes and enterprises

**Veneto:** Veneto's agricultural sector produces on average 6,1 gross billions per year, namely the 11% of total national production, and generates an added value of 3 billions euro. Its growth rate in the last years is around 1,5%, in particular for the agri-food sector showing an increase of more than 3% per year[8]. The Italian Ministry of Agriculture will particularly promote in Veneto the improvement of farms' profitability and the generational turnover in the agricultural sector. A particular effort will be put therefore in:

- Rationalization of water used for irrigation

- Energetic optimization

- Encouraging young people to start new business in the agricultural field

## 1.2 High-performing OEMs (HW & Equipment), by technology

Components manufacturing definitely represents one of the greatest Italian contributions to Precision Farming. Italian farm equipment manufacturers produce the largest variety of equipment in the world[9] and Northern Italy, in particular Emilia-Romagna with its long-time tradition in the field of automotive (brands like Ferrari, Lamborghini, Ducati originated here), presents a cluster of firms producing high quality components for agricultural machinery.

### 1.2.1 Steering Systems

Concerning Steering Systems, the biggest share of the Italian market, in particular in terms of quantity produced, belongs to two multinational companies: Topcon and Trimble.

**Topcon:** Topcon Corporation is a Japanese multinational operating in different industries (mainly medical equipment and engineering). The engineering branch, Topcon Positioning Systems Inc., created in 2016 Topcon Agriculture Group with main seat in Turin (Piedmont), focused on Geopositioning, BIM and Precision Agriculture. Topcon provides a wide range of

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[8] *L'agricoltura veneta verso il 2030*, June 2019

auto-steering systems like the AGI-4, a modular GNSS receiver and steering controller and X14, X25 or X35 consoles, to be used in combination.

**Trimble:** Trimble Inc. is a California-based software as a service (SaaS) technology company. Trimble operates in Geospatial, Building & Construction, Agriculture and others. The Italian headquarters are in Vimercate, near Milan (Lombardy). It produces the Trimble® Autopilot™ automated steering system.

Other smaller but important high-performing OEMs grouped by region are:

## Emilia-Romagna

**AMA:** settled in Reggio Emilia, AMA is a leading company in the supply of components and equipment for outfitting and maintaining Off-Highway Vehicles, agricultural and gardening machines. Its 6 product areas are: solutions for cabins, seats and steering wheels, solutions for hydraulic, point linkage and PTO shafts, soil working, solutions for garden. They produce several steering components (steering units, steering colomns, steering wheels, etc.)

**ARAG:** Established in 1976 in Reggio Emilia, ARAG is a main reference point in the spraying accessories field and in the precision farming area at a national and international level. For what concerns precision farming technologies, the company produces multifunction joysticks, TTC BLC, GPS Navigators and Rate Controllers, accessories for navigators and computers, monitors, computers for auxiliary circuits, electronic control units, GPS receivers. For what concerns automatic steering systems in particular, it produces Polaris, ECU-S1 Control Unit and Automatic steering system MDU-4.

**COMER:** Settled in Reggiolo (near Reggio Emilia), COMER operates both in Agriculture (Engineering system for agricultural machinery) and Industry (Integrated solutions for construction equipment, marine industry and airport equipment, components and systems for the renewable energy sector). Main agricultural applications are: land preparation machines, soil tillage machines, crop treatment machines, forage and hay machines, biogas systems,

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corn and grain headers, combine and forage harvesters, forage mixing and distribution machines, tractors.

Considering that three over three Emilia-Romagna based relevant companies are not only in the same region but also in the same district (Reggio Emilia), this may be reasonably considered as a potential excellence node for the supply of agricultural machinery components.

### Lombardy

**Bondioli e Pavesi:** Founded in 1950 in Suzzara (near Mantua), Bondioli & Pavesi is an industry leader in the power transmission sector thanks to a Group of eleven manufacturing companies in Italy and around the world. They created the HUB system, a range of intelligent components integrated into a power transmission system to provide unique control and data capabilities. In such system, the integration of electronics makes the component fully compatible with remote links: data can be sent and received for application of IoT techniques and control via mobile devices. Bondioli & Pavesi produces power transmissions and control tools (drive shafts, gearboxes, servocontrols, electronic control units).

**COBO Group:** Settled in Leno, Brescia, COBO is composed by several companies, mainly located around Brescia and Reggio Emilia. The group produces electrical and electronic components, seats, steering wheels and completely assembled column kits for manufacturer of industrial vehicles, agricultural machines, earth moving machines and lift trucks, as well as custom-built cars and motorcycles.

**SAME (Società Accomandita Motori Endotermici):** SAME is a historical firm funded in Treviglio in 1942. Now it's part of the multinational SAME Deutz-Fahr (SDF). It produces mainly tractors and relative components, among which SDF Guidance, monitors and Isobus systems.

### 1.2.2 Tillage/Soil Cultivation and Seeding Equipment

Relevant companies grouped by region are:

## Piedmont

**ROJ:** develops and produces mechatronic solutions for customer-unique industrial and vehicle applications, in medium-sized volumes. In the field of seeding equipment, PCS 200 is the ROJ pneumatic precision planter control system, allowing to replace the mechanical transmission of seeding discs with an electric motor to achieve greater machine flexibility and provide new functions which are not possible with the mechanical transmission. ROJ also produces the PCS FS, a new pneumatic and mechanical seed drill control system based on the rugged Agri-Motion DMD 0 motor, controlled by the PCS 100 ECU.

## Veneto

**Sfoggia:** in the district of Treviso, Sfoggia is a historical firm founded in 1956. It produces a range of precision seeding drills, strip trillers and cultivators. For what concerns Precision Farming, it produces Elektra Drive and Isobus, a completely automatic electronic system for seeding drills.

**MC Elettronica**: settled in Rovigo, offers a wide range of electronic equipment for sowing spraying and harvesting machinery. They offer customized agricultural technologies for OEM customers and standard products for retailers and private customers. They produce innovative soil tillage monitors and Isobus planter monitors compatible with third party electronic devices including then main GPS navigators on the market.

**Maschio Gaspardo:** settled in Campodarsego (Padua), Maschio Gaspardo is an international Group leader in the production of agricultural equipment for tillage, seeding, planting and fertilization, crop care and haymaking. The Group produces a wide range of rotary tillers, power harrows, mulchers, precision planters, cereal seed drills, combination cultivator-drills, flail-mowers, ploughs, minimum tillage, spraying and hay making equipment. For what concerns in particular PA technologies, they produce seeding monitors, sprayers and mist-blower control groups, Isotronics and Isobus terminals.

To be noticed, that Maschio Gaspardo's tractor *Crono* was prized during the event *Machine of the Year* (a contest for the most innovative agricultural machines) at 2019 Sima event in Paris as best precision seeding drill of the year.

For what concerns tillage and seeding equipment, the area of Veneto is apparently one of the most advanced in Northern Italy. This is coherent with the particularly consistent agricultural production of this area, both today and in the past.

### 1.2.3 Plant Breeding & Research

Some of the most relevant universities and research institutes devoted to plant breeding:

**Emilia Romagna:**

**KWS:** KWS is a German seeds producer founded in 1856 in Klein Wanzleben. The main Italian branch is in Forlì and works on corn, soy, beets, rapeseed. They also make research in plant breeding, particularly on corn, and offer consulting services to farmers.

**Friuli Venezia Giulia**

**Udine University**: Genomics and Genetics Department is currently focusing on genome analysis in plants, including genome sequencing and resequencing, epigenomic analysis, genome evolution studies, and on sequence diversity analysis and association mapping. Here scholars contribute to sequence grapevine, peach, citrus, barley genomes and are currently sequencing the olive tree. A major research activity is related to resequencing using NGS technologies (Illumina) in order to detect sequence, structural and epigenetic variants and in developing the genomics and bioinformatics technologies needed for this.

**Vivai Cooperativi Rauscedo:** a grapevine nursery business with a yearly production of more than 60 million grafted vine plants. Beside production, Vivai Cooperativi Rauscedo perform high-quality research ranging from micro-propagation to green-grafting, health checks through Elisa test and PCR, from cloning with weak selective pressure to the characterization of the clones through the evaluation of fine parameters.

**Lombardy**

**Insubria University:** University of Insubria (Varese, Lombardy) operates in the field of Plant Breeding and research through its Applied Botanics Laboratory, the Padiglione Spallanzani.

Some research areas comprehend for example the identification of molecular factors controlling root system development and morphological analysis of root systems in agronomics plant grown under compost and biochar applications.

### Trentino Alto-Adige

**Edmund Mach Fundation:** a high-tech research institute located in S. Michele all'Adige (Trento) carrying out interdisciplinary research and innovations in the fields of modern and sustainable agriculture, food and nutrition, environment and health. They operate in genomics, computational biology and and biology of fruit crops, with the aim of spreading further genetic improvement of crops and/or to develop new varieties of commercial interest.

### Veneto

**Padua Univeristy:** within the Department of Agronomy, in DAFNAE Laboratory, the main research fields are agronomy and field crops, fruit tree crops, vegetable and flower crops, agriculture genetics, agriculture and microbiology.

## 1.2.4 Animal Monitoring

### Liguria

**Cynomis:** Cynomis srl is an innovative start-up settled in Genua and operating in the IoT sector. They develop solutions aimed at increasing farm animals' welfare. Their main solution is Plinio, a stable kit making it is possible to accurately monitor environmental parameters in the housings and take prompt action before situations dangerous for the animals and the workers could occur.

### Veneto

**Technos:** in Chioggia (district of Venice), Technos offers high-quality monitoring and control in the aquaculture. Among its products: oxymeters, oxywifi2, oxygen probes. They also produce breeding facilities for shellfishes.

Animal monitoring is not a particularly developed sector in Italian PA. In most cases, animal monitoring solutions are sold within big firms producing agricultural equipment (for example: D&G Equipment, a multinational in the field of agricultural tools, or CIMA, producing animal feed in Reggio Emilia)

## 1.3 High-performing service providers, by service

### Emilia-Romagna

**IBF Servizi S.p.A:** BF (Bonifiche Ferraresi) is a 7.000 Ha farm operating also in the field of Precision Farming consultancy through its consulting branch IBF Servizi S.p.A., the first Italian HUB for agriculture. IBF promotes the development of precision agriculture in Italy, supporting farms to adopt and implement innovative technological solutions: optimization of production processes, reduction of production costs, improvement of environmental sustainability and quality.

### Lombardy

**Vantage Italia (former Spektra Agri):** a service company offering technical assistance on a variety of PA practices and tools: collection and analysis of data, mapping and guidance systems, tools maintenance.

**Arvatec:** Arvatec produces, sells and spreads innovative technologies in agriculture: data managing, production mapping, seeding systems, automatic guidance, levelling.

### Veneto

**Veneto Agricoltura:** an instrumental body of the Region of Veneto which carries out support activities for the Regional Council in the field of agricultural sector policies, agribusiness, forestry and fisheries. It deals with applied research and

experimentation aimed at testing and disseminating technological and organizational innovations in order to improve the competitiveness of businesses and supply chains production as well as environmental sustainability in the agricultural, agri-food, forestry and fisheries sectors.

## 1.4 High-performing research bodies, by typology

## 1.4.1 Universities

### Emilia-Romagna

**Modena and Reggio Emilia University**: within this University, the laboratory BIOGEST-SITEIA is a research institute for the optimization and valorisation of biological and agri-food. It offers technical consulting for the agri-food production chain mainly in the sector of vegetable production.

**Bologna University:** The DEI (Ingegneria dell'energia elettrica e dell'informazione Guglielmo Marconi) within the university of Bologna operates in precision agriculture with a remarkable specialization in drone technology, both flying and on the ground. They work moreover on Intelligent Sensor Systems, Field Control Systems, Radio Frequency energy harvesting radiating systems.

**Parma University:** The Department of Life Science and Environmental Sustainability has been selected by the Italian Ministry of Education, University and Research as a "Department of Excellence" (they are 180 across Italy) and has been awarded with a special ministerial fund (9 million euros) for the five-year period 2018-2022. Parma University also participates a Precision Agriculture project funded by AGER with the collaboration of Padua, Florence and Teramo Universities. The focus of the project is on the optimization of wheat manuring.

### Friuli Venezia Giulia

The already mentioned **University of Udine**[10]

## Lombardy

**Milan University:** the public university of Milan recently launched its first course in Precision Agriculture for the academic year 2019/2020. The main subjects are agricultural machinery and mechanization and plant pathology. Students will learn how to apply methods and sensors to monitor the phytosanitary status of crops and to apply plant pathology and crop protection basic principles to process site-specific data for prescribing maps of agrochemical distribution. They will moreover acquire the ability to manage, interface and program the precision farming systems on operating machines for crop management.

**Polytechnic of Milan**: The DEIB Department (Dipartimento di Elettronica, Informazione e Bioingegneria) is a scientific institution committed to forefront research, education, and technology transfer in computer science and engineering, electronics, systems and control, telecommunications, and bioengineering. They operate in Precision Agriculture also and recently participated GRAPE (Ground Robot for vineyArd monitoring and ProtEction) project, whose focus is developing the tools required to execute (semi) autonomous vineyard monitoring and farming tasks with Unmanned Ground Vehicles (UGVs) and, therefore, reducing the environmental impact with respect to traditional chemical control.

**Insubria University**[11]

## Piedmont

**Polytechnic of Turin:** Polytechnic of Turin is one of the most renowned scientific universities in Italy and has a department specialized in sensors. iXem Labs are a component of the LACE (Laboratorio di Antenne a Compatibilità Elettromagnetica) of the Electronic and Telecommunications Department of Politecnico di Torino: the field of activity is mainly related to the assembling of wireless transmission systems and the realisation and management of wireless networks. In PA field, iXem Labs developed iXem Wine, a project consisting in a free platform for the monitoring of vineyards through a network of sensors which collects and analyses data.

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[10] See section 1.2.3 Plant Breeding & Research
[11] See section 1.2.3 Plant Breeding & Research

**Veneto**

**University of Padua:** University of Padua offers a master in Precision Agriculture in collaboration with the Universities of Florence, Teramo and Viterbo, and a master degree course in Sustainable Agriculture. Moreover, the department of land, environment, agriculture and forestry (TESAF) is an important research centre participating at the moment in several EU projects in agricultural sector: Horizon2020, Life, Interreg, PSR (Programma di Sviluppo Rurale).

# Research Institutes

**CREA**: CREA is the leading Italian research organization dedicated to the agri-food supply chains. It operates as a legal entity under public law, and is supervised by the Ministry of Agricultural, Food, Forestry and Tourism Policies (Mipaaft). Scientific activity covers agricultural crops, livestock, fishery, forestry, agro-industry, food science – and socio-economics. CREA was established in 2015, from the merging of CRA (Council for Agricultural Research) and INEA (National Institute of Agricultural Economics).

Headquarters of CREA are in Rome, but in northern Italy two important seats are in Conegliano (Treviso, Veneto) and Bologna (Emilia-Romagna).

**FIAT Research Centre:** the research centre of FIAT, with offices in Mirafiori (Piedmont), Trento and Bologna, develops innovative power units, vehicle systems, materials, methods and processes to improve the competitiveness of FCA products. FIAT operates in the agricultural sector through CNH (Case New Holland).

### Liguria

**IIT (Istituto Italiano Tecnologia):** the Italian Institute of Technology is a scientific research centre based in Genoa. Its main goal is the advancement of science, in Italy and worldwide, through projects and discoveries oriented to applications and technology. It participates SMASH project (Smart Machine for Agricultural Solutions Hughtech) for the development of agricultural robots.

### Trentino Alto Adige

**Bruno Kessler Fundation:** Top Research Institute in Italy (Trento), ranked at the 1st place for scientific excellence within 3 different subject areas (ICT, History and Sociology. Specialized in ICT and AI, It works on PA too: it recently developed a special photocamera able to take multi-spectral images of a field by flying on a drone, in order to evaluate different soil types.

**Fondazione Edmund Mach**[12]

## 1.5 Overview of existing networks

**Federunacoma:** The Italian Agricultural Machinery Manufacturers Federation, formed in 2012 to replace Unacoma (the Italian Farm Machinery Manufacturers Association set up in 1945), brings together, and represents in Italy and abroad, the associations of Italian manufacturers of implements (Assomao), self-propelled machines (Assomase), tractors (Assotrattori), components (Comacomp) and gardening machinery (Comagarden).

**Assotrattori:** the main activities of Assotrattori are:

- reporting data for compiling statistics and information

- the organization of specific events such as seminars in the framework of trade fairs

- providing incentives for research projects which foster cooperation between member companies and research institutes; providing assistance and consultations in technical and regulatory fields.

**Comacomp:** an association of components manufacturers in Federunacoma. The production of components represented by the association for machinery for agriculture, earthmoving and gardening, OEM and spare parts, can be divided into macro areas:

- mechanical components (drive shafts for power trains, speed reducers and increasers, gearboxes, free wheels, clutches, axles, etc.)

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[12] See section 1.2.3 Plant Breeding & Research

- hydraulic components (cylinders, pumps, motors, valves, etc.)

- electric-electronic components (electric plant, cable harnesses, electronic regulation and control devices, GPS systems, onboard computers and instruments, etc.)

- various components (belts, cabs, seats, brake systems, frames, three-point hitches, etc.)

- irrigation components (hoses, couplings, filters, pumps, sprayers, accessories, etc.)

- sprayer components (bars, pumps, fans, filters, ECDs, nozzles, etc.)

**IDEAgri:** IDEAgri is a company network set up to develop common activities within the frame of ISOBUS standard and more generally of Digital Electronics for agricultural machinery. All the 8 founder companies are under the leadership of Reggio Emilia Innovazione (REI) and have joined their specific skills. The 8 companies are AMA, Arag, COBO, COMER, Agro Tractors, Salvarani, Walvoil and ReLab.

**CL.A.N.:** The National Technology Agrifood Cluster is a multi-stakeholder network of the key Italian players of the entire agrifood chain - a partnership of companies, research centres and institutions set up to promote sustainable economic growth, based on research and innovation in the industry and acting as partner for Italian and European Institutions.

# 2. Hungary[13]

## 2.1. Overview of regional PA status

According to Kemény et al. (2017) and Takácsné György et al. (2018) PA is present in Hungary since the 1980s-90s, while for many people it is still an unknown way of plant growing or animal husbandry. The authors introduce the results of numerous researches dealing with the evaluation of the PA among the Hungarian growers. Main points of these results are the followings: influenced by the farm size, 50% of the growers know about PA, the use of PA is

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[13] provided from: Szent Istvan University (SZIU) – Researcher Prof. *Dr. Borbala Balo*, et.al (2020)

influenced by the age (mainly people younger than 40 years old adopt PA), farm size, education level. The use of GPS is also influenced by the age of the growers. Practices, for example site-specific soil sampling, guidance system and automatic steering are standard operations. While others are less frequent among the growers for example: guidance systems (more than 50%), autopilot (around 30%), machine control, VRT seeding and fertiliser application (25%). Only around 5% of the growers are applying pest control sensors, drones or precision irrigation.

Takácsné György et al. (2018) reported the results of their representative research based on the answers of 656 (out of approximately 1000) farms. According to the report 95.5% of the growers heard about PA, while 6.9% were involved in PA. Among the cultivated crops winter wheat were grown on the largest surface according to PA. The report details the use of Annual Real-Time Kinematic signal subscription, tractor auto steering and on board computer, self-propelled sprayers, field boundary mapping, field mapping, pest and weed monitoring. Authors report the possible factors influencing the adoption of the PA technologies such as excess investment, farm size, financial possibilities.

One of the most important Hungarian internet portals, www.agroinform.hu provides many up-to-date information about PA for readers both agricultural, horticultural or stock farming.

Among the agricultural sectors horticultural production is an important user of PA methodologies. Both vegetable (for example tomato), fruit (for example apple) and viticulture sector investigate the possible PA solutions for many different aims such as labor shortage, plant protection, nutrient supply. In viticulture main PA technologies are the macro-, mezo-, and microclimatic evaluation and forecast of wine regions, vineyards or even the canopy of a single plant. Climatic data such as radiation, humidity, wind speed and direction, temperature provide information about the canopy structure, phenological stages, ripening and qualitative and quantitative properties of the fruits. Also climatic data are the base of plant protection against fungal diseases (eg.: downy mildew, powdery mildew) and pests. UAV based indexes (mainly NDVI) today is still rarely applied even though it helps to detect plant decline or low phytosanitary status. Based on these data missing vegetation is not treated when plant protection is carried out. Continental climate of Hungary requires careful vineyard establishment. Both winter and spring frost can cause damages, in this way DTM (digital terrain model) provides essential information of the lower elevations where frost damage is frequent.

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*Takácsné György et al.* (2018): Precision agriculture in Hungary: assessment of perceptions and accounting records of FADN arable farms. Studies in Agricultural Economics 120. 47-54.

*Kemény et al. eds.* (2017): A precíziós szántóföldi növénytermesztés összehasonlító vizsgálata. Agrárgazdasági Kutatóintézet. Budapest. 170p.

## 2.2. High-performing OEMs (HW & Equipment), by technology

### 2.2.1. Steering Systems

Steering systems are provided (among others) by the following companies: **KITE, Axiál, Agrárin Ltd.**

### 2.2.2. Tillage/Soil Cultivation and Seeding Equipment

**KITE** (www.kite.hu) is one of the main agricultural companies in Hungary. Among others the main sectors are seed production, machine and equipment trade together with irrigation, plant protection, fertilization. In viticulture several machines are provided to the sector such as tractors and equipment: sprayers, defoliators, electric pruners, mulching devices, and machines for undervine care.

**Bartifarm** (www.bartifarm.hu) among others provides machinery for harvest, transport, pruning, frost protection, and soil cultivation.

**Sióagrár Ltd.** (www.sioagrar.hu) is an agricultural machine and equipment company providing shoot trimmers, soil cultivators, trunk cleaners.

**Axiál Ltd.** (www.axial.hu) is one of the main companies among the agricultural machinery.

**Agrárin Ltd.** (www.agrarin.hu) is one of the earliest companies, main products are among others agrometeorology, nutrient supply documentation.

### 2.2.3. UAV and Drone technology and remote sensing

**ABZ Drone** (www.abzdrone.com) is a merchant company dealing with drones and related technologies including cameras, sprayers with different services: evaluation of agricultural sites, plant protection. Eurosmart Ltd. (www.eurosmart.hu) is providing drone technologies to the agricultural, architecture, railways, roads and solar panel sector.

**Agron Ltd.** (www.agron.hu) is providing equipments and education in drone technologies, and evaluation of multispectral imagery.


## 2.2.4. Plant Breeding & Research

### 2.2.4.1. Grapevine breeding

Plant breeding has a long history in Hungary, dating back to the beginning of the 20th century. New grapevine cultivars were mainly provided by private breeders or institutes and universities. After the phylloxera epidemic new rootstock cultivars were started to breed by Sandor Teleki. One of the main targets of the breeding was to provide phylloxera resistant cultivars with lime tolerance suitable for the soil conditions in many of the Hungarian wine regions. Based on Teleki's work many rootstocks were quickly spread all around the world, among others: Teleki-Fuhr SO4, Teleki-Kober 5BB, Teleki 5C, Teleki-Kober 125 AA, Teleki 8B and Teleki 10A (Hajdu, 2015) Breeding new rootstocks (for example Georgikon 28) and the evaluation of those are still important research topics. Evaluation of the rootstocks carried out in the Georgikon Faculty of Pannon University (Keszthely) is still important in the Hungarian programs. Another important breeding target is the improvement of the table grape cultivars. In the 19 century mainly local cultivars were in the table grape assortment. It was changed with the introduction and spread of the Chasselas cultivar. Later new cultivars were bred by János Mathiász, Adolf Start, Pál Kocsis and others providing larger bunches and berries or earlier ripening time. Hungary mainly has continental climate which requires frost tolerant grapevine cultivars. In this way it was one of the most important breeding targets in the 20th century. Also an important breeding target is the biotic resistance. The resistance against downy mildew and powdery mildew are two of the earliest aims of interspecific breeding. Nowadays most important breeding centers are the Research Institute for Viticulture and Oenology University of Pécs, and the Pannon University.

Hajdu, E. (2015): Grapevine breeding in Hungary. In.: Eds: Reynolds, A.G.: Grapevine breeding programs for the wine industry. Elsevier. 466.

https://books.google.hu/books?id=LNFzAwAAQBAJ&printsec=frontcover&dq=grapevine+breeding&hl=hu&sa=X&ved=0ahUKEwjO7IuX_oDoAhUHpIsKHXL2AdgQ6AEIKTAA#v=onepage&q=teleki&f=false


### 2.2.4.2. Grapevine research

Grapevine research in Hungary started at phylloxera epidemic when the Institute of Ampelology, Budapest was established in 1896. During the first decades the main focus of research was on grapevine diseases, then later on, breeding projects were emerging. For effective research a complete network of research stations was constructed involving the most significant vine growing areas of Hungary (i.e. Tokaj, Eger, Badacsony, Pécs-Villány, Mór and Kecskemét). In the 80ies grapevine physiology studies started to get into limelight. Several field experiments dealing with physiological relations of training systems, canopy management, bud loads, row direction, soil covers, fruit zone management, nutrition, rootstocks, cultivars and clones, water relations, terroir, etc. have been conducted and continued in different wine districts in Hungary. During the last 5 years promising remote multispectral and thermal camera observations applying drone (UAV) techniques completed and validated with proximal sensing and biophysical field measurements have emerged.

### 2.2.5. Animal Monitoring

The OkosFarm (SmartFarm) is a unified installation monitoring, automated system, operating with modern tools and working properly on agricultural farms, as well as promoting energy efficiency as management, a powerful resource, controlled alert when the vehicle is inadequate, and alerting needs during data monitoring. OkosFarm is able to create a customized system for each industry and type of farm and is made up of several other sub-units.

## 2.3. High-performing service providers, by service

### 2.3.1. Meteorological data providers and disease forecast

**The Hungarian Chamber of Agriculture (NAK)** (www.nak.hu) is a public body established in 2013. Today it has 360.000 members representing agriculture, food industry and rural development according to the 3 chamber departments. The main goals are to improve farming circumstances of the members, competitiveness of the sector and living conditions of the rural people. The plant protection portal of the site provides meteorological data and disease forecast information.

**BASF** is one of the main companies providing products for grapevine plant protection and weed control. Based on the iMETOS system BASF provides meteorological data with risk of

diseases (botrytis, downy and powdery mildew and black rot) from more than 60 vine growing regions of Hungary (https://defenso.hu/szolo/allomas-adatok).

**Bayer** (https://bayer.co.hu/uzletagak/crop-science) is one of the leading agricultural companies providing information about the most important pest and diseases and meteorological information.

**Syngenta** (https://www.syngenta.hu/service/idojaras) also provides meteorological data information.

**Agrontech** (www.agrontech.hu) systems were developed to provide meteorological data and decision support systems for the growers to help proper plant management according to the on-site sensors.

**WineData** (www.winedata.hu) is a monitoring system developed to support grapevine growers. It provides different modules. Environmental data (precipitation, wind directions and speed, temperature, etc.) provided by sensors. Plant protection module follows phenological stages and based on the meteorological data helps the growers to keep the vineyard healthy. Operation monitoring provides on-line real time information on the machines based on GPS data. With the help of the 3 modules, the whole process of vine growing can be monitored, the software assists the administrative tasks of the company, performs economic calculations.

**SmartVineyard™** (www.smartvineyard.com) systems were developed by the QuantisLabs Ltd. to provide meteorological data and decision support systems for the growers to help proper plant protection according to the on-site sensors.

The **Research Institute of Tokaj wine region** (www.tarcalkutato.hu) provides weekly meteorological data and information about the presence of pests and diseases.

## 2.4. High-performing research bodies, by typology

Main research centers of PF in viticulture are Universities and Research Institutes in Hungary.

**Szent Istvan University (SZIU)** is one of the leading higher education and research institutes in the field of agriculture and horticulture. Among other research areas in the SzIU PF is

dealing with horticultural plant production. In **SZIU Viticulture Department** the main research topics are vine physiology, molecular biological background of powdery mildew and black rot infections, vine water status, irrigation, canopy architecture, canopy temperature, ecology of the vineyards, climate change investigations, remote sensing.

**National Agricultural Research and Innovation Center (NARIC) Research Institute for Viticulture and Oenology Badacsony and Kecskemet**. NARIC provides research and advisory services to the growers and collaborates with higher education organizations. Among the main activities the Institute selects new clones, evaluates newly bred cultivar candidates and maintains genbank for genetic resources. Based on the accredited laboratory soil and plant analysis are provided for the growers for proper plant nutrient management.

**Research Institute for Viticulture and Enology of the University of Pecs** is the most important grapevine breeding institution in Hungary. Main activities are consultancy (vine nutrition), research and grapevine breeding. Grape collection of the Institute contains more than 1800 accessions. Main research topics are: disease resistance, plant physiology, molecular genetic investigations, clonal selection and evaluation of cultivars.

**Research Institute of Tokaj wine region**. Main research topics of the Institute are linked to: investigation of yeasts, effect of erosion, soil science, cover crops, and grapevine trunk diseases, climate change investigations.

**Eszterhazy Karoly University** is located in the Eger wine region. Main research topics are linked to the region such as evaluation of cultivars, plant protection, clone selection, biology of the botrytis infection, downy mildew and black rot.

## 2.5. Overview of existing networks

Networks between the growers and high-performing research bodies are already existing. The evaluation of the vegetative performance and the qualitative and quantitative monitoring of the vineyards are supported by PF elements. Remote sensing evaluation of vineyards based on UAV were carried out by the **Viticulture Department of SZIU** in Csongrád wine region (Koch winery), Kunság (Gal winery), Eger (Kovacs Nimrod Winery).

In the past 4 years in Tokaj wine region a large state investigation (directed by **Grand Tokaj Ltd.**) was carried out on mapping the different aszu or dry wine producing terroirs. The investigation included LIDAR, multispectral and heat camera technics, vineyards' registration

on digital platform, describing soil and microclimatic properties and missing vines for the vineyards of the region. Unfortunately, this data base is closed, only vineyard's owner has access to it.

**Agrobot Ltd.** and **ABZ Drone** together with Sauska winery made trials on plant protection based on drone sprayings in the Tokaj wine region. Drone spraying is not yet permitted in practice in Hungary.

https://www.agrarszektor.hu/noveny/igy-permeteznek-dronnal-a-sauska-boraszatban-itt-vannak-az-elso-tapasztalatok.19677.html

https://abzdrone.com/blog/sauska-boraszat-tokaj/

# 3. Slovenia[14]

## 3.1. Overview of regional PA status

In general precision agriculture has gained a lot in importance and use in the last few years also in Slovenia, mainly because of the savings and many other advantages. It is used in large to medium-sized agricultural companies for the optimal use of fertilizers and plant protection products. As they can save up to 20% of the resources and reduce our adverse environmental impact, more and more framers are embracing PA technologies. For example, drone supported inspections and the use of precise GNSS systems for optimal navigation of agricultural machinery are just one of these and some companies are investigating possibilities of incorporating precision engineering (sensors, electronics, automation, electrostatics) into their agricultural implements and machines to further improve the food production processes. Of course, there are regional (demographic and geographic) characteristic that shape the use of PA and are investigated in the following paragraphs.

The statistical data (2016) shows that the average Slovenian farmer is old, with 57 years of age. Only 4.6 % of farmers are younger than 35 years and 28.5 % are older than 65. A lot of the farmers do not have a successor and young people are moving from the countryside to

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the cities which makes the problem of aging farmers even harder. But those young farmers that remain are well education, with an increase of 18 % more formally educated farmers from 2013 to 2016 alone. The education plays an important factor when embracing new technologies such as in the area of PA.

The other obstacle that farmers face is the geographical characteristic of the region. 75.7% of all arable land in Slovenia have limited possibilities for farming, where 56 % if this are mountain areas, 16 % special areas and 3,5 % other areas. Farming in mountain areas presents a bigger challenge where special, more expensive equipment is needed. According to the data from 2016 there were 69 902 farms, out of which 231 were companies and 69 671 family farms that managed and average farm of 6.9 ha in size and 898 365 ha in total for the whole country. 57% are of this are grasslands and pastures, 36.8% fields and 5.6 % permanent planation.

In retrospective to this the overview of the OEMs related to PA has identified the following regional characteristics; rigidness of big manufactures to the solutions in the area of PF, integration of non-domestic products to the OEM's solutions, agility of new smaller (start-up) companies and the tendence to service driven business plan.

Some of bigger OEMs in Slovenia were removed from the list of manufacturers after product portfolio was investigated in greater depth. Some of those that remain develop their own precision farming solutions and some integrate (non-domestic) third party solutions into their product, making their products smarter and precision farming enabled.

On the other end of the spectrum, we have small (usually start-up) companies with new ICT related solutions to help the farmers to save on input resources and to help manage the farms. In most cases they incorporate cloud driven service which is offered to the farmer and capitalised in form of a monthly at a fee.

Both of this aspect are understandable when taking into account the demographic characteristics of the area that were already explained. The big producers still relay on the development of the equipment for the aging population that buys simple equipment that is cheaper than the precision farming enabled one. The farms in Slovenia are small which prolongs the return on investment factor. So the precision farming enabled solutions are in general sold abroad. The presence of smaller companies on the other end can be explained by the interest of younger farmers that have the formal education, which are the farmers that are taking over the farms and grew up with ICT. This farmers embrace solutions

(services) offered by smaller companies that are making their way in to the market because they help to make a saving on the resources and they help them manage their farms.

The following figure depicts the location of identified OEMs (blue flags), service providers (green flags) and research institutions (red flags) in Slovenia.
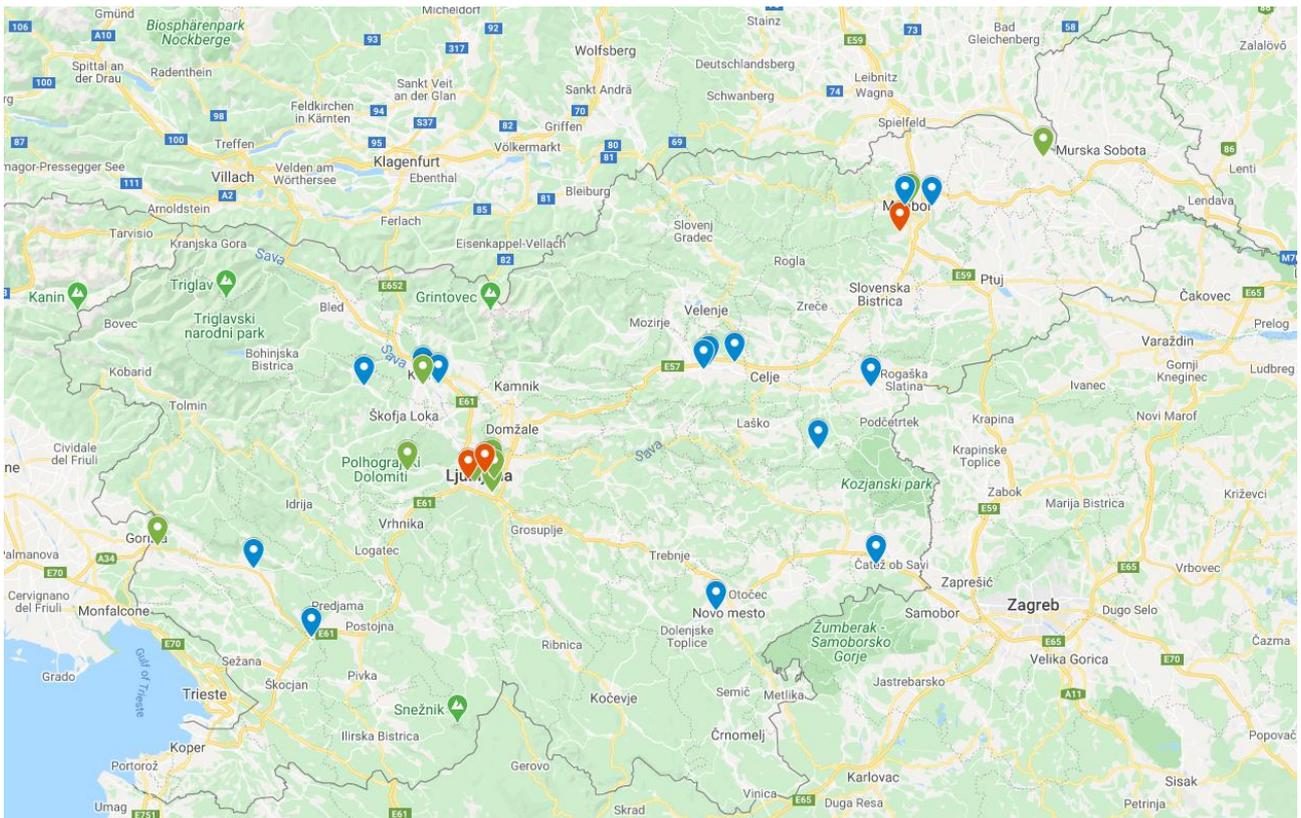


**Figure 1**: Depicts PF related businesses (15 blue flags), PF related service providers (9 green flags) and reserch institutions (3 red flags).

## 3.2. High-performing OEMs (HW & Equipment), by technology

### 3.2.1. Steering Systems

The following business entitles have been identified in Slovenia in the area of steering systems:

**AGROMEHANIKA D.D.,** Hrastje 52a, 4000 Kranj (https://agromehanika.si/) - Agromehanika is the leading producer of agricultural machinery in Central and South-Eastern Europe. For over 50 years, Agromehanika has been synonymous with quality, reliability and development - features recognized by many farmers and business partners. It produces AGS sprayers, AGP mist blowers and compact AGT tractors.

Agromehanika incorporates into their systems equipment from other manufacturers such as GPS navigation G7 Farmnavigator from AvMap, which is an innovative agricultural navigator, designed to precisely farm agricultural land. It enables satellite guidance over the field and more precise crop processing. It is used for sowing, spraying and fertilization.

## 3.2.2. Tillage/Soil Cultivation and Seeding Equipment

The following business entitles have been identified in Slovenia in the area of tillage / soil cultivation and seeding equipment:

**INO BREŽICE d.o.o.,** Krška vas 34b, 8262 Krška vas (https://www.inobrezice.com) – Produces solutions such as flail mowers, fertiliser spreaders, seed drills, vibrational subsoilers and smart solutions such as smart align (patented safety device for aligning the PTO shafts flail mowers), smart assist (that controles the speed of the tractor, PTO RPM, linkage position and other), smart flow (spreader control), smart hopper (indication system for hopper machines that inform the operator when the loading box is full), vibration control (IoT device used to control of the level of vibrations on INO flail mowers and on other devices) and secure tronic (folding protective system for flail mower).

**SIP Strojna Industrija d.d.** Juhartova ulica 2, 3311 Šempeter v Savinjski dolini (http://www.sip.si/company) - SIP is the biggest producer of agricultural machinery in Slovenia. The core product range consists of: mowers, tedders and rakes. They incorporate the use of sensors and end switches to make smart turrets and rakes.

## 3.2.3. Forestry equipment

**PIŠEK-VITLI KRPAN** Jazbina 9 a, 3240 Šmarje pri Jelšah, Slovenia (http://www.vitli-krpan.com/en/contact) - Vitli KRPAN is the producer of agricultural and forestry machinery. It is the company with the longest tradition in production of forestry winches in Slovenia which started in 1977. Several decades of experience in this field clearly serve as the company's major competitive advantage, as well as a guarantee for quality, durability and the robustness of its products.

The forestry winch still remains the most important product of the company, for Vitli KRPAN presents itself as the world's leading winch manufacturer. These include smart sensors that prevent excessive inclination of the machinery.

**UNIFOREST D.O.O.** Latkova vas 81 d, 3312 Prebold, Slovenija (https://uniforest.si) - An environmentally friendly company with high-quality, innovative machines. They include on their products the so-called smart end switches that can turn off the machine in the event of improper operation of the machine and potentially dangerous tilts.

**ROBUST d.o.o.,** Arja vas 105, 3310 Petrovče, Slovenija (https://www.robust.si/) - Under the registered trademark ROBUST, they produce and market hydraulic log splitters with a nominal strength of 13 to 25 tons of their own design. Products are innovated, patented and modelled, manufactured according to EU standards and meet all safety and health requirements. Like the two predecessors they incorporate electronic devices that stop the machines if tilting is detected.

**TAJFUN d.o.o.,** Planina 41 a, SI-3225 Planina pri Sevnici (http://www.tajfun.com/) – focuses on the production of winches, firewood processors, mobile tower yarders, forestry trailers, tractor cranes, hydraulic cranes and forestry information systems. Besides the smart antitilt winches the TajGO is the closest solution related to precision agriculture. It uses digital camplers and mobile application for reading, recording, editing, and printing of acquired data from measuring the forest wood assortments (trees, logs and boards). It is designed for individual forest owners, owners of small sawmills and professional users – foresters and wood-handling professionals.

## 3.2.4. Spraying equipment

**AGROMEHANIKA D.D.,** Hrastje 52a, 4000 Kranj (https://agromehanika.si/) - Agromehanika is the leading producer of agricultural machinery in Central and South-Eastern Europe. For over 50 years, Agromehanika has been synonymous with quality, reliability and development - features recognized by many farmers and business partners. It produces AGS sprayers, AGP mist blowers and compact AGT tractors.

Their novelty in the field of sprayers is the AG tronik M1. It is an advanced sprayer computer for sprayers designed for more demanding users. Its features are: smaller and more efficient use of the spray, better and more precise spraying, control of the sprayer from the tractor cabin, and therefore less exposure to chemicals.

**ZUPAN d.o.o.,** Celestrina 3, 2229 Malečnik (http://www.zupan.si/) – is the company for the production of high quality machinery and plant protection and care products with a focus on

of custom-made machines and wishes for the demanding customers. They focus on different kinds of spraying equipment, cleaners and also movers.

In the area of precision farming they use ultrasonic equipment and electrostatics to control the deposition of the plant protection products on the plants. The integrate spraying computers from Inovel (Germany), ARAG (Italy) and Gotrack (Poland).

### 3.2.5. Plant inspection and environmental control

**C-Astral d.o.o.,** Tovarniska cesta 26, SI-5270 Ajdovscina (https://www.c-astral.com/) - C-Astral is an aerospace solutions provider based in Ajdovscina, Slovenia, the "hub" of advanced aerospace development and integration in this part of Central Europe. The company is a global market leader with established reputation in the specialized, fixed wing small Unmanned Aircraft Systems (UAS) manufacturing and services field, with a specific focus on high productivity, endurance, surveying and remote sensing. C-Astral's customer base is diversified between the commercial UAS operators, larger institutional networks, scientific users as well as government entities. In the area of precision agriculture the aerial vessels are used in mapping services (orthophoto, termography, poit cloud, multispectral, laser).

**LOTRIČ Meroslovje d.o.o.,** Selca 163, SI - 4227 Selca (https://www.exactum.com/) - LOTRIČ Metrology is a family company with 83 employees that have been developing and offering metrology solutions for 25 years. They are developing state of the art, highly perfected, but easy to use metrology products and services. One such interesting solution that also covers the field of precision agriculture is exactum.

Exactum is smart automatic control system - is an innovative measurement systems solution that enhances the workflows in industry, healthcare, labs, warehouses, greenhouses, galleries, transportation, or wherever conditions are demanding. It is an investment in quality that makes your work easier and safe and comfortable. In the case of greenhouses, the system collects and analyses climate and soil data in order to optimize greenhouse cultivation and reduce the use of resources - water, fertilizers, electricity.

**TRAPVIEW HQ - EFOS d.o.o.,** Razdrto 47B, 6225 Hruševje (https://www.trapview.com) – EFOS d.o.o. is a company that produces TRAPVIEW, which is an automated pest monitoring system that monitors all kinds of insects, which can be lured into insect traps. The system

consists of three fully integrated, automated and easy to use tools. With significantly raising accuracy and decreasing costs of pest control TRAPVIEW provides an innovative solution for farmers, advisers and researchers.

### 3.2.6. Animal Monitoring

The producers of animal monitoring equipment in Slovenia:

**IRNAS – institute for development of advanced applied systems**, Valvasorjeva ulica 42, 2000 Maribor (www.irnas.eu) – the company focuses to apply the vast scientific knowledge to everyday reality by creating effective and affordable systems. They offer end-to-end IoT solutions for specialized use-cases, ranging from LoraWAN IoT node development, drone mapping sensor network coverage and edge computing off-grid devices for advanced sensor and image processing in limited bandwidth scenarios. A few practical examples of these solutions are: Sea Turtle Tracking, Air Quality and Radiation and Penguin Monitoring.

**SENSEDGE d.o.o.,** Podbreznik 15, 8000 Novo mesto (http://sensedge.co) - Sensedge has developed a sensor platform for agriculture of the future. AgriSense MicroUnits allows you to monitor many parameters in fields, greenhouses and plant canopies. The platform also allows monitoring of the movement of animals and the condition of grazing equipment. MicroUnits are based on LoRaWAN technology, where the data is sent to a cloud platform to analyse the measured parameters that can be monitored and performed. If the pre-set thresholds are exceeded the sistem triggers and alarm, notifying the farmer that it needs to react.

**TELOS d.o.o.,** Ljubljanska cesta 24G, 4000 Kranj (http://www.telos.si/) - Establish advanced smart management and control systems. The LoRa system enables tracking and monitoring of livestock by identifying diseased animals while detecting toxic gases in stables and cages.

### 3.2.7. Bale dryers

There following producers of bale dryers equipment in Slovenia has been identified:

**GROS d.o.o.,** Ljubljanska cesta 4, SI-4000 Kranj (https://www.gros.si/) – focuses on the production of hay blowers, drying systems, spreaders and other. Their interesting solutions in the area of precision farming include bale dryers and spreaders.

Automated bale dryer works according to the reading of the probe that is located inside the bale and the other on the external site to measure the air, which makes possible to precisely control the fans. This saves electricity and time.

Automatic hay spreaders are computer guided which makes it extremely adaptable to the shape of a senile. The telescopic spreader spills up, down, left, right but only when hay is present in the hose. The built-in photocell allows extremely uniform spread of hay across the available surface. Hay does not accumulate, which allows faster and more efficient drying.

## 3.3. High-performing service providers, by service

**SLEDAT, Uscom d.o.o.,** Polhov Gradec 93, 1355 Polhov Gradec (http://sledat.si) - Sledat Agriculture is an information solution for agricultural holdings that works in the cloud an it is designed to support and manage all key data on jobs on farms both in the office and on the ground. The information solution consists of a web application designed for entering and managing various records and a mobile application designed to capture data directly on the ground.

Sledat Agriculture is a solution composed of several modules that form a single and efficient system tailored to the needs and requirements of your farm. Access to data directly in a stable, on a field or in an orchard. This was followed by a follow-up mobile application that allows you to use your smartphone or tablet anywhere, at any time, to enter data or access the data you have entered where you need it. The information entered is automatically saved directly to the server and displayed in the web application. The web application enables the preparation of data for various reports, as well as for strategic decision-making.

**Elmitel software development,** Orehovci 1a, 9250 Gornja Radgona (development.elmitel.com) – focuses on the development of smart could services tu support vine and orchard growers with two dedicated web platforms eVindeyards and eOrchards. In addition, it also offers EIGIS GIS software and IoT Sensing platforms aimed to support precision farming applications.

**GEOSERVIS d.o.o.,** Litijska cesta 45, 1000 Ljubljana (http://www.geoservis.si/) - Company Geoservis, d.o.o. is an authorized seller of measurement equipment for geodesy, GIS, construction and mechanical engineering and navigation equipment. They are representatives by the world-renowned brands Leica Geosystems and geo-Fennel.

The activity comprises certified service, technical support and consulting, management of the permanent GNSS network, and implementation of projects with specific requirements, such as planning, setting up and operating systems for observing movements and deformations, consulting, installation and implementation of machine management solutions.

The reference station GNSS Geoservis is the first ever operating reference station in Slovenia. It was installed in 1999, and in 2000 it was included in the European network of reference stations of the EPN (Euref Permanent Network).

**TERMODRON d.o.o.,** Ulica škofa Makismilijana Držečnika 6. 2000 Maribor (http://www.termodron.si/) - They offer drone inspections to help the farm optimize its use of fertilizers and plant protection products. They ensure that their service can save up to 20 % of these resources and reduce the environmental impact. After the flight, the data is processed and compiled by Vegetation Indexes (NDVI). After consultation, they prepare target models for importation on mechanization, where variable fertilization is possible with electronically controlled mechanization, with or without GPS support.

**SINERGISE d.o.o.,** Cvetkova ulica 29. 1000 Ljubljana (https://www.sinergise.com) - The company has developed and advanced GIS information system that is an integral part of the IACS (Integrated Administration and Control System) policy. The main part of the system known as GERK is used as a tool for the entire agricultural policy and outside the institution. The company also participates in international projects and their clients are important institutions. They have developed: agricultural Register (web application), GERK (Java based tools), Giselle Farm Management (Information System, Farm Management), Controls (support for inspectors during fieldwork), Visual control (LPIS change control application), Disease control (control of infectious diseases in animals), Land consolidation (application, computer support for the management and process of agricultural land consolidation), Reclamation (management of reclamation infrastructure and agricultural land where reclamation is carried out), Register of Wine Producers. (https://www.sinergise.com/sites/default/files/attachments/leaflet-agriculture.pdf)

**TELOS d.o.o.,** Ljubljanska cesta 24G, 4000 Kranj (http://www.telos.si/) - Establish advanced smart management and control systems. The LoRa system, with the help of an IoT solution, is intended for agriculture, with the help of which we can optimize watering, fertilization and spraying, thereby significantly improving the hectare yield.

**GDi Business Technology Solutions d.o.o.,** Šmartinska cesta 106. 1000 Ljubljana (https://gdi.net) - They provide smart tools and applications for efficient food production. They use GPS systems, satellite data and drone technology to collect data to provide location-based information. Their ensemble for Smart Agriculture provides: different types of agricultural data, past and current information on crops, yield and fertilization, more optimal decisions for planting, fertilizing and harvesting.

**DATALAB Agro SI d.o.o.,** Hajdrihova 28c, 1000 Ljubljana (https://www.datalab.si/) - Datalab combines different types of agricultural activities (agriculture, fruit growing, livestock production, viticulture, etc.) into one system. Pantheon Farming includes applications, various integrations of the Internet of Things, data sharing and an office background. The system is tailor-made for each agricultural activity. For example, in animal husbandry we can enter records for individual animals, family trees of animals, animal registry, milking and veterinary diary, feeding, housekeeping. They can also keep an overview of costs, goods, bookkeeping and FADN reports.

**SAOP d.o.o.,** Cesta Goriške fronte 46, 5290 Šempeter pri Gorici (http://www.saop.si/) - Their miniMAX online accounting program for farm households simplifies administration. Farms can, through the miniMAX program, keep a book of received invoices, invoices, manage current operations, manage payment transactions and report DURS.

The latest innovation in miniMAX is a farm chart of accounts that makes it easier and more transparent to monitor your business. The chart of accounts replaced the manual management of FADN records and accelerated many bureaucratic tasks.

## 3.4. High-performing research bodies, by typology

There are three institutions related to the area of precision agriculture in Slovenia. The first two are the agriculture faculties – Faculty of Agriculture and Life Sciences (University of Maribor; fkbv.um.si) and Biotechnical faculty (University of Ljubljana; bf.uni-lj.si) – and the third is the Agricultural Institute of Slovenia (KIS; www.kis.si).

**Biotechnical Faculty, University of Ljubljana**

The fundamental mission of the Biotechnical Faculty (Biotehniška fakulteta) is to provide university level, advanced professional, and postgraduate education, as well as to carry out scientific research and technical and consulting work concerning the sciences of living nature

(biology, microbiology) as well as agriculture, forestry and fisheries (forestry, animal husbandry, agronomy) and the related production technologies (wood technology, food technology, biotechnology).

Focal points: graduate and post graduate education, scientific research and technical work.

Sciences: living nature (biology, microbiology), agriculture, forestry and fisheries (forestry, animal husbandry, agronomy), production technologies (wood technology, food technology, biotechnology).

Departments:

- Department of agronomy
- Department of biology
- Department of forestry
- Department of landscape architecture
- Department of wood technology
- Department of animal science
- Department of food science
- Biotechnology studies
- Microbiology studies
- Chair of sports education

The Biotechnical Faculty employs 700 members. At the Biotechnical Faculty in 2018, research work was carried out in the 156 research projects. There were 27 national (basic, applied and postdoctoral) projects, 17 were CRP projects and 112 were international.

**Faculty of Agriculture and Life Sciences, University of Maribor**

The Faculty of Agriculture and Life Sciences (Fakulteta za kmetijstvo in biosistemske vede) is one of the 17 faculties of the University of Maribor. It is a scientific and educational institution and is, due to its integrational work and effectiveness, in league with successful universities around the world. As a university member, the faculty represents the progress of science in many fields of agriculture resulting in a good bibliography (high-impact original scientific papers, conference contributions and patents).

The faculty is located in the centre of the most important agricultural region in Slovenia, facilitates a good combination of theory and practice and enables the application of

academic knowledge to practical work. Part of the research and educational activities of the Faculty of Agriculture and Life Sciences are carried out at the university's agricultural centre. It is located at the foot of Pohorje, about 12 km from Maribor and covers:

- 55 ha of fruit tree plantation,
- 60 ha of fields,
- 18 ha of vineyards at Meranovo,
- 22 ha of grasslands,
- 240 ha of forests,
- 8 ha of botanical garden area.

These are used for research and for the practical work of about 700 students and 70 members of teaching staff.

The Faculty of Agriculture and Life Sciences has numerous accredited undergraduate and postgraduate study programmes. We offer 8 undergraduate study programmes: Agriculture and Environment, Agronomy-Ornamentals, Vegetables and Field Crops, Biosystems Engineering, Organic Farming, Agricultural Economics and Rural Development, Viticulture, Enology and Fruitgrowing and Animal Science. The first one is more academically oriented while all others are professionally oriented. Currently, there are 3 Postgraduate study programmes (Master's programmes): Agricultural Economics, Agriculture and Food Safety and 2 Postgraduate study programmes (PhD): Agricultural Economics and Agriculture.

Educational and scientific research units at the Faculty of Agriculture and Life Sciences:

Animals sciences, Agricultural economics, Biosystems engineering, Botany and plant physiology, Chemistry, agrochemistry, Genetics, Grassland management and forage production, Field crops, Fruit production and fruit processing, Mathematical methods, informatics and statistics in agriculture, Microbiology, molecular biology, biochemistry and biotechnology, Organic farming, Ornamental plants, Phytomedicine, Plant improvement, Rural development, Soil science, Vegetables and Viticulture and enology.

In 2018 FALS employed 61 employees and was involved in the last evaluation period (2014-2018) the research work was on conducted on 127 research projects. There were 104 national (CRP, basic, applied and postdoctoral) projects, out of which 14 were in 2018, and 23 were international, out of which 4 were conducted in 2018.

**Agricultural Institute of Slovenia (KIS)**

Agricultural Institute of Slovenia (Kmetijski inštitut Slovenije) is the leading agricultural research institution in Slovenia. It comprehensively deals with the problems of modern agriculture and expands its activities in the field of environmental protection and ecology. It employs 195 workers, including 89 researchers.

The Agricultural Institute of Slovenia is a public research institute that performs basic, applied and developmental research and professional tasks in agriculture, publishes the results of scientific-research, professional and control work, performs tasks on the basis of authorizations and accreditations, checks the quality of agricultural products and products. used in agriculture. The Institute is also involved in training farmers, educating young people and advising various users in agriculture. Areas of activity:

- agriculture and horticulture with seed production,
- genetics, breeding, maintenance selection and gene banks in agriculture,
- animal husbandry (cattle, pig, beekeeping),
- fruit growing, viticulture and winemaking,
- protection of plants and the environment,
- fertility control and quality of agricultural land,
- ecology of agricultural area,
- land use and protection,
- analysis of soil, mineral and organic fertilizers, animal feed, honey, pesticide residues, plant protection products, wine,
- must and spirits,
- agricultural technology and energy; and economics of agriculture.

In 2018 KIS employed 191 employees and was involved in research work was on 54 research projects. There were 24 national (CRP, basic, applied and postdoctoral) projects and 28 were international.

## 3.5. Overview of existing networks

**ITC, Innovation Technology Cluster, Lendavska ulica 5a, 9000 Murska Sobota** (https://itc-cluster.com/sl/) - Digital Innovation Hub for Agriculture and Food Production (DIH AGRIFOOD). They combine Slovenian and European research and development expertise on digitalisation in agriculture (smart agriculture). Their goal is to provide a 'One Stop Shop' that

will provide organizations with services in the region to provide safe, sustainable and quality food.

**AE-ROBO-NET, Liminjanska 96, 6320 Portorož-Portorose** (http://www.ae-robo.net) – AE-ROBO-NET cluster was funded to provide agricultural and environmental robotics systems and services appropriate to the needs of farmers, road operators, eco remediation providers and underwater construction operators thereby increasing their efficiency, innovative potential and ecologically friendly operations.

The network organization provides an ever-expanding knowledge base, which is be based on user-friendly research and development activity, which stimulates innovation. The network association contributes to the development of competitive agricultural and environmental robotic systems needed by domestic and international agricultural and environmental providers, thereby increasing the efficiency of both sectors, and profit-making ability.

**Slovenian Agricultural Engineering Society, Hacquetova 17, 1000 Ljubljana** (www.dkts.si) - The basic task of the Association is to encourage scientific and professional work in the field of production, use and sale of agricultural technology, its rational and safe use, automation and precision agriculture, organizing various forms of information, training and education of members (congresses, symposia, consultations, workshops, professional courses, lectures, consultations, discussions, excursions, competitions, etc.).

Much attention is paid to informing members and the general public about the work of the Society, taking care of raising the technical culture and publishing professional books, publications and information.

# 4. Poland[15]

## 4.1. Overview of regional PA status

Poland is in third place in Europe due to the share of agricultural area in the total area of the country. The countries ahead of Poland are France and Spain. This area is 18 608 thousand hectares, i.e. 56% of the entire country. Such a large surface area allows the land to be used less intensively as well as the use of environmentally friendly production methods. In 2018, farms in Poland produced production whose global value (in current prices) places Polish agriculture in 7th place in the European Union, behind France, Germany, Italy, Spain, Great Britain and the Netherlands. Its value (over PLN 110 billion) constituted 2.8% of the value of global production in the national economy. In turn, the gross value added generated in the agriculture, hunting and forestry department reached almost PLN 45 billion, and in agriculture alone it amounted to over PLN 38 billion, which constituted, respectively: 2.7 and 2.3% of the country's global production value. The development of agricultural commodity production did not, however, increase its share in the raw materials resources of food processors. Currently, it is estimated at about 60-65%, while the value of this indicator shows a decreasing tendency. In the middle of the last decade, Polish agriculture still supplied approx. 75% of raw materials for the production of food preparations, but the high dynamics of the development of imports of agricultural products and semi-finished products reduced the importance of agriculture in the supply of raw materials to food companies1. The structure of the commodity value of agricultural production was dominated by animal products, which in the years 2006-2016 constituted 56-58%. The best PA companies operate in the Zachodniopomorskie voivodship, e.g. DIS /

On the one hand, in the total number of farms (of which there are 1 405 700 - data from 2017), small farms with an area of 1–10 hectares dominate. According to data from the Central Statistical Office of 2017, they constitute about 75% of the total number of farms, but their use is only about 28% of arable land12. On the other hand, we have larger farms (with an area of over 10 hectares), whose total share in the total number of farms is about 25% (including the largest farms, over 50 ha - 2.5%) and they use about 72% of agricultural land

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[15] Provided from KIRG: Pawel Materka et.al. (2020)

Territorial diversity of the agrarian structure is also characteristic of Polish agriculture. For example, while the average farm area in the Lesser Poland Voivodship is only about 4 hectares, in the Warmian-Masurian and Lubuskie Voivodships it is over 20 hectares, and in the West Pomeranian Voivodship it exceeds 30 hectares1

According to Eurostat, Poland is the second largest in the percentage of farms (13.2%), slightly ahead of Italy (9.3%) and Spain (8.9%) and is one of the largest agricultural producers in the European Union. In 2016, it held a high sixth position among the 27 member countries. According to data from 2018, Poland achieved the value of agricultural production (25 billion or 6 percent) Output of agricultural industry and its components in Poland. Poland is overtaken by countries such as France, Italy, Germany, Spain and the United Kingdom

In Poland, most farms are small. Average size of farm amounts to 8.4 ha UAA. The cereals are main crops with more than 70% share. Low production inputs cause the level of yields to be low.

Therefore, the value of agricultural production is low. Only 0.7% of farms have> 50 ha UAA in Poland. However, they use about 1/4 of total cultivated land. For such farms, more advanced PA systems are needed, which involves higher costs. This reduce these costs, the rational utilization of equipment is necessary. A multi-farm machinery use system can help to diminish fixed costs thanks to higher annual use.

Fragmentatien of farms and low value of agricultural production makes the adoplion of PA difficult in Poland. However, under such conditions, more simple forms of PA can be adopted. There are opportunities to start it without purchasing an expensive yield monitor. The assessment of variability field to field can be applied, cspecialły as the ficlds are small and relatively uniform. Each ficld is assessed as a uniform arca and receives a uniform application of fertiliser, lime, and pesticides. Crop yields for each field can be determined by weighing loads. Records are maintained by field and contain average yield, size or area, soil types, lime and fertility data, and pesticide applied. Costs for adopting this system are minimal. They include the time for record keeping and weighing of each load. This is a practice that crop producers should be using to insure cach ficld is treated properly based on average fertility and pest data. Adoption of this system would be a first step to more complete data registration on farms according to EU standards.

Polish agriculture is still not able to sufficiently use PA when it comes to its practical implementation. The main reason for this lies in the nature of the fragmented Polish

agricultural sector composed of many small farms that lack the potential to adopt PA practices.

## 4.2. High-performing OEMs (HW & Equipment), by technology

### 4.2.1. Steering Systems

Farmers most often use office software, followed by specialized applications created for agriculture. Programs for completing applications, supporting plant protection, reminding of deadlines for field work, product price bases, fertilizers, etc. are the most popular among farmers.

Farmers prefer free software or at a very low price. The main goal of another group of projects was to develop innovative applications and open ICT platforms that aim to advise, inform and support farmers, as well as to encourage users to cooperate actively. This type of open platform, using the power of modern smartphones and the economy of applications, was implemented as part of the AGROIT project. Meanwhile, the FOODIE project has created a cloud platform that is designed to store spatial and non-spatial agricultural data, while the AUDITOR project created a GNSS ground-based support system through which farmers can benefit from highly efficient and cost-effective services and applications.

Among the enterprises available on the Polish market that offer a range of ICT services also include:

**Bitkomp company**

- Bitfarma application - for farmers and agricultural advisors - recording economic events on farms - supporting the planning process and making decisions in the field of current plant production management - GIS functionality and a module cooperating with maps

**Agropower company**

- AgroAsystent - for farmers conducting any sown crops, regardless of their area - supports farm management in crop production - GIS functionality • Map module

- AgroPomiarGPS application - agriculture, forestry, land management - designed for portable Pocket PCs (PDAs) with GPS receiver - GIS functionality, measurement using GPS, graphic presentation of measurements in the form of a map, adding SHP sleepers with record plots

- The RolnikON company - has developed an online farm management system - effective management of crops, stored materials, breeding - GIS functionality • presentation of fields on a Google map

**Agroboss company**

- eLMID-AgrarGIS, introduces GIS functionality, loading and editing various types of maps, description and vector development of cadastral maps of the entire farm and single arable fields, development of aerial photographs, topographic maps and other soil maps. The program databases contain data of surface registers and usage methods, taking into account cadastral data and the possibility of making manual divisions on the farm schedule and aerial photography base, as well as creating application maps of fertilization taking into account soil tests

**Agrar-Office**

- produces agriculture applications for full farm management - works with machines from many manufacturers - 4 modules, Field Journal - field card is a tool for accounting - saving field work on the farm, GIS - for area management, Field Book - for management plots for registration and for creating maps of precise fertilization, spraying and sowing - GIS functionality, GIS Smart Rural module.

**Agro Innovations Center**

- Introduced the application "Virtual Virtual Zootechnik" - WirtualZootechnik.pl. It is a web application that works in a web browser. Basic program for detailed herd management - WirtualZootechnik Farm Manager. The application works on Android phones and is used for daily work directly in the barn. Thanks to the proximity technology, it allows identification of the animal after placing the phone close to the animal's earring.

### 4.2.2. Tillage/Soil Cultivation and Seeding Equipment

In Poland, there are not many manufacturers of machinery and equipment, the main role in providing equipment for farmers is played by distributors who, in cooperation with Polish and, above all, international producers, e.g. CYKOMET. Distributors mediate in the trading of machinery, equipment and control programs.

Among Polish producers, as well as international ones, who decided to produce in Poland (among others) due to low employment costs we distinguish the following. The latest and award-winning products were also presented:

- Przedsiębiorstwo Usługowo-Produkcyjne AGROMIX Sp. z o.o., manufacturer Manitou Group - Manitou MLT 420 telescopic loader

- USARYA POLSKA Sp. z o.o. - Husarya SCS-100 stone collection machine

- UNIA Sp. z o.o. - UNIA HERON 50 27 - Trailed sprayer

- MZURI-AGRO Sp. z o.o. Sp.k. - Mzuri Pro-Til - belt cultivation technology

- Przedsiębiorstwo Produkcyjno-Handlowo-Usługowe A-LIMA-BIS Sp. z o.o. - ALIMAMIX EVOLUTION PRO forage wagon

- NAMYSLO Damian Namysło - Seedbed combination with pneumatic seed drill Namyslo FLYY

- Agroma S.A. - The company provides advanced agricultural tools, blocking monitors, cameras, customer relationship management, data management software, flow meters, GPS receivers, planter clamping force, precision application systems, precision planting unit row, speed controllers, RTK signal providers, UAVs.

### 4.2.3. Plant Breeding & Research

The main crop systems in Poland are:

DIRECT SEEDING

direct (no-tillage) is an extreme method of simplification and consists in sowing seeds into uncultivated soil. This sowing technique has recently attracted increasing interest, but in Poland it is carried out on about 1% of the area sown

BELT CULTIVATION / BELT SEEDING (strip till)

Belt sowing is a cultivation system consisting of loosening only a narrow several-centimeter strip of soil in a row, where seeds are sown and fertilizer is fed at the same time, and lateral soil stripes (inter-rows) remain uncultivated. The cultivating chisel loosens the soil to a depth of about 20-25 cm and at the same time compound fertilizer is applied at one or two depths (depending on the design solutions of the seeder)

To a large extent, success in strip-till depends on how we crush and scatter plant residues across the field. Soil cultivated in belt technology is mulched with plant residues, which allows better management and saving of water.

SINGING CEREAL SEEDS

The seeds are fed from the central tank to the distribution head and are then transported pneumatically to the seeding coulters - as in seeders from other manufacturers. Before they are placed in the soil, they go to a patented dispenser located above the sowing coulter discs, which separates the seeds delivered by pneumatic lines

Precision fertilization is one of the elements of precision farming. It is the use of fertilizers in doses exactly suited to the needs of fertilization, i.e.

- variable dosing depending on the soil's abundance and plant development phase,
- calculation of actual yields and precise guidance of machines in connection with satellite navigation.
- The benefits of precise fertilization that we can get are:
- saving fertilization and increasing its efficiency (dose adjustment),
- crop uniformity,
- reducing fuel costs.

Production is based on performing fertilization treatments in a timely manner and using the right amount of fertilizer. It is justified to use different fertilization and liming on individual parts of the field. We need to adjust the amount of fertilization to the potential plant demand to the knowledge we have about variable soil richness and its efficiency.

The limiting factor for precision fertilization methods are the high costs of introducing this technology, especially on small and medium-sized farms.

The main enterprises providing solutions to the Polish market in this area include:

**IUNG company** - which has introduced several solutions

- NawSald - for agricultural producers and agricultural advisors - preparation of fertilization plans on farms for arable land in accordance with the principles of sustainable mineral management
- MacroBil - balancing nutrients on the farm on the surface of the field
- Plano RSN - creating fertilizer plans with component balance control

- InfoPlant - a comprehensive assessment of the current nutritional status of a crop based on the results of chemical analysis of a plant sample taken during the growing season

**Agroboss company**

- Poultry application - supports management of laying poultry and meat poultry - the possibility of operating a farm consisting of many buildings (poultry houses) and many warehouses (packaging, feed, eggs and chicks) - the possibility of operating an egg sorting plant

### 4.2.4. Animal Monitoring

EU funds are an opportunity to develop precision farming technology also in this area. An example is the SYMPHONY project, which resulted in the creation of an early warning system that quickly detects the presence of toxins in milk, so it can become a huge support for milk producers.

An important element for this area is measuring available feed and adapting it to the needs of cows. Controlled access to pastures improves their use.

The grass should be allowed to grow to the right height, because if it is bitten too low, the cows will not eat as much as they should.

Timer-operated gates and automated fences can be used to control cow access to pasture, and a combination of all these technologies can help lead cows out of the area where the grass has been bitten to the optimal height.

You can record the sounds that animals make while chewing and analyze the frequency of biting and chewing.

This kind of "bioacoustic" monitoring could be combined with activity sensors for better accuracy and thus determine when to open the gate to the next part of the pasture.

The technology is a source of additional information for consumers about the food they buy, e.g. information about the product they purchased could be written in a bar code on the packaging. The more intensive use of precision technologies can benefit the image of dairy farmers.

The main system suppliers that support plant research and breeding include:

**Zeto software**

OBORA application - for dairy farmers - supports the management of a breeding farm covered by the performance assessment - fully integrated with the national system for the assessment of the utility and breeding value of cows and bulls (SYMLEK) –

- GIS functionality
- animal selection
- event forecasting (calving, drying, covering, testing)
- analyzes (performance, reproduction, somatosis and observation)

**Agroboss company**

The "Ferma" application - a computer system for handling a herd of cattle - supports management of a herd of cows - handling databases on cows, bulls and calves

The "Trzoda chlewna" application is a system for managing pig farms - for breeding (breeding) and commercial farms - fast and efficient data processing in the field of animal utilization and the level of production of a given farm - developed by specialists in the field of pig breeding, therefore all operations are adapted to the requirements and habits of pig producers

Hatchery - gathering and processing information on the hatching process - tracking numerical movement of eggs from the egg warehouse (acceptance) to sale from the chick warehouse - the possibility of creating a database of egg suppliers and chick recipients

Veterinary clinic application- supports the practice of a veterinarian in conducting substantive and financial documentation related to the performed activity - the possibility of performing various analyzes of own professional and financial activity

**Mroczko company**

- MR-A WinPro-Genetica - sow insemination station service

**Alima BIS company**

- Afimilk - dairy cow herd management – modules: AfiMilk - control of milk production and udder health, AfiLab - milk composition control, AfiAct - heat detection, AfiWeigh - automatic animal weighing, AfiSort - automatic separation of cows, AfiFeed - individual nutrition with concentrated feeds, AfiFarm - software connecting all modules.

**Meteoryt company**

- Assistant Register of Pigs - for farmers to support pig farming - a register of basic data about animals, e.g. earring number, origin, breed, age, type - gathering data on nutrition and animal weight

- Assistant Cattle Registry - for farmers to support cattle breeding - detailed records of animal data, e.g. earring number, origin, breed, age, type - gathering data on nutrition and animal weight

- Goat Registry Assistant - for breeders to support goat breeding - record of basic data about animals, e.g. earring number, origin, breed, age, type - gathering data on nutrition and animal weight

- Assistant Register of Sheep - for farmers to support sheep farming - record of basic data about animals, e.g. earring number, origin, breed, age, type - collection of data on nutrition and animal weight

- Live Inventory Assistant - for farmers - cattle records on a farm, including, for example, cattle photos, recording milk and weight performance, collecting nutritional data.

**Zeto software**

- OBORA - for dairy farmers - supports the management of a breeding farm covered by the performance assessment - fully integrated with the national system for the assessment of the utility and breeding value of cows and bulls (SYMLEK) - GIS functionality • animal selection • event forecasting (calving, drying, covering, testing) • analyzes (performance, reproduction, somatosis and observation)

**e-stado sp.z o.o. company**

- the company's goal is to provide necessary information about the health of cows and their reproductive cycle. It includes features such as animal health monitoring, heat, insemination and calving. It is non-invasive and safe to use, based on maintenance-free biosensors. Based on data from biosensors, the system monitors herd and barn environment for 24 hours. Data on the animal condition and conditions in the barn are then sent to a central server. The user receives access to the www application and SMS notifications about emergencies, where he has access to all data on an

ongoing basis. The company's main systems and devices are: Ear biosensors, Environmental sensors, Tail biosensors, Radio transmitters in the barn and on the pasture

## 4.3. High-performing service providers, by service

High-performance agricultural service providers in Poland include:

The Agency for Restructuring and Modernization of Agriculture, which in addition to providing extensive consulting services for the agricultural market, has been developing the infrastructure and system monitoring system based on the Splunk software for several years

Also Agricultural Advisory Centers, operating regionally and nationwide, are important institutions supporting the agricultural market.

To enterprises that support agriculture, including in terms of providing solutions to the market include:

- eAGRONOM Sp. z o.o. - eAgronom - a program that facilitates farm management

- KST Konsulting Sp. z o.o., producer UNIFORM Agri - UNIFORM Agri - dairy herd management software

- KUHN-MASZYNY ROLNICZE Sp. z o.o, producer NOBILI S.p.A. - Innovative remote monitoring system of field crusher KUHN CONNECTED SHREDDER -

- SatAgro Sp. z o.o. - SatAgro service module supporting precise soil research and fertilization based on the abundance and satellite images

- CLAAS Polska Sp. o.o - DATA CONNECT - interface enabling the exchange of data on the location, status, speed and fuel level of many brands of tractors and machines

- RHIZA - This is a company that provides independent solutions supporting precision farming in Poland. The company's basic services include: mapping field and crop boundaries, planning precise sowing and fertilizing, rates of variability of doses and abundance, crop growth models and models of disease / pest occurrence (predicting pressure exerted by pests and diseases), forecast yields.

## 4.4. High-performing research bodies, by typology

In Poland, the main research role, driving and analyzing the state of agriculture is mainly played by universities and research institutes. Among them, the greatest role is played by :

- Institute of Machine Operation, Ergonomics and Production Processes
- Agency for Restructuring and Modernization of Agriculture in Warsaw
- Central Center for the Study of Varieties of Crop Plants in Słupia Wielka
- Institute of Agricultural and Food Biotechnology prof. Wacław Dąbrowski in Warsaw
- Institute of Agricultural and Food Economics - National Research Institute in Warsaw
- Institute of Plant Breeding and Acclimatization - National Research Institute in Radzików
- Institute of Agricultural and Forest Environment of the Polish Academy of Sciences in Poznań
- Institute of Plant Protection - National Research Institute in Poznań
- Institute of Horticulture in Skierniewice
- Institute of Technology and Life Sciences in Falenty
- Institute of Cultivation, Fertilization and Soil Science - National Research Institute in Puławy
- Institute of Natural Fibers and Herb Plants in Poznań
- Institute of Animal Production - National Research Institute in Krakow
- National Center for Agricultural Education in Brwinów
- National Agricultural Support Center in Warsaw
- National Institute of Rural Culture and Heritage in Warsaw
- The Vegetable Research Institute Emil Chroboczek in Skierniewice
- the Institute of Pomology and Floriculture. Stephen Pieniazek
- Institute of Plant Breeding and Acclimatization in Radzików
- Central Center for the Study of Varieties of Crop Plants
- Institute of Building, Mechanization and Electrification of Agriculture
- Institute of Animal Production - National Research Institute in Krakow
- National Veterinary Institute - National Research Institute in Puławy

## 4.5. Overview of existing networks

In Poland, the leading networks that distribute solutions, information, and manage communication and funding are Agricultural Advisory Centers, oriented in every region in Poland (ODR). The National Center for Agricultural Support takes care of the regional institutions of the ODR.

In addition, supporting and important in the implementation of system solutions for innovation, as well as the distribution of equipment, machines are also:

- Network for innovation in agriculture and in rural areas - SIR, operates within the National Rural Development Network (NRN subnet) and is of an open nature. Network participants can be all entities involved in the development of agriculture and rural areas. The tasks of the Network for innovation in agriculture and rural areas, including the tasks of an innovation broker, are carried out by WODRs located in all 16 voivodships

- The European Innovation Partnership for efficient and sustainable agriculture (EIP-AGRI) is a new tool to support the agricultural and forestry sector. Its primary goal is to increase efficiency, sustainable economy and create opportunities to solve current problems such as strong competition, unstable market prices, climate change or tougher environmental regulations.

- The EIP-AGRI network focuses on establishing partnerships and contacting people from various specialties within the EIP-AGRI network to carry out work focused on various fields within the EIP-AGRI operational and focus groups.

- ENTAM European Agricultural Machines Research Network, of which a Polish institution is also a member,

An important role in the distribution of solutions and knowledge of precision farming is also played by scientific conferences implemented by institutes and universities in Poland, including:

- the conference "Precision Future of Agriculture, organized by the Center for Precision Agriculture in Medium Ducks.

- Innovative Agriculture conference organized at the Polagra fair

- Conference "Precision farming in Poland - today and tomorrow"

- Scientific conference 'Organic farming - current state and development perspectives - techniques, technologies, food production', whose leader is the

Industrial Institute of Agricultural Machines - The main purpose of the conference is to present the results of scientific research related to organic farming and pro-ecological activities in modern agriculture, carried out in scientific units and universities in the country.

• Conference "Agriculture of the 21st Century" - problems and challenges - organized by the "Krzyżowa" International Conference Center

# 5. Austria

## Region: Upper Austria (LCM)[16]

### 5.1. Overview of regional PA status

Upper Austria hosts top PA companies, e.g., Pöttinger, Steyr Traktoren and Wintersteiger.

Since 2015, *Maschinenring* (https://www.maschinenring.at/) provides a "Real Time Kinematic" (RTK)-Signal for exact driving. Four base stations allow for an area-wide use of this service in Upper Austria. In 2017, about 50 farmers used the MR signal.

Unfortunately, to the best of our knowledge, there do not exist any numbers about the coverage of the use of PA in Upper Austria.

## 5.2. High-performing OEMs (HW & Equipment), by technology

### 5.2.1. Steering Systems

The S-Tech System of *Steyr Traktoren* (https://www.steyr-traktoren.com/de-at/landwirtschaft) provides high precision steering with an accuracy of up to 2,5 cm (RTK+). Functions: Automatic turn-around at the end of the track, Vehicle settings logging, Power monitoring, Intuitive Touchscreen Monitor and ISOBUS interface.

The onboard electronics products of *agris* (https://www.agris.at/de/mueller-elektronik/lenksysteme.html) include automatic steering systems with a precision of 15 cm. Their portfolio also includes measuring equipment (humidity, temperature and soil diagnosis) and weighing machines.

### 5.2.2. Tillage/Soil Cultivation and Seeding Equipment

A major Upper Austrian agricultural technology company that includes grasland care, tillage, seeding equipment and digital farming technology (e.g. driving assistance and precision drill technology) is *Pöttinger Landtechnik GmbH* (https://www.poettinger.at/en_us).

The portfolio of *Einböck* (https://www.einboeck.at) includes machines for crop-care, tillage, grassland care and seeding & fertilizing.

*Regent* (https://www.regent.at/en/) produces equipment for tilling such as ploughs, power harrows, seed drill gear and cultivators.

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[16] provided from: Linz Center of Mechatronics – Researcher DI(FH), Dr. *Martin Scherhäufl*, et.al (2020)

### 5.2.3. Plant Breeding & Research

*WINTERSTEIGER* ([https://www.wintersteiger.com/de/Home)](https://www.wintersteiger.com/de/Home)) is the world's number one in field research equipment and has established itself at the top of a niche market which will continue to gain significance in future. The big challenge faced by agronomists and plant breeders is introducing new developments that make a decisive contribution towards sustainable food and energy supplies for the world.

*WINTERSTEIGER* supplies the technology needed to do this, and its products in this area cover the entire cycle of field research from the sowing to the harvesting. The product range includes: plot combines, plot increase combines, stationary threshers, plot forage harvesters, plot seeders, software solutions for data collection and evaluation, fertilization and crop protection equipment, laboratory equipment.

### 5.2.4. Animal Monitoring

*Smartbow* ([http://www.smartbow.com/en/home.aspx](http://www.smartbow.com/en/home.aspx)) developed a comprehensive system for dairy cow monitoring including Industry-leading rumination monitoring, unparalleled heat detection, truly real-time localization and Animal Pattern Recognition IntelLigence (APRIL).

Benefits: Efficient labor management & Time savings, better insights on dairy cow heat and health, and thus better decision. Results: Potentially achieve more milk, better reproduction, lower disease incidence and better milk quality.

## 5.3. High-performing service providers, by service

*Landwirtschaftskammer OÖ* ([https://ooe.lko.at/](https://ooe.lko.at/)) is the legal representation of farmers and lumberjacks in Upper Austria. This institution provides farmers with information, consulting and all kinds of events.

*Maschinenring* ([https://www.maschinenring.at/leistungen/agrar/rtk](https://www.maschinenring.at/leistungen/agrar/rtk)) is an association that includes agricultural entities which jointly use agricultural and forest machines, and that arranges for agricultural manpower when needed.

### 5.3.1. High-performing research bodies, by typology

The *University of Applied Sciences Upper Austria* (https://www.fh-ooe.at/campus-wels/studiengaenge/bachelor/agrartechnologie-und-management/alle-infos-zum-studium/schwerpunkte/) offers a bachelor study in agricultural technology and management

Focal points:

- agricultural sciences
- agricultural technology
- agricultural management

Topics:

- technology (amongst others: electrical engineering, sensor technology, digitization)
- plants (amongst others: tillage, greenhouses, precision farming)
- animals (amongst others: anatomy, breeding, precision livestock farming)
- management (amongst others: business administration, agricultural markets, digital marketing)

Certificates:

- agricultural skilled worker
- crop protection expert
- drone pilot

### 5.3.2. Overview of existing networks

The *OÖ Bauernbund* (http://ooe.bauernbund.at/netzwerkagrar/) offers agricultural networks (Netzwerk Agrar), where all persons can become members. Aim of the networks is to provide amongst others the following services:

- exchange of experience and information
- interface to politics, business and stakeholders
- lectures, excursions, and events

The *Bauernnetzwerk* ([https://www.bauernnetzwerk.at/startseite/](https://www.bauernnetzwerk.at/startseite/)) is a service platform for farmers and consumers. Aim of the network is to provide amongst others the following services:

- networking

- provide services to farmers and consumers

# Region: Lower Austria (FJ)[17]

## 5.4. Overview of regional PA status

Lower Austria hosts PA companies, e.g. Geoprospectors, agXtend (as a sister company of CNHi), Farmdok, Microtronics.

In the trading business of agricultural products the RWA Raiffeisen Ware Austria AG is widely known. It is the wholesale company and service provider of the Lagerhaus cooperatives in Austria.

## 5.5. High-performing OEMs (HW & Equipment), by technology

### 5.5.1. Steering Systems

There are no OEMs known in for steering systems in Lower Austria.

### 5.5.2. Tillage/Soil Cultivation and Seeding Equipment

Lower Austrian companies for tillage and seeding are:

- *Agri Farm Maschinenbau GmbH*: They build conventional machines for tillage and soil cultivation

- *APV Technische Produkte GmbH:* The company started with disc spreaders for grassland and seeding but continuously enlarged the product portfolio with rotary hoes, tine weeders for mechanical weed control, grassland harrows and grassland rollers, pneumatic seeders. The machines are partly equipped with ISOBUS technology. The competence therefore is established within the company.

- *Geoprospectors* GmbH: Their product Topsoil Mapper supports the farmer in optimising soil cultivation by measuring the heterogeneity of fields (soil type, water saturation,

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[17] provided from: HBLFA Francisco Josephinum (FJ) – Researcher DI.Dr. *Jürgen Karner,* DI *Reinhard Streimelweger* LL.M. (WU), DI *Christian Rechberger* (2020)

and compaction using electromagnetic induction). The products are sold via the CNHi distribution channel "agXtend".

### 5.5.3. Plant Breeding & Research

*Farmdok* (https://www.farmdok.com/en/) is a startup and Farmmanagement- and Informationsystem that provides digital tools for planning and record keeping in agriculture.

### 5.5.4. Animal Monitoring

No companies known in Lower Austria

### 5.5.5. IoT – Internet of Things

*Microtronics Engineering GmbH* (https://www.microtronics.com/index_en.html) stands for very high quality state-of-the-art products and services in the field of GSM-based M2M data transmission. The product range covers wireless GSM data transmission technology enabling data interchange between devices and machines, mobile data acquisition devices for data collection and data monitoring in the field as well as visual representation and storage of data on a central server.

## 5.6. High-performing service providers, by service

*Maschinenring* already operates PF machinery as know how centre.

**Agro-Innovation-Labs** (RWA and BayWa) provide drone services

*LK digital*

The Austrian Chamber of Agriculture supports the web-service "LK digital" (www.lkdigital.at). Established in 2017, it is operated by the LFI - Ländliches Fortbildungsinstitut Österreich, which is the continuing education institute. LK digital was set up as an education campaign to prepare information in the field of digitization in agriculture and to create awareness for new ways of crop and livestock production, marketing and management. It comprises a central hub for digitisation in agriculture. Interested persons can access relevant information, independent from time and place by the help of a knowledge platform. There you can find e.g. useful apps for agriculture and forestry, reports from research projects in digitization, monitoring of pest infestation (European Corn Borer), use of satellite information based application maps, data networking with farm management information systems

## 5.7. High-performing research bodies, by typology

*HBLFA Francisco Josephinum Wieselburg* (https://www.josephinum.at/blt.html):
Competences in Precision Farming at

- Analyzing and optimizing technical and logistic processes in the field of agriculture
- Computer Vision: Machine vision (image analysis) in agricultural applications such as plants, soil etc.
- Data and Information Sciences in Precision- and Smart Farming
- Develop future Product concepts based on agro-mechatronic systems
- Experimentation and field metrology

Campus Francisco Josephinum of the University of Applied Sciences Wiener Neustadt (FHWN), Study programme "**Agricultural Technology**":

Focus:

- crop growing and cultivation
- agricultural engineering
- geo-informatics
- agro-mechatronics
- software development
- precision and smart farming

Certificates:

- agricultural skilled worker
- crop protection expert

*Austrian Institute of Technology* (AIT, Klosterneuburg, https://www.ait.ac.at/en/about-the-ait/): The AIT was partner of the project SafeCon - Safe semi-autonomous convoying and the project RelCon - Safe control of autonomous vehicles. The KIRAS project SafeCon is aimed at developing a technology for the Austrian Federal Army to make army supply convoys semi-autonomous so as to avoid the loss of human lives in hazardous or dangerous situations. The RelCon (Reliable Control of Semi-Autonomous Platforms) project team will now refine this core technology for autonomous supply convoys to meet the specific requirements of civil disaster

scenarios. The intention is to implement the requirements in a simple and inexpensive way, but without compromising on functionality, reliability or safety.

The RelCon project focuses on the integrated use of autonomous vehicles and remote control by teleoperator so as to be able to respond quickly and flexibly to a variety of operational scenarios or conditions. Specifically, the combination of autonomous vehicles and a teleoperator will make it possible to respond appropriately to unexpected events. A robotic system used in a real disaster scenario is expected to respond flexibly to changing and/or unknown conditions and thus prove highly robust in operation. Hence the focus of the RelCon project is on a combination of autonomy and remote control as a means to achieving the high degree of reliability and robustness necessary for use in civil disaster scenarios.

## 5.8. Overview of existing networks

*Ecoplus* (the Lower Austrian business agency, [https://www.ecoplus.at/about-us/facts-figures/](https://www.ecoplus.at/about-us/facts-figures/)) operates so called Technopoles. One is located in Wieselburg, focusing on Agricultural Technology:

- Support stakeholders and companies (Funding and Project Partners, …)
- Stimulate the cooperation between R&D, economy and education
- Organization of meetings and events for knowledge exchange and project development
- Dissemination of project outputs and results

The common goal is to make the production of food, feed and raw materials environmentally friendly, sustainable and cost-effective. A part of Ecoplus is the **Mechatronic Cluster**. It incorporates Precision Farming technologies provided by the industrial sector.

**Platform "Digitisation in Agriculture":** To explore and seize new opportunities the platform "Digitisation in agriculture" of the Federal Ministry for Sustainability and Tourism was established in spring 2017. The platform aims to accompany the trend towards digital technologies in agriculture in the large number of areas concerned with an eye to the future. Short-, medium- and long-term measures are to be taken in a way that this trend can be followed and supported and that domestic agriculture which, in international comparison, is rather small-structured, can make good use of it and utilise it adequately. Specific fields of action have been identified and analysed in a report. They comprise legal framework conditions just as much as economic or environmental aspects and regional development.

Nine areas of activity have been identified [BMNT: Bericht "Digitalisierung in der Landwirtschaft – Entwicklung, Herausforderungen und Nutzen der neuen Technologien für die Landwirtschaft"]:

1. Technology in arable farming: The high rate of development offers a huge potential for an improved, precise and optimized production method. Digitalisation is a challenge for small-scaled Austrian farms. They often can´t afford modern technology (ISOBUS, GNSS, section control, telematics, FMIS) for their own farm. The risk of highly rated transparency or the dependency on reliable technology are rated as risks from farmer´s perspective.

2. Technology in livestock farming: The number of semi- or fully-automatic working processes increases, especially in livestock farming. The systems are digitally controlled and acquire or handle external data. The collected data are used for herd management and for optimized feeding. It has to be mentioned that digitalization in livestock farming must not only be a tool for management control, but has to support animal welfare by the help of existing information.

3. Material management: The information along the value chain shall be improved and standardized. One example is the structured digital data exchange for planning and controlling the processes in the Austrian forestry sector. Meanwhile, about 90 % of the Austrian round timber is managed with the standardized FHP file format to enable automatic cross-company data exchange.

4. Business administration and management: The chance of small scaled farms is to take decisions on the basis of relevant data. Therefore the cost accounting has to be linked with farm-management systems. Farmers need the skills to acquire information out of data. An advantage of digitisation is the simplified proof of origin.

5. Ecology: Digital information from soil and fields supports the decision making process in terms of arable farming (e.g. plant treatment, irrigation, demand-driven fertilization) to minimize environmental impacts (e.g. nitrate concentration in ground water, resistance formation among pathogens).

6. Legal framework: The operation of drones in agriculture to acquire field information requires to fulfil several legal requirements. Uniform standards need to be developed. The permanent storage of data enables Big Data-analysis. From the legal point of view it is relevant that access to data without personal connection enables

benchmarks in wide areas. The combination of various data can lead to new KPIs. But farmers might be supervised by third parties (e.g. service providers) when they collect data from the farmer´s fields. They could draw conclusions e.g. from the site-specific yield value.

7. Administration and agricultural statistics: The ownership of data has to be clarified (open-data).

8. Regional development: Austria is still lacking in technical and social infrastructure. The telecommunication systems need to be established and has to cover the agricultural territory.

9. Education and training, consulting: The digital learning objectives have to be integrated in curricula of courses for future farmers. They learn about the utilization of Smart and Precision Farming. Several training opportunities are offered in Austria by the Francisco Josephinum, University of Applied Science Wiener Neustadt and the University of Natural Resources and Life Sciences.


*House of digitalization (https://www.virtuelleshaus.at/):* The aim of the House of Digitalization is to increase understanding of the significance of digitalization for our (working) lives and our prosperity. It will provide a new creative space where projects can be initiated and implemented. The aim is to provide support for innovative firms, helping them get their ideas onto a commercially viable footing (www.virtuelleshaus.at).

The targets are:

- Accelerated digital transformation for businesses in Lower Austria

- Easy access to research institutions for business enterprises

- Strengthening multi-disciplinary and international research

- Key and demonstration projects

- Raising awareness

- Transforming people's fears into interest through better understanding

The (virtual) House of Digitalization comprises several floor levels:

1. digiPEDIA: This floor is some kind of compendium for items, terms and definitions regarding digitization. This reference work explains abstract terms and definitions of digitization by means of concrete examples or projects.

2.    digiGALERIE: Examples of digital innovation can be presented on this floor, as well as the corresponding companies.

3.    digiEVENTS: This event calendar provides an up-to-date overview about digitization events in Lower Austria.

4.    digiSKILLS: Companies and institutes can describe their skills, abilities, resources and references. If someone is seeking for a project-partner you can access this floor.

5.    digiFIT: Search function for courses and training opportunities related to digitalization. Organizations that offer these types of opportunities are welcome to add them here.

6.    digiLAB: New project ideas can be presented here - expecting to find an appropriate project partner.

7.    digiCROWD: Service to support the development of new products, services and business models.

8.    digiINNOVATION: Service to support the development of new products, services and business models – within a closed format.

9.    digiCHECK: online-check of your digital skills (fit4internet)

10.    digiFörderung: Compilation of various funding measures from the state of Lower Austria and the federal government that are relevant to the topic of digitization.

11.    digiNEWS: Social media news related to the House of Digitalisation.

12.    DIHOST: The Digital Innovation Hub East supports small and medium-sized companies in their digital transformation.

## 5.9. Other federal provinces

_AAC – Austrian Agricultural Cluster_ (Headquarter in Vienna, https://www.aac.or.at/):

The Austrian Agricultural Cluster (AAC) is the export-oriented Association of the most innovative Austrian producers of agricultural, food processing and renewable energy technologies.

The company cluster was founded in 1999, within the Export Promotion Program of the Austrian Ministry of Agriculture, Forestry, Environment and Water Management and of the Austrian Federal Chamber of Commerce.

The Austrian Agricultural Cluster currently represents 19 leading companies and organisations covering all segments of the agrifood chain:

- Agricultural Equipment: Bauer GmbH, Cimbra, CNH Industrial Austria GmbH, Pessl Instruments

- Animal Housing: Schauer, Smartbow, Wolf System

- Animal Nutrition: Biomin, DonauSoja

- Breeding Livestock: pig.at – Austrian Pig Breeders Association, IK Pyra – International Competence Center for Cattle Breeding and Dairy Cattle, ZAR - Federal Association of Austrian Cattle Breeders, ÖBSZ - The Austrian Federal Association for Sheep and Goats

- Consulting Services: BOKU Vienna, Wieser Consult

- Food Processing: Berglandmilch, Bertschfoodtec,Bertschlaska, Biomedica

- Know-How: BOKU, IK Pyra, Wieser Consult

- **Smart Farming:** Bauer GmbH, CNH Industrial Austria GmbH, Pessl Instruments, Smartbow

Through the network of qualified companies in various sectors of agriculture, food-processing and renewable energy, the AAC is a partner for integrated agricultural projects including corporate finance combined with European Union subsidy programs. The core competence

lies in the provision of scientific know-how, consulting and latest technologies of leading Austrian companies and organisations.

*Lindner* (Headquarter located in A-6250 Kundl/Tirol, https://www.lindner-traktoren.at/en/) has been developing and producing tractors and transporters for the alpine and pasture farming industry, cultivated agriculture as well as for municipalities and cities throughout Europe. Various technical innovations allow a very wide range of applications of agricultural machinery. From agricultural use such as farming, mowing, plowing, etc. to special forestry use in the mountains.

*Bauer GmbH* (Voitsberg, Styria, https://www.bauer-at.com/en): Bauer GmbH (OEM) operates in three main product fields: Irrigation, Slurry Technology and Pipes & Fittings. The company has accumulated expertise for over 80 years based on experience, research and development to become a world market leader in irrigation technology. A mobile irrigation management system "SmartRain", a BAUER GPS-supported application, can calculate and plan the optimal irrigation amount based on the measured soil moisture, the existing soil type and on the weather conditions. The app can be used from any mobile device and offers an overview of the irrigation machines on the field.

*Audili* (Styria, https://www.audili.io/) is a start-up company which develops a self-learning software which determines soil characteristics on a satellite basis and thus replaces complex soil analyses. Audili utilise proprietary remote soil sensing algorithms in combination with certified third party soil probes to support, verify and monitor the longterm storage of $CO_2$. Based on these results voluntary $CO_2$ certificates are issued and farmers compensated for taking action.

## D. Transnational capitalization seminar with innovation performers (D.T1.2.2) (FJ)

# 6. Results transnational capitalisation seminar

There are some crucial factors for collaboration success. The lessons learned (key factors) for positive (+) or negative (-) cooperation success in cooperation in projects between companies, producers and scientific partners are shown by the responses from the project managers of the following projects/companies at the transnational capitalisation seminar at LCM Linz, in Austria on the 4th December 2019:

- "AFarCloud" (Massimiliano Ruggeri)
- "GIS-ELA" and "Smart Seeding" (Lukas Handl)
- "Driver assistant system in Greenland farming" and "Smartbow" (Markus Pichler-Scheder)
- "Rovitis4.0" (Cristian Bolzonella)
- Company "Eurosmart LLC" (Jozsef Kranitz and Robert Bors)
- "LIFE13" (F.Marinello)
- Company "Hydromont (Filip Mikolajczyk)

## 6.1. Results transnational capitalisation seminar – Positive key factors for cooperation

The following table shows the positive key factors in project cooperation:

| |
|---|
| + Partners in the near are a benefit (geography) <br> + National network (clusters, etc.) <br> + People with interest, who want really to create something (a product) |
| + practical tests and feedback from farmers <br> + report of problems in the field <br> + project meetings with all partners at least once a year |
| + Try something on the field: got the help from the company in handling technical problems -> know how from company |
| + Company provided a test tractor, specifications, test area <br> + LCM: system development |

| |
|---|
| + Pöttinger -> farmers: mowing services |
| + Farmers -> Pöttinger: field tests feedback |
| + Good support from costumer |
| + Quick technical results |
| + Very interested & active CEO: prevent going into wrong direction |
| + Support from partner company (specifications, test stables,) |
| + Farmers -> company: test stables dataset |
| + Good support from customer (frequent interaction9 |
| + Good technical results |
| + Successful product available |
| + Create a positive little competition between partners |
| + Next 3 years test in the field |
| + Give some devices to the customer -> giving service |
| + Partners (farmers) haven´t time for data analysis |
| + You need a good plan -> pre-work time before flight |
| + Understand the technology -> not only colored pictures |
| + Need of the agricultural knowledge |
| + Support of scientific partners |
| + Cloud solutions help to transfer data/results easily |
| + PF is not only a solution but also an enabling technology |
| + PF is very much studied but not enough applied (5% IT, 10% EU) |
| + Environmental issues play an important role |
| + Big (farm) data will be more and more critical: Lots of data, how we deal with them is a critical factor |
| + Based on: company are on the market |
| + Producer needs a better feeling, what needs the market |
| + Very important to share the knowledge |

## 6.2. Results transnational capitalisation seminar – negative key factors for cooperation

The following table shows the negative key factors in project cooperation:

| |
|---|
| - Some partners come into the project in an old way (for money) |
| - big distance to some farmers |
| - too less resources to aim goals (time and money) |

| |
|---|
| - Possibility to do tests limited to mowing season |
| - No full model of tractor-trailer available |
| - Ground truth data and annotation often not easily obtained |
| - Decisions from early stage (e.g. battery type) difficult to change later |
| - Small farmer benefit of further improvements in certain areas |
| - Understand the technology -> not only colored pictures |
| - Traditional approach! |
| - Need of the agricultural knowledge |
| - Avoid to repeat mistakes |

## 6.3. Conclusions

An effective collaboration, where companies were asking for recommendations, in order to improve the design of their machines, and research partners were learning from machinery producers the "feeling" of the market (i.e. the response of the farmers to the new precision based approaches).

Research needs to look for new improvements, but keeping an eye to the real words (i.e. trying to understand what really farmers want to do or are available to try).

Farmers as well as agricultural machinery producers want to be sure that they profit will increase. This is often difficult, because 1-3 years of a project is not a sufficient time.

The following points should show an overview to the question, how we can benefit from an international cooperation:

- Same problems in different countries, it is very important to share knowledge
- Direct Sensors need a critical mass -> share data optimize the functionality/precise
- Food has to become more value
- Responsibilities private and public
- Global problem -> big data of data
  - o Regional problem -> About Precision Farming less data, simplify the process is the only way for PF dissemination (example FarmDok)
  - o Agriculture is a slow system: a change needs generations
- A lots of facts -> you cannot do the same in one country the same way in another country.
- The farmer needs the basically knowledge in agriculture (stomach feeling). If there where in the future no need of this feeling in the stomach you need any more a

school for agriculture-> Technology can assist the farmer, but not remove the farmer through technology

- Cooperation between farmers and scientific institution: agricultural knowledge is more and more important for solve and create solutions

- Where put the sensors, etc must be done by the technician

- Which soil is it, etc is the part of the agricultural experts

- Some decision are (automated) by the system and help the farmer

- Collaboration (example in Hungary):

- Mikosense website von Eurosmart: very easily calculator for indices

- Collaboration easier between Uni and company, because the easy handling of row data

- How can we share data from a single farm?

- USA: farmers data network; the big data collectors are big companies

- How will it be managed in future, that the profit is shared in future?

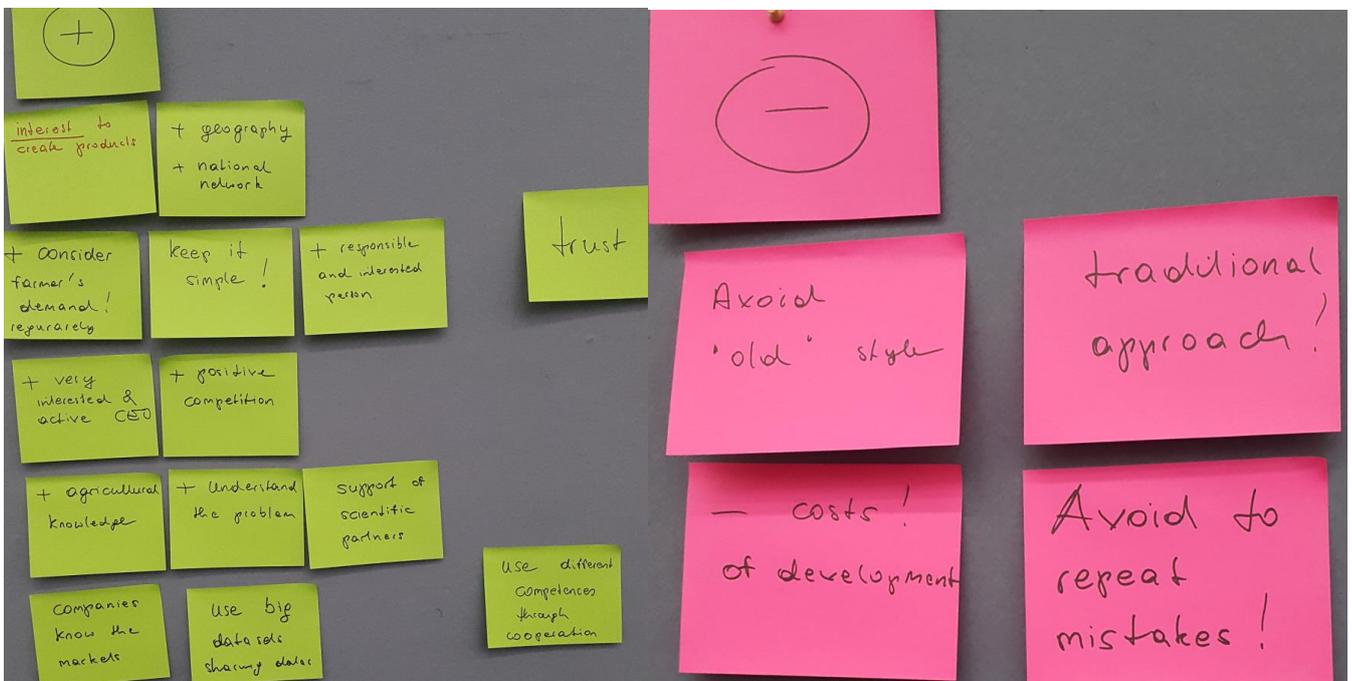- Trust: trustful cooperation is essential precondition for a successful cooperation



**Figure 2: Results transnational capitalization seminar**