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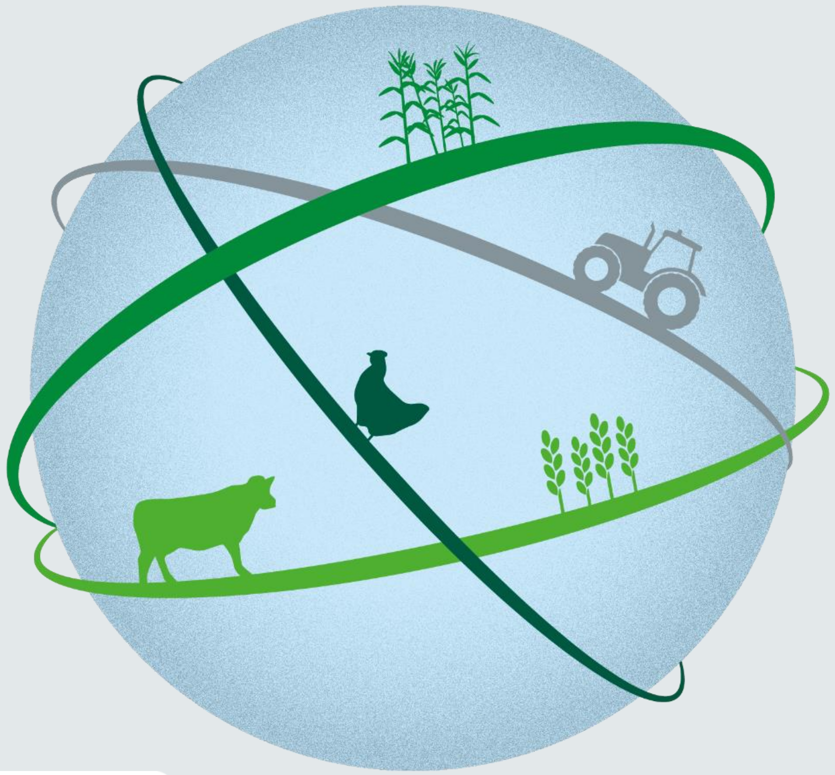
GLOBAL FORUM FOR FOOD AND AGRICULTURE

How can digital agriculture foster resource efficient and environmentally friendly food production?

Transition in crop protection from chemistry to biology with #DigitAg



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#DigitAg Digital Agriculture Convergence Lab

www.hdigitag.fr/en/

#DigitAg

The issue of crop protection

Conventionnal plant protection has led to the exposure of many living organisms to chemicals, resulting in the presence of problematic xenobiotics with many adverse impacts through multiple pathways

- Human Health (cancer, endocrine disruptor,…)
  - Operator exposure
  - Neighbourhood exposure
  - Food chain contamination
  - Water/Air contamination
- Biodiversity (beneficial insects, wild plants,…)
  - Field exposure
  - Soil/water/air contamination

- Many questions arise about current risk evaluation methods on humans and biodiversity
  - Early warning signals not taken into consideration quick enough by regulatory bodies – precautionary principe vs established practices
  - Complexity of the transfert pathways not reflected in current regulatory modeling tools – i.e. volatilisation after application
  - Long term exposure and cocktail effects
  - Combination of multiple factors on bees not properly evaluated
  - Representativeness of model organism sensitivity to exposure questionned
  - …..
- Have resulted in a massive distrust of chemical solutions to protect crops

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The trend for conventional products

It is expected that the use of plant protection products that result in xenobiotics will decrease sharply in the future because of legislative evolution

- Glyphosate ban expected within 2 years in France (round-up)
- Many active substance may fail to pass current european regulation evaluation process at renewal
- Even some organic farming products are at question as copper used for fungal desease control

- The crop protection sector faces a quick regulatory shift
  - Actual pollution problem was underestimated in some evaluation processes, the change in the european and national legislation is underway and will probably result in ever stringent rules
- The time to introduce new molecules after innovation is increasing because of the regulatory process duration

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The biological sciences revolution

#DigitAg irstea

Biological sciences revolution is underway, driven by ever more powerful measurement tools, the understanding of biological processes progress at high pace at various scales and the digital revolution enabling to embrace the complex interactions of living organisms with their environment

- Molecular scale - microbiologists
  - Genomics
  - Transcriptonics
  - Proteomics
  - Metabolomics
- Individual scale - Plant biologists,
  - Phenomics
  - Ecophysiology
- Population scale- plant pathologists - entomologists
  - Ecology (plant-microbial communities interactions)
  - Biological regulations

The biological revolution

- The capability to develop a multiscale understanding of the natural mechanisms has resulted in the mobilisation of various alternative crop protection methods that use living organisms or molecules from animal or vegetal origin

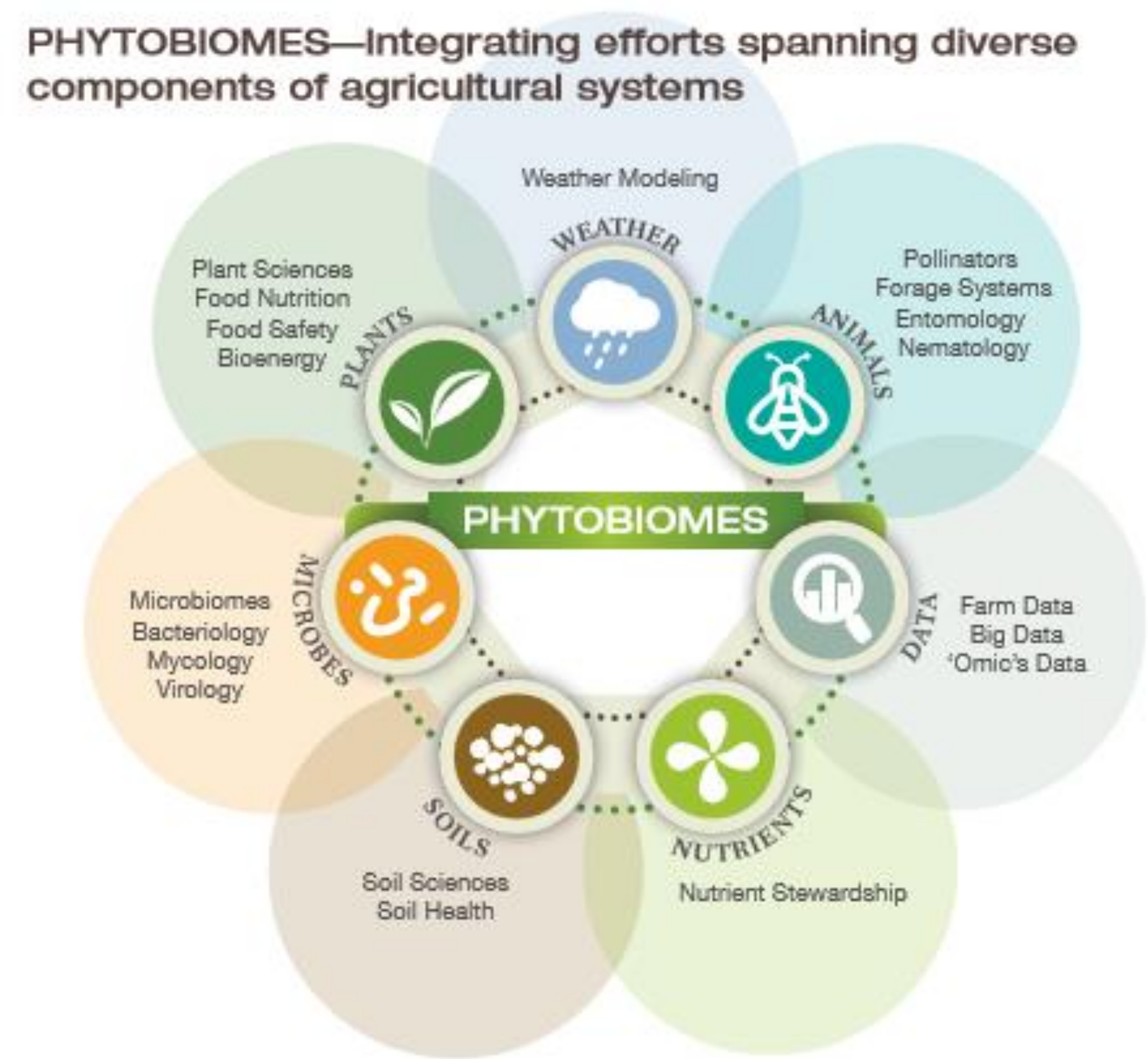
  - Population control using sterile individuals
  - Use of semiochemicals to perturb intraspecific communication of pests
  - Application of beneficial organisms in fields (insects, worms, arthropodes, bacteria, fungi,…)
  - Agroecology mechanisms used to amplify biological and ecological regulations
  - Signal molecules used to control biological processes…

- But many biocontrol methods and strategies still have to be discovered

the current concept is still shaped by the classical agrochemical control that is applied relatively independent the agricultural system

the sustainability of the biocontol is still a statement that has to be investigated

Phytobiomes vision for agriculture



Integrating Phytobiome “big data”

Understanding phytobiomes will require a lot of data and its analysis. Integration of phenotyping, genetic data analysis, soil data, weather data and climate modeling within a changing world requires new computational methods and interlinked thinking. Phytobiome researchers can leverage advances in Big Data analysis to deliver usable knowledge to scientists, policy makers, agricultural industries, growers and consumers. An integrated Big Data-enabled approach is at the core of phytobiomes innovations— enabling us to better understand the linkages and feedbacks inherent in real-world environments where we live and make decisions

French answer #DigitAg

Phytobiomes A Roadmap for Research and Translation www.phytobiomes.org

What is #DigitAg?

#DigitAg is one of the 10 Convergence Laboratories projects selected by the French National Research Agency in 2016/17

Convergence Labs ?

Putting together research and higher teaching ressources with an inter-disciplinarity approach to make advances in a new field with high societal and scientific challenges.

#DigitAg aims at becoming a

world reference in Digital Agriculture

#DigitAg is based on a group of 350 staff members with **interdisciplinarity crossings** between agronomy, engineering sciences (computer sciences, maths, électronics, physics …), economic, and social sciences..

Located in MONTPELLIER (85%) & 2 satellite sites

Toulouse (INRA)

Rennes (INRA et INRIA)

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#DigitAg objective is

To promote the **development of digital tools in agriculture** (from data acquisition to data processing) and to support companies related to Digital agriculture through **research, higher education and transfer.**

Targets are France (& European countries) and Southern countries.

Duration: 7 years **Started: January 1st 2017**

Budget : 147 M€ (Full costs) of which 9,9 M€ public support.

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#DigitAg Partners

17 Partners
25 Research Laboratories

4 national research institutes

3 higher-education institutes

2 institutes dedicated to transfer

8 industrial companies

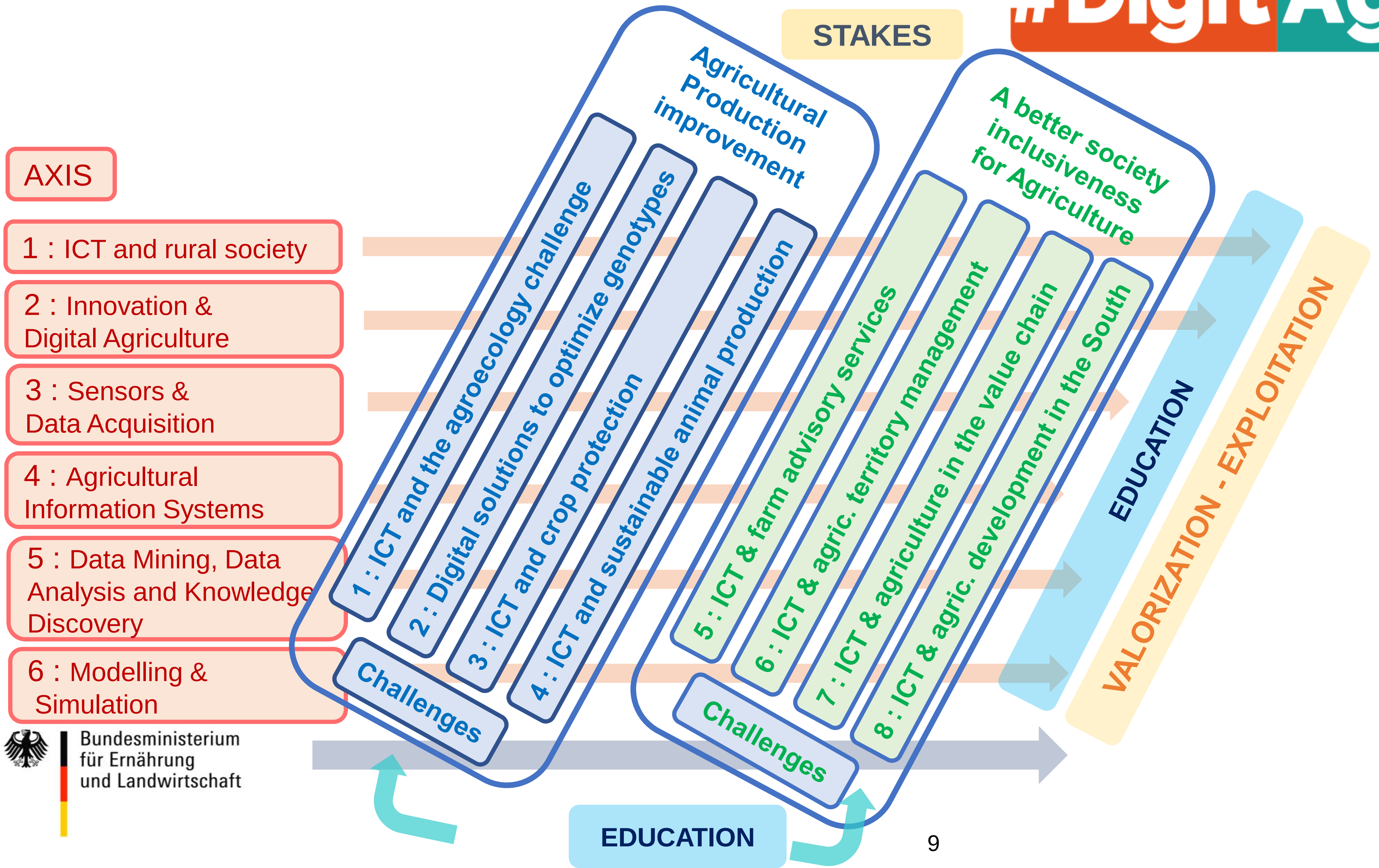
#DigitAg Research means

- + 150 master grants (internship + research support)
- **56 PhD grants (grant + research support)**
- + 100 labelled PhD (support < 1K€)
- 18 years of post-doc,
- 72 months of grants for hosting high-level teachers /researchers
- 10 years of IT development for turning PhD results into demonstrators.
- Data challenges

In collaboration with major local stakeholders

- 3 Labex: NUMEV, AGRO, ENTREPRENDRE
- 2 Equipex: GEOSUD & PHENOME
- MUSE I-SITE: #DigitAg is one of Muse institute

#DigitAg Research



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#DigitAg Challenges

Disciplinary Axis 1 Understanding ICT influence on rural societies

To understand how ICT technologies contribute to improving management at farm level and territory governance

Farms targeting productivity gains may adopt precision agriculture technologies (e.g. sensors, automatic data processing, decision aid systems, etc.) whereas non-conventional farming may use other digital collaborative tools to communicate, access information or trade. A smartphone can link a farmer to a vast amount of comprehensive data of the phytobiome of a farm that could guide its management choice do optimized productivity.

To understand how ICT-enabled new services change the role of actors of the agriculture, including advisory services

ICT tools make it possible build more horizontal collaborations and new networks. New services are created and delivered by organisations of various natures and sizes even with newcomers extraneous to agriculture. It is therefore essential to analyse to what extent these innovations contribute to organizational, economic and institutional changes.

ICT may also induce new relationships between farmers and cooperatives, as well as new organisations and regulatory processes in territory or in agricultural supply chains. Lastly, the impact of such new tools must be assessed regarding productivity, competitiveness and sustainability criteria, as well as changes of governance processes at the rural territory level, and efficiency of public policies related to accompaniment, transparency, control and mobilisation of the agricultural sector

#DigitAg Challenges

Disciplinary Axis 2: Construction of ICT-based innovation: technological, social and legal issues

To understand how to successfully build - technological and organizational - innovation in “digital agriculture”

The issue of innovation building arises regarding design processes and the integration of users in the early stages of design. Co-design of decision support tools with farmers and regional actors, collective exploration activities, are important factors in product and service adaptation to actual needs and in their broader diffusion. Supporting different modes of design and enhancing participatory design implies studying the variety of uses and applications of such tools. Through crowdsourcing, small holder farmers data could enhance database and improve predictive capability for all users

In a context where innovation is increasingly open, new forms of organizations supporting innovation have to be explored (innovation ecosystems, living labs…). The elaboration of this variety of new services raises questions on the development of operating procedures, governance, and funding (business models).

It is needed to analyze the dissemination of these innovations, including forms and determinants of this dissemination to farmers, companies, cooperatives and actors of territories.

To address the legal and ethical issues of intellectual property of data and knowledge, and consequences on value share

Extraction, analysis and dissemination of the data finally poses ethical issues and legal problems related to intellectual property. Who has access to the data? Who controls and owns the data (private? public?), and to which ends? If intellectual property law does apply to the databases, the question will be then: will the databases be open and free for exploitation and will the data be considered susceptible for-meant for a large dissemination?

#DigitAg Challenges

Disciplinary Axis 3: Development of appropriate sensors and data acquisition systems, including crowdsourcing

To study and design sensors to address sensing bottlenecks *e.g*. field phenotyping, disease, plant & animal status

Agriculture is characterized by several strict constraints with regard to data acquisition and sensor development: small markets, low margins, large and variable areas to cover, a high variability of objects of interest, rough conditions of use, and a low-to-medium level of ICT understanding from users. In accordance, sensors/ data acquisition systems must be robust, low maintenance, easy-to-use and with satisfactory metrological properties.

To develop “frugal” data acquisition technologies based on use of smartphone devices and satellite images

Sensors can have different configurations: portable, in field (on animals, plants, soil, etc.), embedded in tractors and other agricultural tools or in aerial drivers (UAV, planes), or in satellites (earth observation). In addition to these classical measurement devices, data acquisition is to be carried out by farmers, though devices such as smartphones and tablet computers. Today, sensor/ data acquisition/processing techniques that match agricultural needs are still lacking.

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Disciplinary Axis 4: Making progress in agricultural information system design

To make progress in agricultural information system design, with the constraints of Big Data and interoperability

The current advanced agricultural data management processes, which can be used to share data and knowledge across disciplines, sectors and countries, falls within several scientific topics in Computer Science. Data must be retrievable, accessible, interoperable, and re-usable in order to produce datasets that will support interdisciplinary cutting-edge research aiming at meeting the present and future challenges of agriculture, food security and market needs.

The main challenges of data management are: Scalability (Big data, big applications), Complexity (relevance, uncertainly, confidence, multi-scale, etc), Heterogeneity of data sources and semantics, Privacy and Ethic (sensitive farm data, fundings, surveys, etc), Data flows and reproducibility (scientific workflows, provenance).

Moreover, due to interdisciplinary requirements and context-aware approaches, data management in the agriculture domain requires adding intelligence to data (common vocabulary, ontologies, rules).

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#DigitAg Challenges

Disciplinary Axis 5: Designing new data mining methods, appropriate to agricultural data, to extract actionable knowledge

To design new data mining methods, appropriate for the big data characteristics of agriculture and preserving privacy

Agricultural data are continuously growing in volume, while at the same time possessing multi-scale (time, space), uncertain, dynamic, and heterogenous features. They can also be sensitive in nature and may require solutions that preserve privacy. Unfortunately, there is no data mining approach capable of simultaneously handling all the features characterizing agricultural data.

To develop visual and interactive methods for data analysis, tailored for non-specialists

The proposed methods will be co-designed with domain actors (data scientists, advisor experts, farmers) and interaction with actors will take place at different levels, either to receive domain knowledge, or help specify the problem at hand or to present results. An important challenge will be the definition of interactive methods specifically tailored for non-specialists (ex: visual analytics, justification and explanation). These methods will lead to a major breakthrough in the practical exploitation of agricultural Big Data. A precise framework for the evaluation of results will be set up, based on statistical model validation, the agronomist expertise (INRA, ACTA) and collaboration with other domain actors. Such a framework represents a resolutely innovative aspect in the data-mining and statistical analysis domain. Assessing current results on agricultural time scales (seasons, years) will allow us to continuously improve the proposed methods

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#DigitAg Challenges

Disciplinary Axis 6: Exploring new ways for model integration/qualification

To make progress in genotype-to-phenotype modelling, using new data integration methods and knowledge injection

the genetic asset has to be considered: genotype-to-phenotype models (ie models who link the genes with plant behaviour in real environment) will be informed by the outputs of high-throughput phenotyping methods. To this end, modular modelling solutions are favoured to easily add and share new models with explicit genetic information.

To develop methods for integrating different types of information & knowledge (generated from data, experts, models)

the operational use of next generation sensors in agriculture (IoT, UAV…) creates the need for new methodologies (*e.g.* spatio-temporal data analysis, including advanced statistical inference) for data integration in models (including seasonal weather projections) to produce more accurate and predictive information in real time. There is also a need to enhance the development of management/decision models based on such data. Production models should be coupled with economic models for strategic decision-making, Fuzzy logic, multi-objective optimization, argumentation etc…) methods are needed for multi-criteria evaluation.

To make advances in quantification of uncertainty in agricultural models

modelling research should also address more transversal issues, *e.g.* quantification of model uncertainty and model integration. Uncertainty quantification is demanded by tactical decision-makers and by policymakers.

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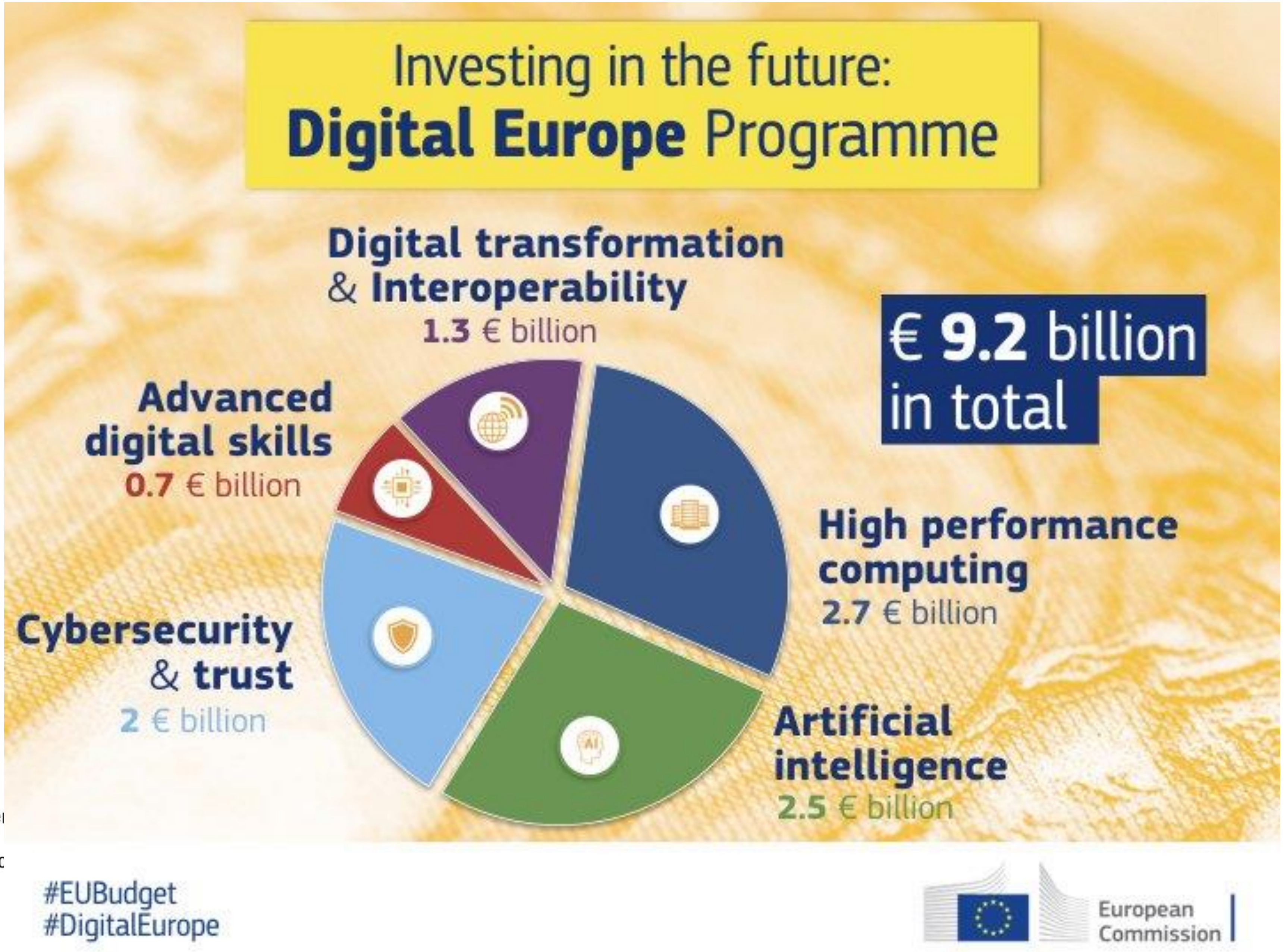
Take home message

Digital agriculture can contribute to integrated agricultural practices for the agroecological revolution to restore biodiversity and ecosystem services

Digital agriculture must restore links between the farmer and the consumer by adressing Social, environmental and economical challenges

The development of alternative to conventionnal agriculture is supported by digital agriculture revolution through #DigitAg research agenda

At european level



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