Sharing and pooling resources in common infrastructures is essential to accelerate research and diffusion of digital innovations in agriculture

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'Digital agriculture' deals with the development, testing and deployment of information and communication technologies (ICT) for agricultural benefits, either at the farm level (optimization of farm operations), in the services (seed producers, advisors) or at larger scales (territory level, global value chain) to build a more inclusive society with regard to agriculture. ICT has entered agriculture in the 70's, with earth observation, and has known a growing interest in research starting in 2010's with smart phones, more earth observation satellites, high-throughput phenotyping, connected objects, IoT, big data. Today, the time for digital agriculture has come with a favorable technology-push / market-pull conjunction. On the one hand, ICT technologies are seen as an opportunity for agriculture for both European countries[1] and developing countries in which "[ICT] contributions to agriculture are both rapidly evolving and poorly understood […] questions remain about how to make these innovations replicable, scalable, and sustainable for a larger and more diverse population"[2]. Digital agriculture has recently been put forward by the "Agriculture-Innovation 2025" report as one of the 4 key technologies needing research to prepare a sustainable French agriculture in 2025[3]. On the other hand, "digital agriculture and food" appears to ICT sector as one of the 10 key areas[4], with 3 main areas of interest: robotics, precision agriculture, and big data.

To boost the convergence of these two worlds, ie agriculture and ICT, and to accelerate the building up and diffusion of innovation in agriculture, we made the hypothesis that it is essential to pool intellectual and material resources in common infrastructure and to share them. This will reduce the costs, facilitate the creation of knowledge. This paper aims at introducing four French projects of resource pooling dedicated to ICT in agriculture, at various stages of development and encompassing various levers of innovation:

- #DigitAg, a convergence institute for digital agriculture in Montpellier.
- The Mediterannean Digital Farm, an exemplary farm for digital agriculture
- AgGate : a gate for pooling data of agricultural interest
- The GeoSud project : pooling satellite data

1 Didelot D et al (2012) ERA-Net ICT-AGRI - Strategic Research Agenda. Deliv. 4.3 of ICT-AGRI FP7 proj no. 235460, Ed. M. Lötscher, FOAG, CH, 42 p.

2 The world bank (2011) ICT in agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. e-sourcebook Report N° 64605, Washington, 406p.

3 Bournigal J.M., Houllier F., Lecouvey P., Pringuet P. (2015) #AgricultureInnovation2025, 30 projets pour une agriculture compétitive & respectueuse de l'environnement. Oct 2015, 135p. http://agriculture.gouv.fr/sites/minagri/files/rapport-agriculture-innovation2025.pdf

4 Schindler H.R et al (2014) Foresight Services to support strategic programming within Horizon 2020 - RAND Europe, RR-900-EC, 28 Oct 2014, 187 p.

#Digitag- the human-centered Digital Agriculture Convergence Lab

In 2016, the French national research agency (ANR) has launched a call for « convergence laboratories », with the ambition of creating, at a national scale, a few institutes that would bring together multidisciplinary scientific forces, both in research and education, to better address major challenges.

#DigitAg, the human-centered Digital Agriculture Convergence Lab, is one of the 5 laureates and the only one in digital agriculture. #DigitAg aims at addressing the questions raised by innovation in digital agriculture: how to develop new ICT adapted to agriculture, how to ensure technology adoption, how will ICT revolutionize the global value chain and rural world... To do so and support the development of digital agriculture in France and in the Southern countries, #DigitAg gathers more than 200 Full time equivalent, at the crossing of agricultural, digital, economic and social sciences. Coordinated by Irstea, #DigitAg is a collaboration of 17 partners, including 4 major national research institutes (INRA, INRIA, IRSTEA, CIRAD), 3 local higher-education actors (Montpellier University, Montpellier Supagro, AgroParisTech Montpellier), development actors (ACTA, agricultural technical centre association and SATT AxLR, a technology transfer agency) and 8 companies (IDATE, Smag, Vivelys, Pera-Pellenc, Agriscope, Fruition Science, ITK, Terranis).

Scientific questions identified by #DigitAg concern 6 axes dealing with digital agriculture: ICT and rural society, ICT and innovation, Data acquisition technologies, Information systems, Agricultural Big data and Modelling and simulation. They are dealt with through 8 operational challenges which feed 2 major stakes of agriculture (See Figure 1).

Located in Montpellier, #DigitAg will encompass a graduate school dedicated to digital agriculture. It will offer more than 150 master scholarships, 56 PhD grants, 19 post-doc year equivalent, a total of 72 month mid-term stays for eminent foreign researchers or professors. Three new courses will be created related to ICT in agriculture. In particular, the executive master « Methods & Technology for digital agriculture » designed for mid-career executive professional will include an option dedicated to digital services (smart phones, remote sensing, open source data) in Southern countries: « Frugal digital technologies for agriculture ».

It is important to conclude by emphasizing that #DigitAg has several assets regarding international cooperation with Southern countries: some research topics and one education programs are specifically targeted to Southern country issues and grants are dedicated to hosting foreign students and professors.

Figure 1
#DigitAg research stakes, challenges and axis for developing research, education and training in digital agriculture (Source: Irstea)
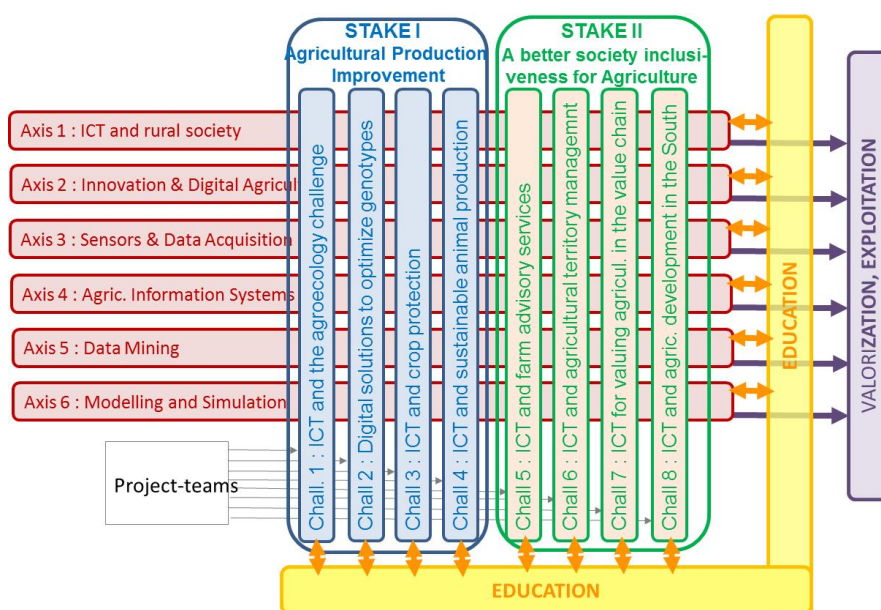
The Mediterranean Digital Farm: an exemplary connected farm equipped with up-to-date digital tools

The Mediterranean Digital Farm is part of the #DigitAg innovative infrastructures. The project has been designed by Montpellier Supagro in collaboration with companies selling digital services. It is based on the observation that, although many digital tools and services were operational for professional use in agriculture, their diffusion was still hindered by obstacles such as the resistance to change and to adoption by users. Training and educating professionals and future professionals of agriculture to ICT were therefore identified as particularly strong challenges[5],[6],[7].

Example-based learning may be a good way to train actors of agriculture to ICT, but to do so, it is necessary to have appropriate premises on which these technologies are up-dated, operational and used. These last requirements are a real bottleneck due to the high scalability of technologies that require regular and sometimes costly investments in hardware and skills. It is therefore essential to develop collaborations with companies able to display and run up-to-date technologies.

Developing such premises is the very objective of the "Mediterranean Digital Farm" project founded by Montpellier Supagro, which aims at setting up an exemplary[8] demonstration infrastructure, in the heart of the research-education-company continuum, on issues related to digital services for Mediterranean agriculture (vineyard, olive trees and durum wheat).

The Mediterranean Digital Farm is an example of collective approach based on a sponsorship framework. Supported by Montpellier SupAgro Foundation, it combines training and research organizations (Montpellier SupAgro, Irstea) as well as several companies selling digital services and products specifically designed for agriculture, such as connected objects, decision aid systems, web-services for farm management, sensor networks, etc. Located in South of France (Villeneuve les Maguelonne), this shared device is an advanced demonstration living site, in which companies ensure the setting up, maintenance and interoperability of their solutions. This partnership guarantees a fully functional infrastructure continuously updated with the most advanced available digital solutions. Pooling financial resources provided by companies and Montpellier SupAgro permitted to open a position for a technical manager.

Figure 2
The Mediterranean Digital Farm - Connected services as they will be implemented: Remote sensing satellite service; GPS ; Sensors, software and data processing; Telecommunication and narrowband networks; Smartphone and mobility (Source: Montpellier Supagro)

With many benefits to companies (as a showroom), education (as a practice infrastructure) and research (as an updated sandbox for validating prototype interoperability), the Mediterranean Digital Farm is therefore a unique tool in France and Europe.

Making data available for boosting open innovation- AgGate, the portal for agricultural data

Whatever the activity sector, data is going to flood the world and is seen as a new fuel for knowledge discovery. Agriculture is no exception. However, the dark side of this field of opportunities is that data and data analyzing skills may be concentrated in the hands of very few companies, e.g. agriculture providers (input suppliers, equipment manufacturers) or GAFAs.

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5 JRC (2014) Precision agriculture, an opportunity for EU farmers :
http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529049/IPOL-AGRI_NT(2014)529049_EN.pdf
6 #agricultureinnovation2025 : 30 projets pour une agriculture compétitive et plus respectueuse de l'environnement, http://agriculture.gouv.fr/sites/minagri/files/rapport-agriculture-innovation2025.pdf
7 L'agriculture française à l'heure des choix. Les notes du conseil d'analyse économique, n°27, décembre 2015 :
http://www.cae-eco.fr/IMG/pdf/cae-note027v2.pdf
8 « Exemplarity » means that this infrastructure is likely to show a diversity of examples, of various situations from which fruitful exchanges, debates, will be generated.

To foster open innovation, one of the recommendation of the « Agriculture Innovation 2025» report is to create a gate to inventory and access data of agricultural interest. This gate, called AgGate, has the ambition of being a « single window » through which any type of companies (including start up) and organizations (including research) could search and find various type of data related to agriculture, e.g. public data, which are generally distributed in various websites or sometimes not available, or even private data (e.g. data related to the farm operation) that farmers normally record in a crop logbook, or new types of data e.g. the one collected by UAVs (Figure 3). Such data is of particular interest to research and start up, for creating new knowledge and models inferred from data thanks to artificial intelligence treatments. But such data may be sensitive. This is why it is particularly important that the governance of such a gate be shared and mostly carried out by representatives of farmers (unions, cooperatives…).

Figure 3
UAV (Unmanned Aerial vehicle) collecting data over the Mediterranean vineyard (Source: Montpellier Supagro)

Each data owner will decide who he or she wants to share the data with. The expected principle is that data be freely delivered; to encourage reuse, but monetization is also possible, either for accessing specific data or for preprocessing web-services (eg aggregation of data of various sources). Privacy protection through anonymization and data security are two major challenges of this gate. In a later stage, AgGate may also ensure a function of data repository for farmers, in order to secure the access to their data, similarly to what is currently done by the AgDataCoalition in the USA (www.agdatacoalition.org). It is also proposed that AgGate offers the opportunity to companies to display their technical products and services and to farmers to exchange about the quality, as done today in « trip advisor » for instance.

Pooling is therefore the keyword of AgGate as it is expected improvement in agriculture will be encourage both by agricultural data pooling, which will boost open innovation, and by feedbacks from users, which will inject more design thinking approach in agricultural digital tools design.

Making remote sensing data available – The GeoSud / Theia unique infrastructure

The GEOSUD project (http://ids.equipex-geosud.fr/) aims to boost the use of satellite imagery within the scientific community, public actors and private companies involved in agriculture, environmental management, and territorial development. It is the result of a long-term strategic vision initiated in the mid 2000s by the founding members of the Remote Sensing Centre in Montpellier (AgroParisTech, CIRAD, IRD and Irstea) with a first funding from the Languedoc-Roussillon Region, the Ministry of Research and the European Community. It obtained in 2011 a new ten-year funding as a laureate of a national call for "Equipment of Excellence" launched by The French National Research Agency. Additional public and private partners specialized in geoinformation and digital technologies joined the project (IGN, Montpellier University, La Réunion and Antilles/Guyane Universities, CNRS, CINES, HPC@LR, Cerema, Afigeo, Geomatys). The strategy consists in overcoming, or at least mitigating, the various obstacles to the operational use of satellite imagery (cost of images and dedicated equipments, data volumes, skills to extract useful information, business models for operational products and services).

For this, the project relies on the synergy between remote sensing, ICT and a user-driven approach. It includes five main components:

- Purchase of high to very-high resolution satellite images (RapidEye, SPOT 5, SPOT 6-7, Pleiades) with multi-user license to allow an open access for GEOSUD members: the annual coverage of France since 2010 is available and collection of images over specific areas can be programmed upon request.
- Since 2015, a "direct receiving station" installed in Montpellier, first equipped for SPOT 6-7 worldwide acquisitions.
- A Spatial Data Infrastructure based on interoperability standards for image cataloging, displaying and downloading as well as on-line image

processing algorithms running on remote high-performance clusters to extract useful information.
- Networking the scientific community with public users and private companies to develop and transfer innovation based on user needs. To date, the project includes 420 members.
- Capacity building through pedagogical engineering, training activities and technical assistance.

In 2012, the GEOSUD project holders have tightly cooperated with CNES, the French national space agency, to create the "Theia, land data and service centre" (https://www.theia-land.fr/) which currently pools the expertise and resources of 11 French public institutions. It aims to foster the use of images coming from the space observation of land surfaces. Theia is based on a distributed services and data infrastructure, including GEOSUD, and a network of the French remote sensing community organized in scientific and regional expertise centers, including one dedicated to partnerships with southern countries. Products and services provided by Theia are intended to be quality-controlled, to cover broad territories and long periods: annual satellite coverage of the national territory, high or very high resolution surface reflectance time series (SPOT 1-5 archives, SPOT 6-7, Sentinel 2, Landsat 8), biogeophysical variables (biomass, water levels, surface humidity, etc), time series and products at various scales, visualization and data processing tools, dedicated algorithms, validation procedures, methodological guidelines for thematic applications. Theia is well articulated with the Copernicus European program and aims at providing some of its products and services. First studies on the economic impact of the GeoSud/ Theia shared infrastructure have been launched (see Highlights).

These initiatives will also be supported by the ESA Montpellier Business Innovation Centre and the NOVA booster coordinated by the Aerospace valley cluster, and including Agropolis Fondation and Montpellier Métropole, to foster innovation and business development in France and Southern countries.

GEOSUD and Theia will fuel the three projects presented above with satellite imagery and derived products in order to develop additional products and services dedicated to digital agriculture.

Conclusion

These four examples described resource-sharing infrastructures as a relevant/ necessary way for building capacities in digital agriculture : data must be shared, be they sourced from satellites or from farmers, disciplines must share knowledge in order to encompass all aspects of innovation, including social issues, up-to-date ICTs must be made available in new example-based learning approaches built in real environment. All these projects also require a strong and long-term collaboration between public and private partners. Last, not least, these infrastructures will be widely opened to students and researchers from Southern countries, from which new challenging issues are expected.

Highlights: How much can your gain through shared infrastructures?

In 2016, the economic impact of GeoSud / Theia has been assessed through a practical application: the satellite-based monitoring of forest clear cutting, an activity currently carried out by State offices. Preliminary results show a return on investment (RoI) of 30 euros per 1 euro invested in the GeoSud /Theia method and shared data. Other similar economic studies are going on!