

Digital Agriculture and the Agridigit project, Italy

Case study contribution to the OECD TIP Digital and Open Innovation project

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Digital Agriculture and the AgriDigit project, Italy: Case study contribution to the OECD TIP Digital and Open Innovation project

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Introduction

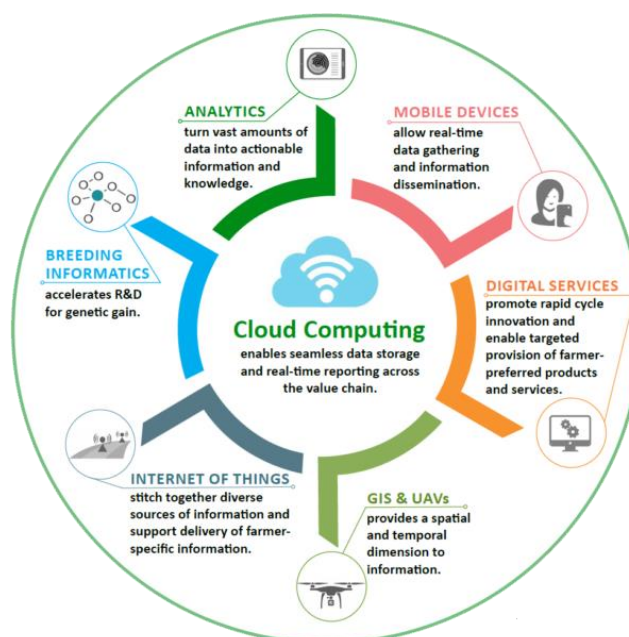
The rapid development of innovation in the field of digital agriculture and agri-food chain, albeit in a chaotic frame of individual proposals, has highlighted an opportunity for a change of paradigm in establishing productivity in farms and of production areas. This has created a link between the production phase and product processing, to finally reaching the consumer.

It is likely we find ourselves at the dawn of a revolution in agricultural sciences, which will mark a fundamental evolution of modern agriculture, brought on by the need for increased efficiency, by a renewed awareness of the complexity of themes relating to food production, and by a more profound respect for people, food, environment and climate.

The new paradigm springs, therefore, from the many innovations available, which permit an increase of real-time information on systems and of the professional capabilities of those involved. The name “Agriculture 4.0” encapsulates an entirety of technical and professional training aids which lead to increased knowledge and intelligence that should be extended to everyone, everywhere and for all production systems.

The components of Agriculture 4.0 are social environments, fed by the development of ICT, technological innovation in sensors, optics and robotics, advances in know-how and research within production systems and in agri-food processing, all of which are centred around cloud computing facilities as shown in Figure 1.

Figure 1. Digital Agriculture



Source: ICRISAT, *Digital Agriculture: Pathway to Prosperity*, <https://www.icrisat.org/digital-agriculture/>

The potentialities offered by the integration of new digital technologies (engineering, mechatronics, ICT, logistics, etc.) are largely unexpressed not only in Italy, but also in a large part of Europe. This is mostly due to high fix-costs, which are typical of network

based technological systems, which require meticulous planning to assure efficient distribution to users.

Not to be underestimated is another element that obstructs rapid and widespread diffusion of such technologies, namely the need to develop and integrate different spheres of knowledge at the same time. In fact, software platforms, applied technologies of precision mechanics, and remote sensing require *in situ* adaptation and calibration to specific production conditions. This can only be done by combining knowledge of the specific system and field trials.

It is indeed the ability to extract knowledge from data collected by means of a variety of sensors that is key to building databases which can be integrated to create a system of knowledge (systems for forecast and management) that would serve at least two purposes: on one hand, it would allow activating and calibrating tools for precision agriculture or monitoring food transformation processes; on the other, it would feed into an IT platform designed to involve everybody concerned. The latter would facilitate access to technologies and services via user-friendly applications (typically, via smartphones).

The AgriDigit project is a research project established by the Italian Ministry of Agricultural, Food, Forestry and Tourism Policies (Mipaaf), to be undertaken in 2019-2021, and coordinated by the Council for Agricultural Research and Economics (CREA) – the Italian public research organization on agri-food, forest and nutrition. The project aims to develop a knowledge system at the farm scale, identifying advanced scopes for precision agriculture, modelling, sensors, and IT, to be used as a core upon which to develop prototypes, which, over three years, may reach at least one of the objectives applied to production systems in agriculture:

- Increase profitability via either or both the reduction of production costs or/and the increase of quality;
- Increase environmental sustainability via the reduction of inputs and an increase in mitigation capability;
- Increase of the awareness and interest of the consumer by way of access to information about the origin of products, their production and transformation, nutritional content and qualitative parameters.

The achievement of such objectives will be met through the following activities:

1. Development of databases and remodelling of the existing ones to build a geo-referenced data source for agricultural land in Italy;
2. Calibration of remote sensing data to build geo-referenced (or type specific such as for animal husbandry or greenhouse) data resources;
3. Development of modelling tools for scenario and in-season analysis, including decision support systems particularly for precision agriculture applications targeting production, plant and animal health, resource use and environmental factors;
4. Tests and adaptation of both tools and technologies for precision agriculture to Italian production systems, particularly irrigation systems, fertigation and waste and use of digestates, equipment for harvest and animal fodder, and for the analysis and management of quality chains;
5. Development of user interfaces to manage tools for precision agriculture, remotely and locally, based on a cloud environment;

6. Design and development of an IT platform for the development of all activities within the project, including the development of pilot trials for the provision of services in the context of digital agriculture.

This case study is structured as follows. Section 1 explores the ongoing trends in the digital transformation of the agriculture and agri-food supply chain, particularly regarding digital technology developments and adoption trends across actors. Section 2 explores how the digital transformation is affecting innovation practices in the agri-food sector. Section 3 explores the role of the Italian AgriDigital project in strengthening research capabilities in the field of digital agriculture.

1. Digital transformation of the agri-food sector

1.1. What are the digital technologies shaping the digital transformation in the agriculture and agri-food supply chain? What are the main applications of these technologies in the agri-food sector?

Many digital technologies could represent a turning point for the agricultural sector and will be introduced and tested in the context of the AgriDigit project.

First of all, the introduction of the **Internet of Things (IoT)** involves the interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data. The most common IoT applications in agriculture include farm vehicle tracking, livestock monitoring, storage monitoring, and open-field monitoring (e.g. in-situ smart sensors for plant and soil conditions). IoT devices allow the remote and extensive data collection from both the individual farm and the whole food supply chain. This technology can be coupled with drones and permits, as well as remote sensing, to make real-time field data available in cloud (i.e: vegetative vigour of the crops, yield forecasts, etc.).

In that sense, the building of an enormous data lake in the cloud allows both the storage of heterogeneous data in their native format and their subsequent analysis, often employing **Machine Learning (ML) techniques**. ML is an application of Artificial Intelligence (AI) based around the idea that we should really just be able to give machines access to data and let them learn from themselves. While the current bio-physical crop models employed in crop forecasting are built on the basis of a priori knowledge and try to describe the processes involved in cropping system evolution, ML models experience from data and assume as immutable their emerging mathematical relationships. Anyway, the use of up-to-date ML methodologies (e.g neural networks, random forest, etc.) coupled with existing crop models could allow to reach even more reliable predictions.

SmartApp and WebServices can provide farmers with decision support systems which query remote data lake deputed to data storage and cloud computing. Conversely, ancillary computing could be assigned to edge devices (IoT) constituting a so-called fog-computation architecture, in the event that lacking measured data, the calculation is based on estimates.

Furthermore, thanks to **blockchain** tools, it is possible to develop product certification processes which guarantee on food safety and quality. In such a way, the whole food supply chain, from stable to table, could be incessantly monitored via IoT devices, so constituting

a certified distributed control system. Here again, cloud computing collects information throughout the whole supply chain, orchestrates processes efficaciously, optimizes resources, so safeguarding Made in Italy products. A blockchain implementation prototype in forestry has been already released as a pilot study of the AgriDigit project (Figorilli et al., 2018). This product allows the electronic traceability of wood from the standing tree to the final user.

1.2. What are the main differences in digital technology adoption across actors in the agri-food supply chain?

Agriculture is still at the dawn of the digital revolution. While digital technologies could already be considered ready-to-use, their applications in the agri-food chain need to be further developed and tested. The different chain actors are interested in adopting in whole or in part these emerging technologies according to their needs:

- **Farmers:** on the one hand, farmers are the principal end-users of custom applications (SmartApp or WebServices) which allows the optimization of the resource use efficiency at farm level (irrigation water, fertilizers, pesticide applications). These applications query a central data lake storing data and performing cloud computing. On the other hand, they play a key role in data providing: installing and maintaining IoT devices, which transmit field data, correcting via feedback crop model simulation results, and providing blockchain information concerning the origin of the products (fertilisations, pesticide treatments).
- **Producers of agriculture machinery:** their principal interest is in testing IoT farm devices, connected to the local farm network and feeding private custom applications (e.g. via RFID systems), or directly enlarging on-line data lake with real time data. Principal applications concern the remote control of self-driving tractors and precision farming, with the aim of spatially differentiating resource allocation (water, fertilizers) during agricultural practices according to crop and soil status.
- **Food transformation industry:** since the sector requires product quality and complete traceability, the introduction of blockchain technology could completely fulfil the needs. The information retrieved by IoT throughout the whole supply chain could guarantee both food safety and the maintenance of health and hygiene standards (e.g. for meat and fruit cold chain). Within-firm IoT allows the real-time control of transformation process parameters (e.g. during curdling process), and leads ultimately to process optimization and automation.
- **Distribution sector:** blockchain could assure retailers the history and shelf-life of the products.
- **Data analysts:** these are up-and-coming and transversal roles in the food supply chain. The principal functions of a data analyst in such a context are the data lake creation and maintenance, its analysis via the most up-to-date Machine Learning techniques in order highlight hidden behaviours, the creation and maintenance of the blockchain infrastructure.

2. The effects of digital transformation on innovation practices in the agri-food sector

2.1. In what ways is digital transformation changing innovation processes of firms in the agri-food sector?

Digital transformation is stimulating the actors of the agri-food supply chain to pursue individual and distinct innovation processes. Hereinafter a brief description of the changes currently ongoing:

- **Farmers:** digitalization is enabling farmers to make rapid decisions tailored precisely to individual fields, from selecting the right crop variety and applying exactly the right fertilizer dose to determining the ideal time for crop protection measures and recognizing plant stress factors at an early stage.

Hence, digital technologies imply an optimization both of the time scheduling of farm operations and in the use of production factors (land, labour, irrigation water, etc). This fundamentally means that the adoption of precision farming systems, which take into account inter- e intra-field variability in crops, ensures that crops and soil receive exactly what they need for optimum health and productivity, in terms of irrigation water, nutrients, and eventually pesticide treatments. Coupling information technologies (sensors, drones, cloud, software application) with agricultural machinery (e.g. tractors, irrigation system) allows to automate farm operations. Innovation reflects, in turn, on product quality, bound to become constant over time.

- **Food transformation industry:** the introduction of digital technologies is allowing the simplification, the optimization, the automation, and the standardisation of processes. Food industries involved in blockchains are able to trace the history of raw materials, to optimize the scheduling of transformation processes (reducing down time), and to deliver standard products.
- **Hi-tech firms:** the continuous incoming of cutting-edge technologies naturally fuels the birth of high-tech start-ups. In such a way, an ever-increasing number of devices and services are made available for both farmers and agri-food firms. The common goal of the new products is to provide useful information in advance, in order to support decision-making process.
- **Distribution sector:** retailers are targeting the certification of the whole agri-food supply chain, from the beginning to the end. The introduction of a blockchain certifying the product history is an added value both for customers, who are increasingly asking for transparency, and also for retailers themselves, who would be sure about the quality of the products they buy.

2.2. How is digital transformation changing innovation processes within firms?

The Blockchain is a computer technology that allows the creation of a large distributed database for the management of transactions, which can be shared between several actors (nodes) of the network. The information is structured in blocks (containing multiple transactions) which are connected to each other, as in a chain.

In this context, the combined use of IoT, modelling tools and Infotracing, which is a procedure that integrates information related to the quality of the product with those related to traceability (physical and digital documents) within an online IT system, could allow to improve firm processes in terms of rapidity, repeatability, standardization (also for quality features of the products), planning, maintenance scheduling, supply chain management and logistics and the responsible use of resources, with reduced waste. As consequence, the need of hiring new professional figures as data analysts, IT and crop modellers will lead to a redefinition of the roles of the employees in the organisational hierarchy of the firm. The increased technological know-how and the automatization of supply and production processes could result in a structural rearrangement of the firm.

2.3. What are the main opportunities and challenges for digital innovation in the agri-food sector?

Digital innovation creates many and diverse opportunities for the agri-food sector and its partners in the upstream and downstream sectors. This applies in particular for food processors, traders and consumers. It allows and simplifies both documentation and transparency as well as traceability for the processes along the entire value creation chain.

A survey¹ conducted among farmers showed that altogether the simplification of farm documentation and the improvement of production efficiency are perceived as top opportunities. Digitization can mean additional value creation for farmers together with promotion of rural areas. It can contribute to improving environmental kindliness, animal welfare and sustainability in farming. The instruments set out above can be divided between a number of different headings – Precision Farming, Smart Farming and – integrating both of these – Digital Farming.

External networking of the farm also offers new opportunities, as farmers can draw on data from suppliers, customers and service providers, such as for example product lifetimes and stability times, the origin of feedstuffs etc. Cross-farm networking could also lead to lower-cost procurement of farm inputs so that farms can produce more cost-effectively.

Challenges for digital innovation in the agri-food sector concern the assuring a safe and sustainable provision of quality food, developing the circular economy, broadening the bio-economy, fostering resource efficiency, combating climate change and reducing the reliance on fossil fuels.

2.4. What do you think policy could do to support digital innovation in the agri-food sector?

A first action may concern the definition of financing policies aimed at promoting the dissemination of digital traceability of agricultural products and related supply chains. This would protect both producers and consumers, ensuring high quality standards of agricultural products, territoriality, the compliance of regional, national and European regulations while protecting national certified brands against counterfeiting.

A second measure could be based on including the technologies 4.0 in the list of technical requirements for obtaining ISO certifications.

In particular, the ISO 9000 family of standards certify that a management system, manufacturing process, service or documentation procedure meets all the requirements for standardization and quality assurance, thus ensuring company's credibility in the market.

¹ Mipaaf 2017 DM 33671 del 22/12/2017 [\[link\]](#)

A third action could be focused on promoting tax breaks for firms that adopt 4.0 technologies to achieve eco-sustainable productions. For instance, given the strict European regulations for nitrogen loads, operational tools and techniques able to increase nitrogen use efficiency represent a solution for limiting the negative externalities from disposal of fertilizers and/or livestock manures, such as groundwater nitrate pollution and greenhouse gases emissions.

A fourth action may concern the funding of educational programs targeting new and old generations of farmers, in order to train and raise awareness about digital technologies and the potential for their application in different lines of agricultural sector. In this context existing degree programs should be updated and modified to meet the market needs, by promoting new professional figures, such as data analysts and crop modelers.

A fifth action may concern both tax breaks and subsidies for renewing traditional firms according to the principles of Digital Agriculture and to launch agri-food startup companies with high technological competence.

A further action could be centred on promoting the use of biophysical models to support national breeding programs aimed at improving qualitative aspects of agricultural productions with the implementation of low impact agronomic practices; this would allow to support stakeholders of agricultural sector in identifying priorities for planning future investments.

3. The AgriDigit project

3.1. Context and rationale of the project

Digital Agriculture and related technologies have recently been included in the "Strategic Plan for Innovation and Research in the Food and Forestry Agricultural Sector", presented by the Italian Ministry of Agricultural, Food, Forestry and Tourism Policies (Mipaaf), to be undertaken in 2014- 2020.

The AgriDigit project is a research project established by the Mipaaf and coordinated by the Council for Agricultural Research and Economics (CREA) – the Italian public research organization on agri-food, forest and nutrition. The project is strictly related to a number of lines of activity, related to specific areas of the abovementioned Strategic Plan, such as:

- **Sustainable increase in productivity, profitability and resource use efficiency in agro-ecosystems (Area 1):** Optimization of production processes (crop management, nutrition and animal health, prevention practices, energy saving, etc.), also through the use of decision support systems (remote sensing, agriculture and precision agriculture and livestock farming, mechanization, robotics and others intelligent automatic systems, application of artificial intelligence-based tools, etc.) and sustainable biotechnologies; Technological solutions for the improvement of company plants and facilities
- **Coordination and integration of supply chain processes, with a view to strengthening the role of agriculture (Area 3):** Technological solutions for the improvement of supply chain processes.

- **Quality, typicality and safety of food and healthy lifestyles** (*Area 4*): Improvement, protection and traceability of product quality and distinctiveness and adaptation of related certification standards.

The AgriDigit project is articulated in six sub-projects, dealing with different thematic areas:

- The sub-project “**Agro-Food Chain**” focuses on the analysis, study, application and demonstration of how digital technologies (engineering, mechatronics, information technology, logistics, communication, etc.) can improve the sustainable strengthening (greater profitability, lower environmental impact, higher quality and safety) of some agri-chains (cereals, vegetables, IV range products, floriculture, olive trees), operating jointly from production, to processing, to the consumer.
- The “**Agro-Models**” sub-project is aimed at providing modelling and data management support across all the actions envisaged by the AGRIDIGIT project, as well as at pursuing specific modeling activities for developing both real-time and scenario analyses support systems at various level and scales. Customized products and services, based on the application of biophysical models, will be released with the aim of supporting the management of cropping systems under current and climate change conditions. The management aspects considered concern: irrigation, fertilization, soil operations, pathogens and pest control, grassland cut, product quality.

These services will be made accessible as they are through tablets and smartphones implementation, but also as data and information that can be used in different applications. The implementation of the OpenData standard is an added value of the project.

- The sub-project “**Livestock farming**” is aimed at optimizing the efficiency of the livestock farms involved in the supply chain of cattle and buffalo milk production. The main objective is the development of an integrated business management system, implementing the approach and related techniques of precision livestock farming, to quantitatively assess and then adequately manage heat stress and emission of greenhouse gases (enteric methane).
- The sub-project “**Forestry**” targets the development and testing of innovative methods and technologies for the enhancement of the national forest heritage and the development of production chains that are in line with the priorities of cohesion policy and rural development policies for the period 2014-2020. In particular the activities will be focused on studying and developing: i) innovative tools for inventorying and managing wood resources, ii) ICT systems to support the collection of woody biomass from forest and woody plantations, and iii) electronic-computer based technologies (RFiD sensors) to ensure high-quality and traceability of woody products; multivariate and economic modeling techniques will be applied to evaluate the sustainability of the whole supply chain.
- The sub-project “**Viticulture**” aims at improving the management and the resilience of the winegrowing potential, with special focus on: i) reducing the environmental impacts, ii) tackling the climate change impacts on primary resources (e.g. water availability), iii) preventing market fluctuations due to crop yield variations, and iv) developing integrated decision supporting tools that allow

producers achieving high quality standards, while ensuring transparency and health protection for the consumer. Main efforts will be devoted to improve the qualitative aspects of productions, to identify possible vegeto-productive anomalies and related corrective actions, to promote traceability the supply chain.

- The sub-project “**AgriInfo**” focuses on the development of an IT platform that is able to support, manage and integrate all the project activities, providing: i) access to data and services to all the authorized users, ii) training for the use of new developed tools and technologies, iii) virtual room to share opinion data and information. The aim is to build a modular, extensible and transparent structure that can be continuously updated with new data and services through continuously connected systems. The project is based on a native CLOUD perspective based on Microsoft technologies and more specifically Azure, Dynamics and Office 365.

The actors covered by the project activities can be grouped in four main typologies

- **Institutional subjects:** Ministries, Agencies, Entities, Research bodies etc. that will be able to benefit from the information and results produced within the project; they will be also actively involved in co-designing and supporting the development of tools and services dealing with planning activities, the control of territory, products certifications, emissions control etc.).
- **Economic operators:** existing and potential actors in the agricultural sector in a broad sense, including the transformation sector and the tourism / promotional sector.
- **Professional users:** professional workers in the agricultural sector, including farmers, breeders, processors, producer groups and organizations, technical assistance companies, producers of agriculture machinery. All these actors will be involved at the same time as end users and co-designer of the services and products development.
- **Daily users:** the responsible consumer, i.e. Italian and foreign citizens, who need information concerning a healthy and responsible diet and the environmental issues connected to a responsible use of agricultural resources.

The AgriDigit project will last three years and will cover the entire Italian territory. While simulation experiments will be conducted on a 10 x 10 km spatial resolution, considering site-specific weather data, management information and crop distribution maps specific for the cropping systems under study, the application of other technologies will be focused on local case studies conducted at field, regional or sub-regional level, identifying critical and/or strategic producing districts depending on the thematic area and field of application considered.

3.2. Main objectives of the project

The AGRIDIGIT project aims to develop such a knowledge system on farm scale, identifying advanced scopes for precision agriculture, modelling, sensors, and IT, to be used as a core upon which to develop prototypes, which, over three years, may reach at least one of the objectives applied to production systems in agriculture:

- Increase profitability via either or both the reduction of production costs or/and the increase of quality;

- Increase environmental sustainability via the reduction of inputs and an increase in mitigation capability;
- Increase of the awareness and interest of the consumer by way of access to information about the origin of products, their production and transformation, nutritional content and qualitative parameters.

The achievement of such objectives will be met through the following activities:

1. Development of databases and remodelling of the existing ones to build a geo-referenced data source for agricultural land in Italy;
2. Calibration of remote sensing data to build geo-referenced (or type specific such as for animal husbandry or greenhouse) data resources;
3. Development of modelling tools for scenario and in-season analysis, including decision support systems particularly for precision agriculture applications targeting production, plant and animal health, resource use and environmental factors;
4. Tests and adaptation of both tools and technologies for precision agriculture to Italian production systems, particularly irrigation systems, fertigation and waste and use of digestates, equipment for harvest and animal fodder, and for the analysis and management of quality chains;
5. Development of user interfaces to manage tools for precision agriculture, remotely and locally, based on a cloud environment;
6. Design and development of an IT platform for the development of all activities within the project, including the development of pilot trials for the provision of services in the context of digital agriculture.

3.3. Principles for the use and management of data

The AgriDigit project will implement FAIR guiding principles (Findability, Accessibility, Interoperability, and Reusability) supporting data reuse. Good data management is the key conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the community after the data publication process. A good data management plan should have the following features (Wilkinson et al., 2016), which will be implemented on AgriDigit data:

To be **findable**:

- (meta)data are assigned a globally unique and persistent identifier
- data are described with rich metadata (defined by R1 below)
- metadata clearly and explicitly include the identifier of the data it describes
- (meta)data are registered or indexed in a searchable resource

To be **accessible**, (meta)data:

- are retrievable by their identifier using a standardized communications protocol: the protocol is open, free, and universally implementable; the protocol allows for an authentication and authorization procedure, where necessary
- metadata are accessible, even when the data are no longer available

To be **interoperable**, (meta)data:

- use a formal, accessible, shared, and broadly applicable language for knowledge representation
- use vocabularies that follow FAIR principles

- include qualified references to other (meta)data

To be **reusable**, meta(data) are richly described with a plurality of accurate and relevant attributes; (meta)data:

- are released with a clear and accessible data usage license
- are associated with detailed provenance
- meet domain-relevant community standards

The AgriDigit project aims at making data and tools available, allowing to reproduce the simulations run during the project. Data access will be made possible following the constraints due to the IPR of external data, and by making data developed by the project available after either a grace period, or jointly to the publication of scientific papers and reports.

The implementation will be based on the Microsoft Azure cloud technology, providing a public API to data access. Data views will be made available as maps via the Azure mapping services, and via the Azure Power BI charting and reporting services; other software platforms will be evaluated if needed. Data services will be implemented in cooperation with all partners involved on data collection and development, according to the requirement in the next paragraph.

Data management will comply with GDPR (General Data Protection Regulation) of the EU, providing at project start:

- information about the procedures for data collection, storage, protection, retention, destruction, and confirmation;
- confirmation that beneficiaries have appointed a Data Protection Officer (DPO) and that the contact details of the DPO are made available to all data subjects involved in the research.

For beneficiaries not required to appoint a DPO under the General Data Protection Regulation 2016/679 (GDPR) a detailed data protection policy for the project will need to be kept on file and submitted to the Agency upon request.

The project will not need to access personal data. The cloud platform selected for data persistence and data services supports enforcing GDPR requirements via security services.

3.4. Fostering collaboration for research and innovation

To date, the Council for Agricultural Research and Economics (CREA) Authority has an IT infrastructure that is mainly devoted to fulfil organizational and administrative needs, and its application to research is often aimed at supporting individual operational tasks.

In this context, the project aims at building an extensible and flexible information system, providing an informative and methodological basis for all research sectors, that can be used by both researchers and non-specialist operators by means of apps and an Enterprise Social Network.

In particular, the CLOUD solution allows:

- using advanced techniques for modeling and data processing, also accounting for data assimilated via IoT connected systems;
- modeling data on a georeferenced basis;
- providing access to advanced visualization tools;

- using technologies that allow teams of experts and different stakeholders groups working together to solve problems or provide guidance in real-time collaboration.

In this way, it will be possible to do more with less, facilitating the organizational transition to more advanced and effective operational level. For instance, the assimilation of IoT data in advanced crop models will allow building early forecasting and warning system that are more adherent to real conditions and that can thus be a valuable support to farmers in optimizing the management of cropping system before harvest or modulating their site-specific adaptation responses to climate change conditions. Obviously, feedback from farmers and technical assistance companies, through mobile apps and social networks made available by the IT platform, will allow developers to build supporting tools that are increasingly more accurate and responsive to users' needs.

As a matter of fact, the sharing of data, ideas, solutions, needs and scientific and technological advancement in research through a shared platform, facilitate the collaboration among different stakeholders of agricultural sector, thus accelerating the technology and knowledge transfer for the development of integrated supporting tools to:

- optimize the efficiency of agriculture machinery,
- improve crop harvest techniques,
- rationalize the use of irrigation and fertilization techniques,
- increase the potential application of IoT data derived from remote and proximal sensors,
- improve the traceability of the supply chain.

All these activities could result in increasing crop productions, forecasting abilities, reducing the distribution costs, enhancing profitability and workplace safety.

Moreover, these new-developed products can also be helpful for national and supranational supervisory bodies in identifying i) producing districts where production is currently constrained by climate fluctuations and/or water and nitrogen shortage and ii) hot spot areas that are likely to become critical due to climate change impact. In the same way the development of automated measuring systems for monitoring emissions from livestock can certify the farmers adoption of best and sustainable management practices, while facilitating the role of environmental management and pollution control agencies.

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