Agricultural and AgriFood Supply Chain

Data Analytics for Smart Agriculture
Filippo Renga

Agriculture: articulated and relevant sector

Farms in EU*
- **10,5 millions**
- **434.3 billions € of production**

EU world leader in agri-food trade*
- **38 billions € of exports**
- **965 billions € of revenue**
- about **310,000 companies**

EU world leader in the trade **of agricultural machinery:****
- about **60% of world exports**
- more than **7,000 companies**

In the EU, agriculture and related food companies employ **44 million workers***

+ 104%: average annual growth of Agriculture 4.0 in Italy in the period 2017-2020***

*Eurostat, European Commission, 20118 e 2019   ***EU Agricultural Machinery Industry Association, 2019*   ****Osservatorio Smart Agrifood, 2021*

Agriculture: a sector facing important challenges
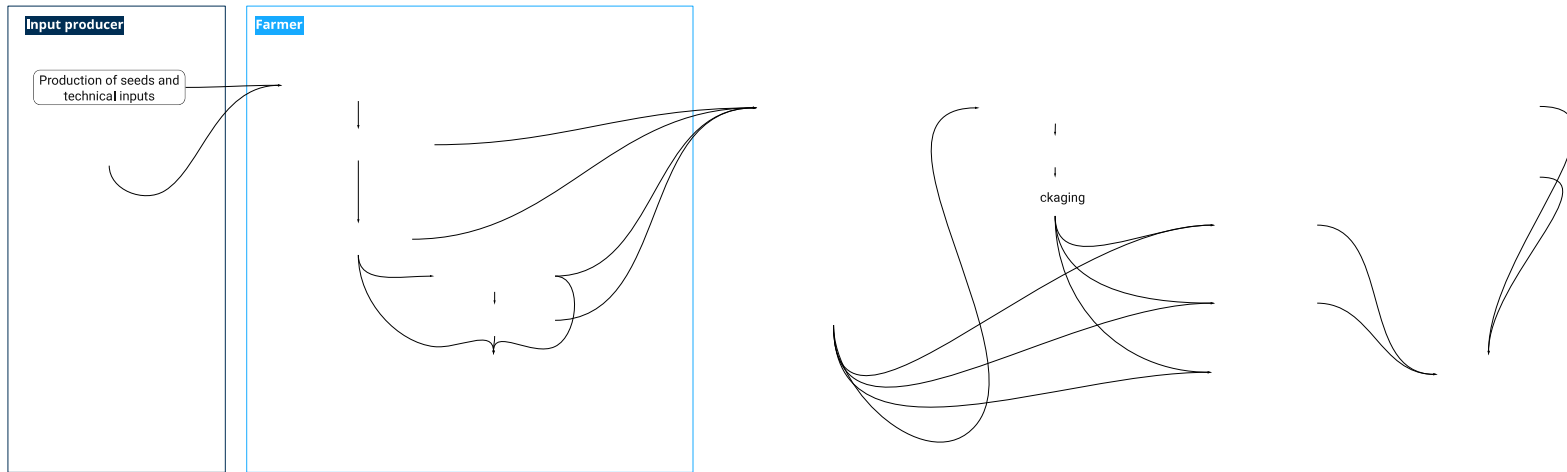
Innovation

Sustainability

Integration

What's Agriculture?

Agriculture is a supply chain

Input producer

Production of seeds and technical inputs

Farmer

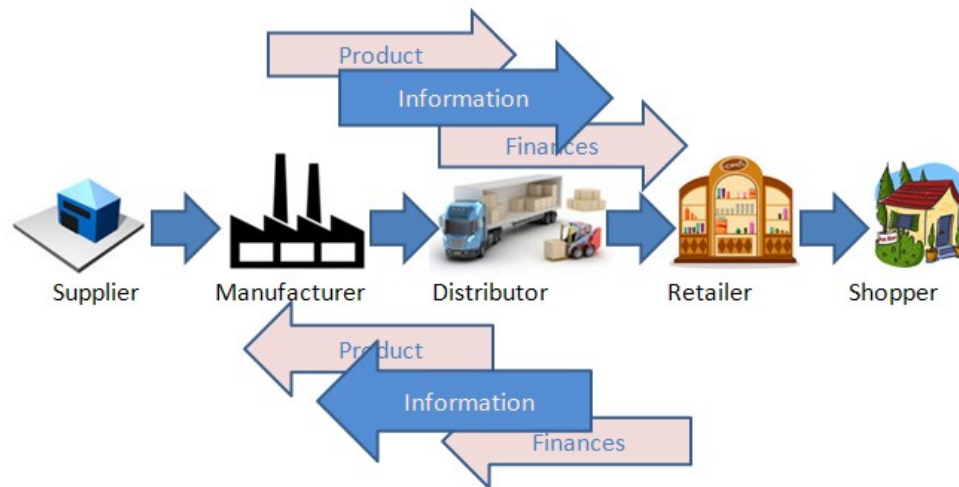ckaging

What is a supply chain?

Network of companies that **interact** to transform raw materials into finished products and services and deliver them to **final customer**
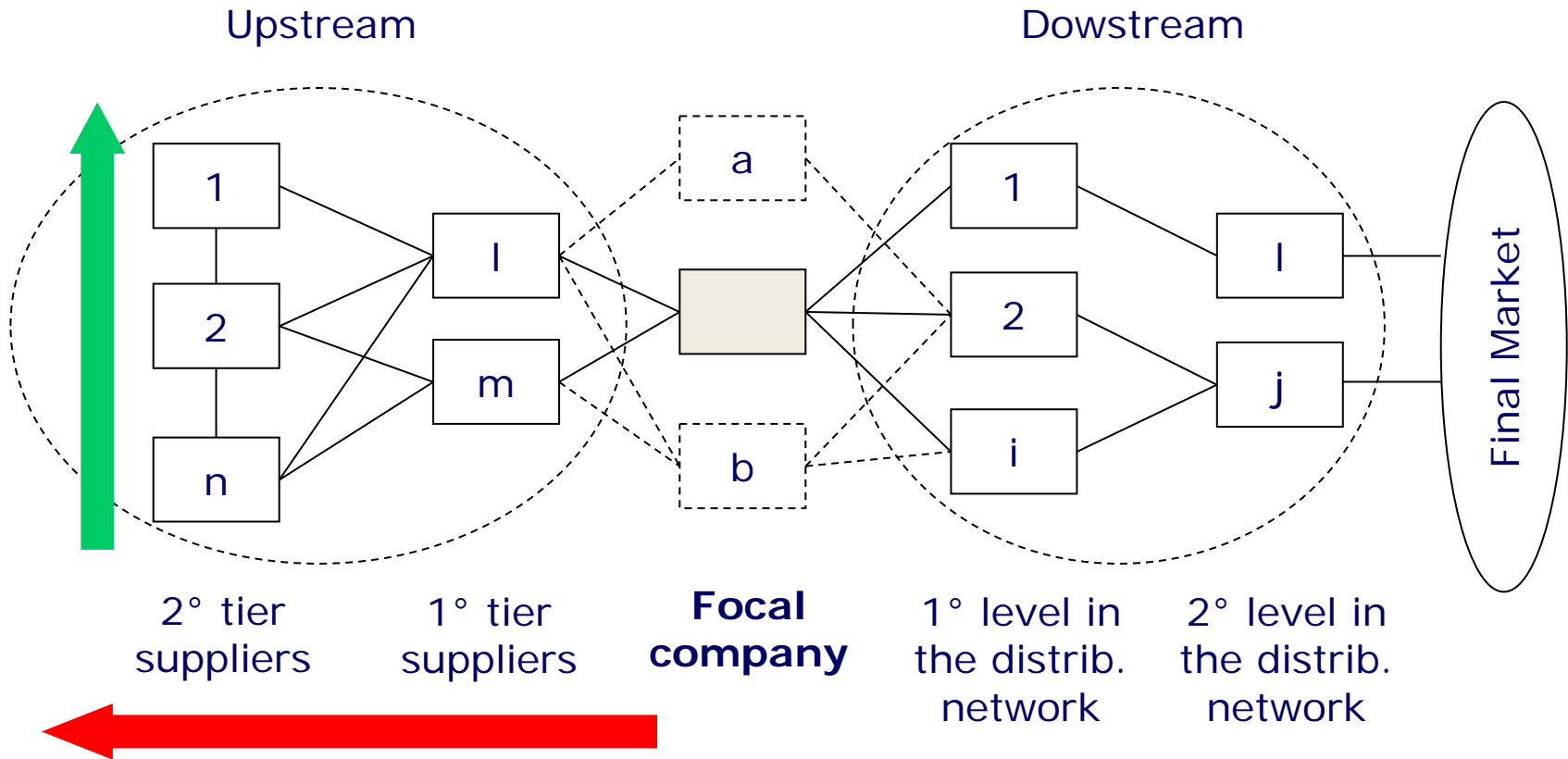
Includes movement of products from suppliers to manufacturers to distributors, but also includes movement of <u>information</u>, <u>funds</u>, and <u>products</u> in both directions

All stages may not be present in all supply chains
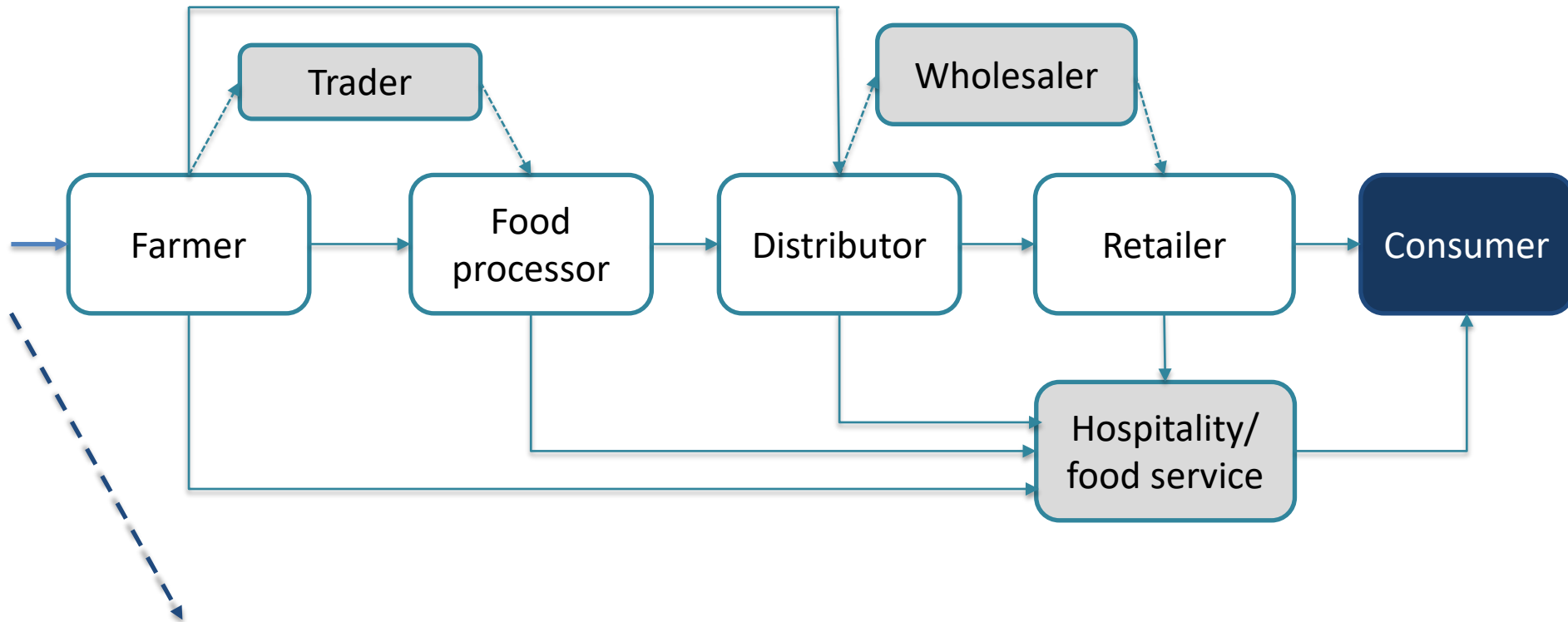(e.g., no retailer or distributor for e-commerce channel)

Supply chains and supply networks

Horizontal view of a supply chain

Upstream

Dowstream

```
    1                            a                    1
                                                              l
    2        l                                        2                Final Market
             m                                                  j
    n                            b                    i
```

2° tier
suppliers

1° tier
suppliers

**Focal
company**

1° level in
the distrib.
network

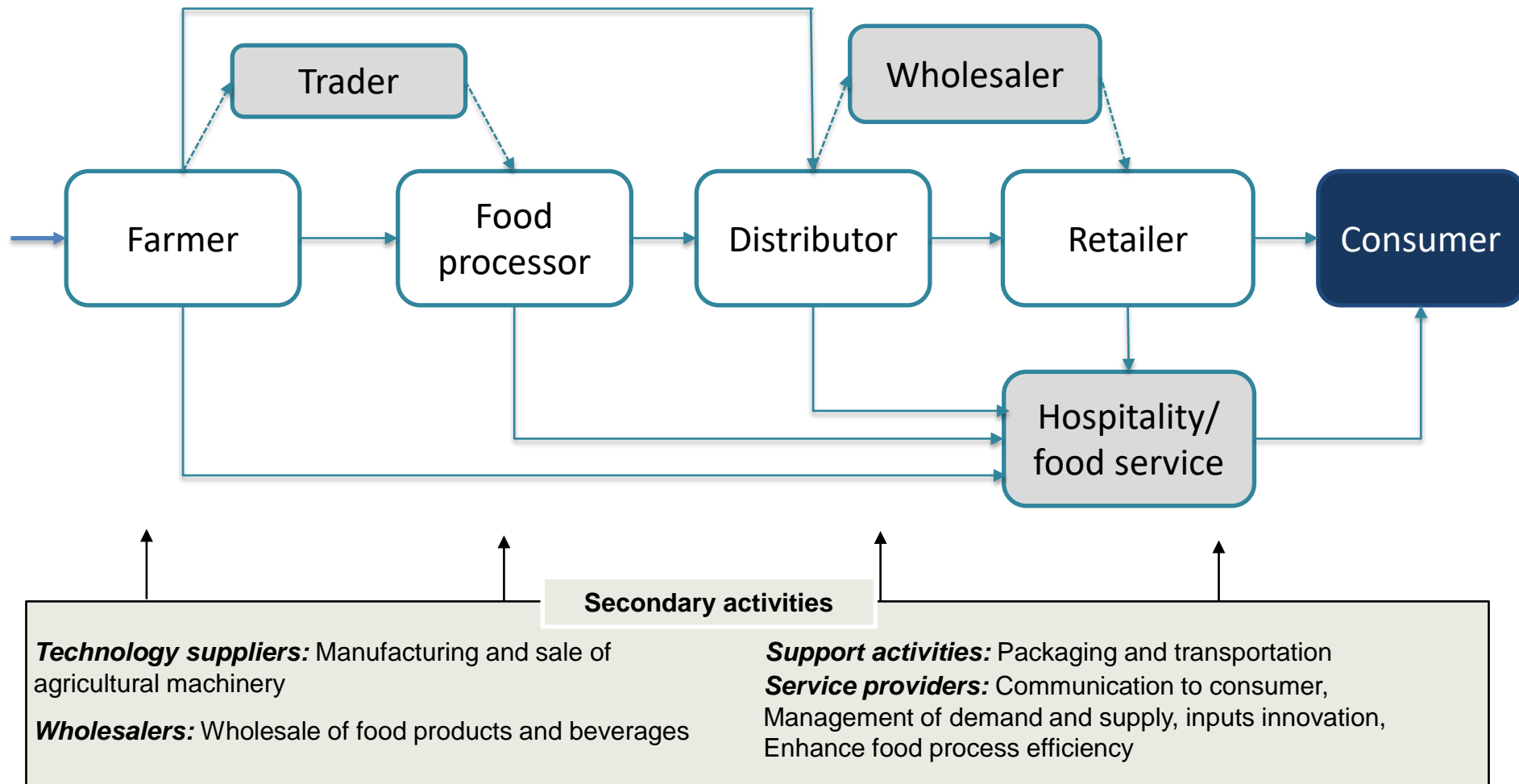2° level in
the distrib.
network

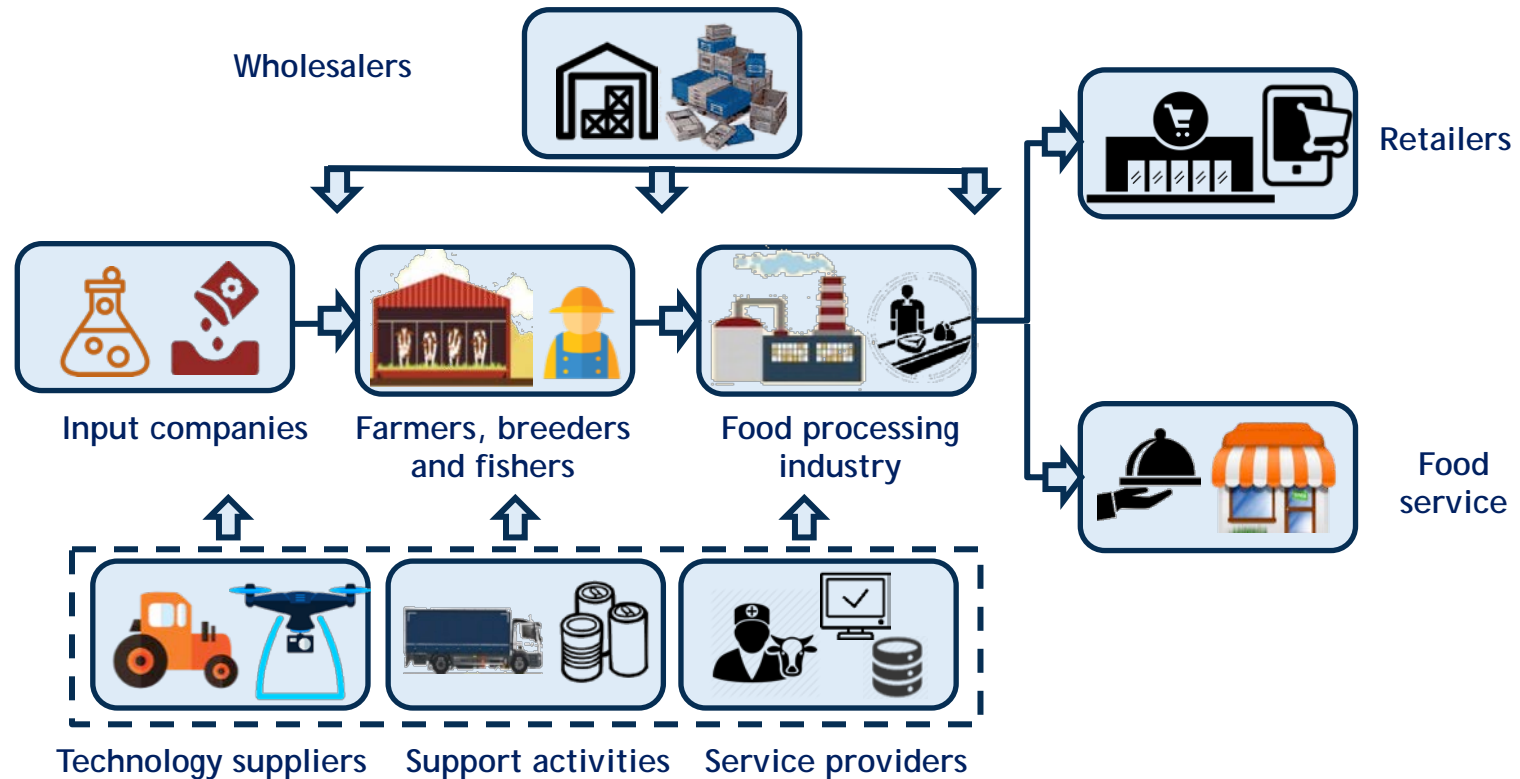**Vertical view of a supply chain**

Actors in the AgriFood supply chain

Input Companies: production of fertilizers, pesticides, agrochemical products, animal feeds

Actors in the agrifood supply chain

Secondary activities

Technology suppliers: Manufacturing and sale of agricultural machinery

Wholesalers: Wholesale of food products and beverages

Support activities: Packaging and transportation
Service providers: Communication to consumer, Management of demand and supply, inputs innovation, Enhance food process efficiency

Actors in the agrifood supply chain

Agriculture is a supply chain
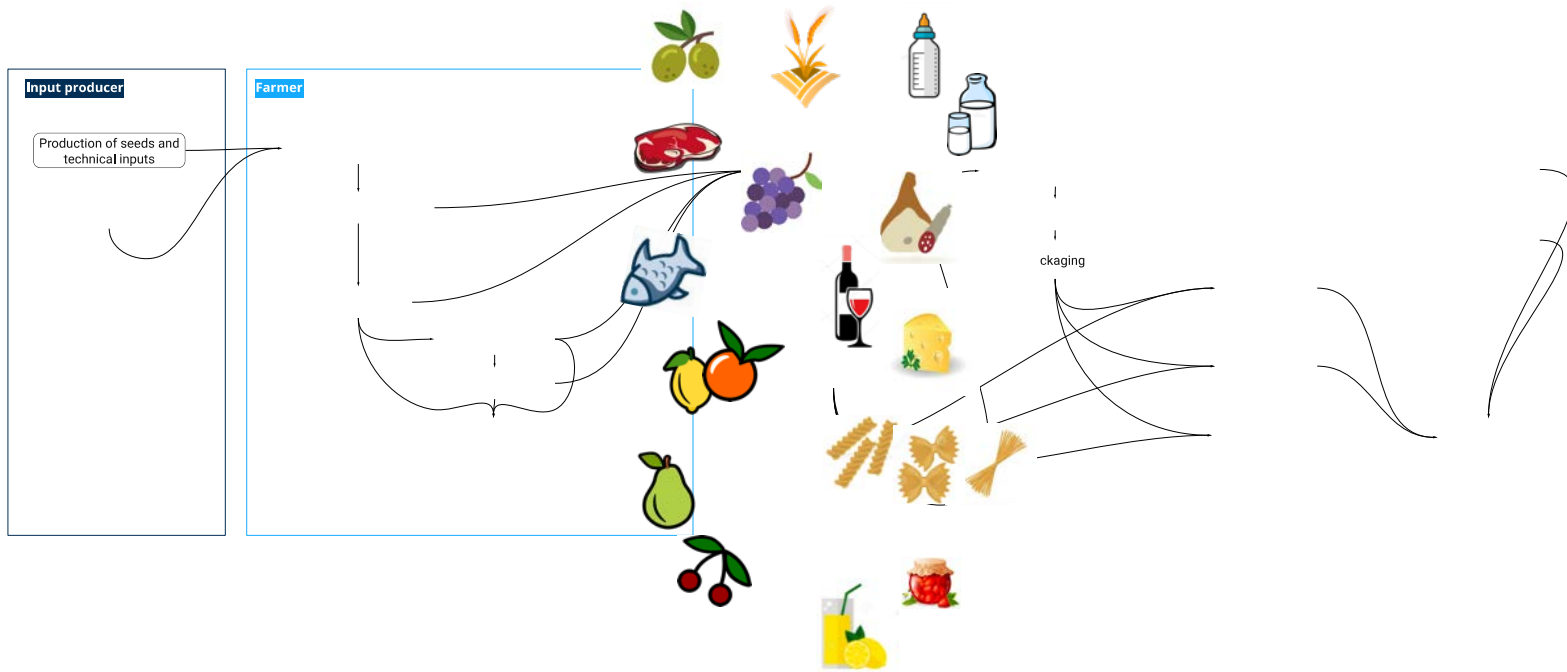
Input producer

Production of seeds and technical inputs

Farmer

ckaging

Agriculture and AgriFood SC - Filippo Renga

POLITECNICO MILANO 1863
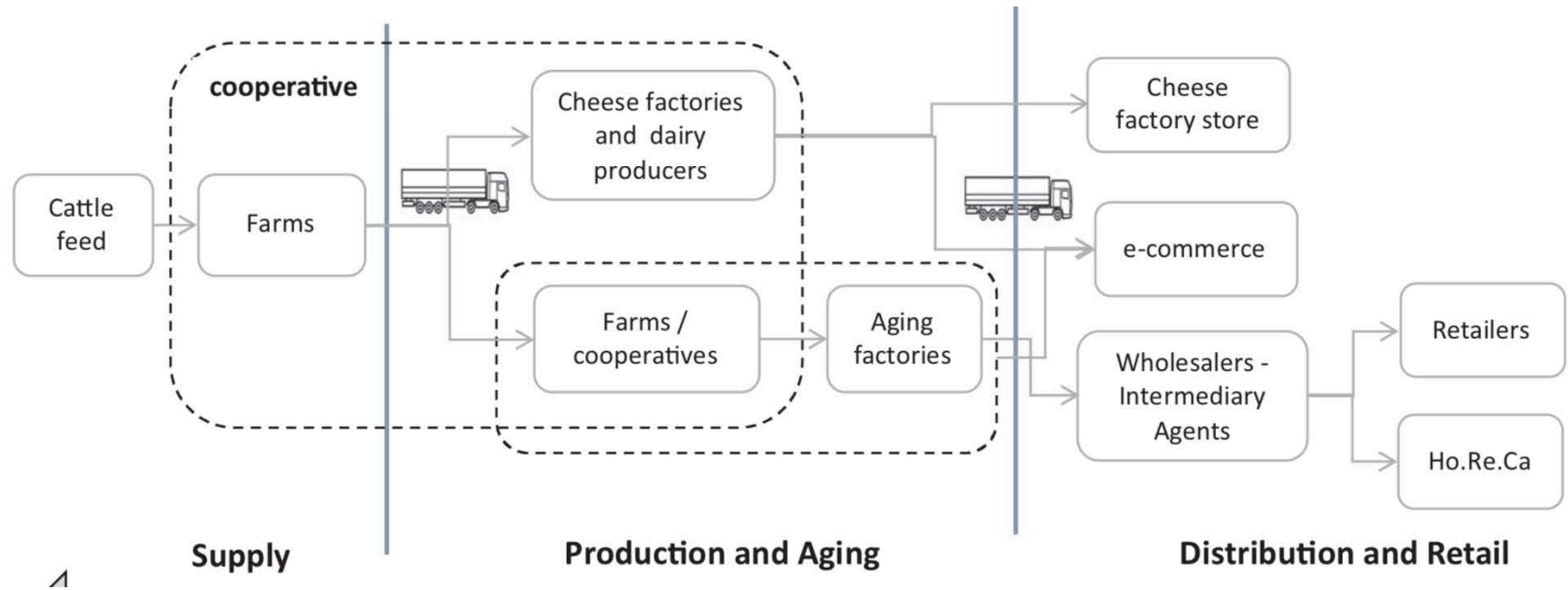
Case: Grana Padano

What's Agriculture 4.0 ?

Introduction and Research Question

Precision Farming

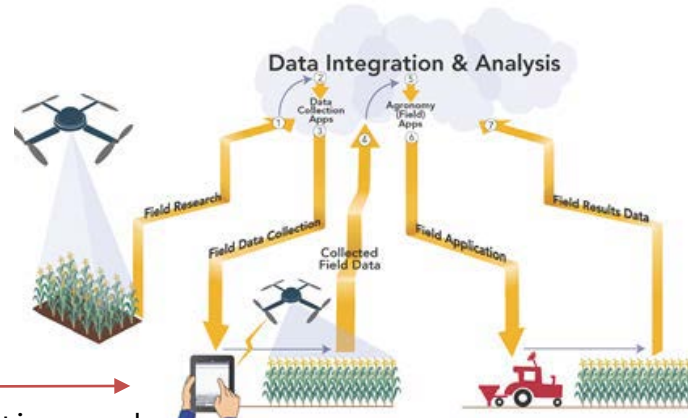*(Yao et al., 2012; Nishina, 2015; Bilali et al., 2018; Fresco et al., 2018)*

Mid-1990s

Cloud, IoT, Robotics and Big Data Analytics

Agriculture 4.0

(Sonka, 2014; Wolfert et al., 2017; Braun et al., 2018; Zambon et al., 2019)
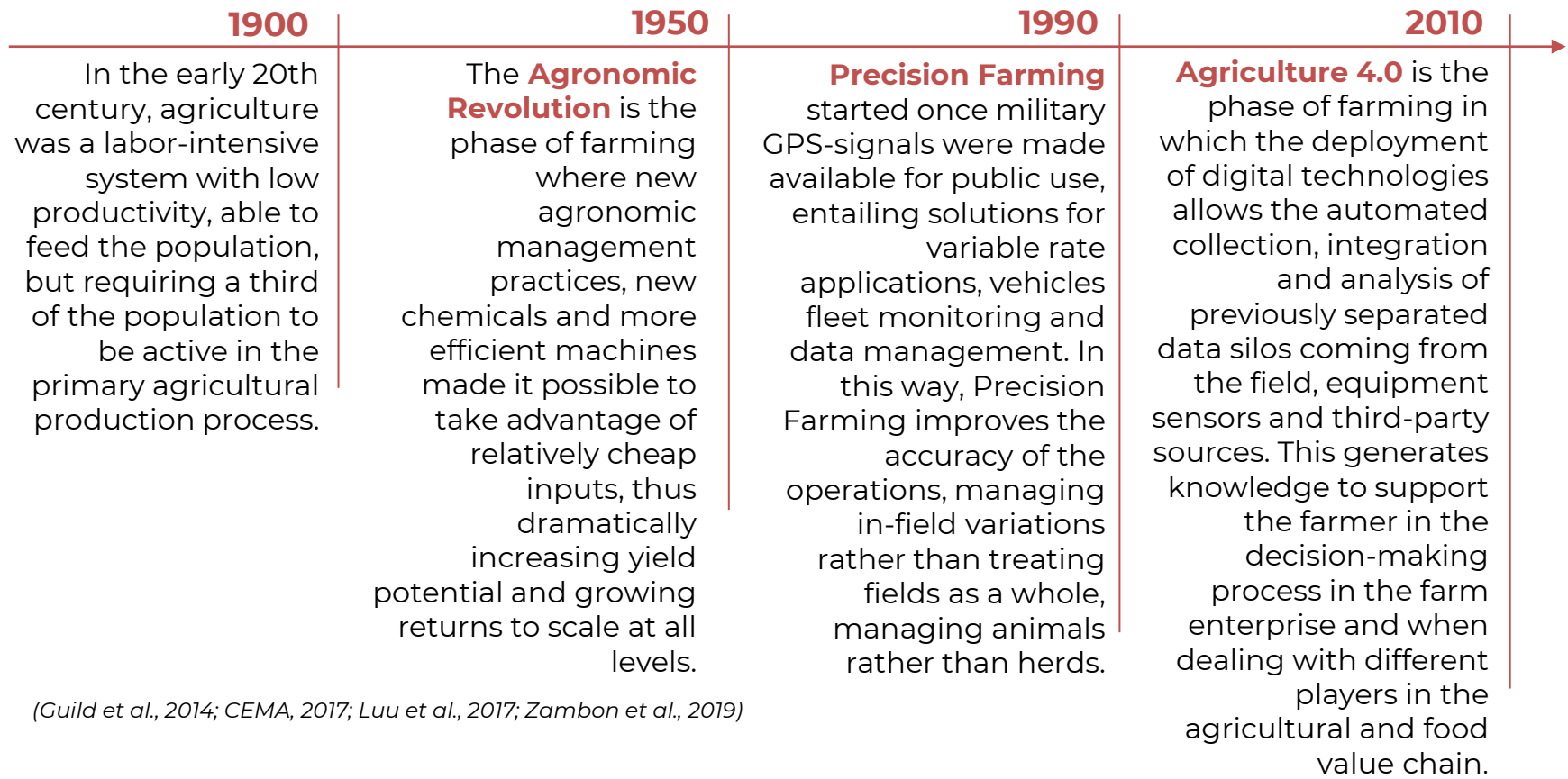
Early 2010s

The global population is expected to reach 9,1 billion of people in 2050.

(FAO, 2009; Drucker, 2014; Lesser, 2014; Carolan, 2017)
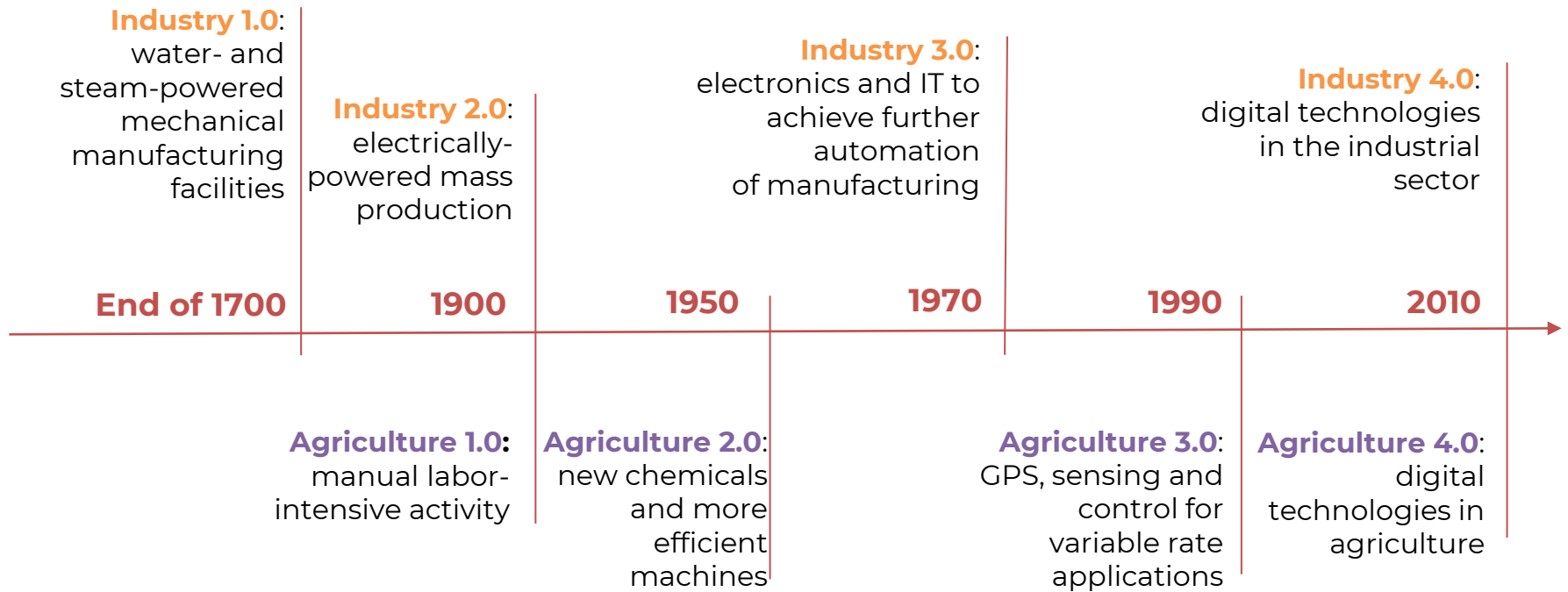
Historical phases in agriculture
Timeline

1900	1950	1990	2010
In the early 20th century, agriculture was a labor-intensive system with low productivity, able to feed the population, but requiring a third of the population to be active in the primary agricultural production process.	The **Agronomic Revolution** is the phase of farming where new agronomic management practices, new chemicals and more efficient machines made it possible to take advantage of relatively cheap inputs, thus dramatically increasing yield potential and growing returns to scale at all levels.	**Precision Farming** started once military GPS-signals were made available for public use, entailing solutions for variable rate applications, vehicles fleet monitoring and data management. In this way, Precision Farming improves the accuracy of the operations, managing in-field variations rather than treating fields as a whole, managing animals rather than herds.	**Agriculture 4.0** is the phase of farming in which the deployment of digital technologies allows the automated collection, integration and analysis of previously separated data silos coming from the field, equipment sensors and third-party sources. This generates knowledge to support the farmer in the decision-making process in the farm enterprise and when dealing with different players in the agricultural and food value chain.

(Guild et al., 2014; CEMA, 2017; Luu et al., 2017; Zambon et al., 2019)

Agriculture 4.0 vs Industry 4.0
Timeline

Industry 1.0: water- and steam-powered mechanical manufacturing facilities

Industry 2.0: electrically-powered mass production

Industry 3.0: electronics and IT to achieve further automation of manufacturing

Industry 4.0: digital technologies in the industrial sector

End of 1700   **1900**   **1950**   **1970**   **1990**   **2010**

Agriculture 1.0: manual labor-intensive activity

Agriculture 2.0: new chemicals and more efficient machines

Agriculture 3.0: GPS, sensing and control for variable rate applications

Agriculture 4.0: digital technologies in agriculture

(Guild et al., 2014; CEMA, 2017; Luu et al., 2017; Zambon et al., 2019)

Agriculture 4.0: literature review
Definition

A comprehensive framework for
Agriculture 4.0

Sponchioni, Vezzoni, Bacchetti, Pavesi, Renga, 2019

Agriculture 4.0: Solutions
Main categories

- **Mapping (fields and cultivations)**

- **Monitoring and control:**
  - fields, cultivations
  - Livestock
  - agricultural equipment & farm's infrastructures
  - indoor farming

- **Variable Rate Distribution Systems**

- **Satellite guide**

- **Precision irrigation**

- **Drones for in field treatments**

- **Robots**

- **Decision support systems**

- **Farm Management Information System (FMIS)**

- **…**

Mapping

Data survey from satellites, drones or other instruments, like sensors installed on agricultural machinery, to produce maps that can represent:

- soils conditions and health;
- cultivations conditions;
- advices on the quantity of inputs to be used or on the treatments to be done.

Some examples of the outputs obtained are maps that can state the water needs of plants, the health of plants and the Leaf Area Index or the composition of soils and their nutritional needs.
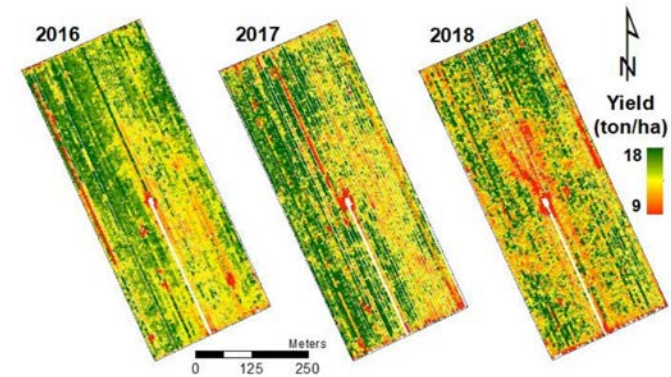
Monitoring and control (fields, cultivations, livestock, …)

Hardware elements (sensors, actuators, gps, cameras, …) applied to agricultural equipments which are able to gather data on the functioning of the machine and on the activities done in order to monitor and control the machinery and/or the activity.

Data can refer to the quantity of fertilizers or agrochemicals used, fuel consumption and the time spent by the machine to perform the activity or the amount of product collected which in turn is used to devise production maps.

Variable Rate Distribution Systems
Set of technologies that enable the automatic distribution of technical inputs in a field according to specific prescriptions.

For instance, fertilizer application based on the nutritional needs shown in prescription maps, or sowing according to the composition of different parcels of soil.

Satellite guide
Native or added instruments to agricultural machineries that enable automatic or assisted guide owing to data gathered from satellites.

Precision irrigation
Set of technologies that enable the automatic distribution of water based on specific prescriptions coming from a decision support system or from prescription maps.

For instance, open field irrigation plants where water is redistributed through actuators that open or close according to prescription maps.

Drones

Use of drones to do agricultural treatments on the fields.

For instance to put down eggs to contrast a corn's parasite. The legislation on the use of drones for agricultural treatments vary from country to country, for instance in Italy it is not possible to spray fertilizers or agrochemicals through drones.

Robots

Machine able to carry out, more or less independently, a task associated with an on field activity.

*For instance, collect strawberries, eradicate weeds or spray agrochemicals.*

Decision support systems

Software platforms to analyse public and private data in order to support farmers in their decision making processes.
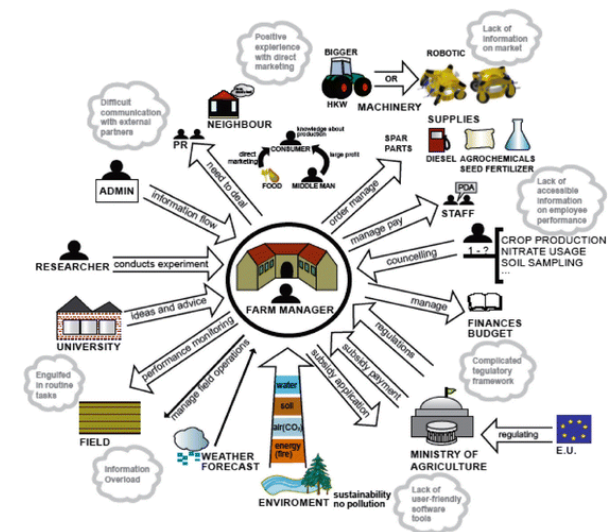
For instance, software to assess the water needs of cultivations or to advise on the right moment to carry out certain agricultural treatments.
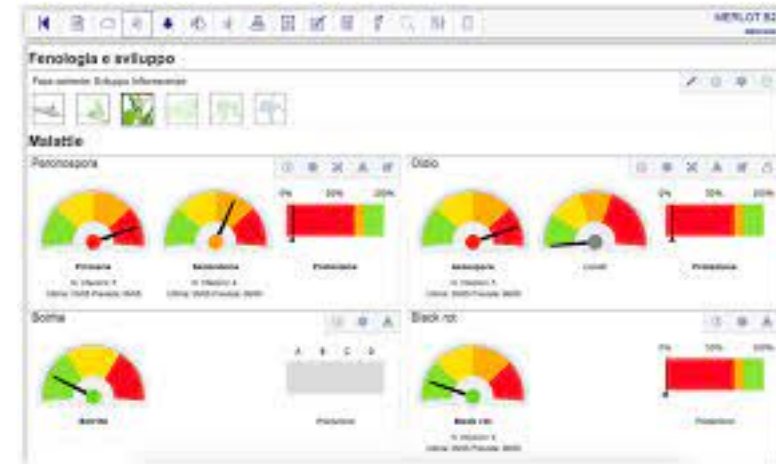
Farm Management Information System (FMIS)

An enabler, rather than an Agriculture 4.0 solution. Informative systems that support the farmer in carrying out its tasks, such as planning, accounting and reporting.
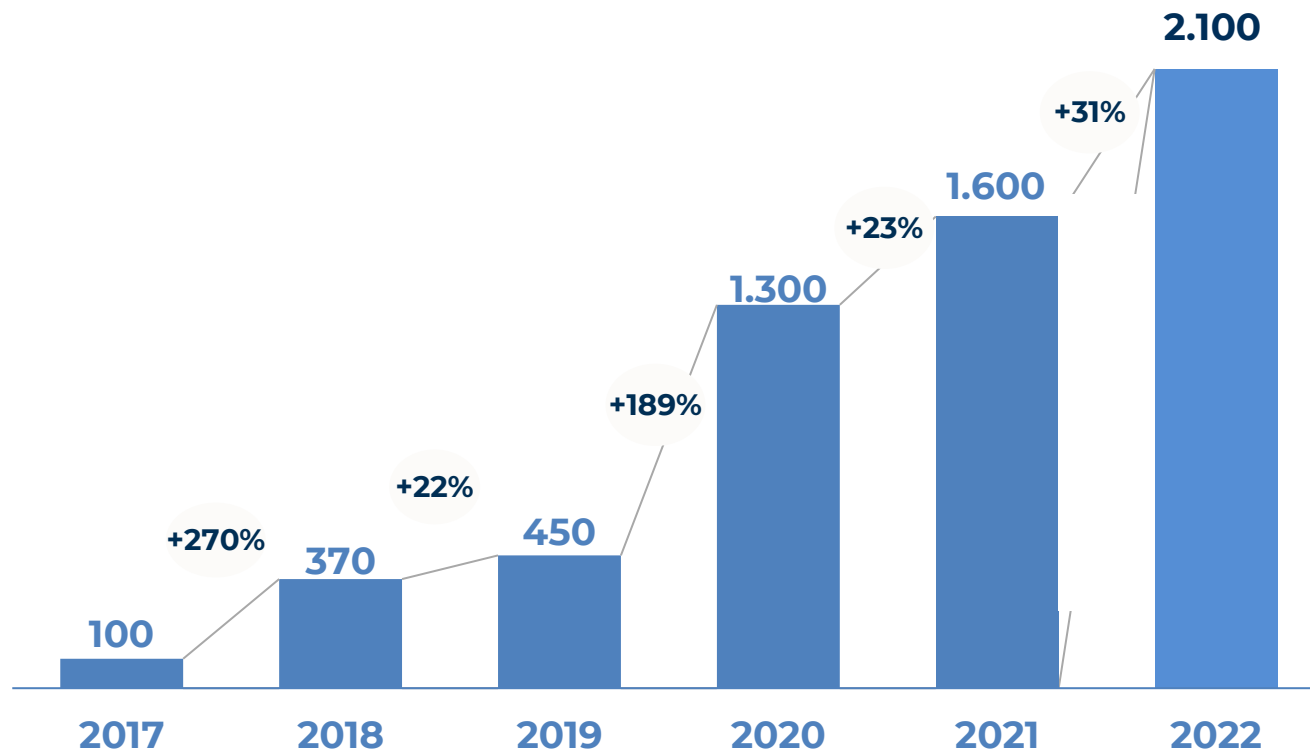
They might be used to manage the fleet, to gather all the data to comply with laws or to help with food traceability.

Where are we?

(... regarding Agri4.0 diffusion)

The market of Agriculture 4.0

Italian market value (millions of €)

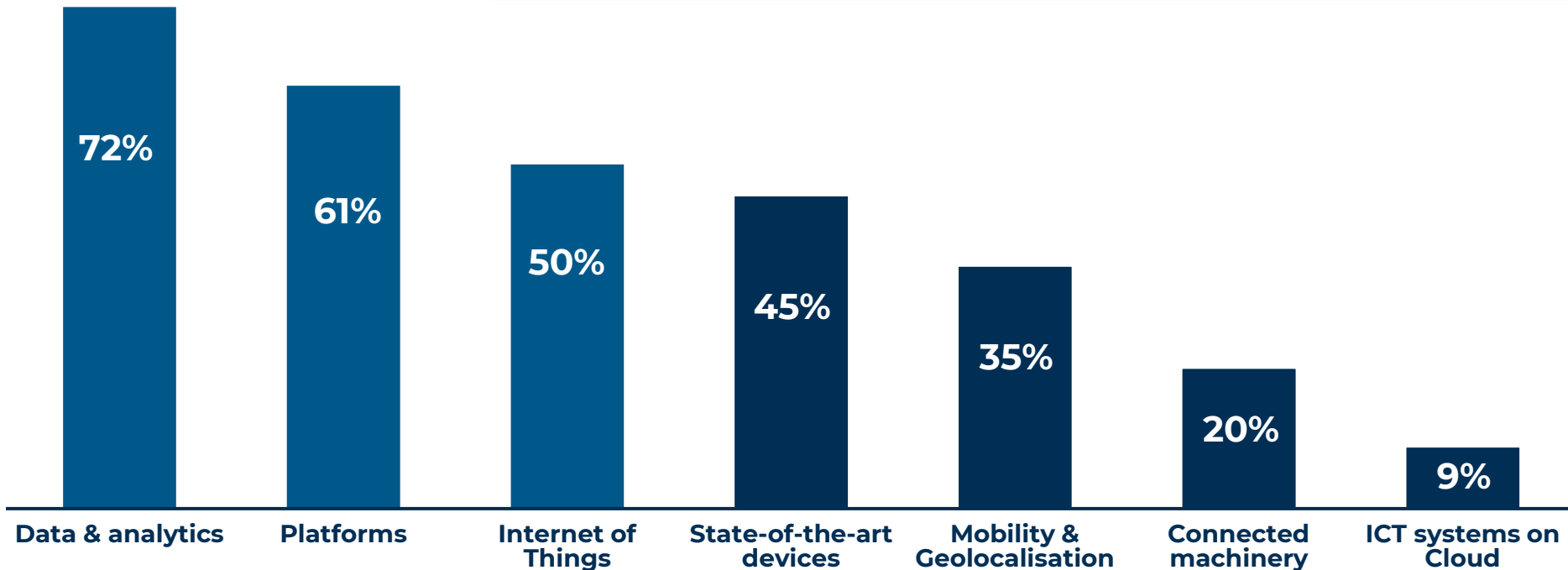| Year	Value	Growth
2017	100	
2018	370	+270%
2019	450	+22%
2020	1.300	+189%
2021	1.600	+23%
2022	2.100	+31%

Source: Osservatorio Smart Agrifood, 2023

Technology enablers of Agriculture 4.0 solutions

Data, and those technologies able to gather and analyse them, are the main enablers of Agriculture 4.0

Technology	Percentage
Data & analytics	72%
Platforms	61%
Internet of Things	50%
State-of-the-art devices	45%
Mobility & Geolocalisation	35%
Connected machinery	20%
ICT systems on Cloud	9%

Sample: 415 Agriculture 4.0 solutions. A solution might be based on more than one technology.

Why are you so important?
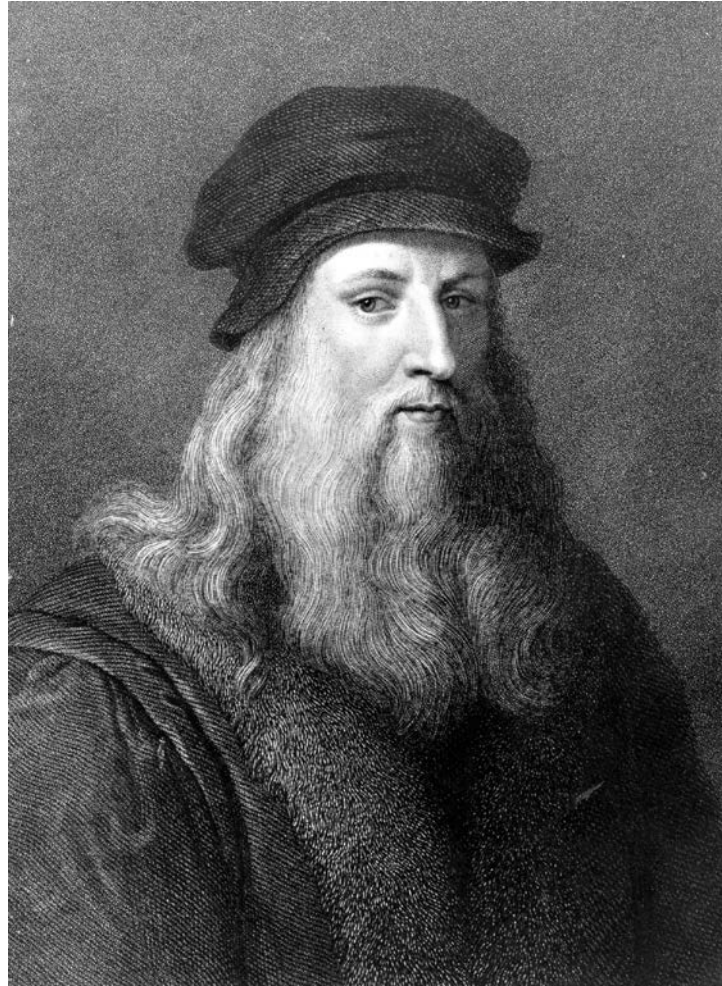
To measure
is to know.
If you can not
measure it,
you can not
improve it.

– Lord Kelvin

"You can't improve what you don't measure"

Who are you?

What are you looking for?