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Workpackage L

Preparing Smart Statistics

Deliverable L1: Description of the findings regarding Task 1: Smart Farming

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1. Executive Summary

The use of modern information and communication technologies is increasing in agriculture. Intelligent sensors in machinery and equipment produce more and more data, which are then analysed and combined with other relevant sources to increase the efficiency of agricultural production. This study is intended to give an overview on identification, access and analysis of data generated from smart farming systems and its possible use as an additional source for agricultural statistics. However, significant challenges, like poor network coverage in rural areas, lack of interoperability of systems and data privacy issues are limiting its immediate usage for official statistics.

Main digital technologies used by farmers can be listed in the following categories: satellite-based systems, sensor technology, robots used in animal production (such as automatic milking systems, feeding machines), Farm Management Information Systems and agricultural applications. By precisely measuring various conditions within a field and adapting the strategy accordingly, farmers can greatly increase the effectiveness of pesticides and fertilizers, and use them more selectively. Similarly, using livestock management systems, farmers can better monitor individual animals and adjust their nutrition accordingly, thereby preventing disease and enhancing herd health.

There is a huge variety of agricultural technology providers of machine manufacturers and farm/livestock management systems developers, which is presented in the report with their major characteristics and capabilities. Considering this diversity, it is very important to have the possibility of data exchange between systems and products of different producers. This can be achieved by using standards and formats like ISOBUS, agroXML and platforms like ‘agrirouter’. In this regard, there are project on open data systems performed that are funded by the Horizon 2020 Programme of the European Commission.

Surveys regarding the use of digital technologies by farmers in Germany show that the number of farmers using smart equipment in a comprehensive way still seems to be limited. Digitalization in agriculture is a continuous progress and it is hard to predict how the situation will look like in a couple of years. Next to closed, proprietary systems, there are also initiatives to develop more open standards, interfaces and platforms, which seem to be promising for a possible use to prepare reports for National Statistical Institutes (NSIs).

A possible way forward could be to support agricultural technology providers to include the necessary reporting facilities in their systems to fulfil reporting obligations by the farmer. In this case, it will be necessary to introduce appropriate legal solutions imposing obligations on them. The most promising data sources to be used, in order to produce agricultural statistics in short- to medium- term, are earth observation data. Attention should also be paid to the outcomes of the project on wine data collection. It is important to continuously monitor the ongoing digitalization of agriculture and to keep machine data as a possible additional data source for future agricultural statistics in mind.

2. Introduction

Digitalization is playing an increasingly important role in agriculture. Digital technologies can make workflows more flexible and efficient. Sowing and harvesting can be optimised, the environment protected and a significant contribution made to animal welfare. Complex processes can be monitored and organised in real time.

The statistical offices of Austria, Germany and Poland plan to observe the progressing digitalization in agriculture and, if possible, to use it as an additional data source for agricultural statistics.

1.1 Project Goal

The European Statistical System (ESS) is only at the beginning of understanding the potential use of agricultural input and production to complement the traditionally collected information in order to produce trusted smart statistics. The aim of task 1 is to explore the possible use of data coming from smart farming in agricultural statistics and to identify potential data sources.

Task 1 is intended to give an overview related to identification, access and analysis of databases concerning various issues related to agricultural production such as production resources used in plant and animal production (equipment, fuel, fertilizers, fodders), health and crop protection valuation, animal welfare, water and soil resources.

Moreover, the task helps to further explore the possibilities of using the obtained data from smart farming information to determine the vegetation differences, crop water requirement and nutrient supply, estimation yields and occurrence of diseases and pests. Furthermore, the databases may also be used for analyses of animal production, which means for milking of cows (quantity and quality of the milk), animal welfare, livestock feeding and livestock buildings. This information is the basis for achieving the goals in the field of eco-development, animal welfare, food safety and, as a result, to increase the efficiency of agricultural farming.

The subject of the task will be to consult farms equipped with devices that meet the requirements of smart farming, companies offering services for precision farming and companies providing smart technology. We investigate smart farming to identify early developments, data sources and potential partners, who could provide us with alternative data sources for agricultural statistical surveys.

1.2 Smart Farming

Smart farming (also known as digital farming) is the application of modern information and communication technologies (ICT) in agriculture.

The digitalization in agriculture becomes more and more important. Digital technologies can make workflows on the farm more flexible and efficient. Complex processes can be monitored and organized in real time.

Today, precision farming, a subfield of smart farming, dominates all major agricultural machinery manufacturers. Satellite-supported systems can take over guidance and turning manoeuvres. The sensor technology makes it possible to, for example, give fertilizer recommendations in real-time by recording the leaf colouring using optical sensors or to detect the degree of weed cover and plant diseases.

In the field of livestock farming, sensors - placed on the animals and in the stable - record data, and sometimes cameras are also used additionally. This data is then processed and compiled into information that can be interpreted in order to detect diseases and births at an early stage for example. Standardized data interfaces are most important for this precise use of the data.

The goal of a farm management system is to provide ways to make use of available data and to provide an infrastructure to collect necessary data. The usage varies from the maintenance of a simple field log to the effective implementation of precision farming.

Robots are still rarely used in agriculture. One exception is animal husbandry, where many farmers already use robotics. Automatic milking systems and automatic feeders stand out here in particular.

So far, drones have hardly been used in agricultural fields, but they will also find increased use with growing digitalization. They could, for example, be used for animal localization with infrared detection (especially for fawns) or for soil fertilizer and plant protection monitoring.

In contrast, agricultural apps on smartphones are already very widespread and are primarily used for obtaining weather information, detecting plant diseases and monitoring animal welfare.These trends are discussed in more detail in the chapter on data landscape.

1.3 Challenges

Digitalization in agriculture still faces significant challenges, which will also have a crucial impact on the usage of data from smart farming in a project.

The main challenges are:

- Development of the digital infrastructure - low network coverage in rural areas
- Standardization of interfaces
  - Compatibility between manufacturers
  - Software solutions (a wide variety of stand-alone solutions)
- Data protection and data sovereignty
- Quality of algorithms used in farm/livestock management systems
- Media competence of the farmers

A major obstacle is the poor network coverage in rural areas in most European countries. Without a powerful internet connection, the use of many systems and apps is hardly possible for farmers. So for new technologies in agriculture to move forward, it is crucial to have modern telecommunication infrastructure available.

Also, the interface standardization is particularly problematic. In everyday life, the majority of farmers work with tractors, implements, machines and software from a wide variety of manufacturers and suppliers. However, their interfaces are usually neither manufacturer-independent compatible nor connectable. The same applies for the Farm-Management-Information System. Although many start-ups offer apps for the use and analysis of the collected data, they usually focus on different areas such as livestock farming, land management, detection of plant diseases and so on.

Farm/livestock management systems may vary in the quality of output data – it depends on algorithms, especially the training sample used by software developers to create machine learning algorithms and of course the collected data itself.

Another central point, which is currently unresolved, is the legal situation in the areas of data protection and data sovereignty. This might be one of the major reasons why farmers refuse to use IT solutions for data analysis[1]. In addition, farmers often have limited digital competence.

1.4 Current Variables Collected in Agricultural Statistical Surveys

The basic legal act regulating the scope of agricultural data collected by NSIs is the Regulation (EU) 2018/1091 of the European Parliament and of the Council of 18 July 2018 on integrated farm statistics and repealing Regulations (EC) No 1166/2008 and (EU) No 1337/2011[2].

Data that shall be collected by the Member States, is divided into core structural data that shall be collected for the reference years 2020, 2023 and 2026, and module data collected for the same years or only for selected ones depending on the specific module.
Core structural data and module data, which mostly should be available from a comprehensive farm/livestock management system are presented below:

a) Core structural data:
   - Location of the agricultural holding
   - Agricultural area utilized for farming
   - Area by crop/plant species
   - Area of irrigation
   - Number of animals by the species: cattle, pigs, poultry, sheep, goats, rabbits (split into subcategories)

b) Module data:
   - Detailed data on irrigation (methods, sources, equipment, groups of crops irrigated)
   - Soil management practices (tillage methods, soil cover, crop rotation, ecological focus area)
   - Machinery and equipment

Data that might not be available in such a system:

c) Core structural data:
   - Socio-demographic information of the manager/holder

d) Module data:
   - Labour force
   - Animal housing and manure management
   - ‘Orchard’ module
   - ‘Vineyard’ module

3. Data Landscape

In this chapter, we start with an overview of smart technologies and their generated data, look into more detail at the systems and then list specific providers for the different types of systems.

3.1 Overview of Smart Technologies

In the following, the most important current trends in agriculture are briefly presented in an overview.

- **Satellite-based Systems**

Satellite-supported software systems can take over automatic guidance and turn manoeuvres of machines. Steering aids, steering assistants and automatic steering systems support the driver of a tractor for example in his work. This is made possible by satellite signals and Real Time Kinematic (RTK) base stations. RTK surveying is a geodetic method for measuring or staking out points with the aid of satellite-supported navigation systems such as GPS, GLONASS or, in the future, GALILEO. The control of a tractor with a GPS receiver can be up to 2 cm accurate. In this way, nutrients or pesticides can be applied precisely to or into the soil and without overlapping. Standardised data interfaces are indispensable for this precision.

- **Sensor Technology**

Nitrogen sensors (N-sensor) can detect the leaf colouring via light waves and give a fertiliser recommendation. This is done in real-time. The computer receives the measured data from the tractor, and the on-board computer then informs the fertiliser tax that it should increase or reduce the quantity to be applied. It is also possible that the technology also takes soil quality into account via soil maps. The applied quantities are georeferenced at the same time. In addition, a real-time analysis of the liquid manure contents with near infrared sensors can make it possible to distribute the amount of nutrients more evenly over the area. Sensors can also be used in fungicide treatment. Digital camera systems can distinguish weeds from cultivated plants during the crossing and also record the degree of weed coverage. This also applies to the detection of plant diseases. Set of sensors located on combine harvesters measuring the weight of grain in relation to the data from the GPS receiver allow to calculate yields from a given area with high accuracy.

Sensors can already be used to record process data from the technical installations in the barn as well as animal-specific data. For example cow herd management system sensors, placed on animals, measure and analyze feeding and rumination as well as body temperature. They also detect symptoms of diseases; determine the optimal insemination time and the time of coming calving.

- **Robots, Automatic Milking Systems (AMS) and Feeding Machines**

AMS are more common nowadays. Also robots for the presentation of the basic fodder, for the cleaning of running surfaces and for the transfer of pasture fences are partly already used.

Automatic feeders can ensure an age- and performance-optimised nutrition of the individual farm animal and alert the farmer if there are problems with feeding. AMS provide information on milk production for each animal.

- **Drones**

Drones could be increasingly used in agriculture in the future. Areas of application are, for example, fawn identification with infrared detection as well as soil, fertilizer and plant protection monitoring. So far, however, hardly any drones have been used on fields.

- **Farm-Management-Information Systems (FMIS)**

FMIS can help to maintain data and use it sensibly. They are used for documentation, to plan work steps and manage contracts and invoices, but also, for example, to send orders to machines using ISOBUS (software protocol complaint to ISO 11783 standard providing interoperability of data transfer between the sensors, actuators, control units, cloud server and display units whether mounted or part of the tractor, or any implements). The range of FMIS is very wide, according to the diversity of the different companies. They can range from a simple field record file to precision farming systems.

- **Agricultural Applications**

Agricultural apps are used by farmers using the smartphone. For example, an app can be used to detect important diseases on agricultural crops or to obtain weather information. Apps to support farm management provide data on areas and their cultivation and provide information on stock levels etc. In some cases, this data can also be used to generate application data for agricultural subsidies.

3.2 Use of Smart Technologies by Farmers on the Example of Germany

This chapter is intended to provide a brief overview of the use of digital technology in agriculture in Germany. This overview is based on studies from Bitkom (2016), PwC (2016), DBV (2016), AgriDirect (2016) and Kleffmann (not published yet).

3.2.1 General Use of Smart Technologies

A study commissioned by the digital association Bitkom[3] and supported by the German Farmers' Association DBV (both in 2016), in which 521 farmers and contractors were interviewed, shows that every second farmer and contractor uses digital technologies (54%).

However, the spectrum of digital technologies is very broad and the fact that more than half of the farmers use digital solutions says relatively little about the actual use of individual digital technologies. In general, public perception shows a trend towards overestimating the use of these technologies. Many farmers are still not as digital in some areas as it is widely assumed.

3.2.2 Use of Selected Digital Technologies

According to the non-representative study "Smart Farming - Sustainability and Efficiency through the Use of Digital Technologies" by the consultancy PricewaterhouseCoopers (PwC) in 2016[4], in which 100 owners or managers of German farms were surveyed, satellite supported systems are already used by more than half of the respondents (58%). 14% plan their deployment. Meanwhile, it is estimated that about half of all mid-range tractors produced are equipped with a GPS receiver. Smaller companies, however, are sometimes still cautious. 43% of the respondents with an area under 200 ha do not want to use GPS-controlled systems.

The study from Bitkom shows that only 29% of respondents use agricultural management systems, 9% plan to purchase them.

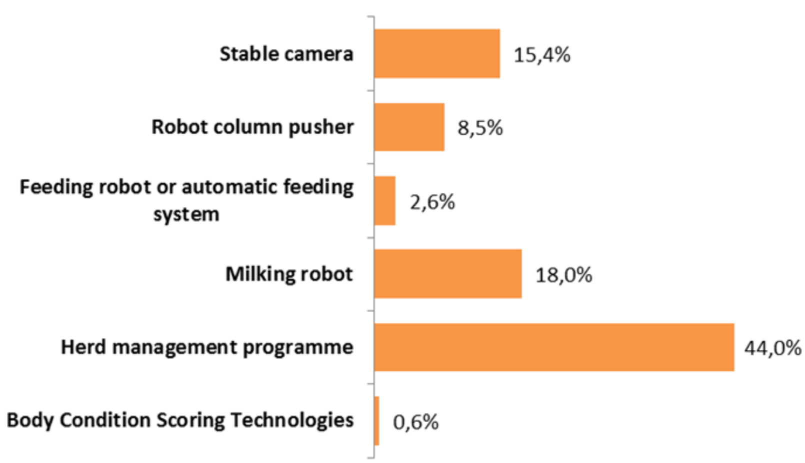
In several ongoing studies, the market research company Kleffmann investigates the use of new technologies, programmes and processes by agriculture. In 2017/18, the Kleffmann Group interviewed 800 farmers and 100 contractors as part of the "Smart Farming Tracker". The "Smart Animal Tracker" study is based on the first study and only surveyed farmers with more than 20 cattle in 2018.The study "Smart Farming Tracker" (800 participating farmers and 100 contractors)[5] proves that 58% of the farmers still use a handwritten field register.

According to the Kleffmann Group, sensor technology is currently only used in 15% of all farms surveyed. For 47% of those surveyed, it will not play a role in the near future. Drones, for monitoring the soil and vegetation development, on the other hand, are still rarely used and only 11% want to use drones in the medium-term. These findings are supported by the study of Bitcom, in which it is stated that only 4% of the farmers use drones. According to the PwC study, robots are also still severely underrepresented. Only 5% of respondents use them.

3.2.3 Use of Digital Technologies in Livestock Farming

Compared to other areas of agriculture, more robots are used in livestock farming. Bitcom's survey speaks of 37% of all farmers that already rely on robotics. According to the Bitkom study, automatic feeders are already used in every second farm (51%). However the recent study “Smart Animal Tracker” by the Kleffmann Group partly contradicts the figures of Bitkom and DBV. As part of the study[6], 331 cattle farms (fattening and dairy farms) in Germany were surveyed on automation in the area of housing and feeding technology, digital solutions for animal health and herd management. First results of this study were presented at the Bitkom Digital Farming Conference in Berlin in May 2019. According to the study, only 2.6% of cattle farms have a feeding robot or an automatic feeding system and only 4% want to invest in the future. The use of milking robots is somewhat more widespread and amounts to 18%, a further 18% want to invest in milking robots. Further results can be seen in Figure 1.

Figure 1: Use of digital technologies in animal husbandry (cattle)



© „Smart Farming Tracker“, Kleffmann Group

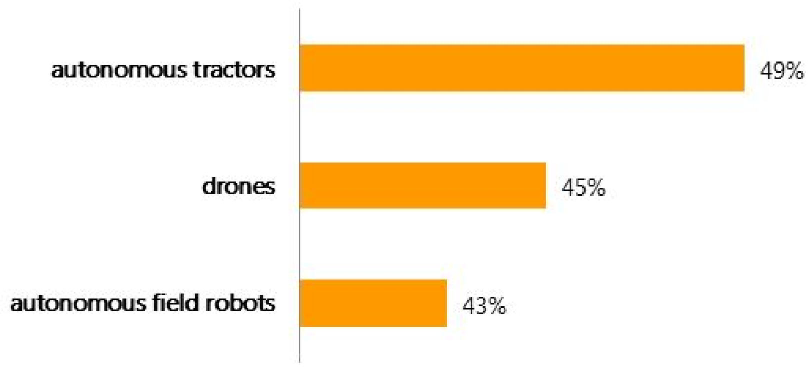
3.2.4 Use of Agricultural Applications

Agricultural apps are already very widespread at present. This is confirmed by the study "Information Behaviour of Farmers in Germany", which was conducted by AgriDirect Deutschland GmbH in 2016 and classified as representative by the Münster Research Institute. According to this study, 52.2% of all farmers surveyed, who own a smartphone, have installed an agricultural app. The apps are primarily used to obtain weather information, information on crop protection, fertilisation and navigation. The study "Smart Farming Tracker" of the Kleffmann Group speaks of 82% of farmers who only use the internet for weather information.

3.2.5 Future Scenarios

In the Bitkom study, farmers and contractors were also asked about future scenarios. It was found that 49% of all respondents rated driverless tractors for the year 2030 as very common or more common. 45% estimate this for the use of drones and 43% for the use of autonomous field robots.

Figure 5: Prediction by German farmers on the use of digital technologies in the year 2030



The trend across all digital technologies is that "the larger the operation, the more digitized it is."

4. Generated Data

FMIS and applications produce or import data on:

- Crops planting
- Fertilization
- Harvesting
- Prediction for harvesting
- Optimal fertilization strategies/amounts

Some systems also use auxiliary data from:

- Satellite images
- Weather forecasts
- Aggregated or modelled information from (all) other users from a farm management system

Machine data:

- Machines are communicating with each other and possibly via a central hub/system based on a standardized ISOBUS terminal
- Besides the manufacturer data portal on basis of the ISOBUS system, it is possible to use the produced data with many systems.
- This kind of data is one of the raw inputs for farm management systems.
- Data produced here is mostly quite directly related to what the machines do, common variables include:
    - position
    - time
    - amount of water/fertilization/seed used
    - amount of material harvested

Data Holder

- Farmers
    - Data can be stored locally on the farmer's computer
- Software providers
- Machine producers
    - They might also have their own farm management system or it is compatible with multiple platforms

The issue of data sovereignty is crucial for a potential use in statistics. Machine data that is collected during farming or on the farm is hardly legally protected. There is still no generally applicable legal basis. If an agricultural machinery manufacturer stores all data generated by his machines on his own servers, the data does not automatically belong to the farmer, but also to the technology manufacturer. Even if, according to the current prevailing opinion, the consensus is that the data belongs to the farmer.

5. Agricultural Technology Providers

5.1 Machine Manufacturers

The world's five leading manufacturers of agricultural machinery and agricultural technology are:

- Deere & Company (US company based in Moline, Illinois, USA), turnover: USD 26.644 billion (2017)
- CNH Industrial (multinational company registered in the Netherlands, operational headquarters London, England), turnover: USD 24.872 billion (2016)
- Kubota (Japanese company based in Osaka, Japan), turnover: 12 billion euros (2015)
- AGCO (multinational company headquartered in Duluth, Georgia, USA), turnover: USD 7.41 billion (2016)
- Claas (German company based in Harsewinkel, Germany), turnover: 3.6 billion euros (2016)

5.2 Farm-Management-Information Systems

In this section a list of FMIS with a link to their respective homepage, where detailed information can be found, is given. Each element of the list is described shortly. While being incomplete, the list should still give an overview of this heterogenic market not limited to the Austrian, German and Polish one but still generated from country perspective. Most FMIS are not limited to certain countries; however they mostly focus on certain markets.

Farmdok: Austrian-based start-up, http://www.farmdok.com/:

- App-based system
- Keeps track of activities, for example fertilization -> precision farming
- AMA (Austrian regulatory authority) data can be imported
- Planning features for planting and cultivation
- Legally required reports can be generated

My Data Plant: German-based company, https://www.mydataplant.com/:

- Web-based application
- Measurements for area, current crop, sowing time, historical and actual weather data, precipitation sum, wind velocity
- Provides fertilization recommendations, amount of seed to match soil and conditions
- Independent of manufacturer and technology (imports various kind of data)
- Uses satellite imagery

Onfarming: Austrian-based farm management system, http://onfarming.at/:

- Should use data from all "important" machine companies
- Seed, fertilization management
- Uses weather data

Geocledian: German-based company, https://odoo.geocledian.com/

- Uses the information from other providers on crop, fertilization etc. and combines it with additional information from for example earth observation and weather to produce insights for the farmers

Agrivi: https://www.agrivi.com/de/farm-management-software

- Active in several countries (UK, PL, HR, LT, LV, HU)
- Records planting, fertilization, irrigation and harvesting
- Uses weather data to make predictions
- Yield/Harvest tracking and analysis/comparison features

365FarmNet: German-based company, https://www.365farmnet.com/en/

- Web-based application
- Basic program with components for plant cultivation, machine data, and management of animals herds
- Field mapping, fertilizer planning, nutrient balance, herd management, analysis software

SatAgro: Polish-based company, https://satagro.pl/

- Uses satellite imagery from EU's Copernicus Programme and weather data
- Data are used for mapping the fields, which enables precise sowing, irrigation, fertilization and spraying
- The application is free for farms of an area of up to 50 hectares
- It comes in Polish, English and Spanish

Agridata: https://agridata.eu/

- Web-based application
- Field mapping, management of machines
- Reports on selected fields generated automatically

Livestock Management Software

These systems often track the number and characteristics of the livestock as well as the position of each individual animal. Additionally, various health-related measures might be used from sensors directly on the animal.

The following list was collected through research in this area and should mainly give additional references with more detailed information available at the websites of the companies.

Tambero - https://www.tambero.com/de

Ranch manager - http://www.ranchmanageropen.com/

Cow Management System - https://www.smartbow.com/de/home.aspx

Cattle Max - https://www.cattlemax.com

e-stado - https://e-stado.net/en (contacted by Statistics Poland)

- System based on data from biosensors, monitors the herd and the barn's environment.
- Data are sent to the central server, where it is processed and compiled into transparent and easy to interpret information (system based on SQL).
- Access to a web app and SMS notifications concerning urgent cases.

DeLaval DelPro - https://www.delaval.com/en-gb/

6. Standardization of Interfaces and Products of Different Manufacturers

In everyday life, farmers often work with tractors, implements, machines and software from different manufacturers or suppliers. Nevertheless, many digital offers are neither compatible with offers of different manufacturers nor networkable. There is a wide variety of "island solutions" that cannot be integrated into an overall concept. Apart from the lack of broadband expansion, lack of compatibility is one of the most important obstacles for farmers to invest in certain technologies.

ISOBUS has meanwhile established itself as the "language and transmission technology" for communication between implements and tractors as well as PCs. Devices and machines that are not compatible with ISOBUS are hardly sold anymore. ISOBUS enables manufacturer-independent operation of implements and machines, controls the documentation of work steps in the field and manages data exchange with the farm PC.

The working group **agroXML** of the "Association for Technology and Structures in Agriculture" (German Kuratorium für Technik und Bauwesen in der Landwirtschaft, KTBL) has meanwhile established the data format "agroXML" in agriculture as a data exchange format. This allows different PC programs to exchange data via a common standard. In particular, it shall enable the automated data exchange between FMIS of different manufacturers as well as the data exchange between FMIS and software systems of different partners in agriculture, authorities and the upstream and downstream areas of agriculture.

There are also systems using more open formats for databases (for example 'e-stado' livestock management system based on SQL).

In addition, there are initiatives of official institutions regarding open data systems. Two projects regarding standardization of interfaces are being developed under the Horizon 2020 Programme of the European Commission: 'DT-ICT-08-2019 - Agricultural digital integration platforms'[7] :

- DEMETER Project: The aim of the project is to build an interoperable, data-driven, innovative and sustainable European agri-food sector. It is planned to provide an open and interoperable data integration model that will cover the integration of many systems and many data sources, taking into account not only the Internet of Things, but also older systems, open data, geographical and satellite information (1 September 2019 - 28 February 2023)[8].

- ATLAS (Agricultural Interoperability and Analysis System) Project: This project aims to develop an open digital service platform for agricultural applications providing software, which enables the acquisition and sharing of data. The platform is supposed to allow the flexible combination of agricultural machinery, sensor systems and data analysis tools to overcome the problem of lacking interoperability (1 October 2019 - 30 September 2022)[9].

Platforms

The two listed platforms are just examples of "aggregators" platforms, where the system is itself a router for information between different actors in the smart farming data landscape. In the future such platforms might play a crucial role to be able to handle data from many different data sources.

- **Agrirouter**

https://my-agrirouter.com (contacted by DESTATIS and STAT), company based in Germany, but available in several European countries:

- Platform to harmonise the data from different vendors.
- Many agricultural technology vendors are supported (currently there are 14 listed on the homepage).
- Receiver of the data can be the farmer himself, a dealer, a supplier, a contractor or a farm management system.
- Data is not stored, just routed.

The ten agricultural technology manufacturers Agco, Amazone, Deutz-Fahr, Grimme, Horsch, Krone, Kuhn, Lemken, Pöttinger and Rauch jointly founded DKE Data GmbH in 2014. The internet-based data exchange platform "agrirouter" is intended to connect machines and agricultural software from different manufacturers. DKE-Data GmbH & Co. KG operates as a non-profit company. Software supplier of the agrirouter is SAP. The agrirouter is a data exchange platform for farmers and contractors, with which machines and agricultural software can be connected across manufacturers. However, data is only transmitted and translated, but not stored, which rather excludes a use for official statistics.

- **„Agrar-Masterplattform“ in Germany**

The development of a state-run IT platform to provide agriculturally relevant data for smart farming is under discussion. A scientific consortium is currently working on a concept.

The advantage of an agricultural master platform for farmers would be their independence from globally operating companies. The organization, maintenance and updating of the necessary data would be carried out by a fiduciary administrator.

The establishment of such a data platform would be interesting for statistics. The further development should definitely be monitored.

7. Promising Data Source for Official Statistics – Wine Data

A big European project "Big Data Grapes" (http://www.bigdatagrapes.eu/) is currently under way to improve the usage of new data sources in the production of wine. There is a wine statistic within the ESS, which includes the wine growing area, the yield per area and the actual production and all of these are split into several subcategories. Therefore, the data used in the "Big Data Grapes" project, might also be very interesting for official statistics and could be further explored in a follow-up study. The use cases of the project and the available data are described here:

Use Case A. Earth Observation Data Anomaly Detection and Classification. The purpose of this use case is to develop models that differentiate between Earth Observation data issues and anomalies. This is for triggering warnings to farmers concerning farm management practices or damage events. The data sets involved in this use case are: Sentinel-2, Landsat-8, and TripleSat, provided by GEOCLIDIAN partner. Plus, data from AUA PA Lab consisting of: soil and elevation maps, IoT stationary data, canopy sensing and laser scanner as well as images captured by drones.

Use Case B. Yield and Quality Prediction. The purpose of this use case is to leverage historical earth observation data combined with additional relevant information to make educated guesses about yield and wine quality. Regarding the yield prediction, GEOCLIDIAN would provide Earth Observation data (for example Sentinel-2, Landsat-8, TripleSat) plus other datasets for weather, soil, elevation, exposition, variety, anomalies (for example, pests/diseases), management practices and historical yield/quality. Earth Observation data sets are in GEOTIFF and PNG format plus metadata in JSON format. For predicting biological efficacy, the data would be provided by AUA PA Lab and APIGEA. Most of this data is semi-structured (.csv and .xls files). Finally, for the crop quality prediction, data used for predicting biological efficacy would be enriched with data collected by proximal sensors, multi-spectral and thermal cameras in the JSON, GEOTIFF, and PNG format and by the land-based weather data which is binary.

Use Case C. Farm management. This use case would take care of optimizing the farm practices and of farm management in general. This would mean modelling climate, sunlight exposure, soil quality, slope and topography to predict the vine specific needs. Indeed, an inadequate management, such as over- or under-cropping, irrigating, spraying, inadequate pruning and poor canopy management can affect the grape quality. Each plant has its own specific needs and can be monitored by sensors. AUA PA Lab would provide sensor data which would be integrated with the satellite imagery geo-spatial data from GEOCLIDIAN in order to initiate the management procedures required to produce high-quality grapes.

Use Case D. Risk Assessment. The purpose of this use case would be minimizing the waste in the production as we all as ensuring minimal impact on the environment. This would be possible by analysing the weather and land surface elevation data for a specific field and also its neighbours. Data is represented by images from North American cartographic plus land-based weather data, IoT stationary data, canopy sensing, laser scanner, drone images, as well as farm data and Eca sensing.

Use case C should have all data available that is currently surveyed from the farmer, area, grape type and quantity of the final product (being either grapes or wine).

Data on the wine itself could also be of interest. The data measured in this use case includes:

1 - fixed acidity: most acids involved with wine or fixed or non-volatile (do not evaporate readily)
2 - volatile acidity: the amount of acetic acid in wine, which at too high of levels can lead to an unpleasant, vinegar taste
3 - citric acid: found in small quantities, citric acid can add 'freshness' and flavour to wines
4 - residual sugar: the amount of sugar remaining after fermentation stops, it's rare to find wines with less than 1 gram/litre and wines with greater than 45 grams/litre are considered sweet
5 - chlorides: the amount of salt in the wine
6 - free sulphur dioxide: the free form of SO2 exists in equilibrium between molecular SO2 (as a dissolved gas) and bisulfide ion; it prevents microbial growth and the oxidation of wine
7 - total sulphur dioxide: amount of free and bound forms of S02; in low concentrations, SO2 is mostly undetectable in wine, but at free SO2 concentrations over 50 ppm, SO2 becomes evident in the nose and taste of wine
8 - density: the density of water is close to that of water depending on the percent alcohol and sugar content
9 - pH: describes how acidic or basic a wine is on a scale from 0 (very acidic) to 14 (very basic); most wines are between 3-4 on the pH scale
10 - sulphates: a wine additive which can contribute to sulphur dioxide gas (S02) levels, which acts as an antimicrobial and antioxidant
11 - alcohol: the percent alcohol content of the wine
12 - quality Output variable (based on sensory data) (score between 0 and 10)

8. Recommendations and Conclusions

The data landscape is still in a development state and it is not straight forward to envision how it will look like in a couple of years. At the moment it seems quite cluttered with a lot of, often local, players. This heterogeneous landscape makes it difficult to gain data access to a significant amount of farmers using smart farming. Additionally, the number of farmers using smart equipment in a comprehensive way still seems to be limited. Many farmers in possession of smart farming equipment apparently only use a very specific part of its capabilities, for example the GPS precision route planning and/or navigation features to optimize their routes.

A very important issue is data interoperability and protection. On the one hand, there is a tendency towards closed, proprietary systems. It has become a common practice to sign agreements on data ownership and control between farmers and agricultural technology providers.[10] On the other hand, there are also initiatives towards development of more open systems based on open source, standards and interfaces, which is most promising for a possible use to prepare reports to NSIs.

A possible way forward for a short- to medium-term success could be the support of NSIs to software/platform/system developers to include the necessary facilities in their systems to export the obligatory reports to NSIs (or regulatory bodies, which then may forward the data to the NSI). In accounting systems, this approach for business statistics is quite common, namely to have such a reporting tool included to comply with business statistics obligations. The farm and livestock management systems could play a similar central role in future reporting of farmers to the businesses' accounting systems. However, it will be necessary to introduce appropriate legal solutions imposing obligations on agricultural technology providers.

It is important to continuously monitor the ongoing digitalization of agriculture and to keep machine data as a possible additional data source for future agricultural statistics in mind. Nevertheless, special attention should be paid to the quality of this data.

Earth observation data, for example satellite images and height measurements, seems to be the most promising data source to be used to produce agricultural statistics in a short- to medium-term. Attention should also be paid to the outputs of the project on wine data collection. These kinds of data sources should be intensively researched and tested, whereas smart farming software solutions might be a good data source in the more distant future.

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