POLITECNICO
MILANO 1863

# Data Analysis for Smart Agriculture

## - Introduction to the course -

*Prof. Matteo Matteucci – matteo.matteucci@polimi.it*
*Prof. Filippo Maria Renga – filippo.renga@polimi.it*
*Eng. Riccardo Bertoglio – riccardo.bertogio@polimi.it*

# «Me, Myself, and I»

Matteo Matteucci, PhD
Full Professor
Dept. of Electronics, Information & Bioengineering
Politecnico di Milano
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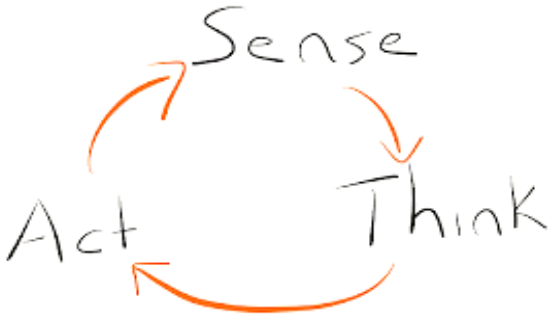
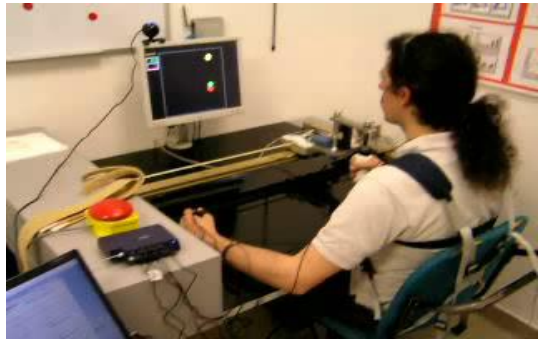
My research interests

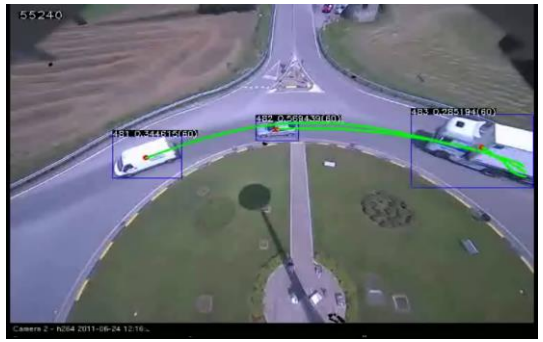
- Robotics & Autonomous Systems
- Machine Learning
- Pattern Recognition
- Computer Vision & Perception

Courses I teach

- Robotics (BS+MS)
- Cognitive Robotics (MS)
- Machine Learning (MS)
- Deep Learning (MS+PhD)





***Enable physical and software autonomous systems to perceive, plan, and act without human intervention in the real world***

# «I'm not alone»

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Riccardo Bertoglio
PhD Student
Dept. of Electronics, Information & Bioengineering
Politecnico di Milano
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Research interests

- Robotics & Autonomous Systems
- Digitalization in Agriculture
- Machine Learning
- Computer Vision & Perception

PhD DADS

METRICS

***Enable physical and software autonomous systems to perceive, plan, and act without human intervention in the real world***

# «… and we build robots (and their brains)»

# «My Business Pal»

Filippo Maria Renga, PhD
Researcher
Dept. of Management Engineering
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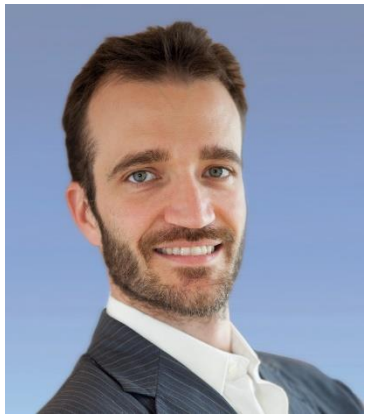
filippo.renga@polimi.it



My research interests

- Agriculture 4.0
- Impacts of Blockchain
- Data valorization

Courses I teach

- Business Economics and Organization (BSc)
- Data Valorization (Executive Masters)

***Makes data a value***

POLITECNICO MILANO 1863 SCHOOL OF MANAGEMENT

osservatori.net digital innovation

UNIVERSITÀ DEGLI STUDI DI BRESCIA

RISE Research & Innovation for Smart Enterprises

The Smart AgriFood Observatory, born in 2016 and now in its sixth edition, is the reference point in European Union to deeply understand the digital innovations that are transforming the agricultural and agrifood supply chain

AGRICULTURE 4.0

AGRI-FOOD INDUSTRY 4.0

FOOD TRACEABILITY

BLOCKCHAIN IN AGRIFOOD

DATA VALORIZATION

AGRIFOOD STARTUPS

# What about you?

What is your background?

- …

Why did you chose this course?

- …

What do you expect from this course?

- …

SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

# Food Security & Climate-Smart Agriculture

End hunger, achieve food security & improved nutrition, and promote sustainable agriculture

By 2030, ensure ***sustainable food production*** systems and implement **resilient agricultural practices** that ***increase productivity and production***, that help maintain ecosystems, that strengthen capacity for ***adaptation to climate change***, extreme weather, drought, flooding and other disasters and that progressively ***improve land and soil quality***

# Soil Health & Food

EUROPEAN UNION

## Horizon Europe Missions

DELIVERING SOLUTIONS TO SOME
OF OUR GREATEST GLOBAL CHALLENGES

#EUmissions #HorizonEU

#MissionSoil

© European Union, 2020

# 2030 Targets for sustainable food production

## PESTICIDES

Reduce the overall use and risk of chemical and hazardous pesticides

## NUTRIENT LOSSES

Reduce nutrient losses by 50% whilst retaining soil fertility, resulting in 20% less fertilisers

## ANTIMICROBIALS

Reduce sales of antimicrobials for farmed animals and aquaculture

## ORGANIC FARMING

Increase the percentage of organically farmed land in the EU

#EUFarm2Fork #EUGreenDeal

European Commission

# Modern Agricultural Revolutions

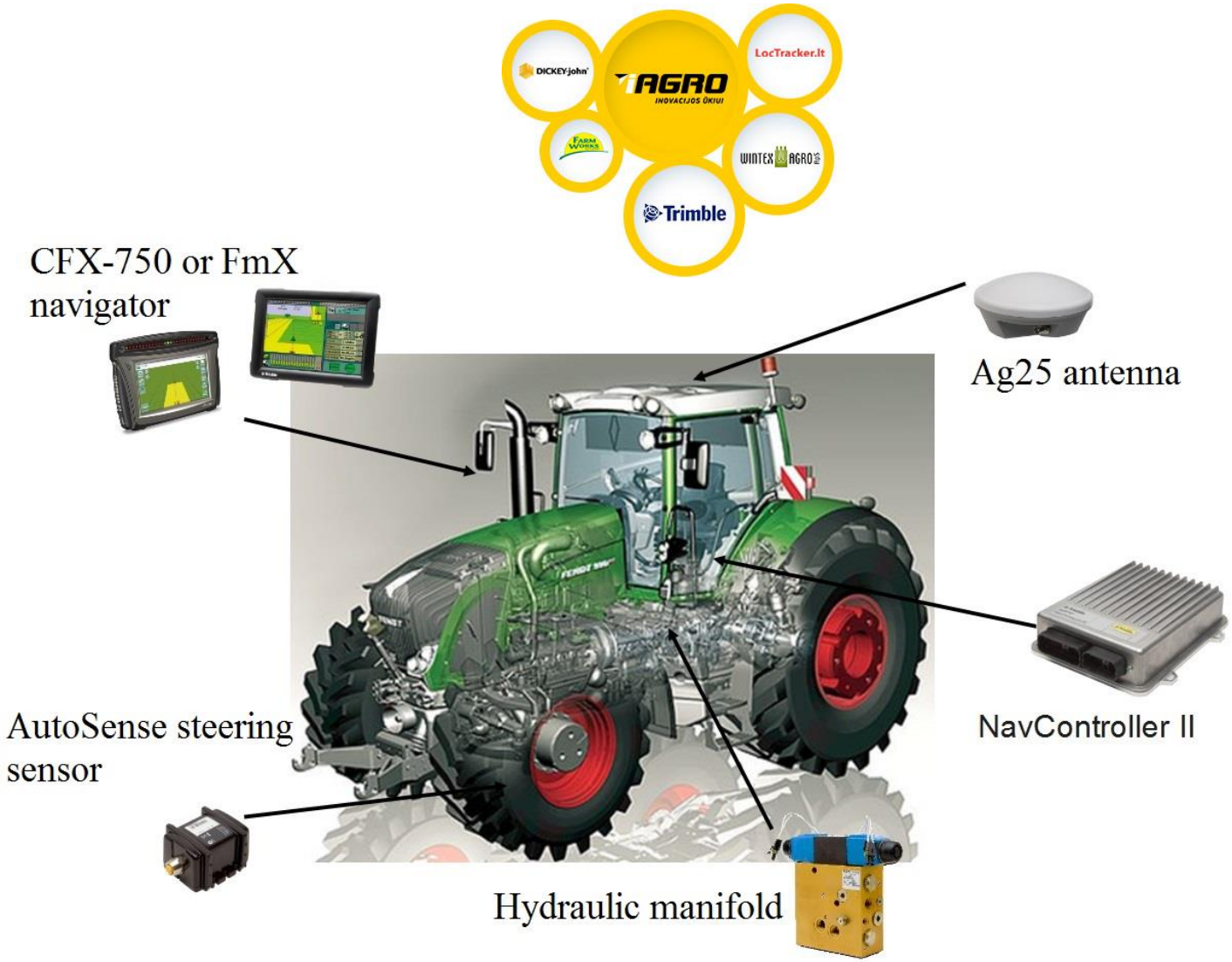
**Post-WW1 Mechanization (1.0 – 1920s)**

**The green revolution (2.0 – 1960s)**

**Precision Agriculture (3.0 – 1990s)**

# Precision Agriculture (3.0)

- ✓ Global Positioning System
  - Assisted / automatic steering



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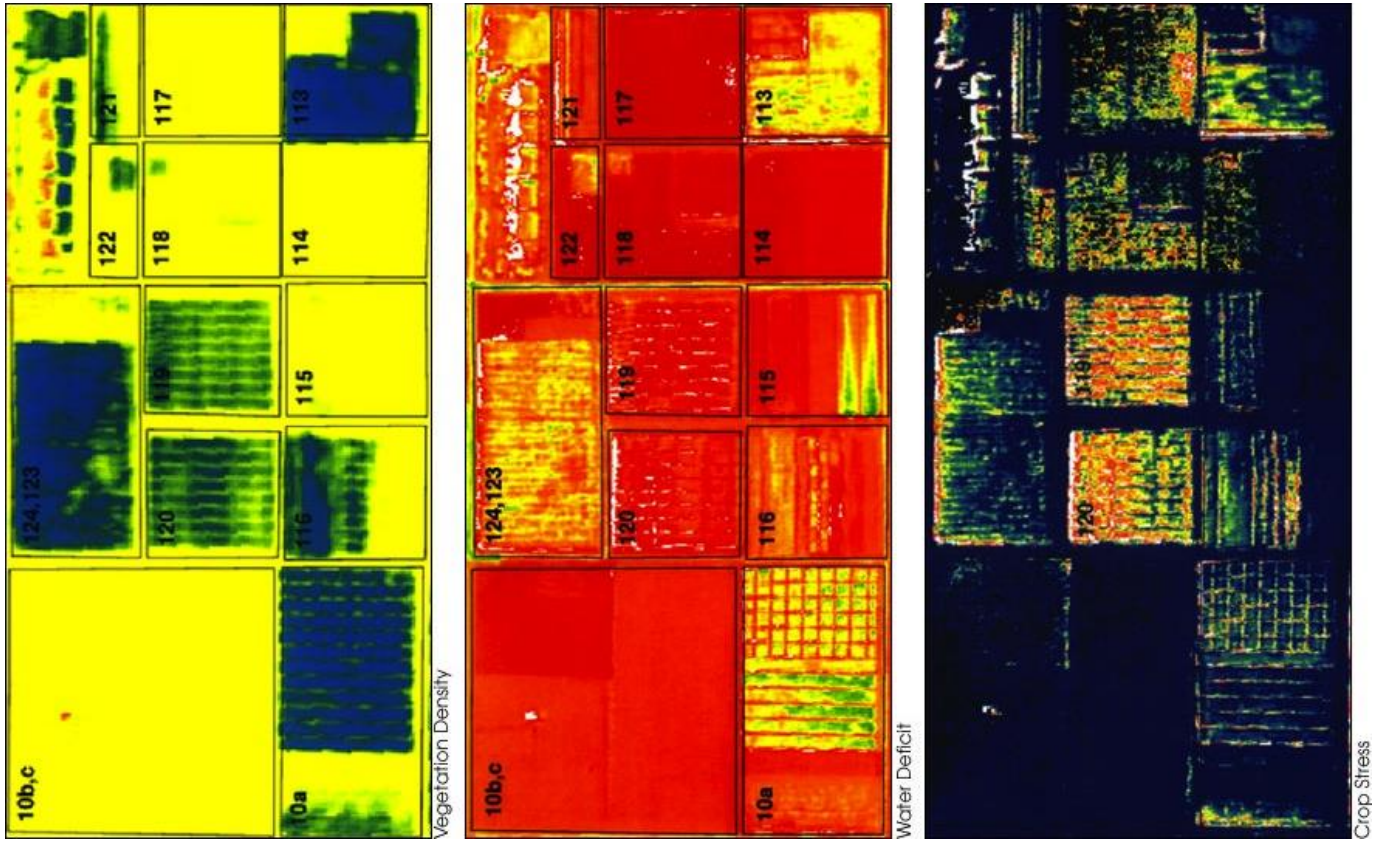

# Precision Agriculture (3.0)

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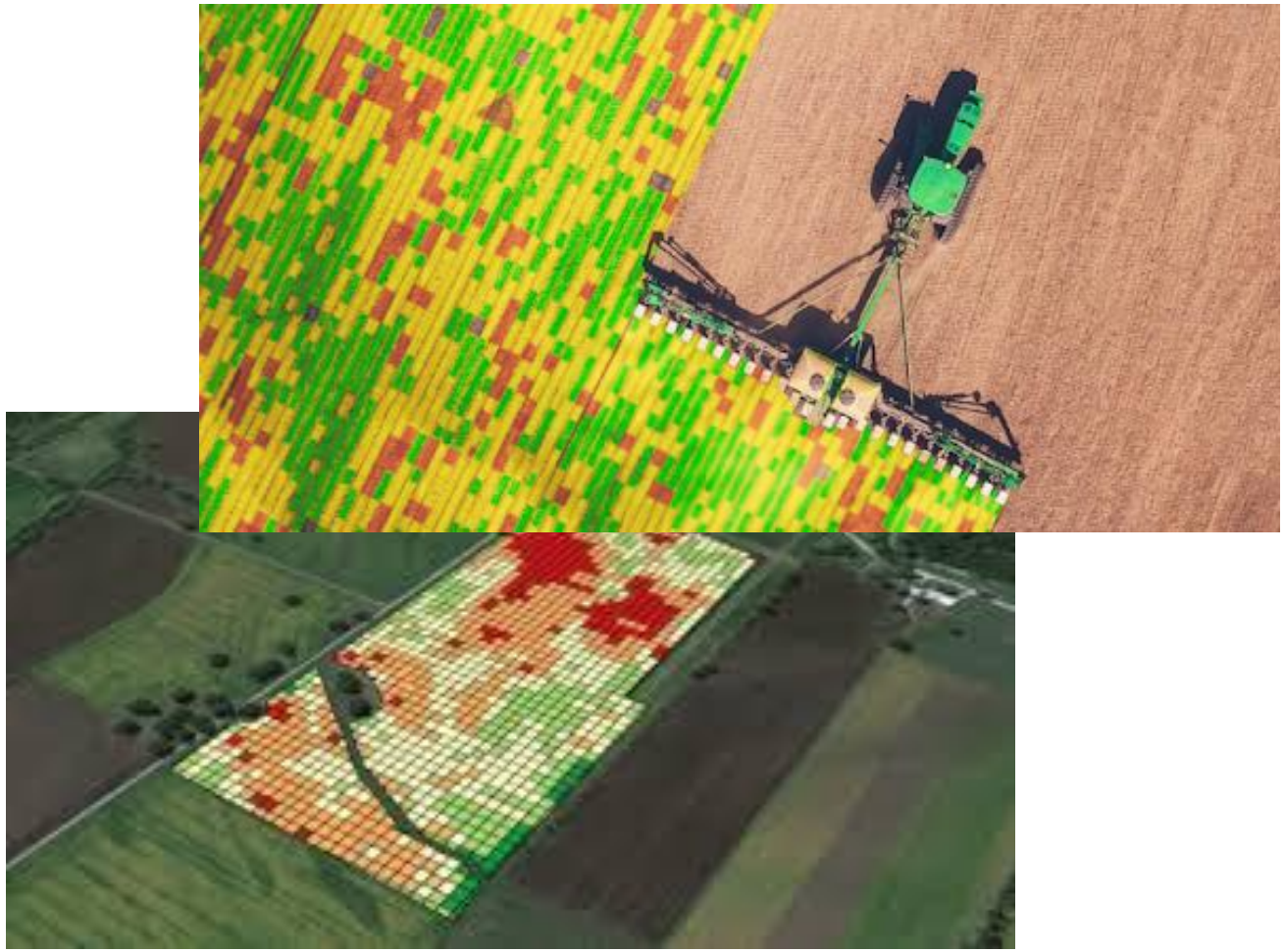
- ✓ Airborne multispectral & hyperspectral imagery
- ✓ Prescription maps to apply
  - The right input
  - At the right location
  - At the right time



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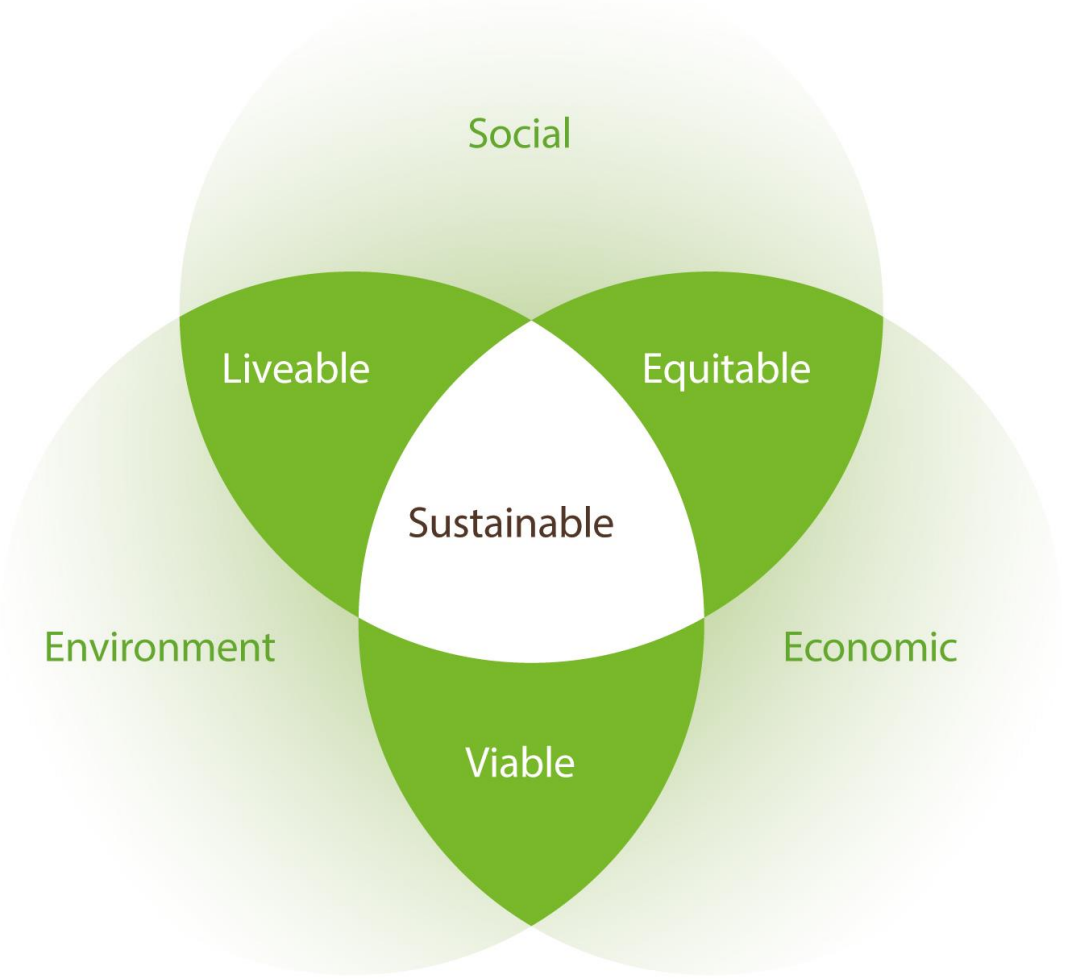
- ✓ Prescription maps to apply
  - The right input
  - At the right location
  - At the right time
- ✓ Enhance production and reduces resources usage



# Modern Agricultural Revolutions

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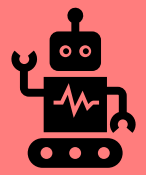
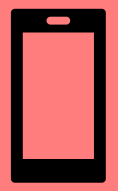
**The green revolution (2.0 – 1960s)**

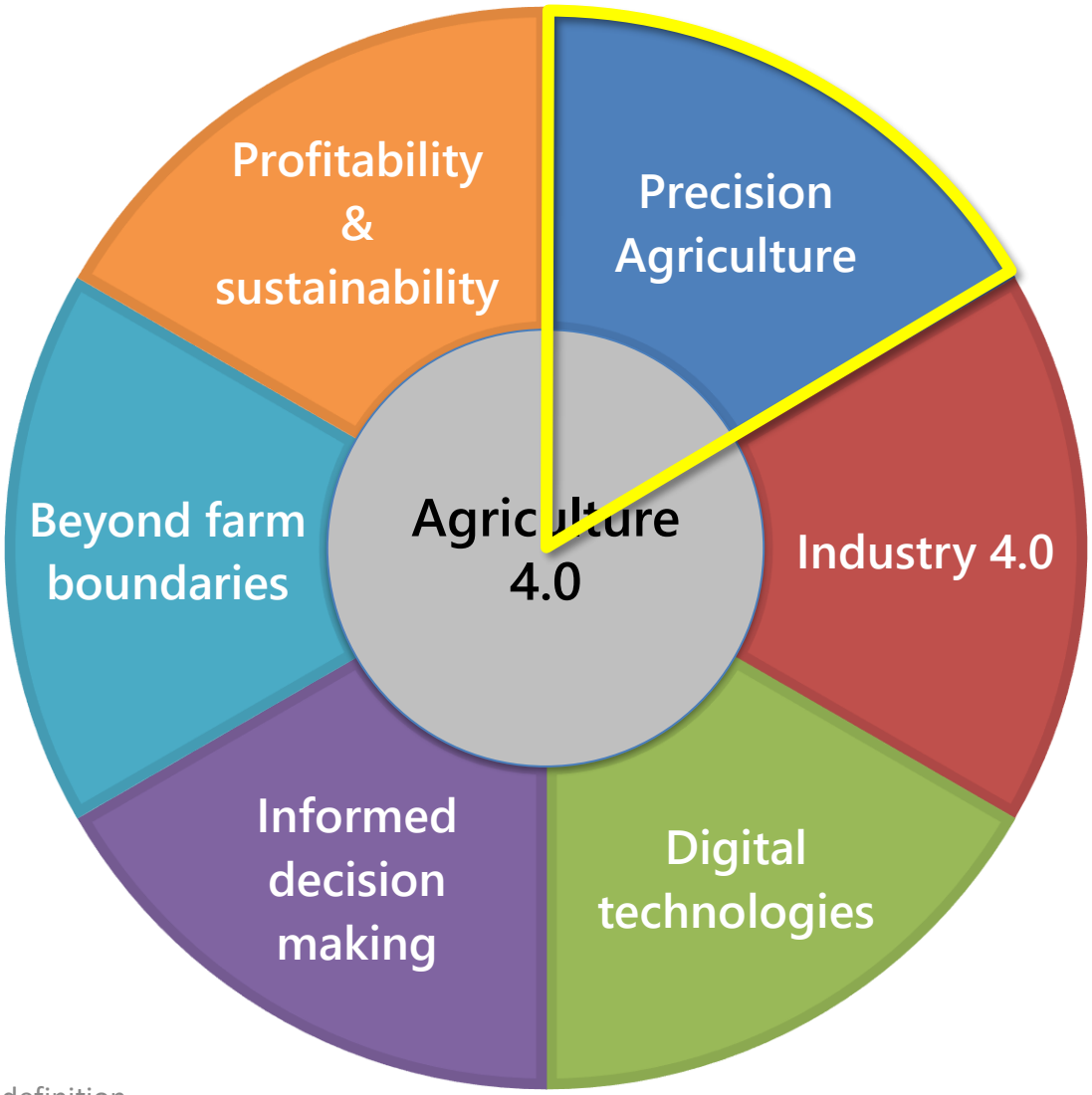
**Precision Agriculture (3.0 – 1990s)**

**Agriculture 4.0 (2010s)**



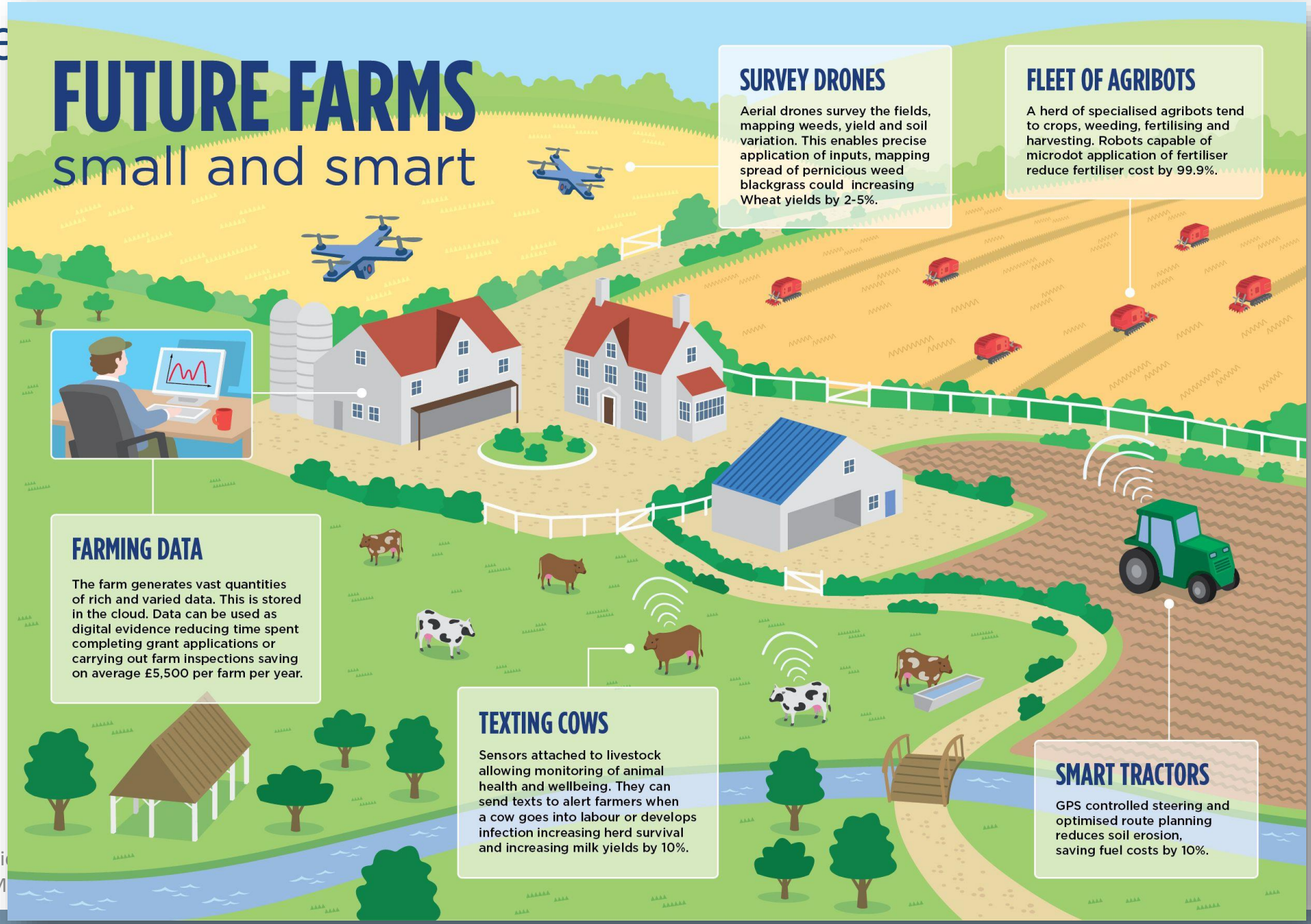


# Multiple Facets of Agriculture 4.0




The 4.0 revolution in agriculture: a multi-perspective definition
Sponchioni G., Vezzoni M., Bacchetti A., Pavesi M., Renga F.

# Multiple




The 4.0 revolution in agri
Sponchioni G., Vezzoni M

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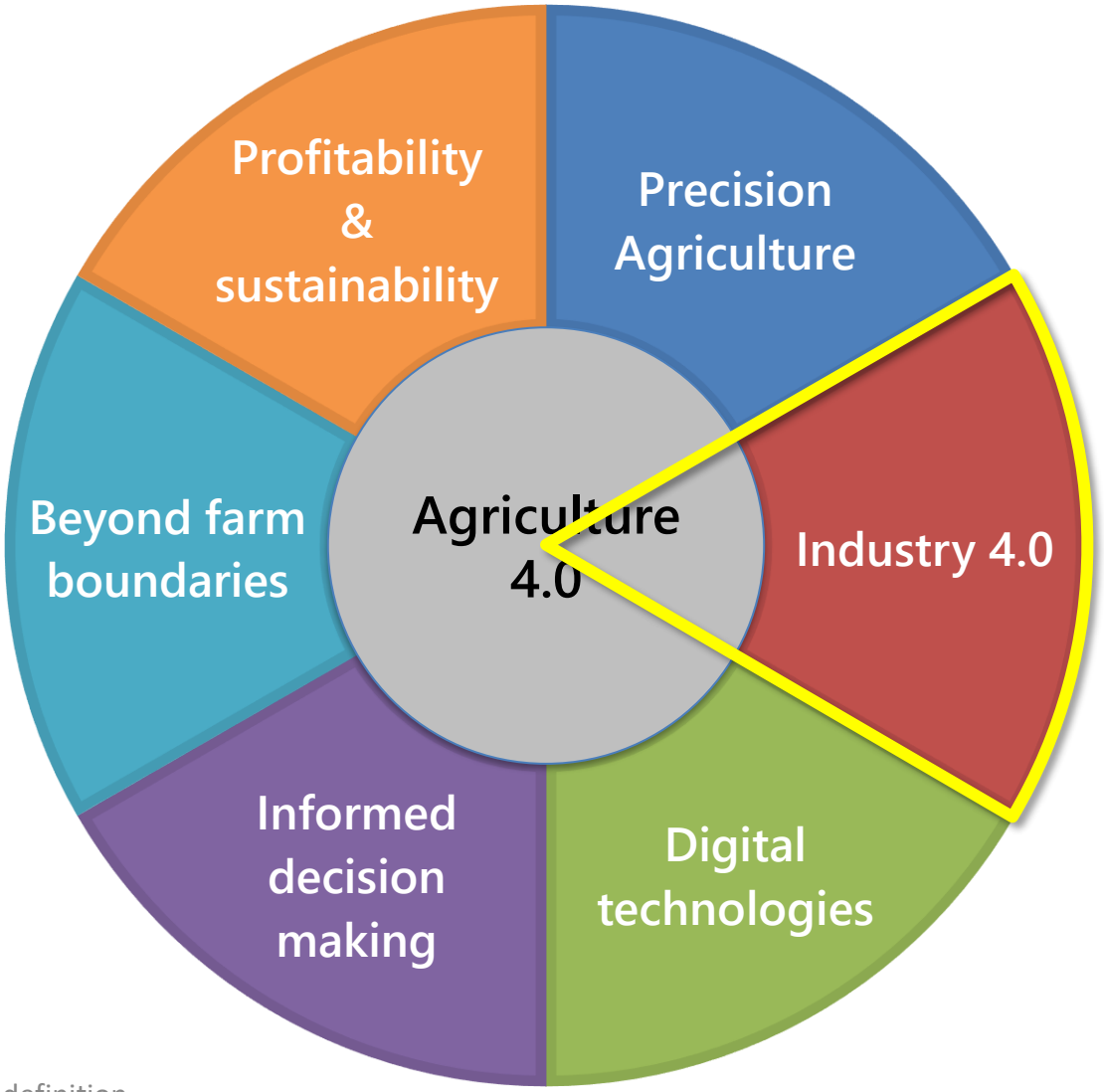


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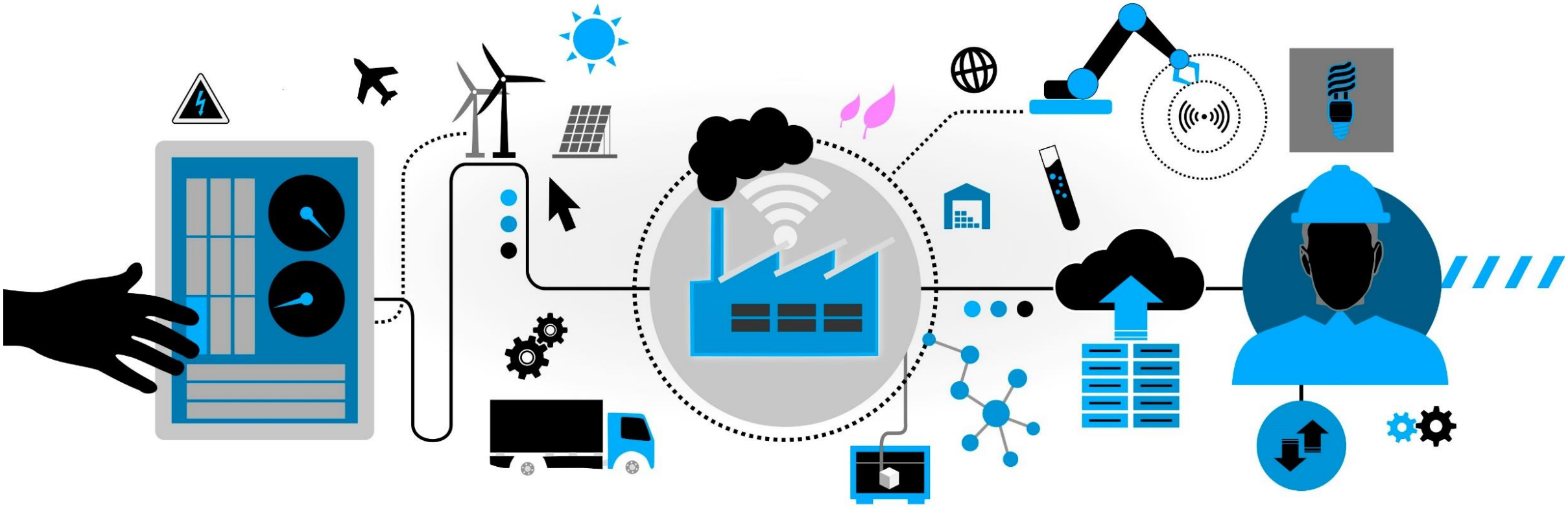
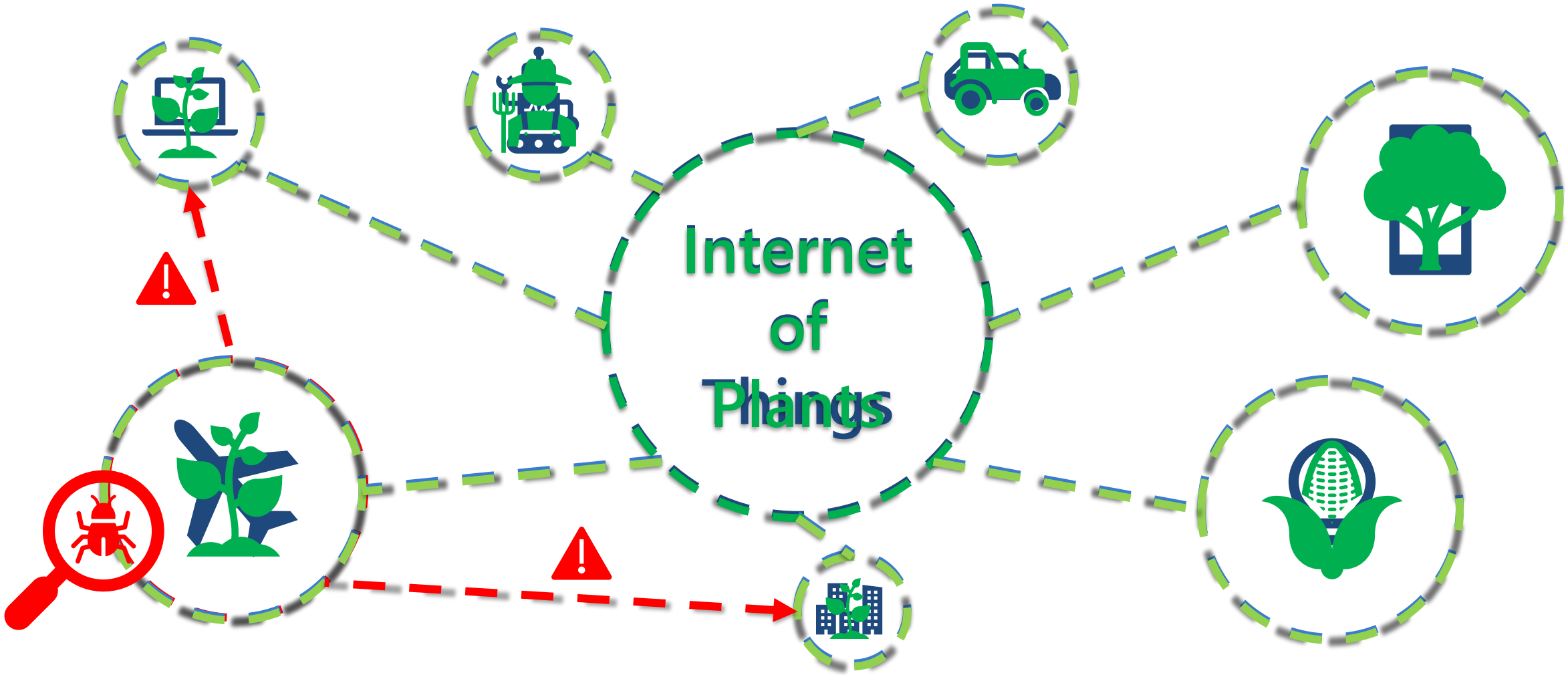
# Industry 4.0 Analogy

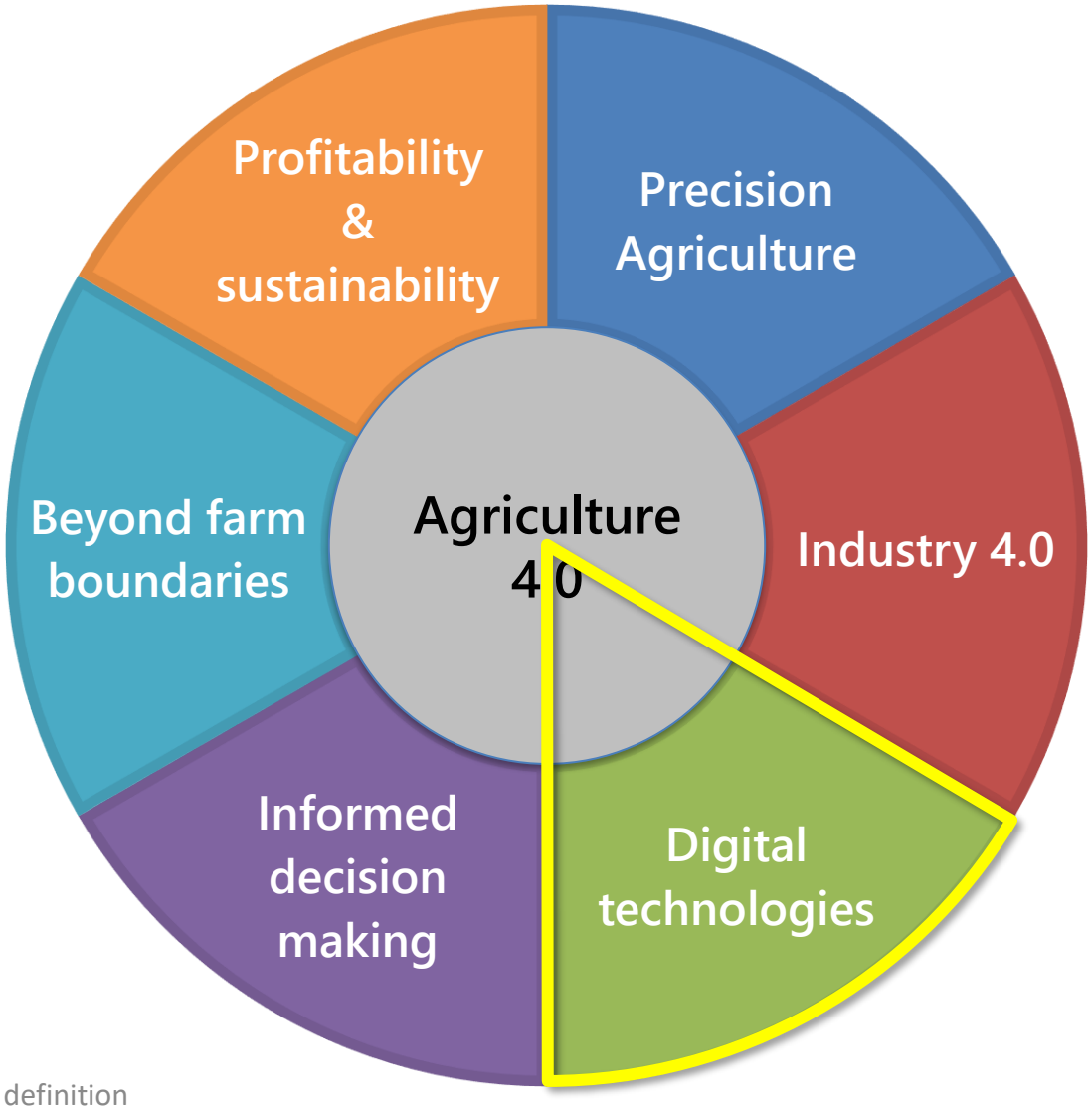
In the Industry 4.0 the entities of the working environment are linked to each other in a continuous and effortless way



# Industry 4.0 analogy



# Multiple Facets of Agriculture 4.0

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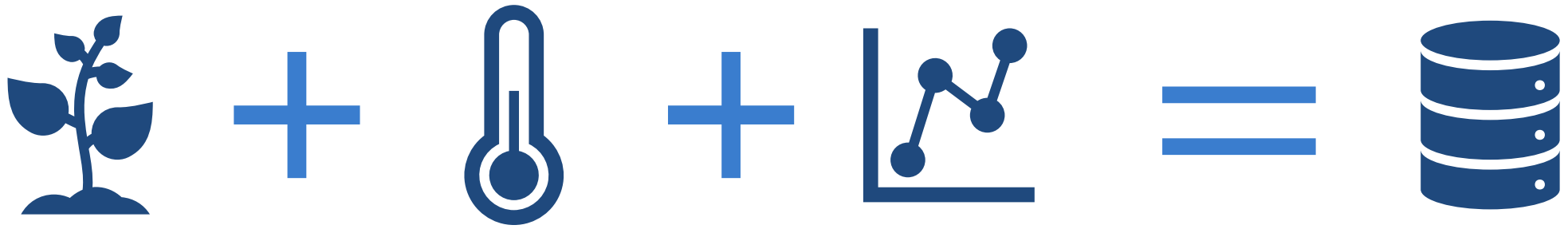
# Digital technologies

The digital technologies enable the collection, integration and analysis of data silos unlocking new prospects for the farmer

- IoT allows to collect data from the field, from the surrounding environment and from the market
- UGVs / UAVs increase the amount of data collected from farming operations
- All the data are stored in the cloud



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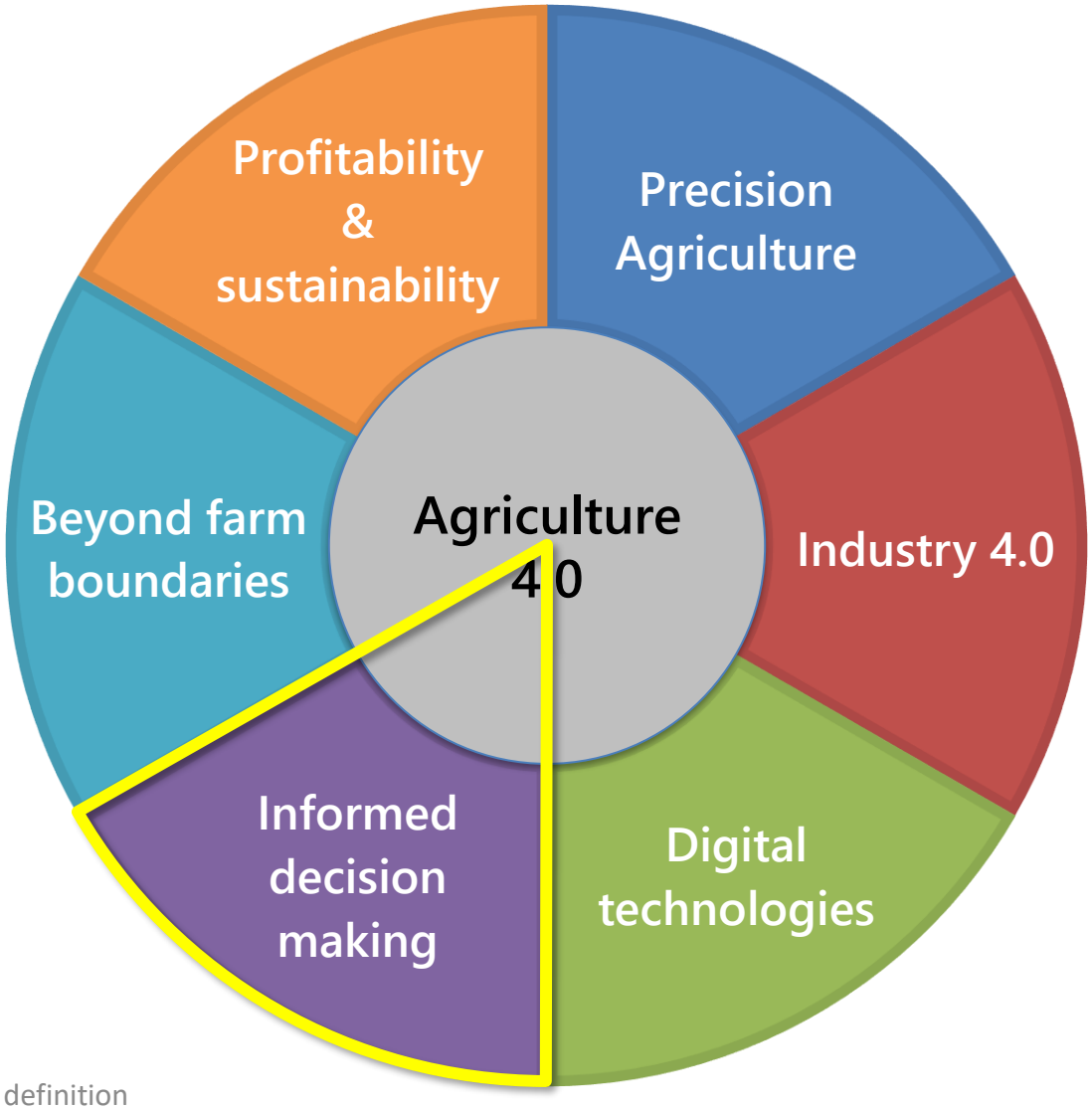


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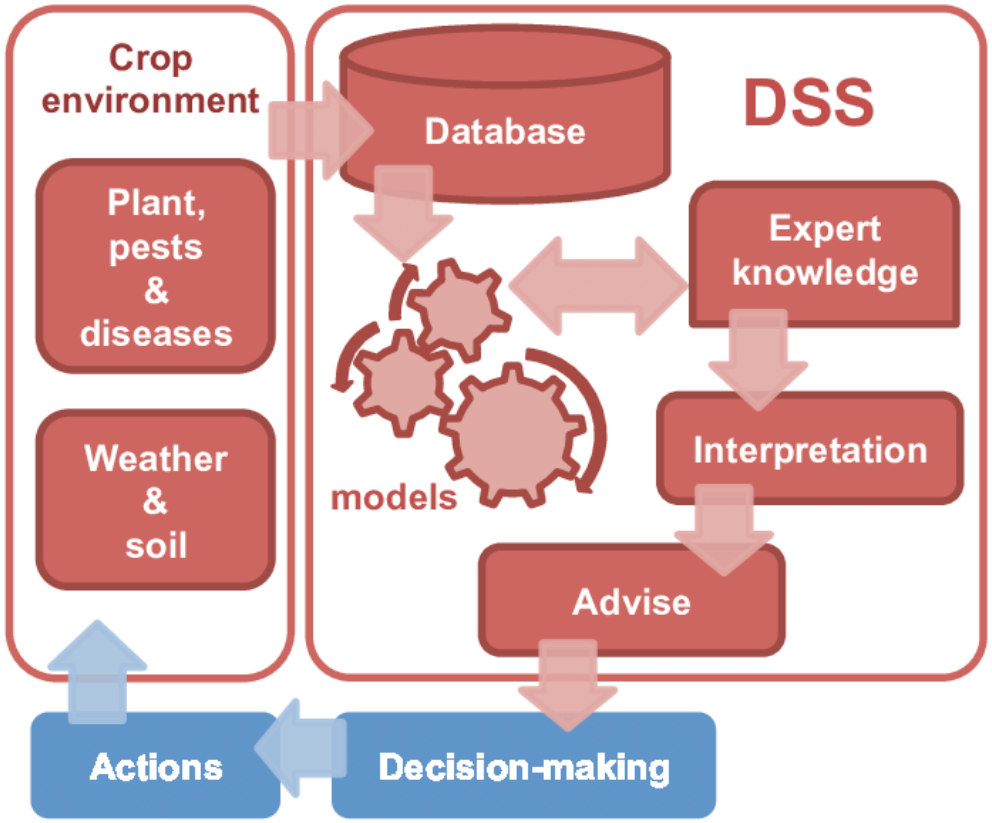
# Informed decision-making

Farmers make decisions based on their personal goals, their subjective beliefs

- Collecting, integrating and analyzing vast amount of data gives birth to a Decision Support System
- Agriculture 4.0 makes the farmer's decisions more fact-based and math-based and less intuition-based



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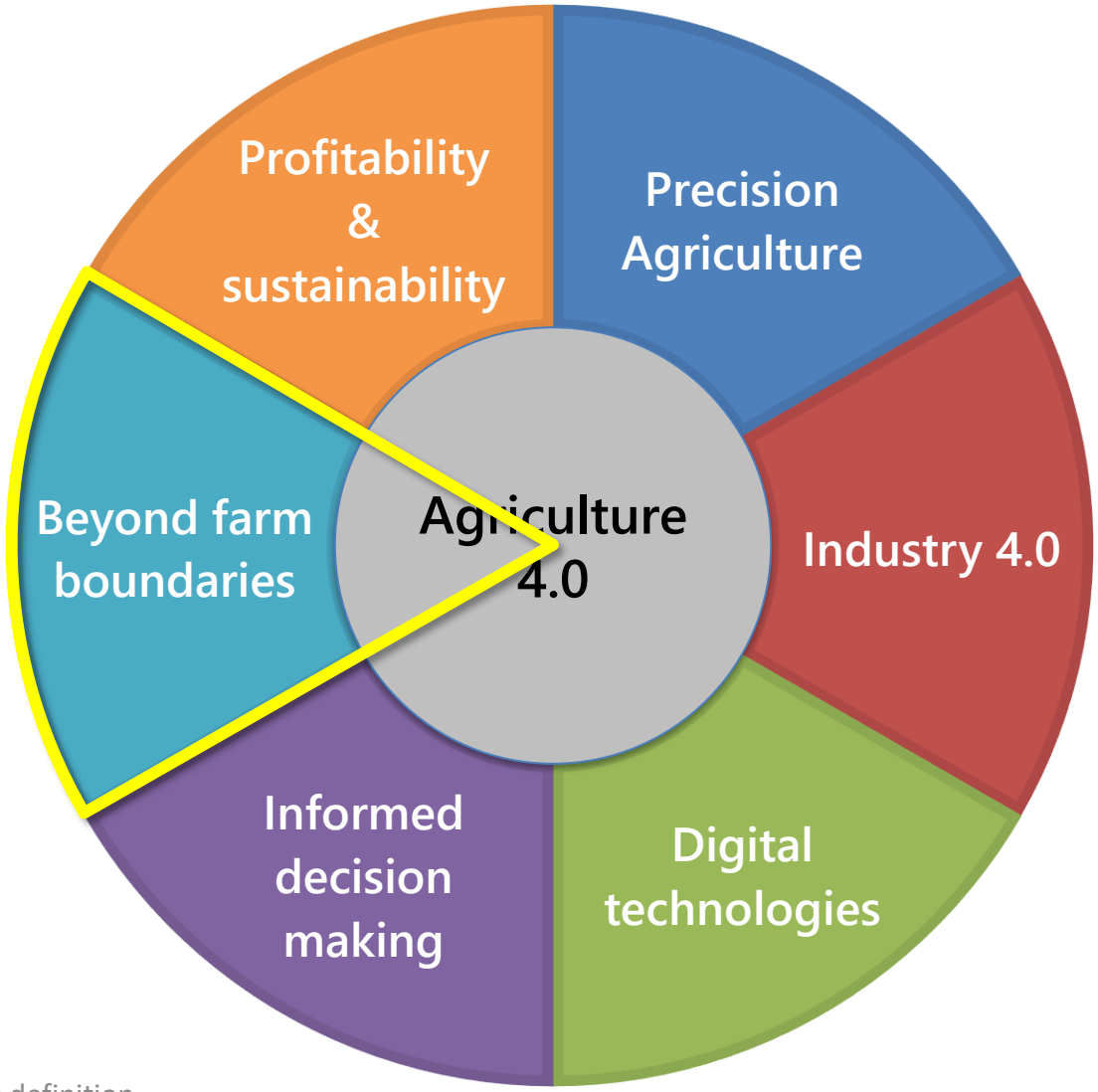


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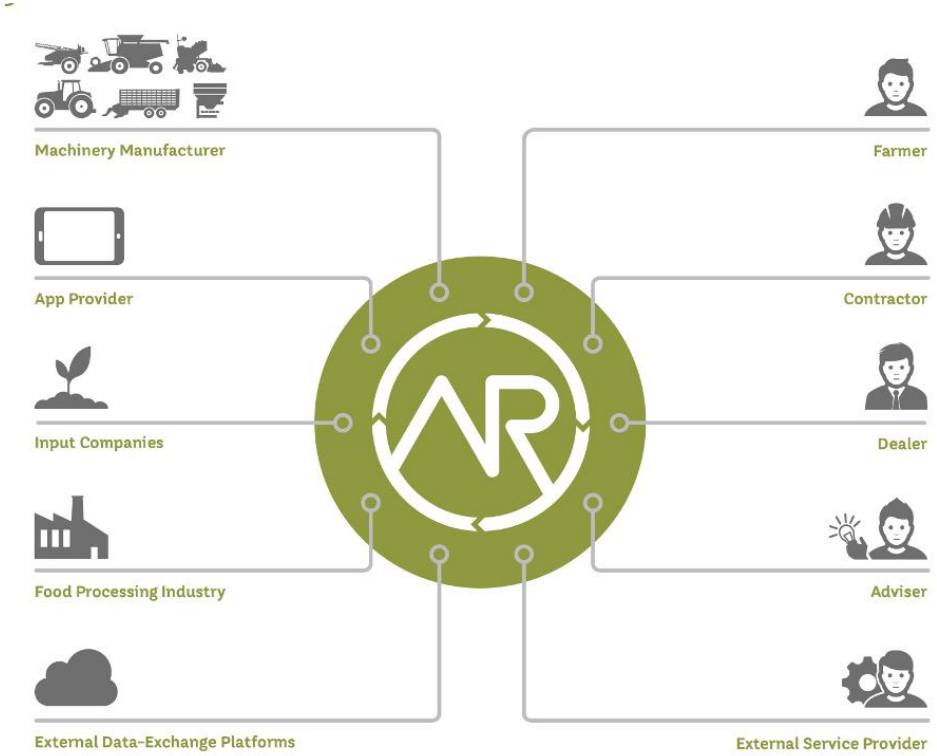
# Beyond Farm Boundaries

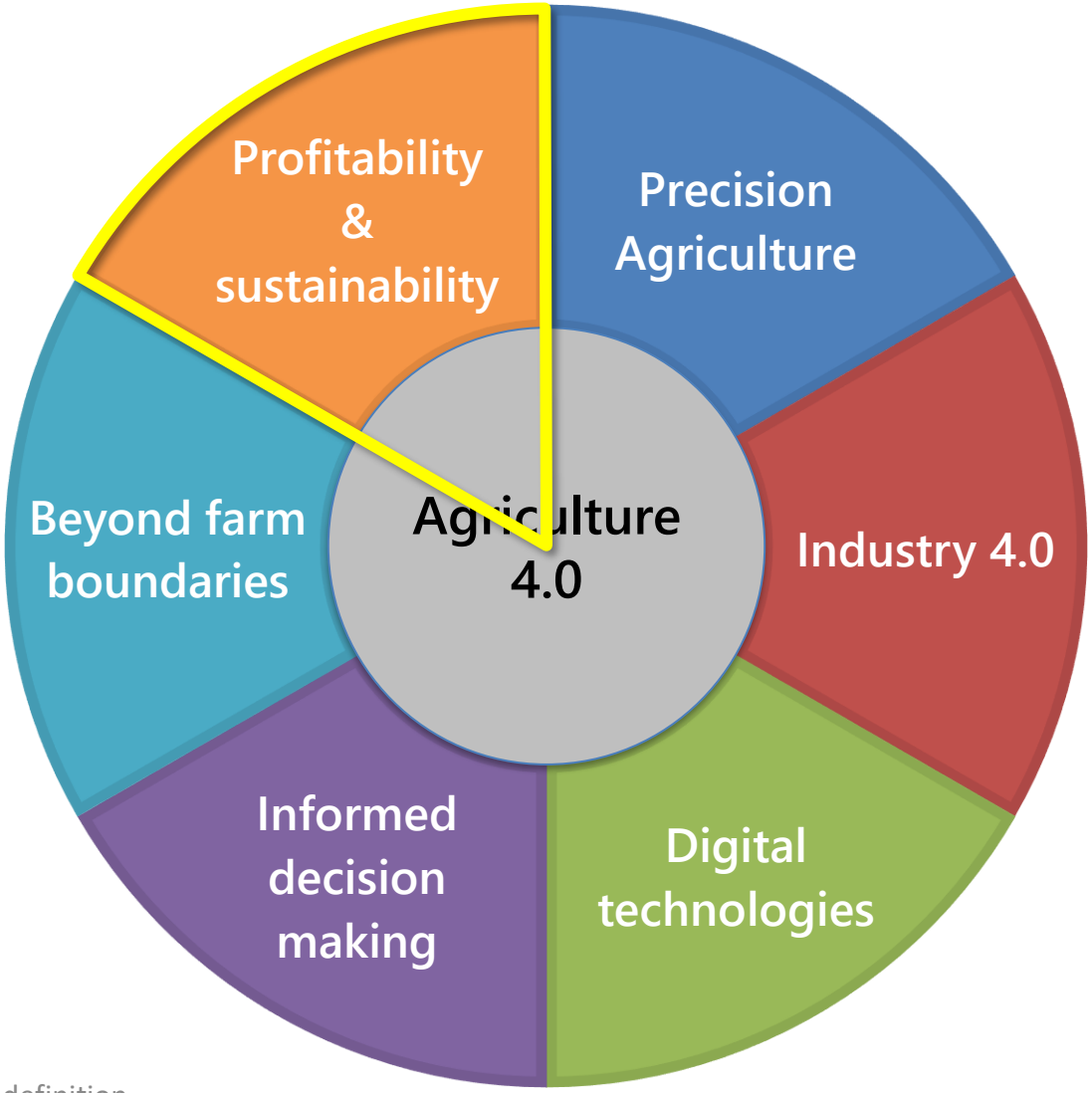
Integration in the farm process of external actors

- Suppliers of seeds, pesticides, nutrients, veterinarians, machine vendors, financial service providers, …
- Agriculture 4.0 allows the coordination between the different actors involved in the farms process and along the supply chain



agrirouter

# Multiple Facets of Agriculture 4.0

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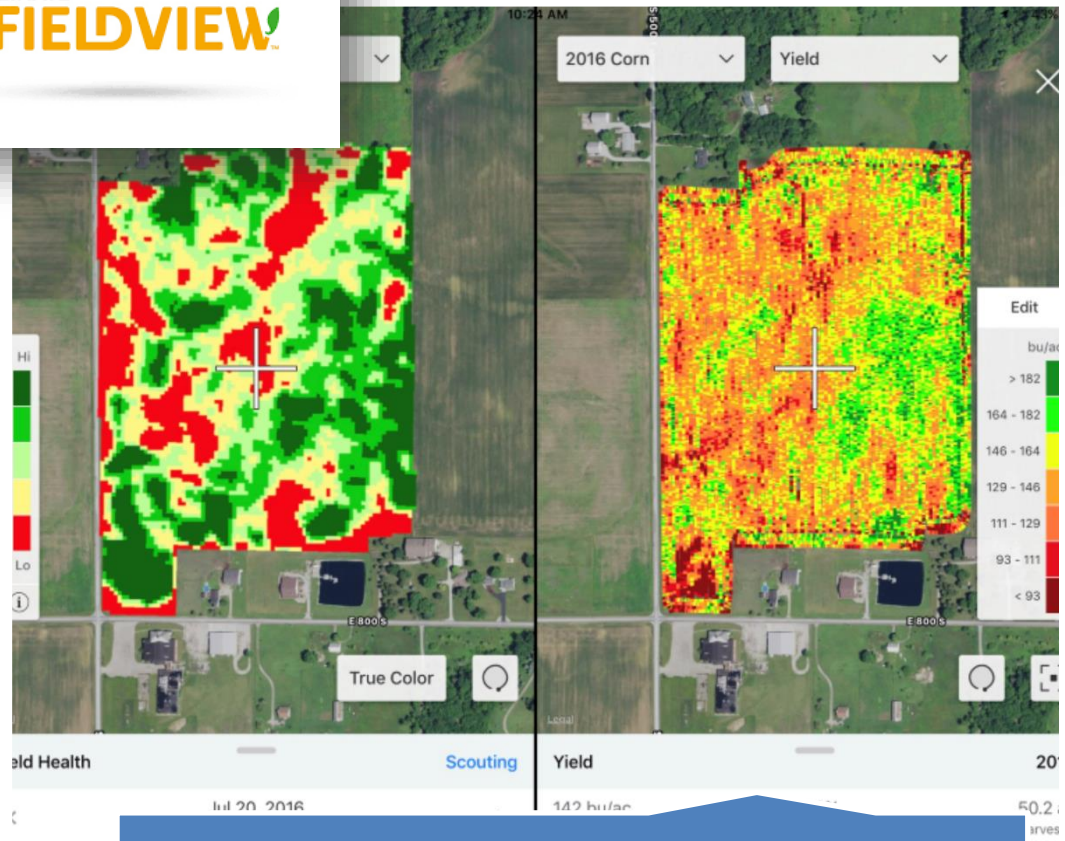
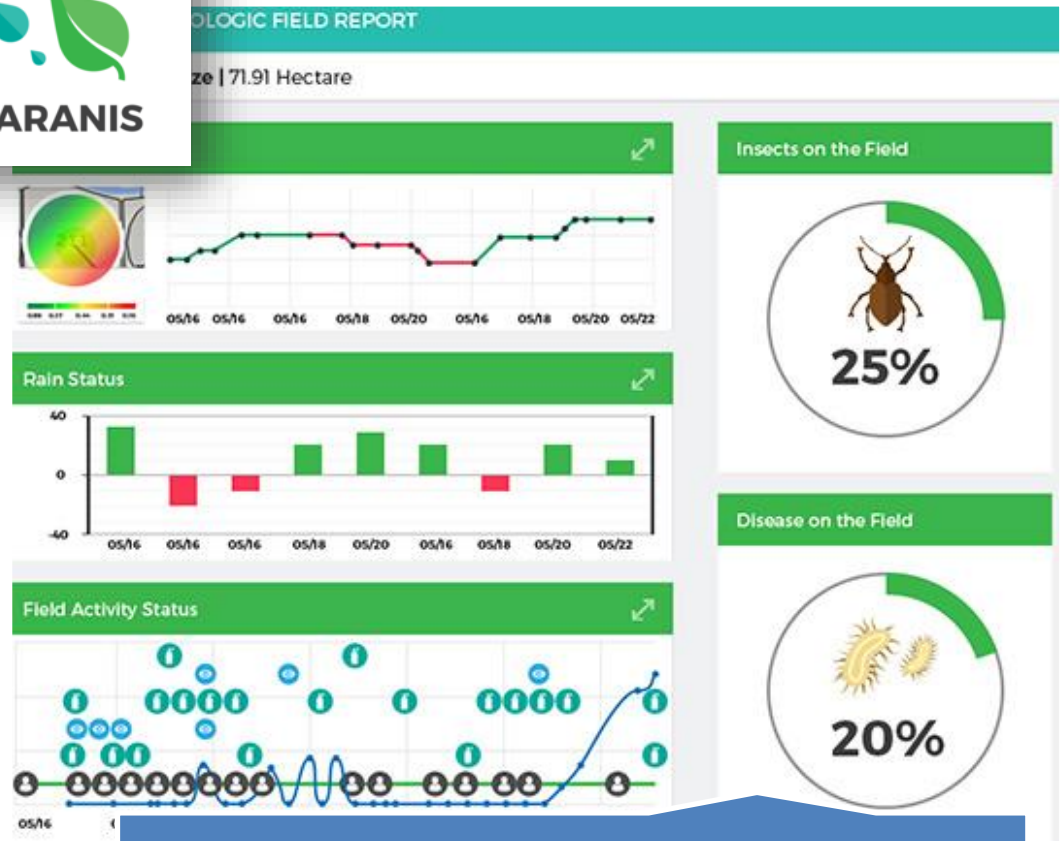
# Agriculture as a Service (some examples)

CLIMATE FIELDVIEW



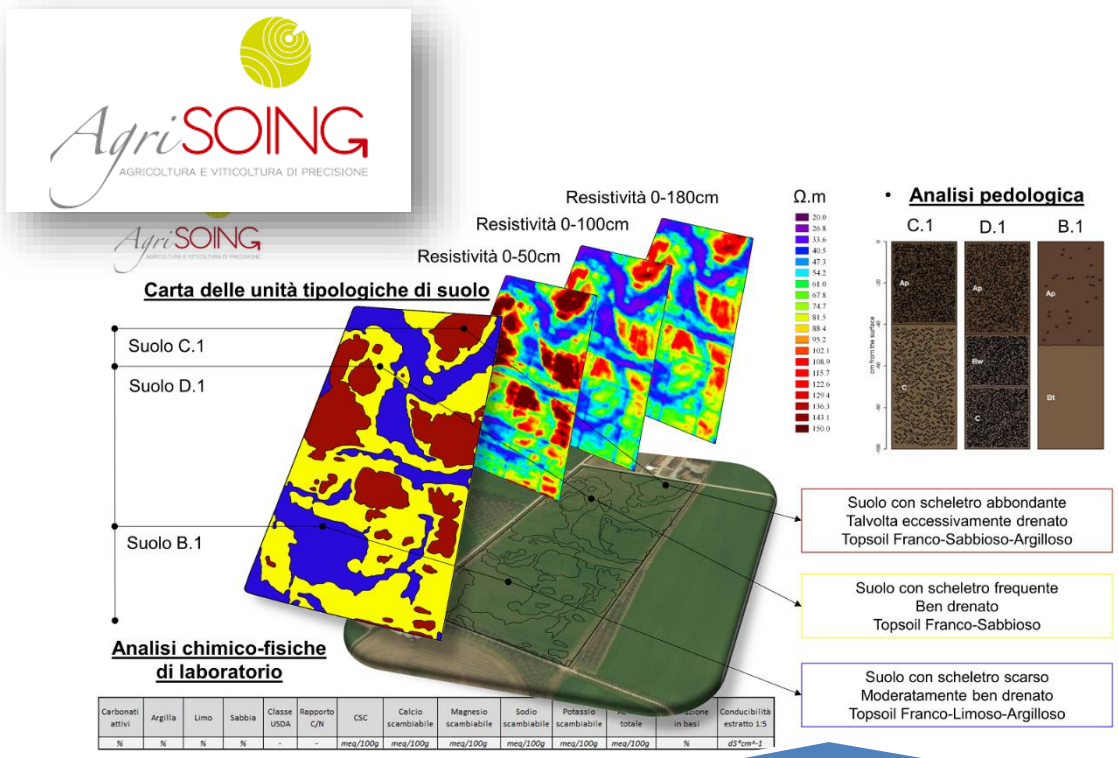

Satellite imaging and machines connectivity

TARANIS




Computer vision and deep learning for disease monitoring

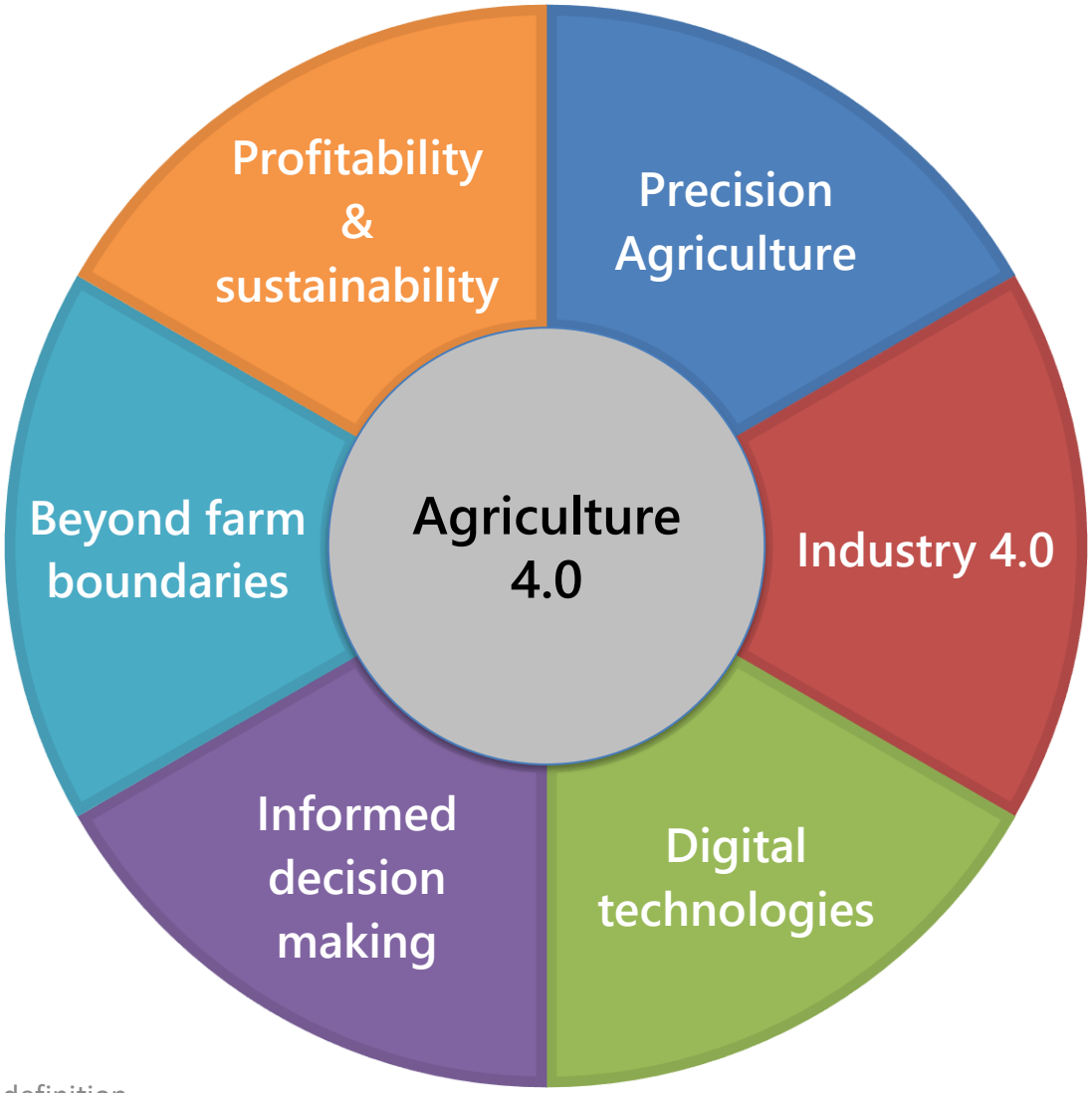
# Agriculture as a Service (some examples)




Soil characterization service

Multi-sensor images combined with agronomic models

# Multiple Facets of Agriculture 4.0

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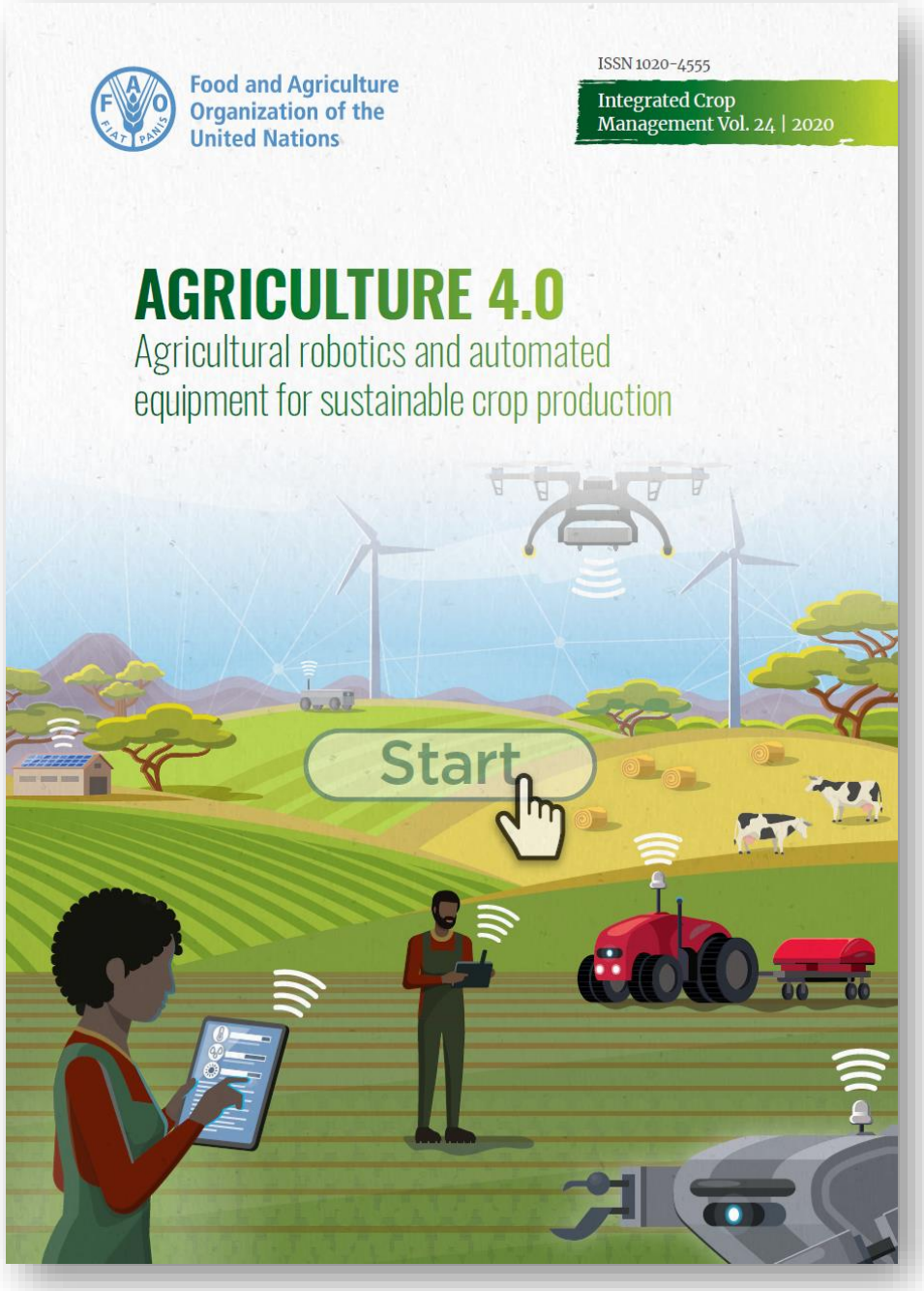
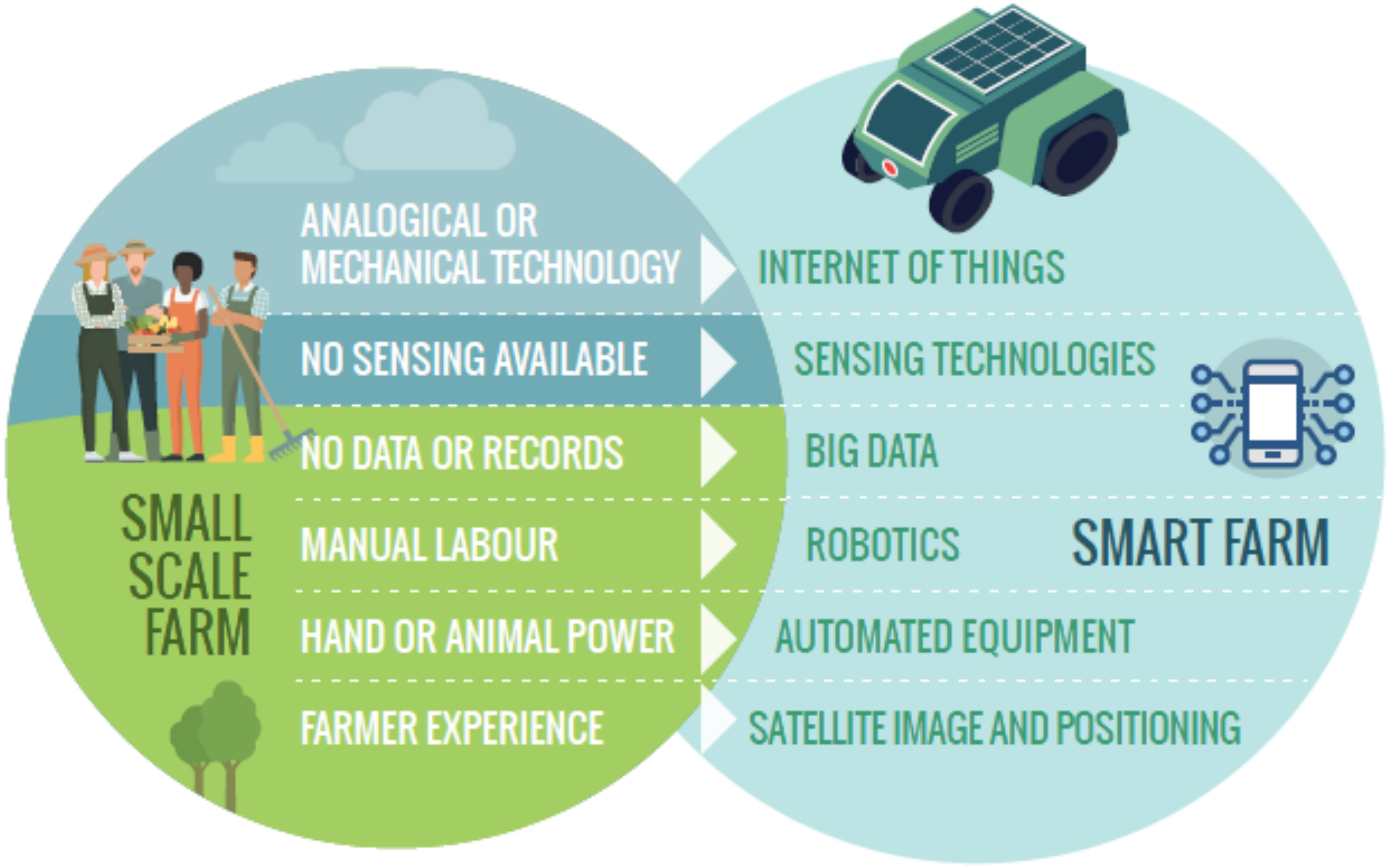
# Agriculture 4.0 (FAO)

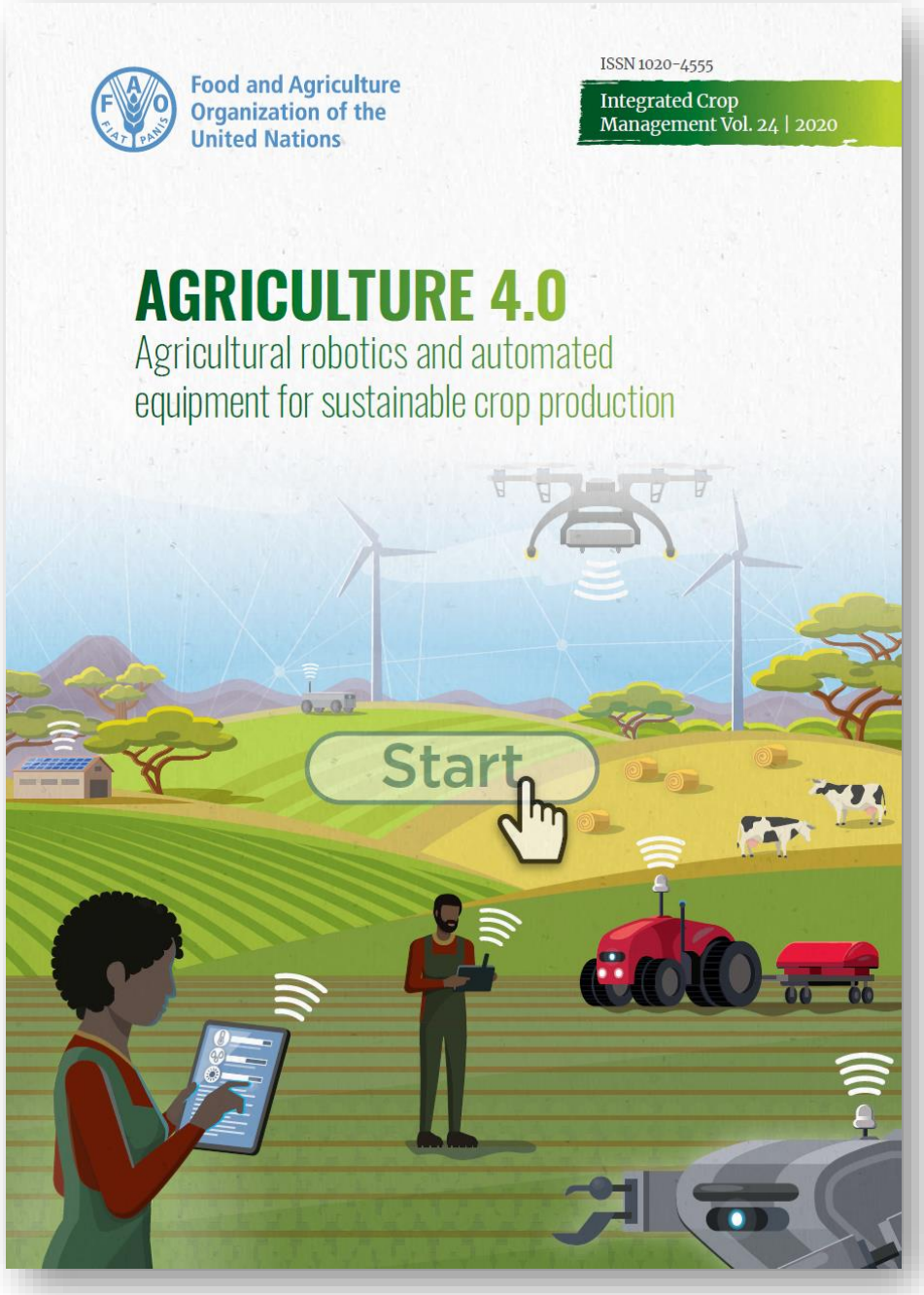
**Figure 12. Sustainable Development Goals to which agricultural robotics can contribute**




*"Agriculture 4.0 – Agricultural robotics and automated equipment for sustainable crop production"* published by FAO in 2020

# Agriculture 4.0 (FAO)

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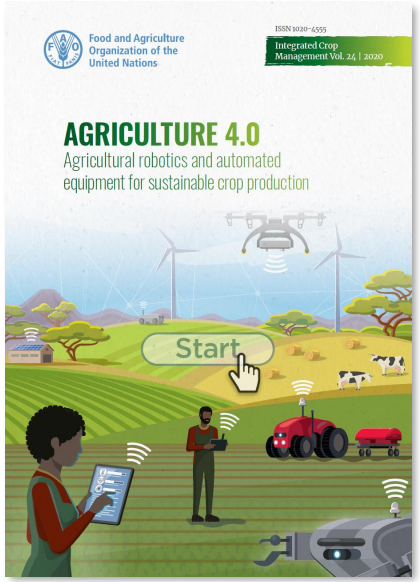
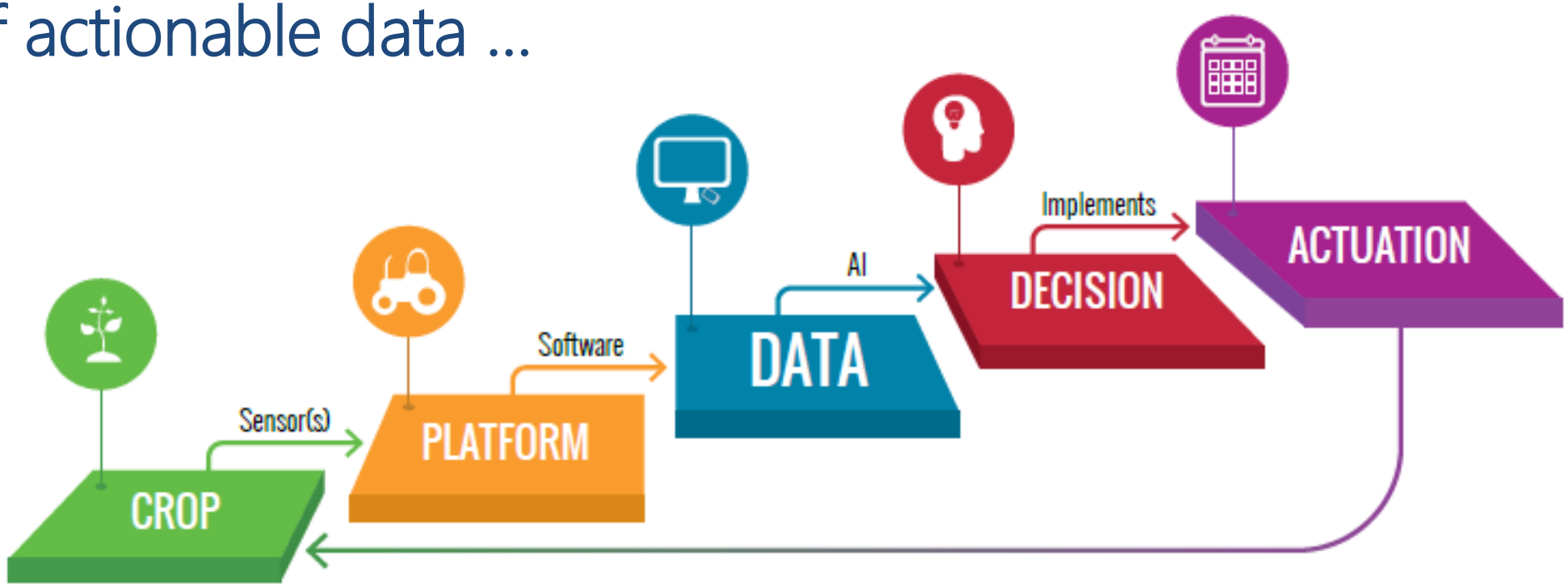
# The value of actionable data …



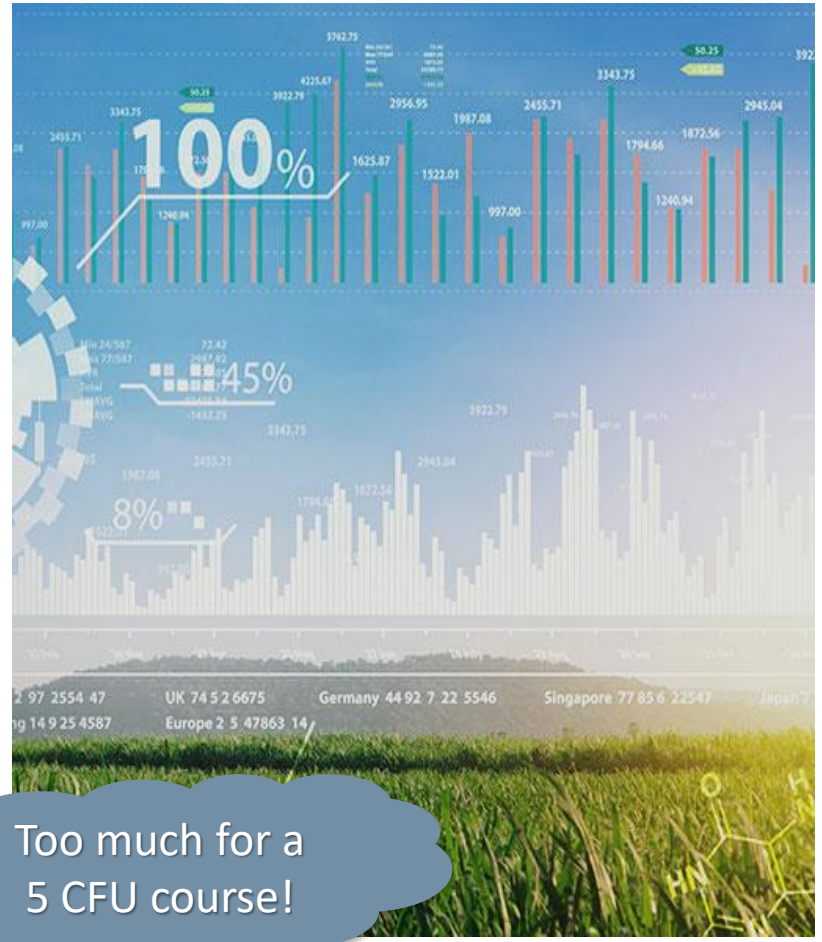



*days* *minutes*

# Challenges Ahead: Big Data

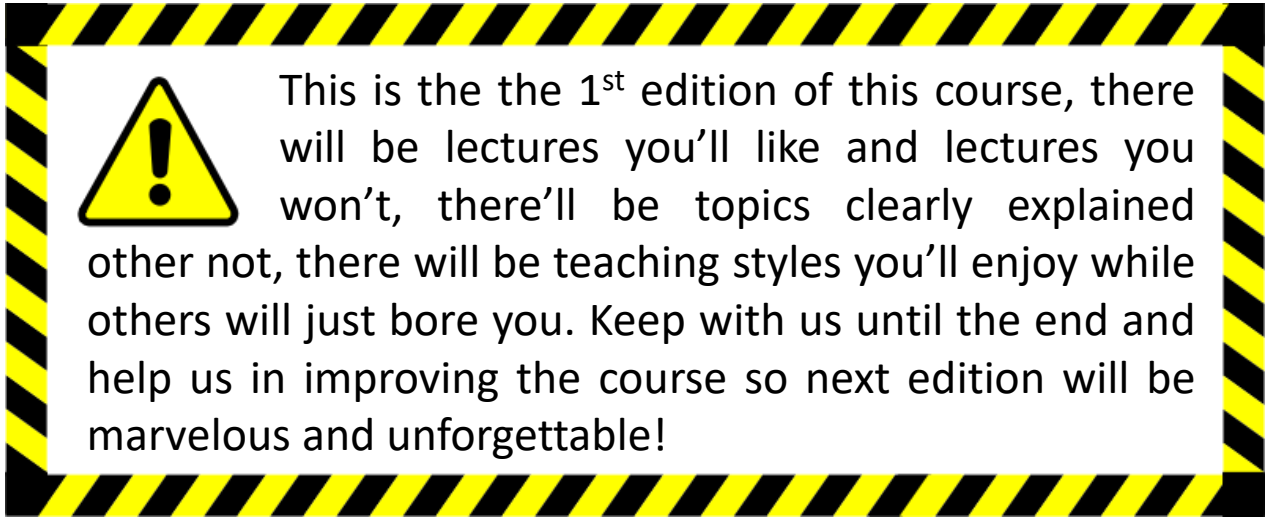
How to effectively exploit the huge amount of data collected by such an amount of sensors

- Analysis method should be developed
- Agronomic models should be studied to understand the benefits of their adoption
- Prediction and simulation models (e.g., yield and demand estimation) to be investigated
- Need of high-throughput screening methods that offers precise and accurate data
- Need of studies to evaluate the impact of Big Data and Agriculture 4.0



# Course Objectives

*"Approach the Agriculture 4.0* ***data value chain****,*
*from the means to acquire data to the techniques for data processing,*
*presenting how data can be turned into an actionable source of*
*information which can impact the* ***agri-food value chain****."*



# Course syllabus

Lecture on data value chain in agriculture (Prof. Renga)

- Agri-food value chain
- Data Strategy
- Impact evaluation

**~10h lectures**

Data sources and data processing (Prof. Matteucci)

- Data sources and data representation
- Regression and Classification
- Time Series and Spatial Data analysis

**~12h lectures**

Practicals on agricultural data analytics (Eng. Bertoglio)

- Python and the Pandas library
- Scikit-learn, statsmodels, and …

**~12h practicals**

*Add > 26h on Use Cases (practical project)*

# Course Evaluation (Tentative)

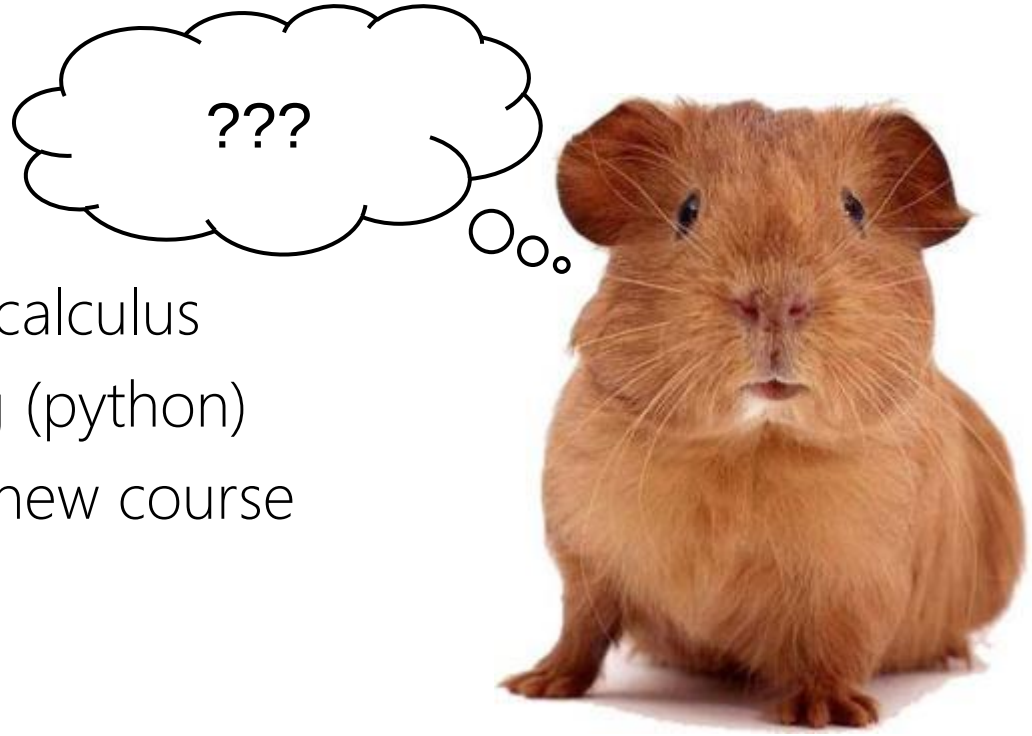
Grading is based on a practical data analysis project in the agrifood domain which covers all aspects of the course (November to January):

- Use cases presentation (November)
- Data Sources (November)
- Processing (November)
- Processing / Impact (December)
- Impact (December)
- Project presentations (January)

*2h projects revisions with teachers and teaching assistant*

Can bring / search you own data too (e.g., Kaggle, Our World Data, etc.)

# The Students




Students are expected to:

- Feel confortable with basic statistics and calculus
- Feel confortable with basic programming (python)
- Be ready to act as «guinea pigs» for this new course
- Be curious and willing to learn …

Students are not expected to:

- Know more than what is usually tought in basic engineerig courses
- Know already about machine learning
- Be hyper-skilled python hackers
- …

# Lectures Schedule and Timings

Classes (there is no distinction between lecture and exercises):

- Monday, 16:15 – 18:15, in 25.1.1 (starts at 16:30 end by 18:00)
- Friday, 14:15 – 16:15, in 25.1.2 (starts at 14:30 end by 16:00)

A detailed schedule will be provided

Check the teacher who will be in class on the detailed schedule

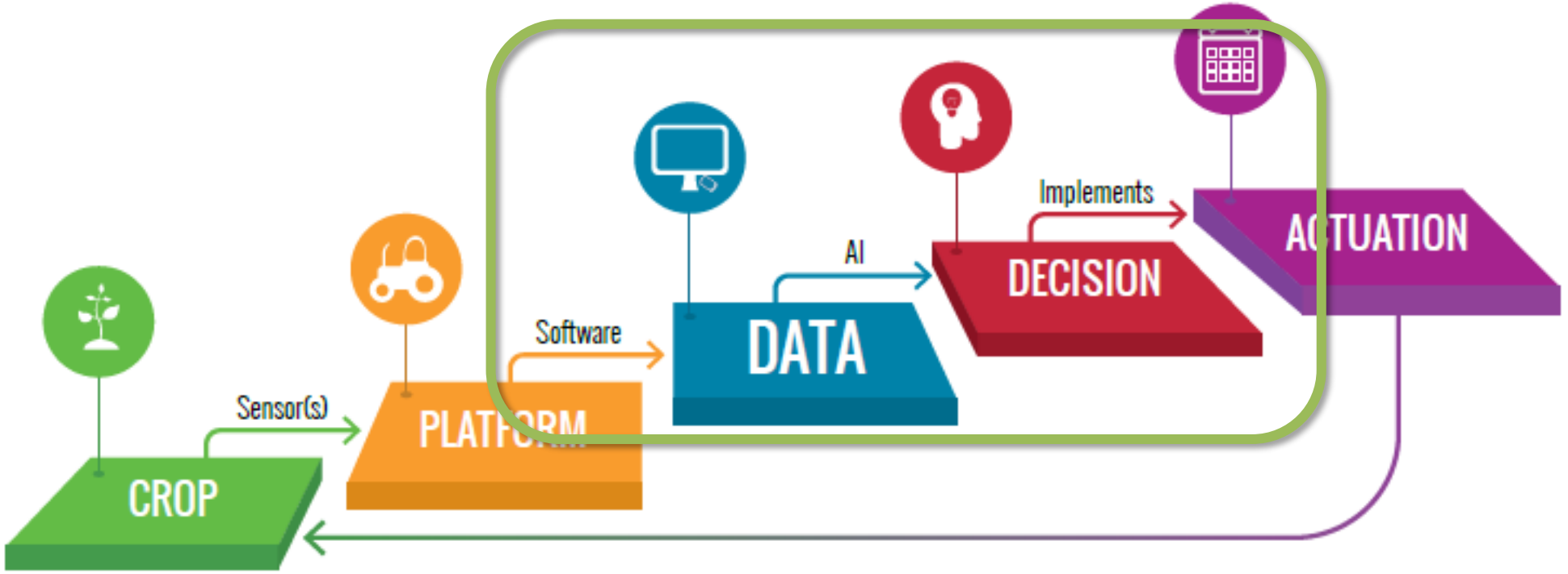
- Classes are in presence, but lectures will be recorded
- Connect to proper teacher webex room in case you need to attend remotely
- Use your POLIMI credentials, we will not admit external students
- Interaction is prioritized for in presence room students

# Ironing out the kinks …

Some details have not been sorted out yet, we are working on that …

- WeBeep Management
  - Registered students (?)
  - Detailed schedule of lectures (?)
    - On Friday 16/09 Prof Renga on Value Chain
    - On Monday 19/09 Prof Renga on Value Chains
    - …
- Projects:
  - How many people per group (?)
  - Which are the use cases (?)
  - How to handle remote revisions (?)
- Practicals format

# … let's build this together.




*Thanks for your attention!*