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Towards Farm-Oriented Open Data in Europe: the Scope and Pilots of the European Project "FOODIE"

T. Řezník[1], V. Lukas[2], K. Charvát[3], Š. Horáková[3], K. Charvát junior[3]

[1] Masaryk University, Faculty of Science, Department of Geography, Brno, Czech Republic
[2] Mendel University, Faculty of Agronomy, Department of Agrosystems and Bioclimatology, Brno, Czech Republic
[3] WirelessInfo, Litovel, Czech Republic

Anotace

Rozdílné skupiny osob zainteresovaných v zemědělských aktivitách musí nakládat se značně heterogenními zdroji informací, ať už jde o ekonomická či environmentální rozhodnutí. Typickými úlohami, kde se kombinují rozdílná data, mohou být například definice pravidel (pro dotace, standardizace a regulace, národní strategie pro rozvoj venkova, změny klimatu), vývoj udržitelného zemědělství, načasování a ohodnocení sklizně či detekce poškození porostů. Evropský projekt nazvaný "Farm-Oriented Open Data in Europe" se zkratkou "FOODIE", financovaný v letech 2014 až 2017, si klade za cíl adresovat tyto požadavky. Tento článek se věnuje zaměření projektu s bližším uvedením pilotních testů. Detailněji je následně popsán český pilotní test skládající se ze tří scénářů: zvýšení efektivity dopravy v zemědělství, telematika zemědělských strojů a správa monitoringu variability plodiny na konkrétním místě.

Klíčová slova

Otevřená data; zemědělství; zemědělství s cloudovým řešením; telematika; strategické plánování; faremní informační systémy.

Abstract

The different groups of stakeholders involved in the agricultural activities have to manage many different and heterogeneous sources of information that need to be combined in order to make economically and environmentally sound decisions, which include (among others) the definition of policies (subsidies, standardisation and regulation, national strategies for rural development, climate change), development of sustainable agriculture, harvest timing and yield estimation, crop damages detection, etc. The European project called "Farm-Oriented Open Data in Europe" with abbreviation "FOODIE", funded between years 2014 and 2017 addresses the above mentioned issues. This paper describes the scope of the project with emphasis on its pilots. The Czech pilot is then analysed in detail including its three scenarios: Improving efficiency of transport in agriculture, Telematics of farm machinery and Monitoring of in-field variability for site specific crop management.

Key words

Open data; agriculture; farming on cloud; telematics; strategic planning; farm management information systems.

Introduction

The agriculture sector is a unique sector due to its strategic importance around the world. It is crucial for both citizens (consumers) and economy (regional and global) which, ideally, should make the whole sector a network of interacting organizations. Rural areas are of particular importance with respect to the agri-food sector and should be specifically addressed within this scope. The different groups of stakeholders involved in the agricultural activities have to manage many different and heterogeneous sources of information that need to be combined in order to make economically and environmentally sound decisions, which include (among others) the definition of policies (subsidies, standardisation and regulation, national strategies for rural development, climate change), development of sustainable agriculture, crop recollection timing and pricing, plagues detection, etc.

In this context, future agriculture knowledge management systems have to support not only direct profitability of agriculture or environment protection, but also activities of individuals and groups allowing effective collaboration among groups in agri-food industry, consumers, public administrations and wider stakeholders communities, especially in rural domain.

The European project called "Farm-Oriented Open Data in Europe" (FOODIE), funded between years 2014 and 2017 addresses the above mentioned issues. After presenting the state-of-the-art and methodology in this paper, the pilots of the project are discussed separately depending on the country where the pilot is conducted. The Czech pilot is then analysed in detail including its three scenarios: Improving efficiency of transport in agriculture, Telematics of farm machinery and Monitoring of in-field variability for site specific crop management. At the end, benefits, opportunities and future development are mentioned.

An in-depth review of the different aspects is needed in order to design and implement the aforementioned service platform proposed by the FOODIE project. Such review must be considered to be in line with current initiatives and policies relevant in the environmental and agricultural domains as well as commonly and widely used standards, technologies, service oriented architectures and systems developed in other projects, together with the numerous data sources repositories available at local, national and European level that will enable the provision of new and added value agricultural services for the different stakeholders of the platform.

First of all, we have been inspired by the existing international and European initiatives that aim at facilitating the exchange and access to a wealth of heterogeneous data sets related to the environmental and agricultural domains. We have also included references to the main European policies that are directly involved in the agriculture sector, such as Common Agricultural Policy or Water Framework Directive and that have to be taken into account in the decision making process of the stakeholders. In this sense, call for global data collection for agricultural monitoring is analysed by Sachs et al. (2010). Principles of common agricultural policy are provided by Donald et al. (2002). Influence of Water Framework Directive on agriculture is discussed by Bateman et al. (2006). See Řezník (2013) for information on Infrastructure for spatial data in Europe (INSPIRE) including the application schemas for agriculture and aquaculture. European nitrate directive and its influence on the farm performance were described by Ondersteijn (2002).

To sum up, the FOODIE project has a lot of similarities with the above mentioned initiatives. Data model and searching including metadata originates from INSPIRE. Parts of global initiatives called GEOSS (Global Earth Observation System of Systems) and COPERNICUS could be used and integrated as a part of FOODIE hub. It is important for the FOODIE implementation to establish link with GODAN (Global Open Data for Agriculture and Nutrition) initiative, which is trying to define world Wide standards for Agriculture Open Data and CGIAR (Consultative Group on International Agricultural Research), which is active in global scale on simmer area as FOODIE.

As the second, we have paid the attention to the standards commonly used in the geospatial and environmental domains to encode, visualize and access to the datasets, e.g. sensor information. We would also like to stress the specific standards used in the agriculture domain for exchanging information, such as agroXML and SoilML, as well as the standards necessary for semantic tagging and publishing the datasets contained in FOODIE platform.

As the third, the results from relevant projects provide us an overview of the different architectural approaches followed by various projects in the environmental and agricultural domain which represent the basis for designing FOODIE architecture and specifying its building blocks. For instance, an architecture for soil data that may be re-used for FOODIE purposes is advertised by Douglas et al. (2008), Bröring et al. (2011), Feiden et al. (2011) and Kubíček et al. (2013). In addition, we also had a look at the results obtained by some projects in the areas of Big Data and Future Internet which are interesting from the point of view of the agriculture due the large volumes of data that can be generated over the time, e.g. sensor data from the in-situ sensors deployed on the farms, satellite imagery, its management, visualization and integration as well as in terms of new agriculture services that could be built/offered in the scope of the Future Internet architectures and paradigms respectively. Big Data represent in agriculture especially the biological data as described by Howe et al. (2008). Future

Internet, as described Moreno-Vozmediano et al. (2013), significantly changes the generally accepted principles of internet usage for agricultural purposes that were recommended by Thysen (2000).

As the fourth, the data and knowledge sources compile an exhaustive list of openly available datasets and vocabularies that can be used in the scope of the project in order to improve the semantic tagging and publication of datasets within the platform repositories as well as by enabling the provision of improved tools and advisory services for the different stakeholders (by integrating and fusing these external data with the datasets stored in the FOODIE platform). Spatial data harmonization of these openly available databases are depicted by Čerba et al. (2012). See Šimek et al. (2013) who described the usage of AGROVOC for the data descriptions in the agrarian sector.

As the fifth, the existing technologies and software solutions focuses on the different available alternatives – many of the coming directly from the open source geospatial community that can be used as building blocks of the FOODIE service platform hub.

Finally, we have also included the analysis of the different sensors and communication protocols used to communicate with/among them and which will be of relevance for deciding which the best option in each pilot is.

The aim of this paper is to introduce a software cloud platform developed by the FOODIE project, which is designed to manage farm data for good agricultural practices and decision support of agronomists. The main part of the Czech research aims at the implementation of INSPIRE methodology and optimization of data model to the specific conditions of the Czech agricultural sector. The results should lead to optimization of intensive cropland management in various pedo-climatic conditions of the Czech Republic in order to ensure the production of food with high quality while respecting the environmental limits of the farmland.

Materials and methods

Request for data management in agriculture increases with the usage of Farm management Information Systems (FMIS) and adoption of precision farming techniques – site specific crop management. Is often argued that, in the cases of precision agriculture, physical inputs, such as fertilizers, pesticides, seeds and other, are substituted by information and knowledge (Bongiovanni, Lowenberg-Deboer 2004). McBratney et al. (2005) identified the development of proper decision-support systems for implementing precision decisions as a major block in adoption of site specific farming. In the cases of data analyses and decision support programmes, it is recommended to focus on:

- the development of protocols and standards for the key data layers (yield maps and other);
- robust methods for data analysis, integration and delineation of management zones;
- innovative designs for the implementation of whole-of-field experimentation based;
- easy-to use software to facilitate the use and adoption of the above by farmers, their consultants and researchers.

An example of development of a model data-flows for decision support in precision agriculture is provided by Nash et al. (2009).

Communication and cooperation in adoption of precision agriculture depends on the farm size, as investigated by Kutter et al. (2011) from the farm survey made by qualitative experts in four European countries – Germany, Czech Republic, Denmark and Greece. Small farms were mainly connected to their local agricultural consultants, while large farms rely more on professional consulting. Services for strategic and tactic planning provided by consulting organization for farm enterprises, represented by MJM Litovel, are the topic of the Czech pilot study in FOODIE project.

In the first part (Scenario A), transport services of MJM are being optimized to supply the application of agrochemicals on the client fields and to support the product purchase using advanced planning and network analysis. In this case, precision agriculture provides tools to monitor the food production chain and manage both the quantity and quality of agricultural production (Gebbers, Adamchuk 2010).

Scenario B aims at tracking the agriculture machinery and evaluation of its movement within the fields. The use of guidance systems based on the satellite navigation can increase the steering accuracy and driving performance within large -scale fields (Holpp et al. 2013). Optimization of machinery passes in fields could help with soil condition improvement and also energy savings (Kroulík et al. 2011).

The third part of the strategic planning in the Czech pilot (Scenario C) is focused on the crop monitoring by remote sensing and agro-meteorological monitoring. Technologies of remote sensing are widely used in precision agriculture for crop monitoring and delineation of soil units (Moran et al. 1997). Satellite imaging offers periodic monitoring of crop vigour and seasonal changes, but with low spatial resolution, periodic revisit time defined by orbit constellation and dependency on atmosphere conditions. For this reason, aerial survey carried out in required vegetation stage provide more reliable input data for site specific crop treatment. The challenge for the future is to combine the remote sensing techniques with the real-time on-the-go measurements and to develop precision farming approaches that provide customized management of farm inputs for individual plants (Mulla 2013).

Results and discussion

FOODIE concepts and objectives are realized by means of the resulting service platform hub, which is demonstrated in three different pilots' scenarios across Europe, providing each of them a set of common and specific requirements:

- **Pilot 1: Precision Viticulture (Spain)** focuses on the appropriate management of the inherent variability of crops, an increase in economic benefits and a reduction of environmental impact.
- **Pilot 2: Open Data for Strategic and Tactical Planning (Czech Republic)** aims at improving future management of agricultural companies (farms) by introducing new tools and management methods, which follows the cost optimization path and reduction of environmental burden, improving the energy balance while maintaining the production level.
- **Pilot 3: Technology allows integration of logistics via service providers and farm management including traceability (Germany).** This pilot focuses on integrating the German machinery cooperatives systems with existing farm management and logistic systems as well as to develop and enlarge existing cooperation and business models with the different chain partners to create win-win situations for all of them with the help of IT solutions.

Description of Pilot 2 in Czech Republic

The arable land of the Czech Republic in areas with high intensity of crop production has specific traits. Large areas of cultivated fields with combination of higher variability of topographical and geological factors result in visible heterogeneity of soil conditions and crop yield. More than 54 % of agriculture land in the Czech Republic is managed by farms with a size of over 1'000 ha (Ministry of Agriculture, 2010). Based on a statistical evaluation of the Land Parcel Information System (LPIS), over 40 % of arable land lies in fields with an area larger than 20 ha. Crop management in these conditions requires advanced decision making. Therefore, there are increasingly applied approaches of site specific crop management.

Site specific management, known as precision agriculture, takes into consideration the spatial variability within fields and optimizes production inputs, thus fulfilling the objectives of sustainable agriculture (Corwin and Plant, 2005). The aim of precision agriculture is an optimization of production inputs (fertilizers, pesticides, fuel, etc.) based on the local crop requirements and plants requirements. Crop management in this way should lead to the effective use of agrochemicals and avoid of environmental risks.

The Czech pilot is represented by one agricultural supply company MJM Litovel (hereinafter MJM) and two corporate farms - Farm Vajglov and Farm Tršice. MJM offers various products for farming industry in the Czech Republic, such as fertilizers, plant protection products, animal feed, seeds, and a large selection of grower equipment. Furthermore, they provide services for farmers, especially for precision agriculture under their proprietary system PREFARM® for efficient use of fertilizers, increased revenues, and stable production quality.

The first farm, Tršice, is located in the most productive region of the Czech Republic, in the Central Moravia. The farm itself is focused on the intensive crop production in arable land (cereals, oil crops and other) and the production of hops. The second Farm, Vajglov, is located in the North Moravia region in the marginal mountain area. Most of the acreage of the farm belongs to the Less Favourable Area (LFA), where is reflected the lower productivity of the land by supporting agricultural land use and preservation of sustainable agriculture in these areas. The farm is focused on livestock production (grazing beef cattle); agricultural land is therefore used in form of permanent grassland and is under organic farming regime. Basic data on both farms are listed in Table 1.

	Farm Tršice	Farm Vajglov
Geographic coordinates	49°32'14"N 17°23'45"E	49°53'56"N 17°21'30"E
Average elevation of fields	284 m	626 m
Average year temperature	8.9°C	5.8°C
Total amount of precipitation per year	570 mm	842 mm
Total area	1’291 ha	1’089 ha
Arable land	1’214 ha	-
Grassland	-	1’089 ha
Orchards	74 ha (hopfields)	-
Organic farming	NO	YES (all fields)

Source: owin processing

Table 1: Basic information about both pilot farms from LPIS database and climatic data.

The improvement of future management of agricultural companies in the Czech pilot is divided into three scenarios:

- Scenario A - Improving efficiency of transportation of a large service organization, which will support better logistics on different levels of agriculture services.
- Scenario B - Telematics of farm machinery for evaluation of the economic efficiency of field operations and improvement of the machinery management.
- Scenario C - Optimization of crop management practices by considering in-field variability for variable rate application of fertilizers.

Scenario A – Improving efficiency of transport in agriculture

In relation to farms, MJM acts as agriculture service organisation, trade partner and advisory organisation. MJM deals to both sided of the market, supply and demand side. On the market of inputs to agriculture, MJM plays the role of supply side by offering fertilizers, pesticides, and other materials to farms as the products or in form of providing complete services including application on fields. In connection with these supplies, MJM must fulfil their legal obligation to take back empty packing. On the market of crop product MJM act as demand side purchasing products from farms. All these tasks meet demands for intelligent logistics system within the organisation.

The main purpose of this scenario is to implement a new system for optimization of transport in agriculture for a use case of MJM. This system should achieve better overview about transport related topics for purposes of MJM management, efficient information sharing between individual departments and between elements involved in the transport processes, and increased economic and energy efficiency of transport.

There are several possible steps to reach the desired optimization, which will be further analysed in the cooperation with MJM and involved into the Foodie platform:

- Creating transport schedules, which satisfy all constraints and minimizing transport costs.
- Creating schedules, which minimize deviation from requested times of loading/ unloading (taking in account priorities) and satisfy other constraints. In this case, allowed costs of transport will be additional constraint defined by a user of the Foodie platform.
- Assigning costs to unsatisfied loading/ unloading times and aggregating the costs with transportation costs. Furthermore, creating schedule respecting other constraints and minimizing the aggregated costs.
- Creating schedules based on some of multi-criteria decision methods.

Scenario B – Telematics of farm machinery

Operation of agricultural machinery significantly influences the economic profitability of the crop management. First of all, it applies to the fuel consumption, machines and operators’ workload, control of performed treatments and the environmental effects such as reducing the risk of deterioration of soil physical properties. Verification of the monitoring system will be done at both pilot farms by an evaluation of tractors’ work during basic operation such as soil tillage, fertilization, sowing, crop protection as well as harvest and grass management. Similar monitoring will be tested at the enterprise which offers services for farmers (MJM Litovel) for assessing the quality of work for customers.

Main purposes of this scenario is:

- Evaluation of the economic efficiency

of machinery operations within the fields.

- Precise records of crop management treatments (mainly for fertilizers, pesticides).
- Improved management of machinery operations and planning of crop management treatments.
- Control of quality of field operations, such as pass-to-pass errors and overlaps, coverage of maintained area, recommended work speed.
- Control of applied input material in comparison to prescribed rates.
- Compliance of agro-environmental limits (Nitrate Directive, Good Agricultural and Environmental Conditions - GAEC, protection of water resources, etc.).

From the technical point of view, the monitoring system involves tracking of the vehicles position using GPS combined with acquisition of information from on-board terminal (CAN-BUS) and their online/offline transfer to GIS environment for spatial analysis and visualization.

Scenario C – Monitoring of in-field variability for site specific crop management

Site specific crop management requires information about the within-field variability of soil condition and crop stand. The use of remote sensing is a key step in obtaining whole-area data to support agronomical treatments during the vegetation season. The aim is to develop a stable monitoring system for effective identification of spatio-temporal variability of crops and to use this information for optimization of the crop management practices.

The monitoring system includes three types of observation to provide information about crop variability at different spatial and temporal level:

1. **Operative aerial remote sensing** for whole-area mapping of the fields at high spatial resolution but with low frequency – temporal resolution. The aim is to prepare the prescription maps for variable applications of fertilizers and pesticides, estimated by the spectral measurement of crop parameters. The frequency of the survey depends on the crop type, agronomical operations, crop management intensity and weather conditions. Aerial imaging will be carried out using multispectral camera by an external provider of photogrammetric services. Within the Foodie project, a workflow will be developed for pre-processing of acquired images (radiometric and geometric corrections) and their analysis and classification according to the MJM interpretation algorithms.
2. **Periodic satellite remote sensing** for wide-ranging identification of spatial variability and simultaneously capturing the dynamics of vegetation growth, both at medium level of spatial resolution (30 metres per pixel, once per 14 days). Suggested satellite survey is based on the free available data of Landsat 8 or in 2015 launched Sentinel-2. The main information is the vegetation index NDVI determined from R (red) and NIR (near infra-red) bands. The absolute values of NDVI, their relative to mean value of the field and change detection will be implemented for assessment of crop stands and delineating of management zones.
3. **Meteorological monitoring** at farm level to capture detailed dynamics of weather conditions on the ground. Weather data will be recorded at the specific localities in high frequency (between 10 and 15 minutes). The main goal is to obtain data for modelling of crop growth and to support decision making by agronomist for plant protection (prediction of the plant pests and diseases infestation), plant nutrition (crop growth and nutrient supply), soil tillage (soil moisture regime) and irrigation (soil moisture).

Conclusion

The discussed Foodie platform represents a new approach to the precision agriculture domain. It uses observing and measuring tools, like remote sensing techniques, similarly to the advanced precision agriculture/farming systems. Moreover, the Foodie platform offers the complex set of tasks in order to enhance the "traditional" view on the precision agriculture/farming. To be more specific, the Foodie platform deals with the issues of telematics to/from the field, fleet management, reduction of environmental impacts, improving the energy balance, etc. that are mostly beyond the advanced precision agriculture/farming systems.

One of the greatest differences is the openness of the Foodie platform when using the cloud computing. As such, it enables the agricultural data interoperability. Pan European activities like INSPIRE, COPERNICUS and/or GODAN may be integrated as a part of the Foodie hub. On the technological level, for instance, any Web service respecting the standards in the geospatial domain may be connected to the system. Examples in this direction may be found in the Open Geospatial Consortium's Web Map Services (WMS), Web Feature Services (WFS), RESTful APIs, etc. As the result, the Foodie platform is significantly customizable and scalable.

One of the main open issues lies in the area that affects Big Data in all its forms. Farmers usually distrust the companies aggregating data. Farmers afraid, that their sensitive detailed data may be misused. Future development would therefore be on the technological level as well as on the personal level to ensure the usefulness of the Foodie platform in daily life.

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Corresponding author:
doc. RNDr. Tomáš Řezník, Ph.D.
Department of Geography, Faculty of Science,
Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic
Phone: +420 54949 4460, E-mail: tomas.reznik@sci.muni.cz

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