
POR CreO FESR Toscana 2014-2020
Asse 1 - Azioni 1.1.3 e 1.1.5
Bandi per aiuti agli investimenti in ricerca, sviluppo e innovazione
Decreto 30.07.2014 n. 3389 - Bando RSI 2 - Progetti di Ricerca e Sviluppo delle PMI

Progetto HT-HG «*High Tech - House Garden*»
La coltivazione in serra del futuro: l'*high tech* al servizio dell'ortoflorovivaismo toscano

www.serra-hthg.it

CONVEGNO DI CHIUSURA
Pescia, 7 novembre 2019
c/o Sala Convegni «Moreno Bambi» - CREA-OF, Via dei Fiori 8, 51017 Pescia ([redacted]

Digitalizzazione, Connettività ed Alta Tecnologia per l'agricoltura di Preciasione Sostenibile

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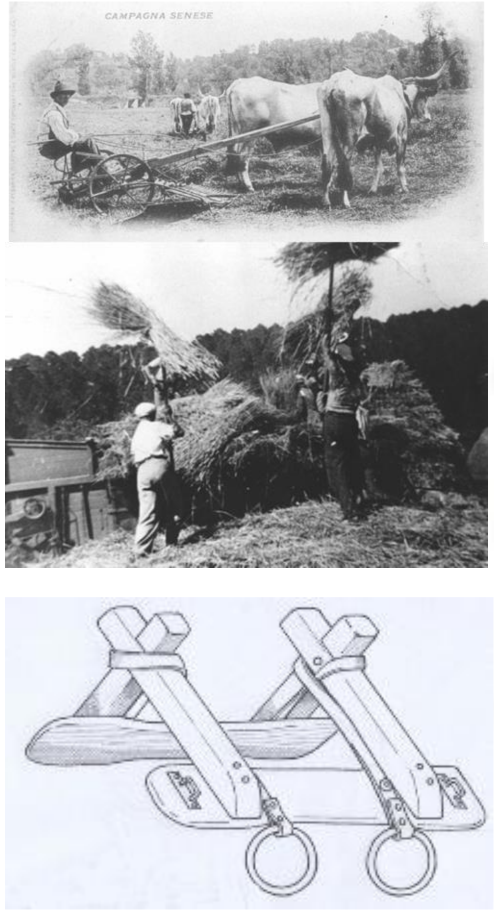
2.Human and Machinery speak digital

The new paradigm: from drawbar and manual labour, to digitalization & connectivity passing trough mechanical revolution



WHY SHOULD WE TALK ABOUT A SYSTEMIC APPROACH?

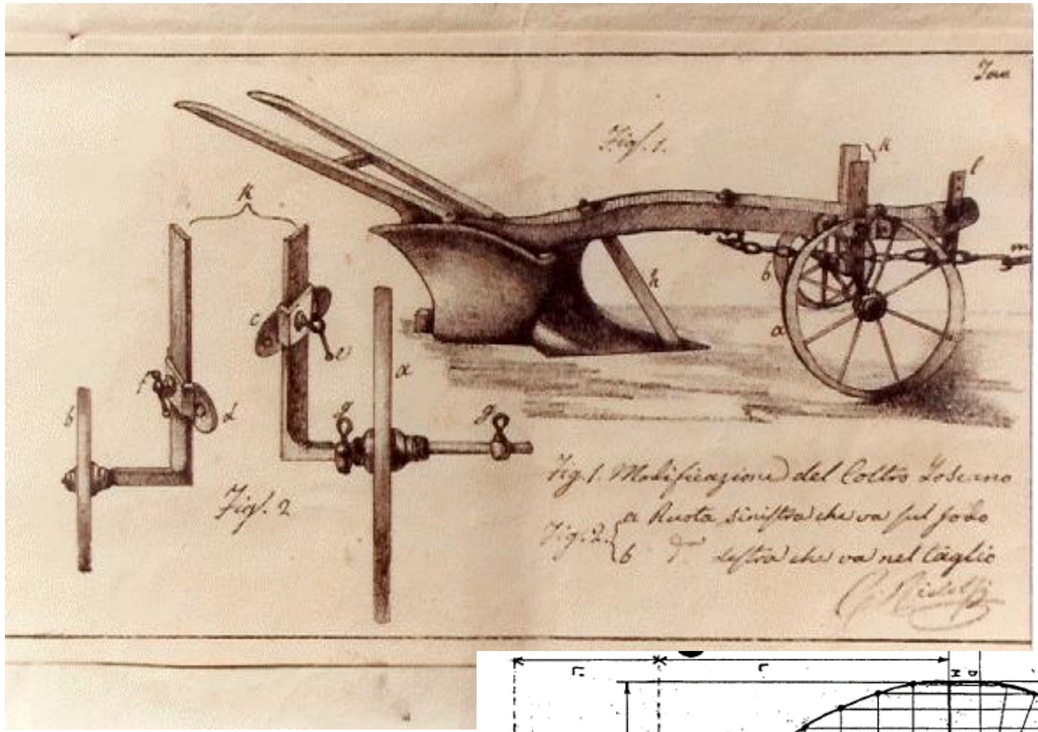
Because technological evolution will be profitable only with an inclusive social and sustainable evolution and giving the right importance to each actor of the chain, Keep in mind that from the start of last century on one hand we loss from 90% to 5% of agricultural employers (today). But mechanization in agriculture became effective only with the rising of services and infrastructures

Fig. 3– Technological jump, from manual labour to digitalization

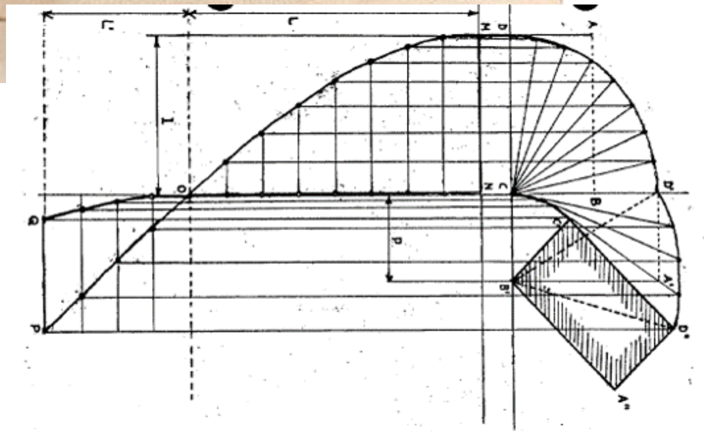
1. Technology evolution in agriculture in the Modern Era of XIX Century.

The evolution of agricultural practices has followed the whole history of humans' civilization that was no longer nomadic and gatherer.

The great changes in agriculture of the modern era since the mid-1700s are due to the development of advanced tools and complex mechanisms such as in Scotland the Patrick Bell's reaper (1828) or in Italy the plough overturning from Lambruschini and Ridolfi (1823) and the first endothermic engine (Barsanti and Matteucci, 1853)



The modern plow , Abbot Raffaello Lambruschini, Marquis Cosimo Ridolfi (1823)



1. Technology evolution in agriculture in the Modern Era of XIX Century.

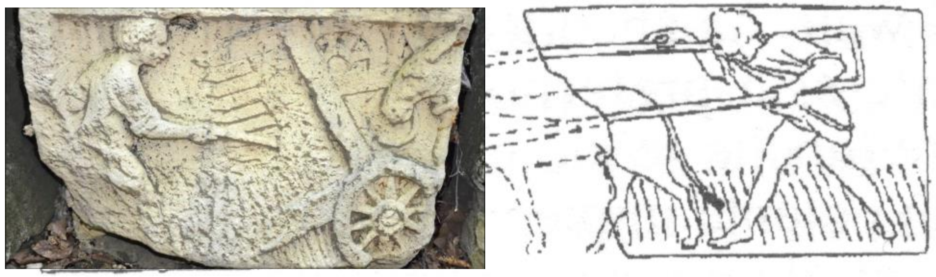


Fig. Example of ancient reaper

Innovation process development – the Patrick Bell's Reaper Case

Patrick Bell was able to invent the reaper thanks to his background knowledge, his position as parish and the social-economic environment he lived in.
He had knowledge both on agronomics and on classic literature and in the end of the XIX century lack of manpower occurred together with bad working conditions (needs).
Thus, he was able to give an answer to a real need with the invention of the reaper, merging different kind of knowledges and domains.

Patrick Bell's (designer and Innovator).

- Parish minister in Scotland he was grown in the rural environment and known the difficult condition of farmer family after the potato crisis and consequential emigration of young people.
- He known classic literature and the "De bello gallico" of Cesare Augusto that mention a particular Gaelic reaper also represented in bas-relief (as in Fig.).
- His had interest in mechanics
- Those elements joined in a design thinking mind led him to work on a horse powered mechanical reaper for speeding up the grain harvest. In In 1828 his machine was used with success on his father's farm and diffused all over the word.

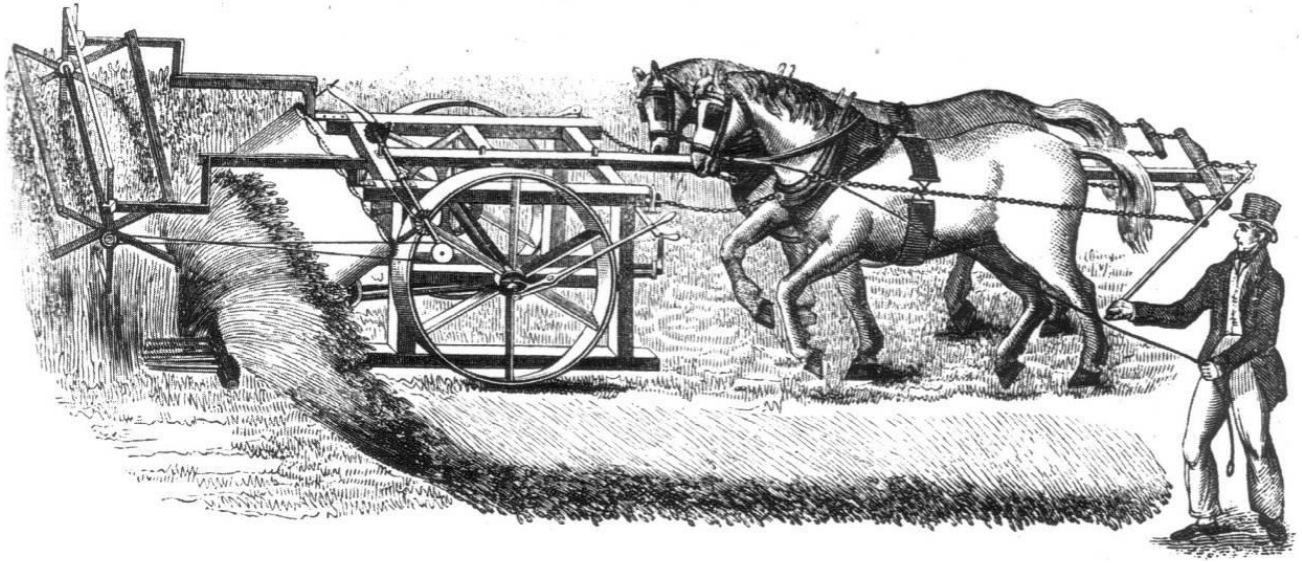


Fig.– The PatrickBell's reaper. Image From Wikipedia

1. Technology evolution in agriculture in the Modern Era of XIX Century.

In Agriculture the technical knowledge on the mills powered by the water of rivers' energy were used, creating mobile machines for the countryside. Great impetus was given by the Academies (Georgofili,1754) and the Agricultural Schools, for example, in Italy these kind of school were especially addressed to peasant's children. This action has a wide spread in many territories mainly thanks to the action of noble and religious Enlightenment thinkers.

- the soil was shaped in appropriate schemes to improve water control (Fig. Up)
- the fields were sized "at ox resistance", 60-80 meters, which corresponds to an effort of 1 - 1.5 minutes with resting in the vault (Fig. Down)
- Tools were improved in quality of work, ergonomics, more efficiency.

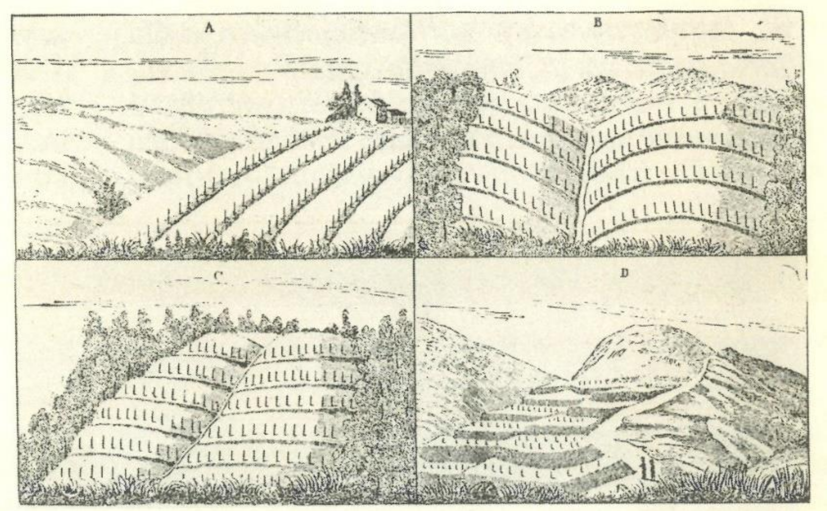


Fig.

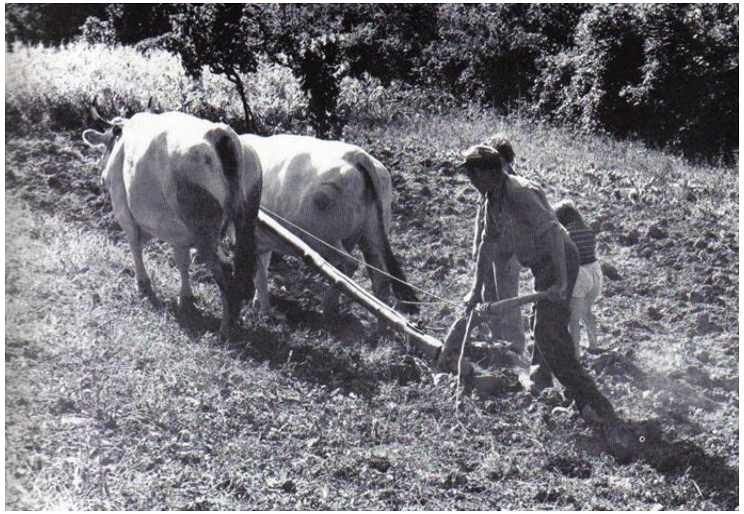


Fig.

2. Sustainable family farms of the XX Century in Europe.

Examples of farming tools from the past

The Rural Humanism from Cosimo Ridolfi in Tuscany brought to rationalization of rural areas, with structured and organized farms. Families of the past made sustainable precision agriculture and circular bio-economy a reality before today, without using such technologies but focusing on renewable materials!

… a deep, pluriennal, accurate knowledge, today defined as site-specific, of every available nutural resources.

Examples of farming tools from today

Renewable materials

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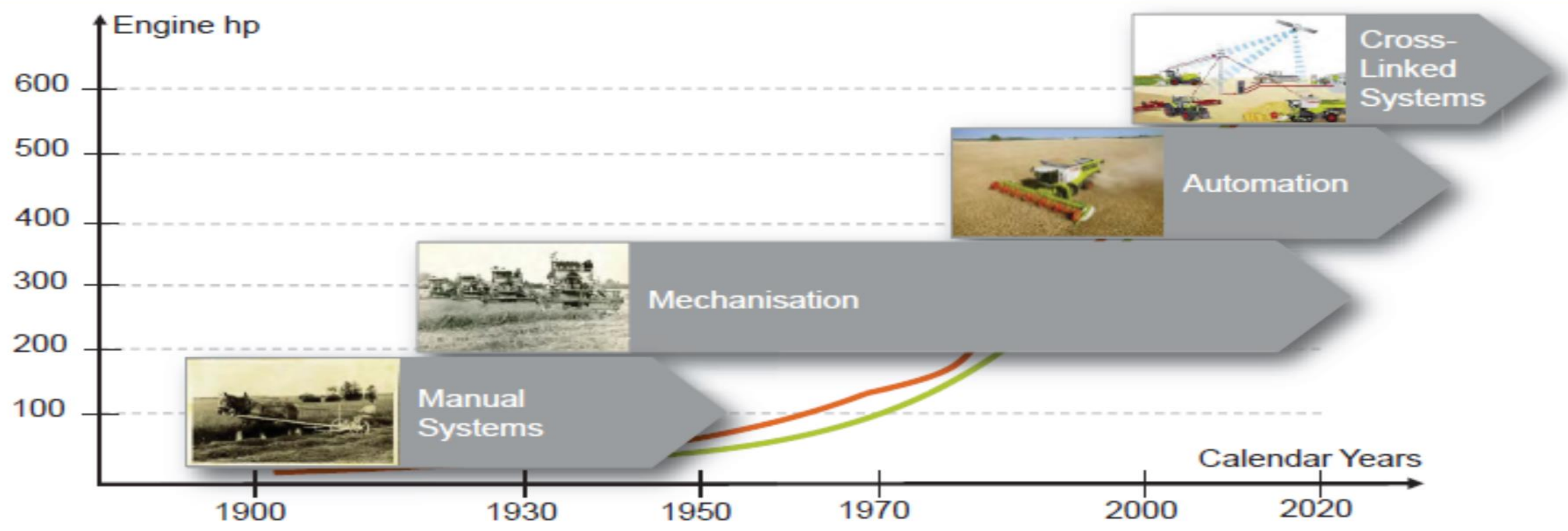
2. FARM MACHINERY EVOLUTION VIEW from the XX century

*

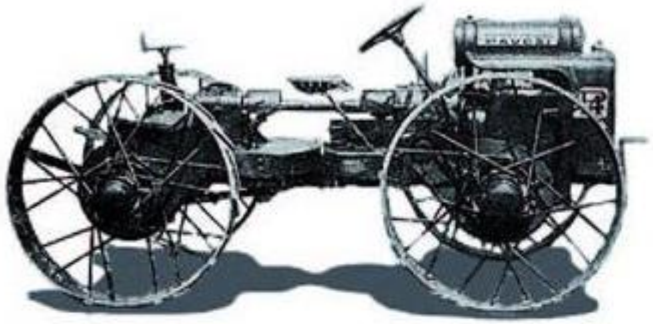


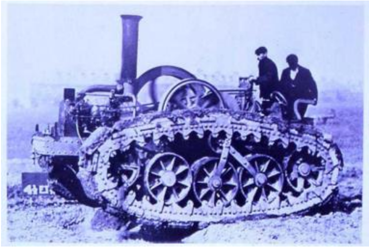
*From CLAAS

3. Agriculture 1.0 – motors and fossil energy for agriculture in the early XIX century

In America, where a large-scale mechanization with animal traction had developed, the secession wars deprived agriculture of the energy of 700,000 young people and 2 million horses; this made it essential the use of steam engine (exothermic) and then the combustion engine (endothermic). The great agricultural machines were born like the "combine". The world wars got great impulse to mechanization as the "mechanical mule" (Pavesi P4)

Animal-drawn combine machine


Pavesi P4


Track Tractor


Steam combine Tractor – D.Best 1893

4.The so-called Green Revolution after World War II.
Agriculture 2.0. Consolidation and Scale of intensive agriculture

After the Second World War, thanks to the enormous availability of chemical and mechanical means provided by the war industry that had to be converted, a global plan for the development of agricultural activity was implemented.

The cultivation techniques induced by this revolution in the middle of the 20th century are based on four factors:

- Chemical inputs
- Mechanical engineering
- Water irrigation
- Genetic improvement

This model was defined as "the Horse Power Model"

by Mark M. Vanacht in "The Businness of Precsion Agriculture".

USDA 2001

Examples of Green Revoltuion

4.The green revolution after World War II.
Agriculture 2.0. Consolidation and Scale of intensive agriculture

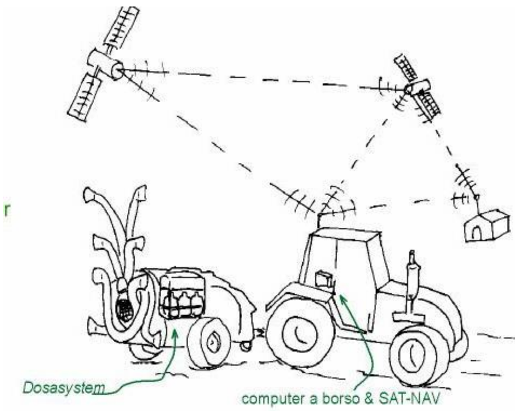
From Hoe to satellite, from Agricultural Illuminism to Modern High Tech Age

The increase in production was enormous and allowed the feeding of a whole continent exhausted by two world wars.

The productivity of human labour was increased

800 times for soil preparation operations at sowing

and 400 times in harvesting.



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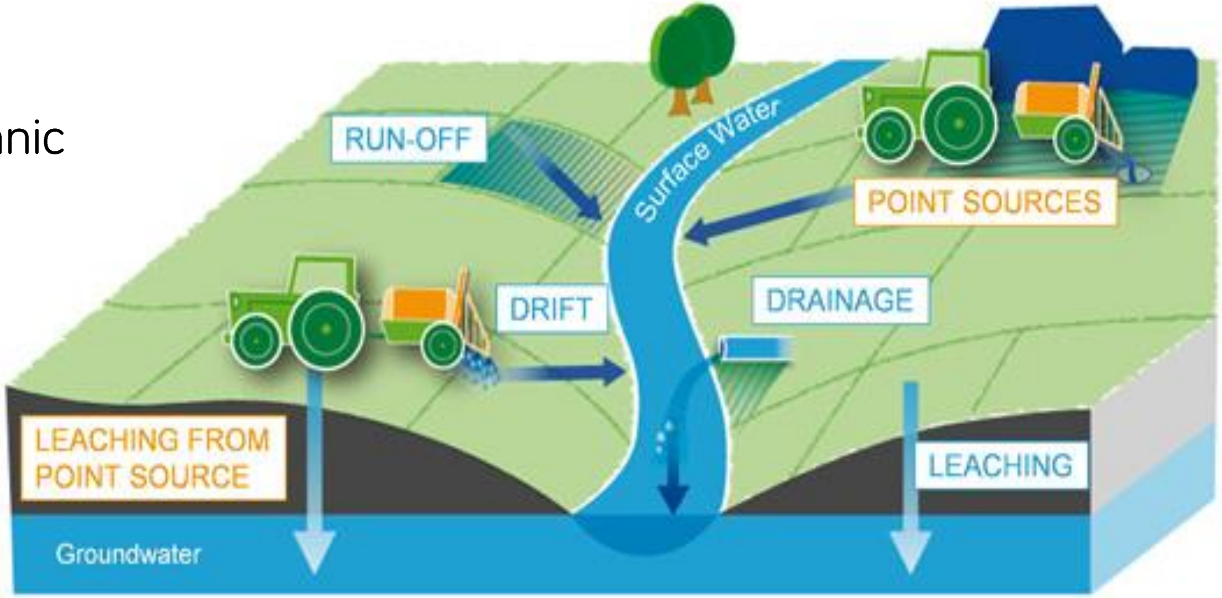
5. Research and agriculture in the middle of XX century.

Crops protection is identified with the chemical treatments for everything that is considered hostile for production.

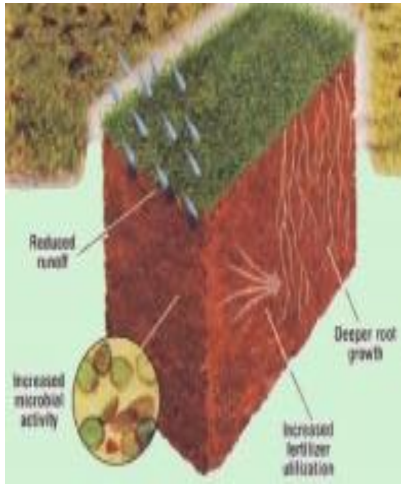
In an extractive approach, it is taken into account only the reintegration of the removed macro-elements. The main effects are depletion of organic matter with loss of fertility, reduction of soil cenobiosis with effects on soil erosion and water pollution with effects on water availability.

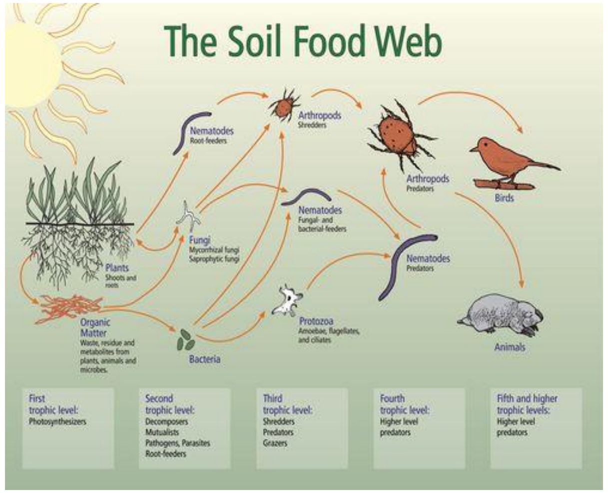


Crop protection model- water impacts

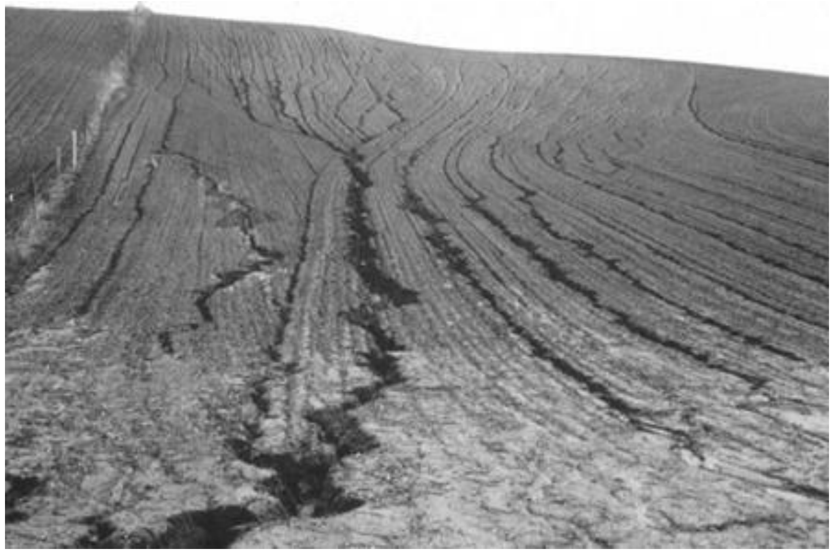
5. Research and agriculture in the middle of XX century.

Years ’90, evidence of negative externalities:
Nutrient waste in the water systems,
Erosion and corruption of the soil cenobiosis that over millennia has built fertility for crops





“Better yield and quality …
but Pressure on resources &
Disruptive social cost”
M. Vanacht The Businness of Precsion Agriculture. USDA 2001



Common green revolution impacts on soil

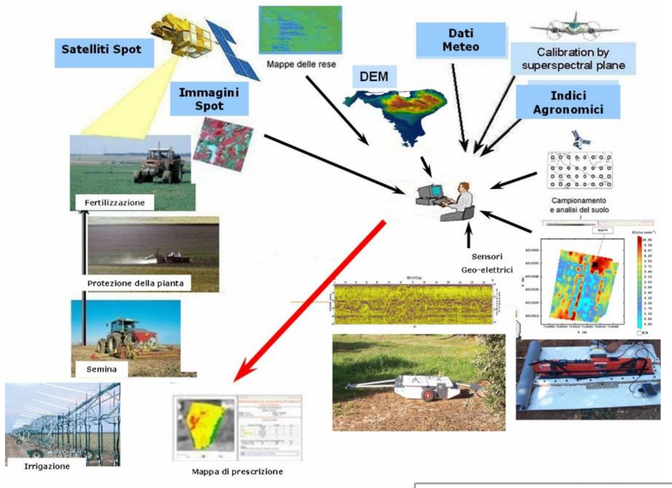
SPARKLE

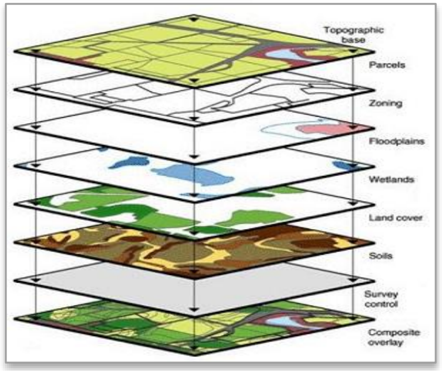
6. Agriculture 3.0 – birth of Precision Agriculture

1990
The "Brainpower" model

M. Vanacht The Businness of Precsion Agriculture. USDA 2001

Precision Agriculture is <u>not</u> Technology.
It is a innovative Management Paradigm to Respond to Spatial Variability;
<u>But Technology Makes It Possible</u>

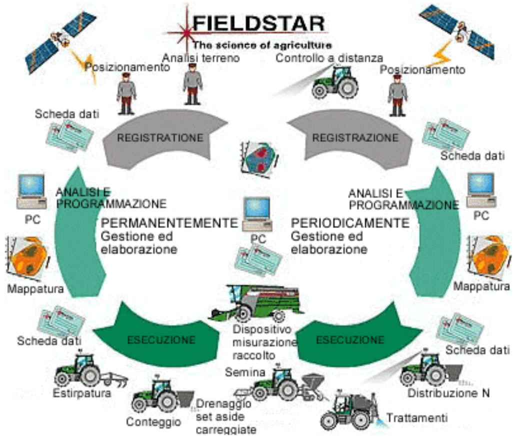




Action STEPS:

- ✓ Determine Variability
- ✓ Determine Cause
- ✓ Determine Possible Actions
- ✓ Determine Economics of Actions
- ✓ Implement Profitable Actions

- Integrated management of
  - ✓ pests,
  - ✓ water and
  - ✓ fertility
- Robotization of Field tasks
- Spatial & Data based Decision Making
- Improved genetics



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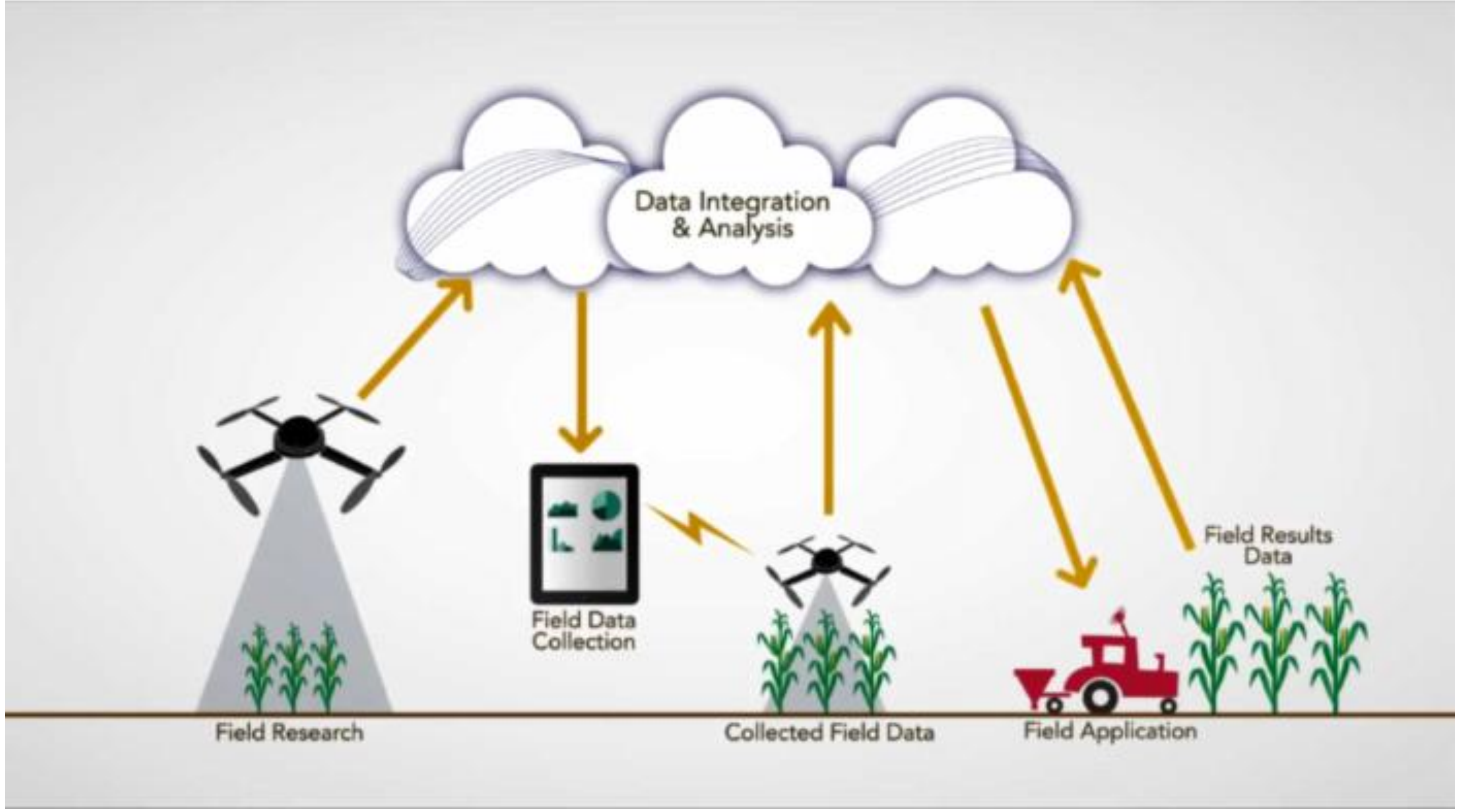
2.Human and Machinery speak digital

Digitalization make it possibile dialogue between human, machines and devices as sensors or actuators.

In the following image is shown the cycle of Precision Agriculture.



3. Agripreneurs in the future scenario of Digitization, Connectivity, SPA and Climate Change

SPARKLE

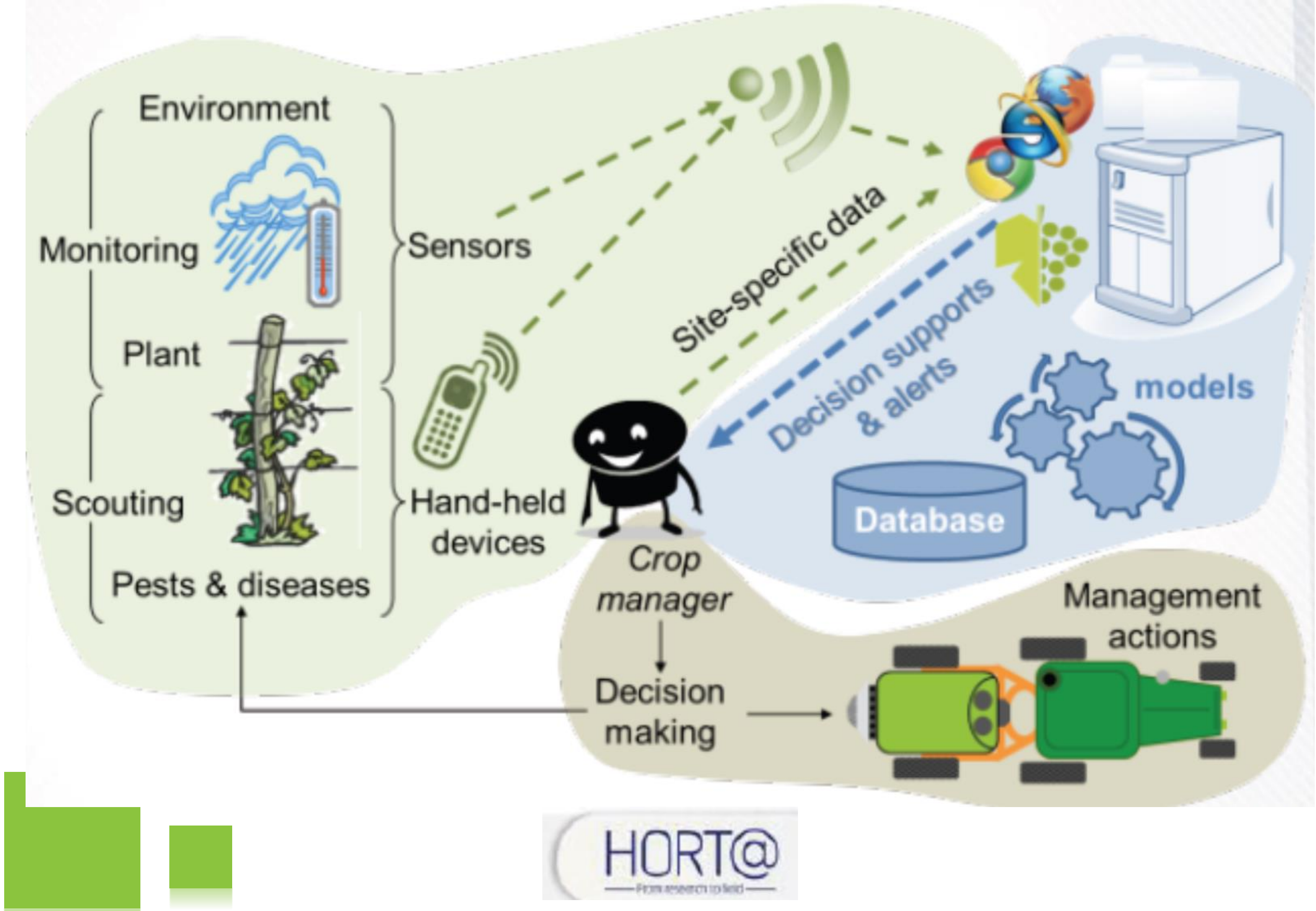


Fig. 5 - There are many technological solutions to support decisions and optimize operations by reducing the number of treatments.
Climate change imposes important choices for the timely management of crop protection.

6. Agriculture 3.0 – birth of Precision Agriculture

Digital systems and algorithms do allow to track the harvest operation precisely

Example of Process: Yield Mapping

What I can know

- GPS position
- Time Yield
- Moisture
- Engine load
- Machine Settings
- Fuel Consumption

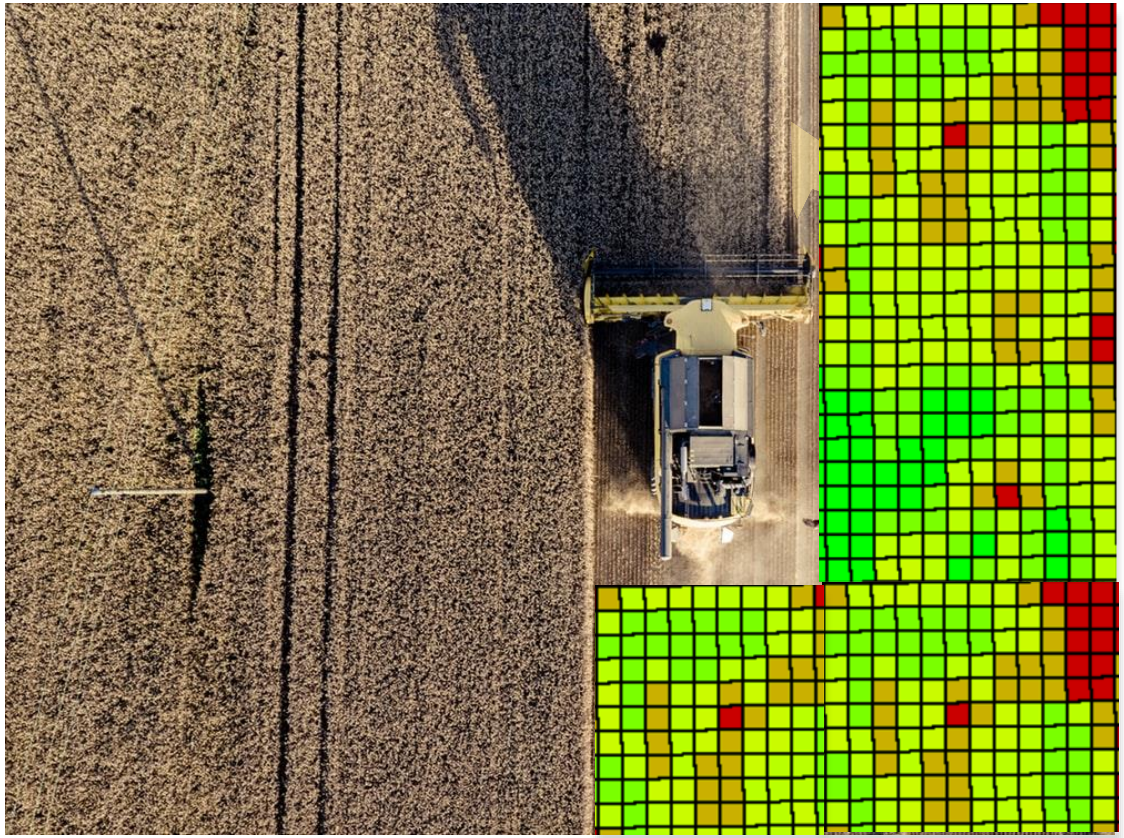


Fig. 23 Yield mapping during harvesting

What I need to get to know

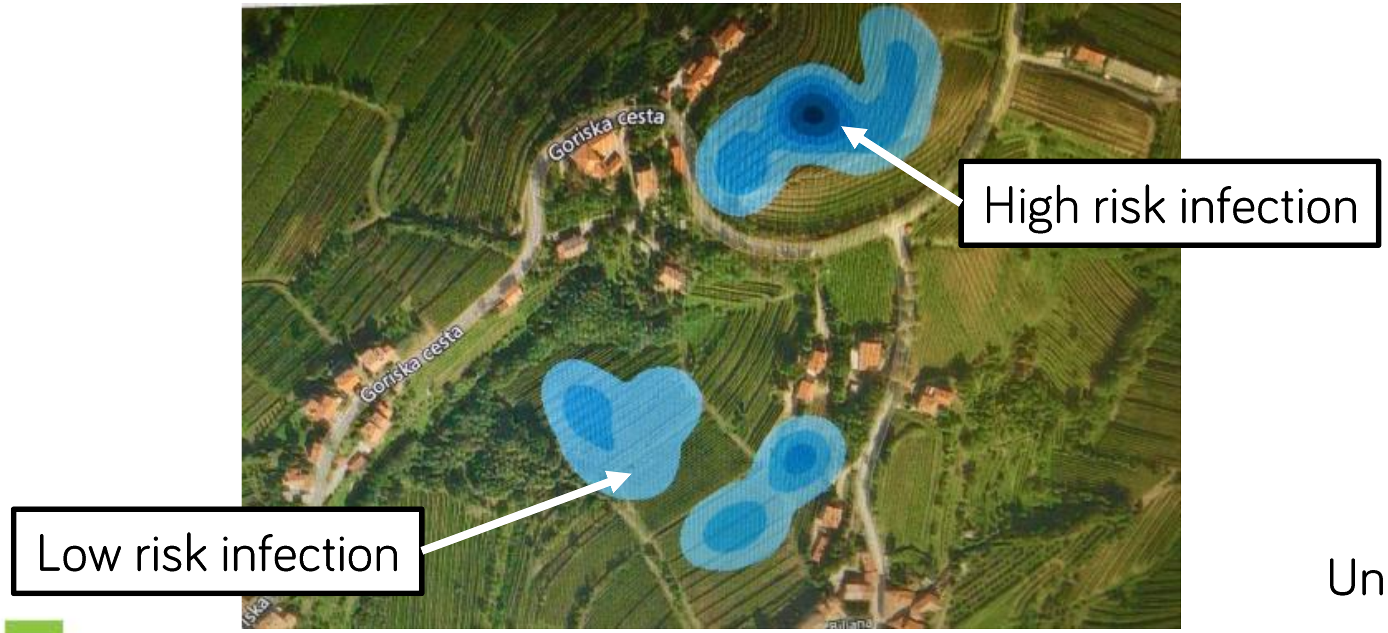
- Phone network
- Communication
- Modules
- Internet
- Computing power
- Server capacity

2. Sustatinable Precision Viticulture Technology view:

2.2 DSS for pest and climate control

Decision Support Systems (DSS) are fundamental for sustainable management of climate and pest control.

Risks outbreaks sites identification, definition of the degree of risk and Timeliness, allow to control vineyard health and avoid wastes in resources, time etc..



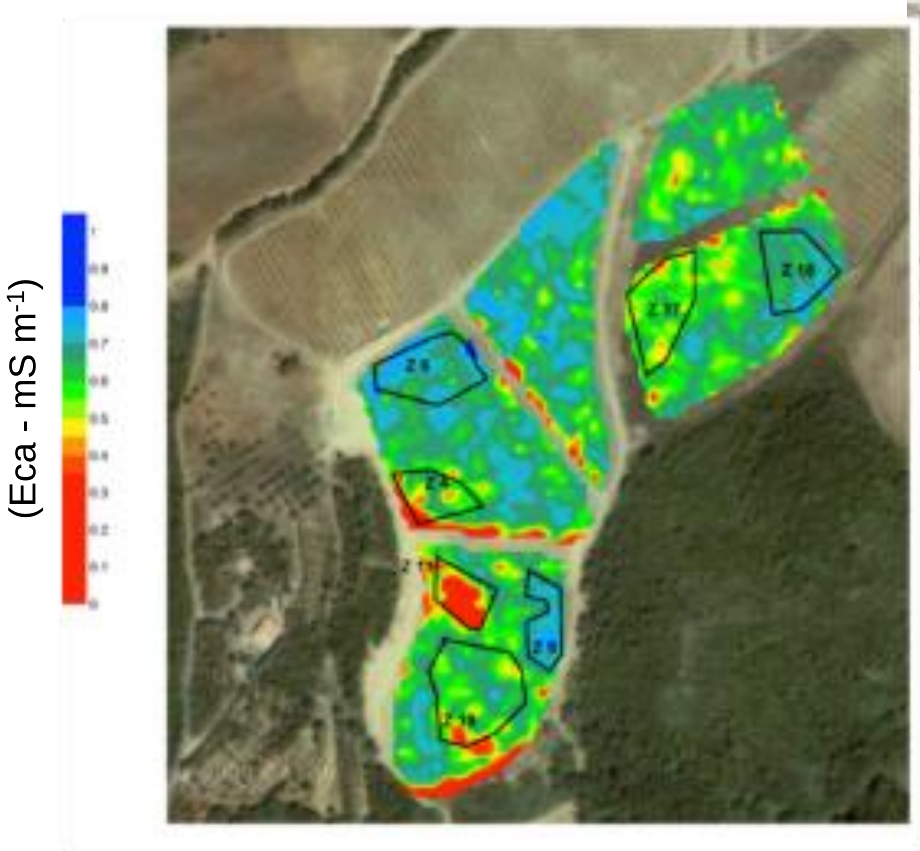
Spatial disease map.

Unmanned aerial vehicle equipped with spraying system for crop protection in hard to reach scenario.

2. Sustatinable Precision Viticulture, Technology view:

2.3. Variable Rate Treatments – Fertilizing

Different soils have different availability of water and nutrients. Soil practices are precisely managed to ensure the better growth of the vine and maximize quality



Site-specific variable rate technology for nutrients spreading based on prescription map made using vigour data or soil apparent electrical conductivity (ECa).

2. Sustainable Precision Viticulture Technology view:

2.3 Variable Rate Treatments – Irrigation and mulching with cover crops.

A different site specific irrigation may ensure best growth of the vine and save water. Moreover, can allows the quality increasing by controlled stress induction techniques.

Cover crops are becoming more and more important to control soil and water waste by mulching management.

Irrigation map

Example of vineyard with variable rate irrigation system and mulching in the row of vine to manage the irrigation

2. Sustatinable Precision Viticulture, Technology view:
2.3. Variable Rate Treatments – Canopy management

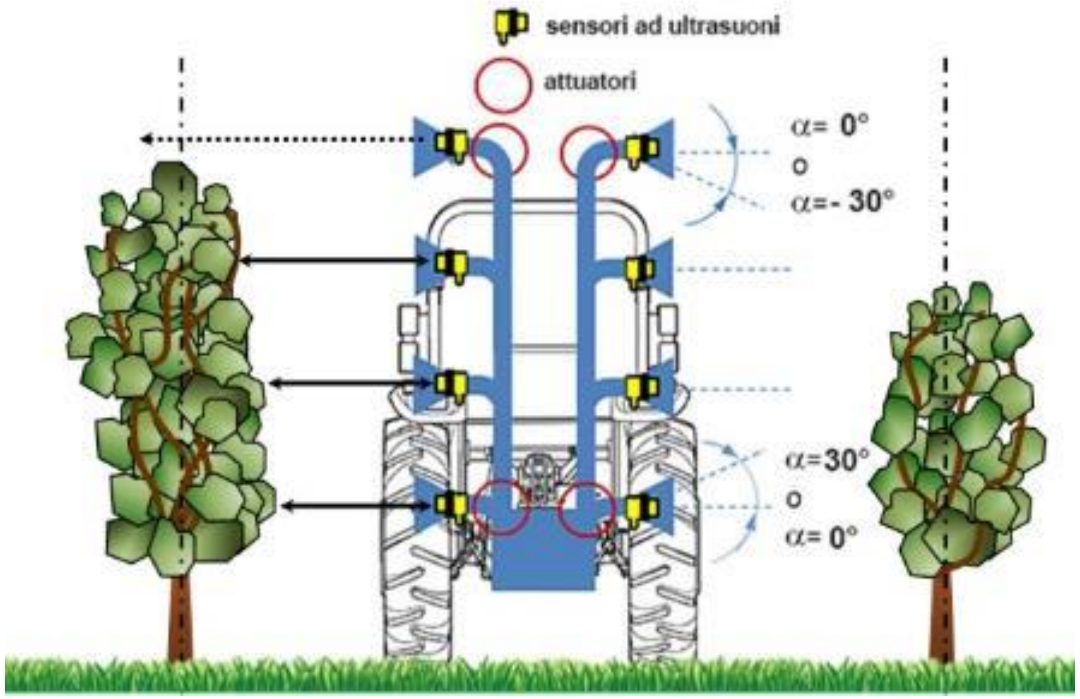
Leaf removal is a controlling method for vine vigour and aeration/insolation on the bunches band. The management is site-specific in relation to the different conditions, needs, and oenological goals.

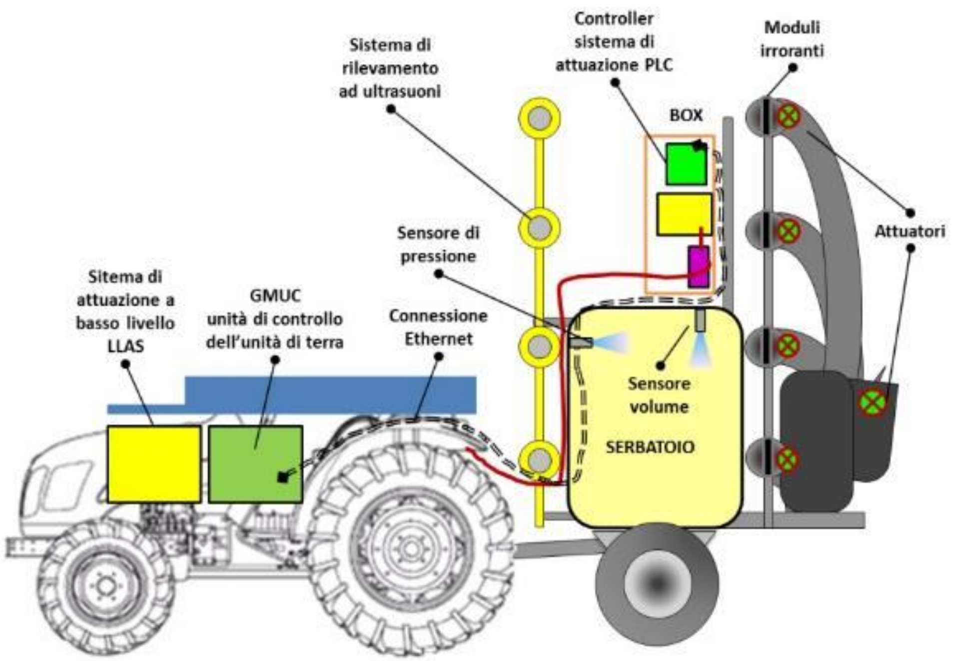
Vineyard leaf stripper with automatic tracking against canopy

2. Sustainable Precision Viticulture, Technology view:

2.3. Variable Rate Treatments – Spraying chemicals

Waste of chemical or nutrients or nutraceutical new substances in vineyard protection figure out up 80%. Precise application on the target canopy or better on the evident disease could reduce drastically the wastes.



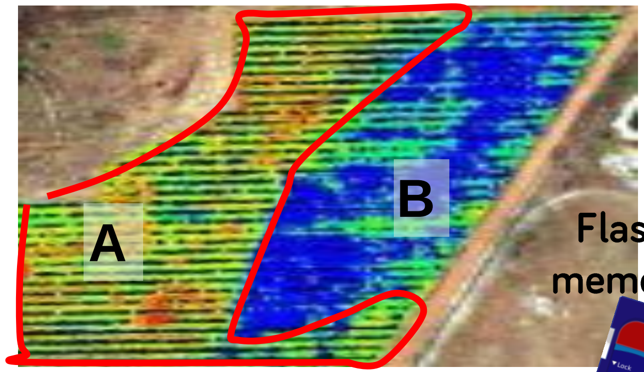


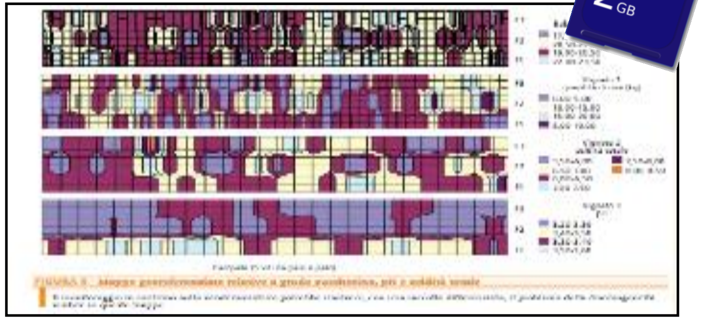
Example of variable rate sprayer with sensing system to scan the canopy feature.

2. Sustainable Precision Viticulture, Technology view:

2.3. Variable Rate Treatments –Differential grape harv

In the conventional management of vineyard often there are wide differences in grape ripeness thus quality.
A differential grape harvest could preserve the best quality.
The map is loaded on USB flash drive for use in the HQS machine. Equipped with the GNSS technology, the grape harvester knows its position and reads the map to determine A and B quality grape areas. Automatically, the harvester moves its conveyor to the right or to the left according to the map information.



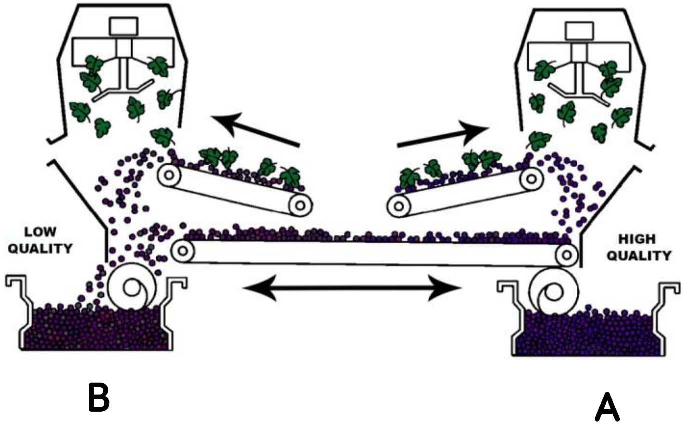


Sugar content map (°Brix)

Flash memory

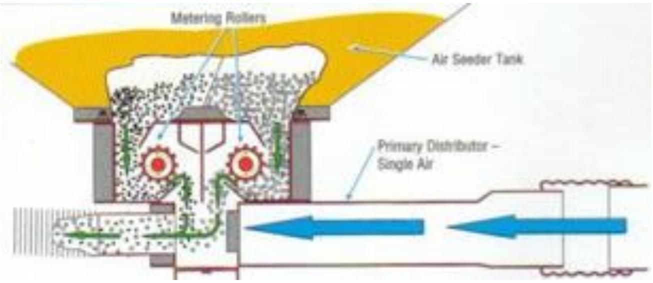
GNSS receiver

Transversal conveyor

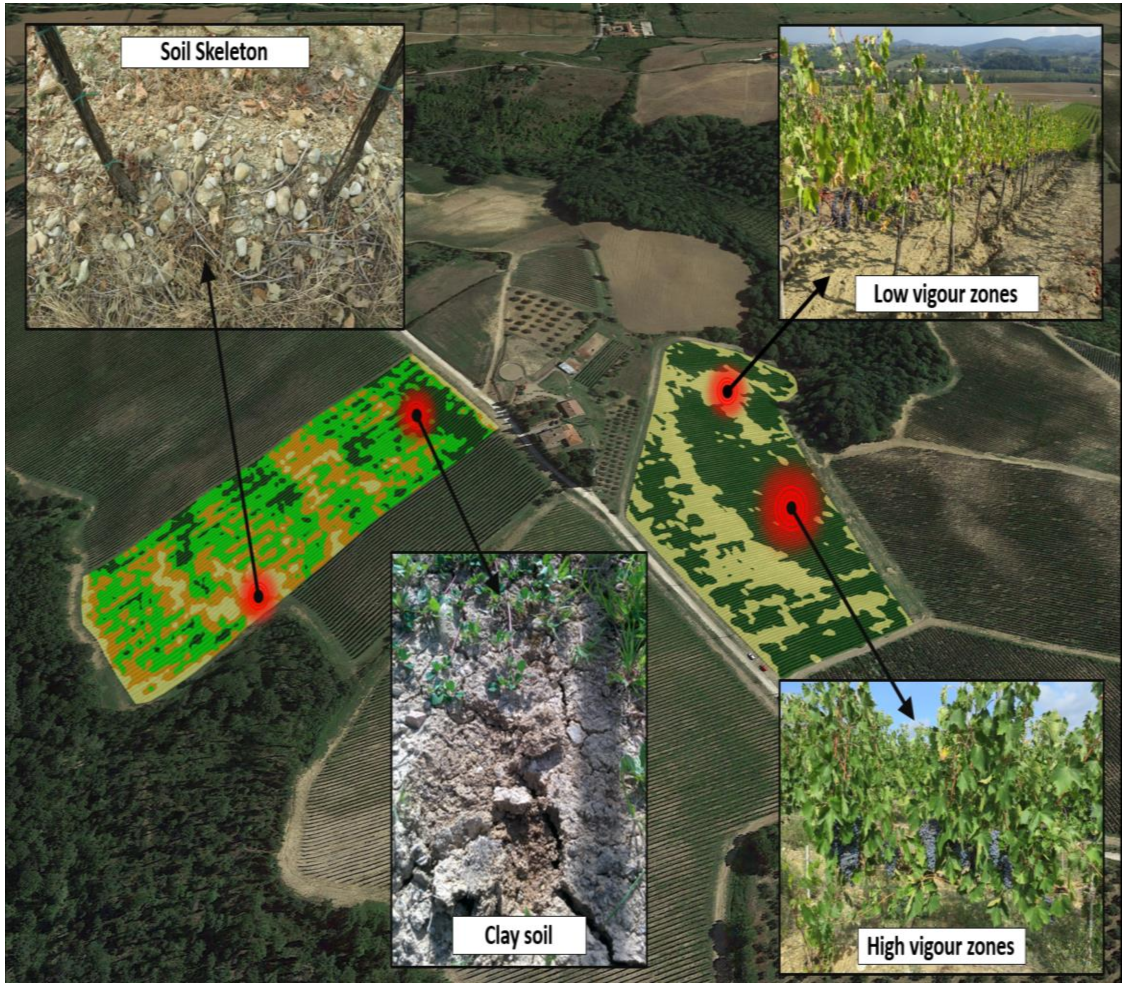


2. Sustatinable Precision Viticulture, Technology view:
2.3. Variable Rate Treatments-Seeding Interrow Winter Cover Crops

Cover crops are becoming more and more important to adbsorb sun energy, to prevent rain splash erosion, to fix nitrogen and give organic matter to the soil system.
Monocots reduce vine vigour, Legumes increase vine vigour, *Sinapis arvensis* plough the soil. All produce organic inputs and enhance water and soil conservation.



Scheme of variable rate seeder: this solution allows seed mixing, specific seed selection and the variation of the amount of seeds per units.



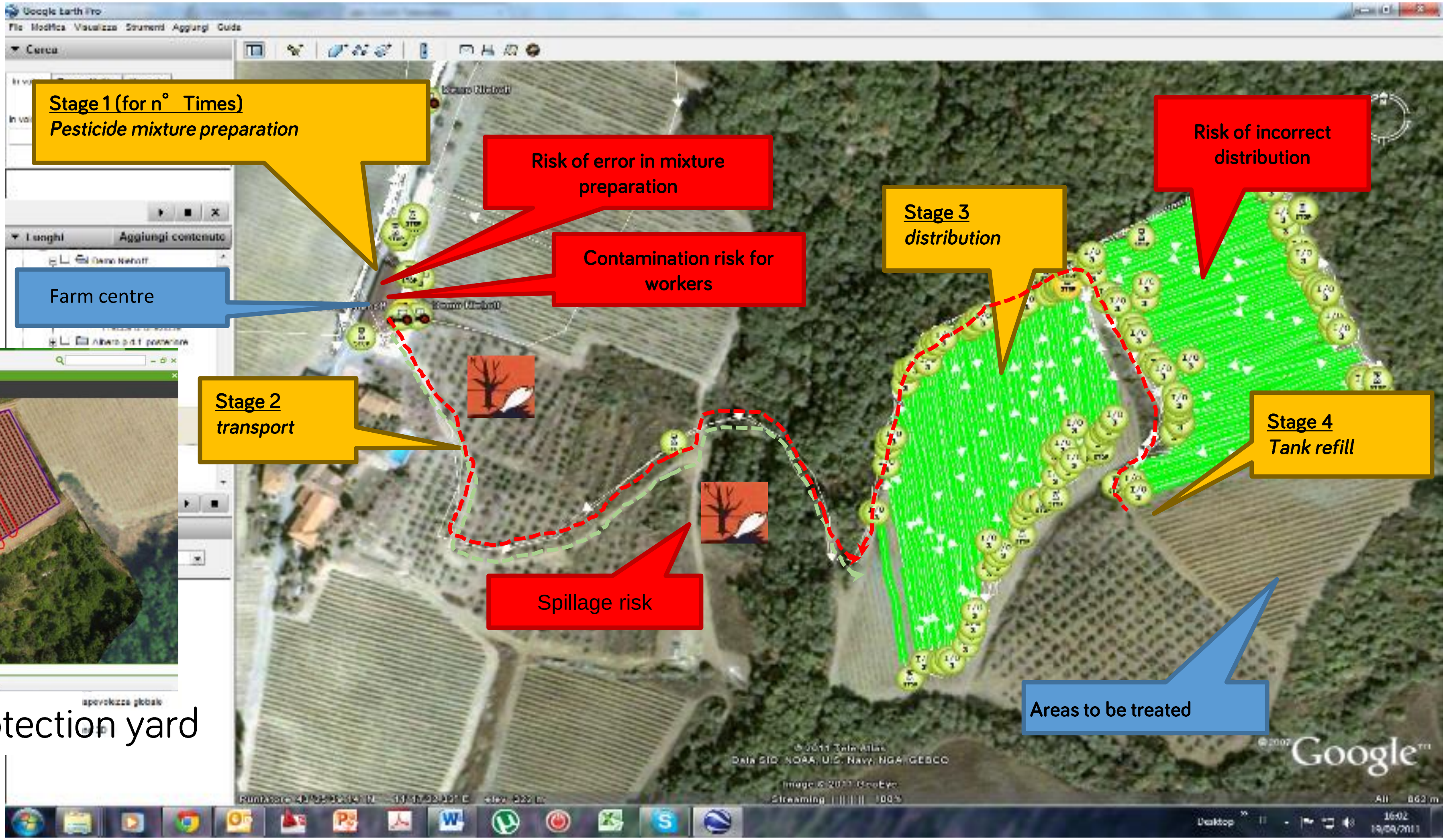
Within variability : variation in soils and canopy growth

2. Sustainable Precision Viticulture Technology view:

2.1 Monitoring Technologies - Telemetry and traceability

Traceability is the lean tools to enhance process and the key value for production chain quality assessment.

Dashboard of a crop protection yard



3. The local digital platform for SPV

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Territorial digital platform devoted to SPV are arising as Digital Hub for the Wineries

Monitoring

Aerial surveys:

RGB Camera
Multispectral camera
Hyperspettral Camera
Gamma rays

Data collections on *crops*:

Physiological measurements
Vigour indexes NDVI - NDRE

Data collection on *soil* :

Conductivity measurements with electromagnetic induction
Profiles and drills
Laboratory analysis

Data collection from *weather stations:*

Atmospheric pressure
Temperature
Rainfall
Humidity of the area
Wind intensity
Solar radiation
Dew point
Leaf wetness

Data processing

BRUNELLO OENO SMART
ALTA QUALITÀ SOSTENIBILE

Field activities

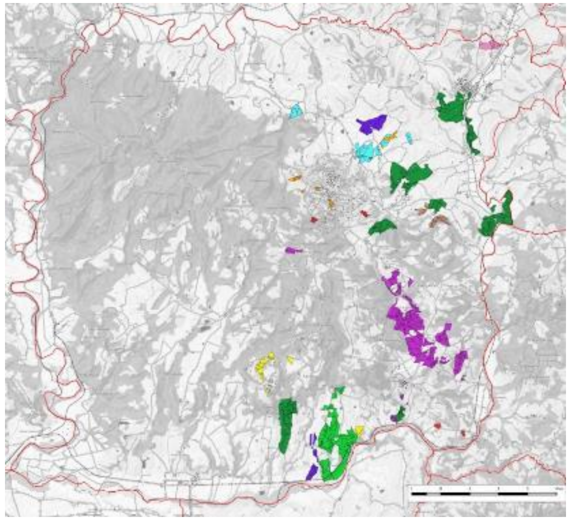
Services to companies and stakeholders

- Digital maps for the management of parcels with 1 sqm mesh:
- Orthophoto (4 cm / pixel)
- Vegetational maps and NDVI
- Pedological maps
- Hydrological modeling:
  - Water at field capacity (FC)
  - Water at the point of withering (WP)
  - Water available for plants (AWC)
  - Saturated hydraulic permeability (Ksat)
- Weather maps
- Prescription maps
- Telemetry fleet control
- Field books
- DSS Services - Decision Support System for:
- Crop protection alarms
- Logistic decisions support for the collection of products
- Analytical accounting of georeferenced parcel
- Traceability
- Typicality
- Identification of biodiversity footprints

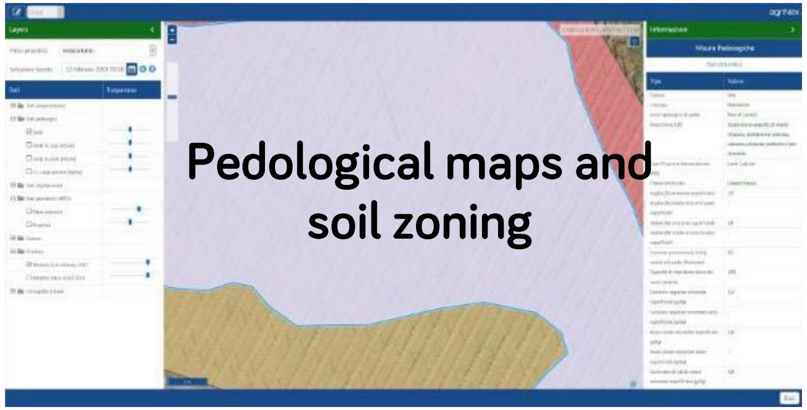
3. The local Digital Platform for SPV

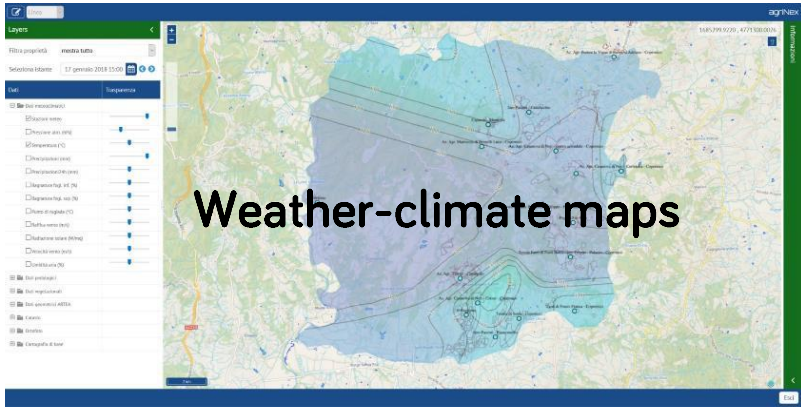
The OENOSMART digital platform devoted to SPV in Brunello di Montalcino Area in Tuscany Italy:

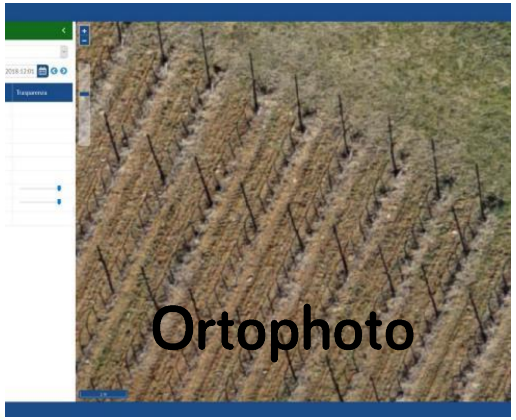
- Open to all winery
- Micro-weather station network with metadata shared to have an integrated monitoring of weather parameters in all site for the whole area.
- GDPR respected.

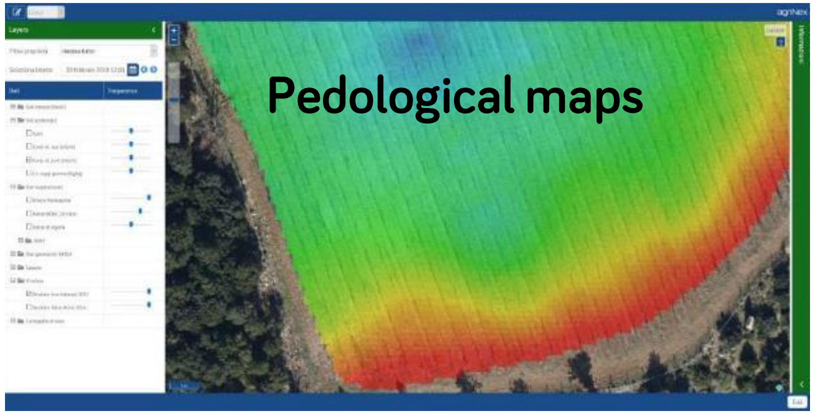


Monitoring district





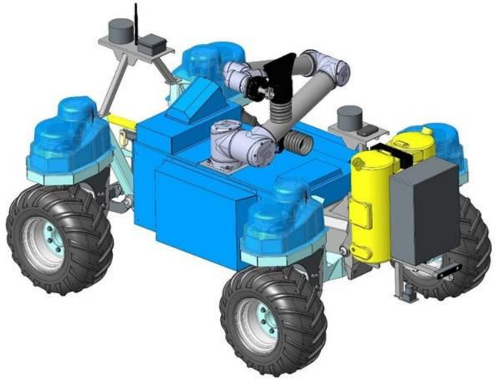


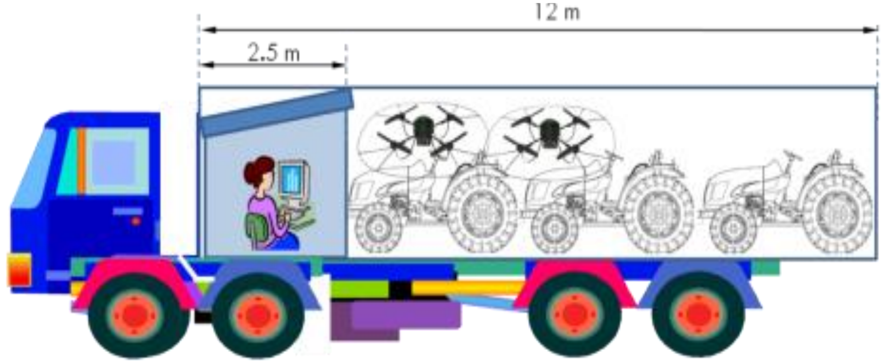


5. Look the future

5.2. Robot for SPV

It become more and more concrete the possibility of use robots in automatic field operations. The most accredited vision is Services Companies that manage Fleet of Robot operating in the vineyard.





5. Look the future

5.2. Robot for SPV

http://wall-ye.com/

www.crops-robots.eu/

https://www.naio-technologies.com/

https://ucdaviscaes.wordpress.com/tag/drone/

www.vinerobot.eu

www.rheaproject.eu

AGRICOLTURA 4.0 nelle macchine per il vivaismo

- Tracciabilità delle piante e dei lotti
- Registrazione pesi e localizzazione
- Analisi tempi e consumi di lavoro

in progress...

Accademia dei Georgofili

VANNUCCI PIANTE

PAZZAGLIA

- Robot per il diserbo nei lotti di vasetteria
- Robot per i trattamenti antiparassitari

1. Technology Readiness Level (TRL)

Technology Readiness Levels (TRL) are a type of measurement system used to assess the maturity level of a particular technology.

For the enterpreneur it is foundamental to identify the TRL of an introducing technology.
Readiness is not only related to the product but to all supporting system of that technology.

TRL 9
- Actual system "flight proven" through successful mission operations

TRL 8
- Actual system completed and "flight qualified" through test and demonstration (ground or space)

TRL 7
- System prototype demonstration in a space environment

TRL 6
- System/subsystem model or prototype demonstration in a relevant environment (ground or space)

TRL 5
- Component and/or breadboard validation in relevant environment

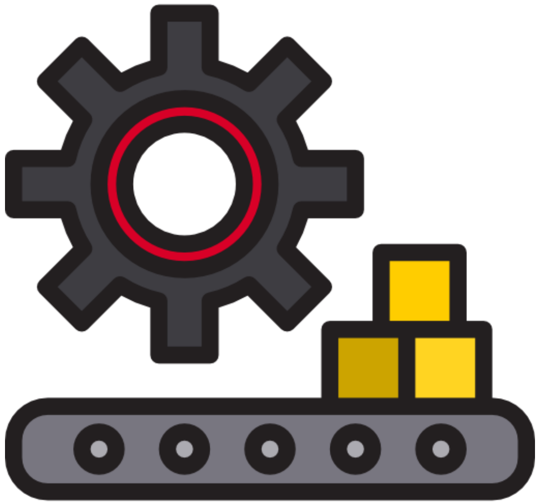
TRL 4
- Component and/or breadboard validation in laboratory environment

TRL 3
- Analytical and experimental critical function and/or characteristic proof-of-concept

TRL 2
- Technology concept and/or application formulated

TRL 1
- Basic principles observed and reported

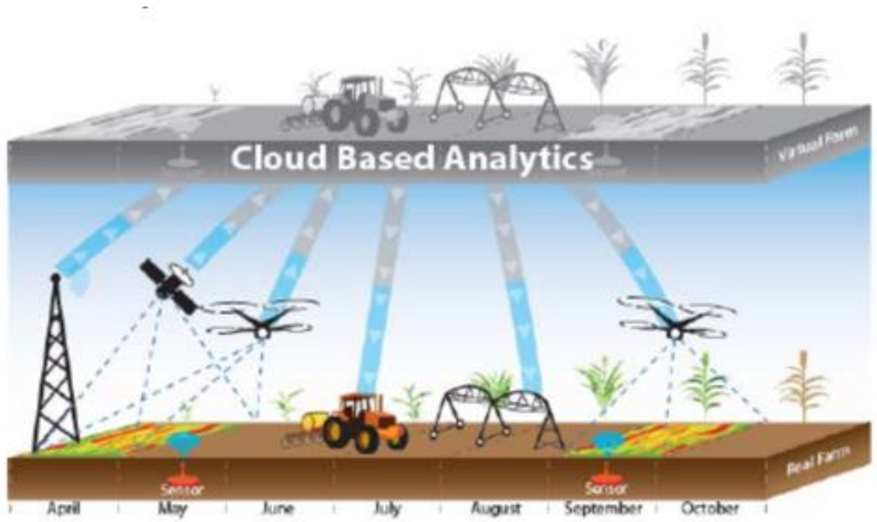
TRL	9	Commercialized
	8	Pre-production
	7	Field Test
	6	Prototype
	5	Bench / Lab Testing
	4	Detailed Design
	3	Preliminary Design
	2	Conceptual Design
	1	Basic Concept



Icons made by xnimrodx from www.flaticon.com

2. Smart Agriculture: the Cyber Physical System Vision

IoT and Agriculture 4.0 it is essentially connectivity and cyberphisics aid. The development of agricultural tools connettivity also determines new challenges in fundamental need of data exchange in the corporate ecosystem and the need to investing in new infrastructure and instruments.



This CyberPhisics approach make possible a multidimensional control. An Augmented Knowledge that allows to act a «Precise» and «Aware» management.

1. Agronomic goals

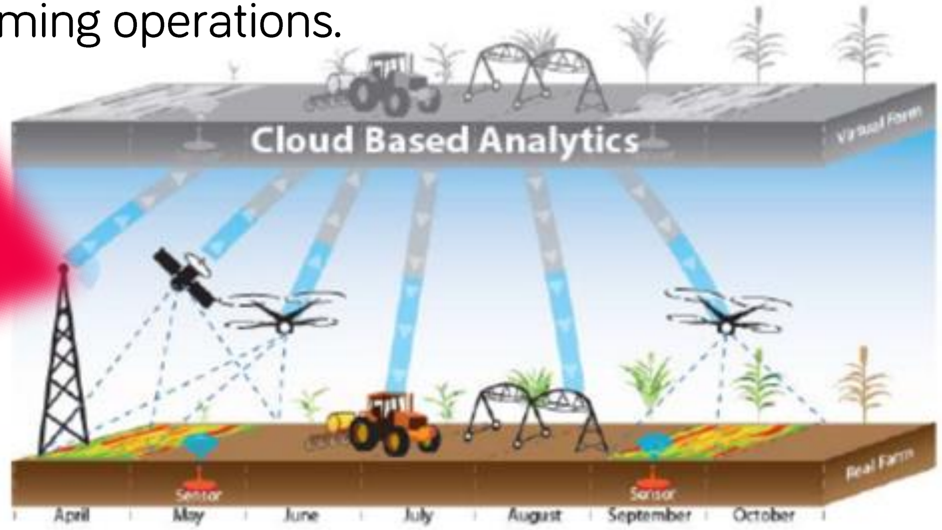
The cultivation activity has as objective the care of the plant, its protection and its production.

This requires the implementation of a set of regularized practices in the seasonal cycle which can be summarized by an operational timetable.

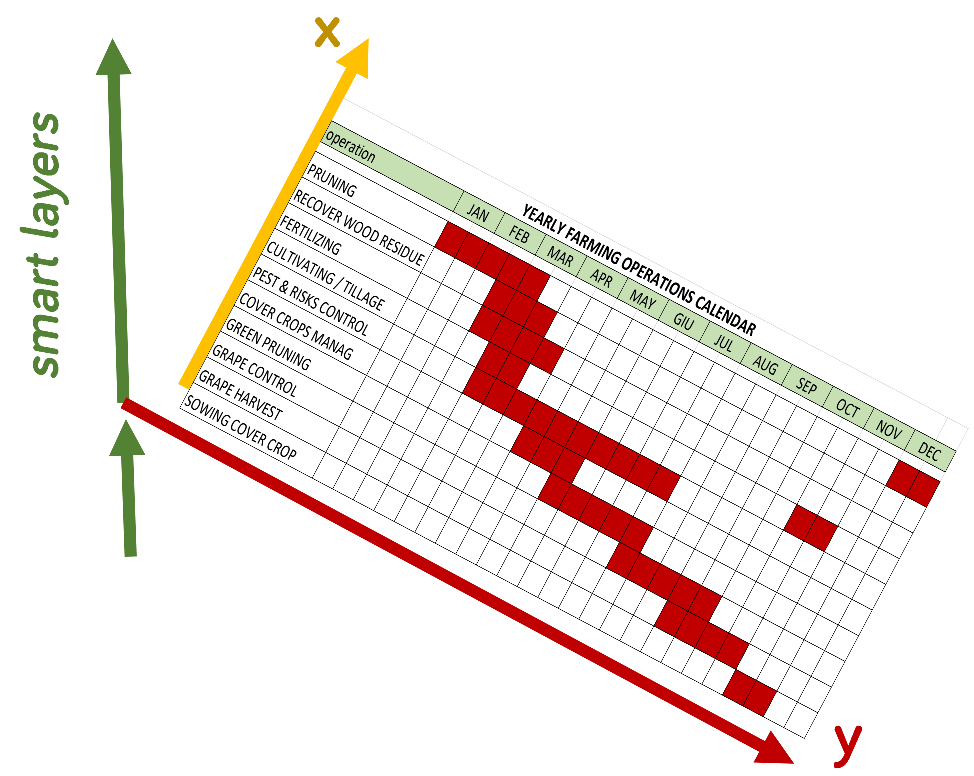
YEARLY FARMING OPERATIONS CALENDAR

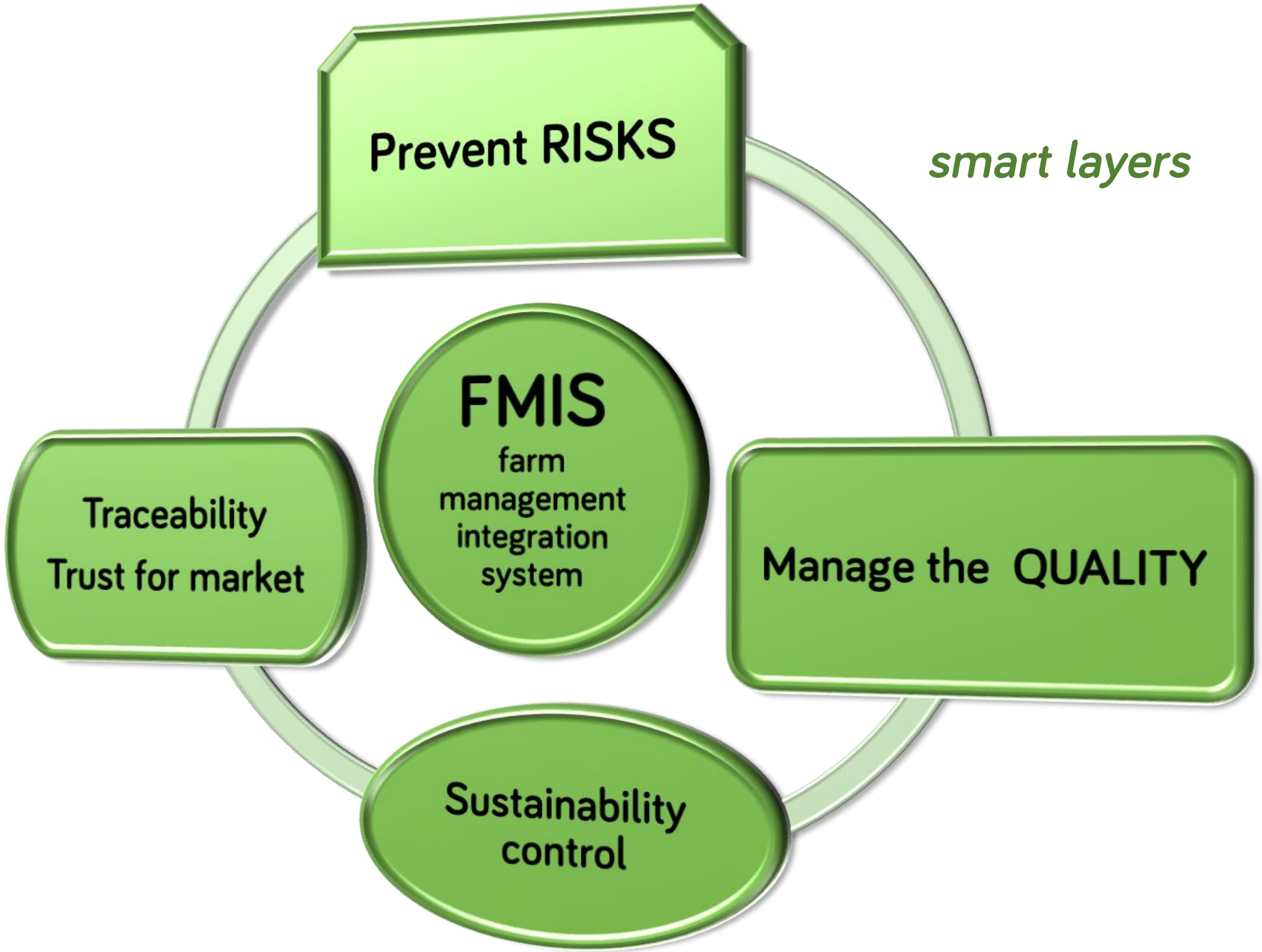
operation	JAN		FEB		MAR		APR		MAY		GIU		JUL		AUG		SEP		OCT		NOV		DEC	
PRUNING	■	■	■	■	■																		■	■
RECOVER WOOD RESIDUE				■	■	■																		
FERTILIZING				■	■	■	■																	
CULTIVATING / TILLAGE					■	■														■	■			
PEST & RISKS CONTROL					■	■	■	■	■	■	■	■	■	■										
COVER CROPS MANAG								■	■	■														
GREEN PRUNING										■	■	■	■	■										
GRAPE CONTROL														■	■	■	■	■						
GRAPE HARVEST																	■	■	■	■				
SOWING COVER CROP																					■	■		

Digitalization, Connectivity and High Technology make it possible a multidimentional approach in the yearly timetable of farming operations.



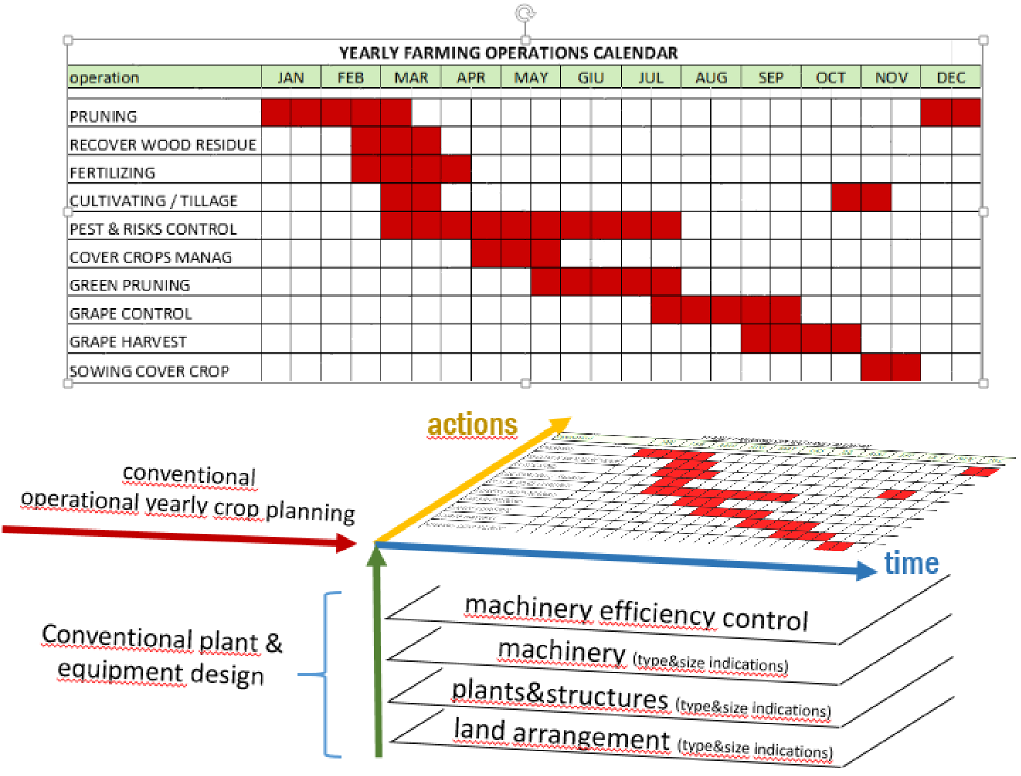
Smart Farming: The 3D cyber-phisical dimension approach



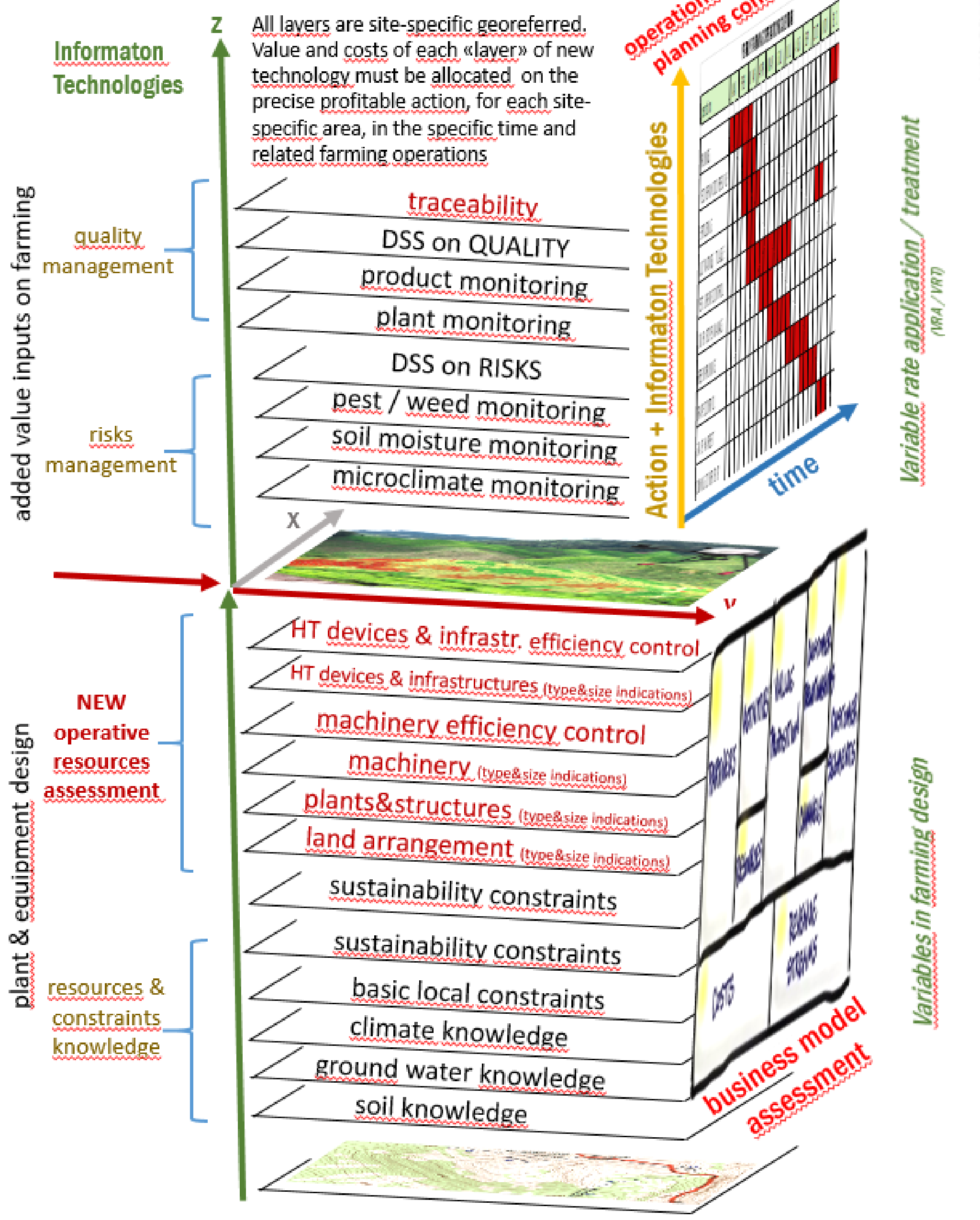


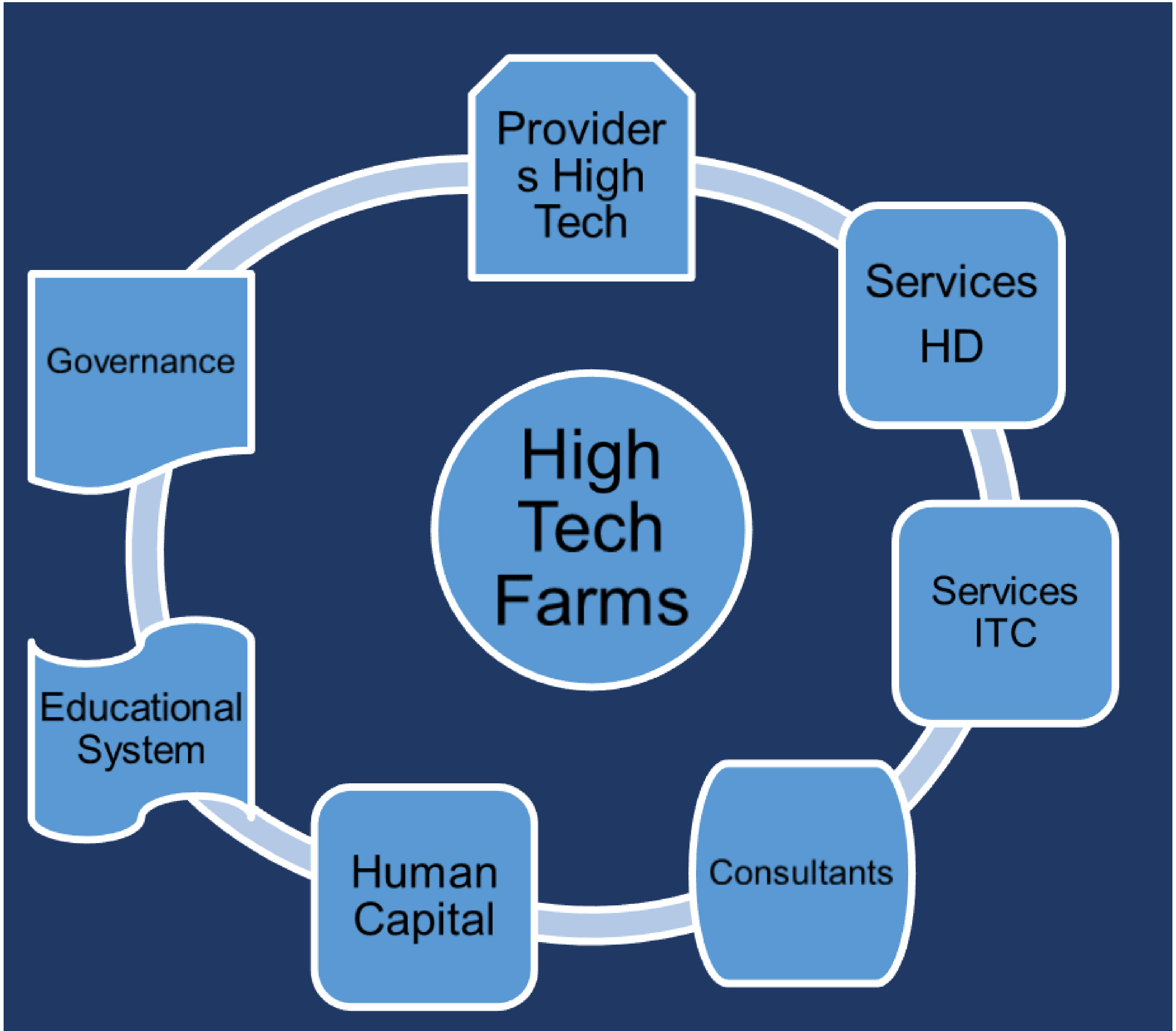
The proper farm management must be consider not only the seasonal operations calendars like a simplified sequence of activities but even all the data and information available (smart layers). This allow to select the more appropriate tools, techniques, input, crop protection strategies and get the so called fam management integration system.

The conventional farming flat view



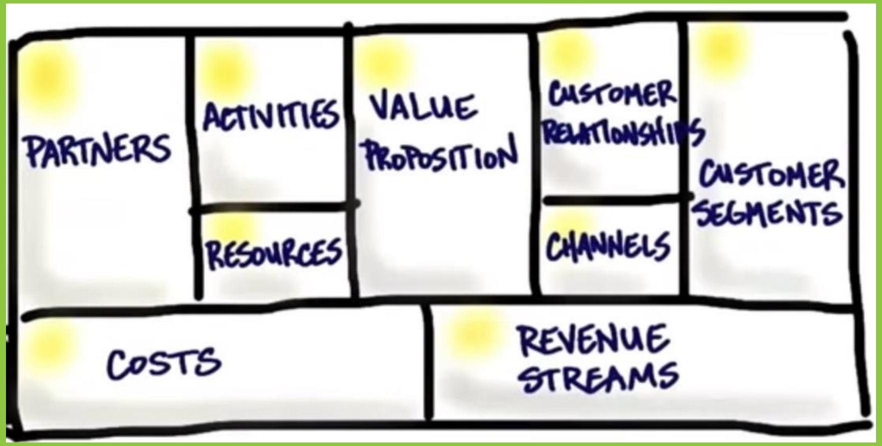
Future farming multidimentional approach for the profitable allocation of new smart tecnologies in the specific field crop operations

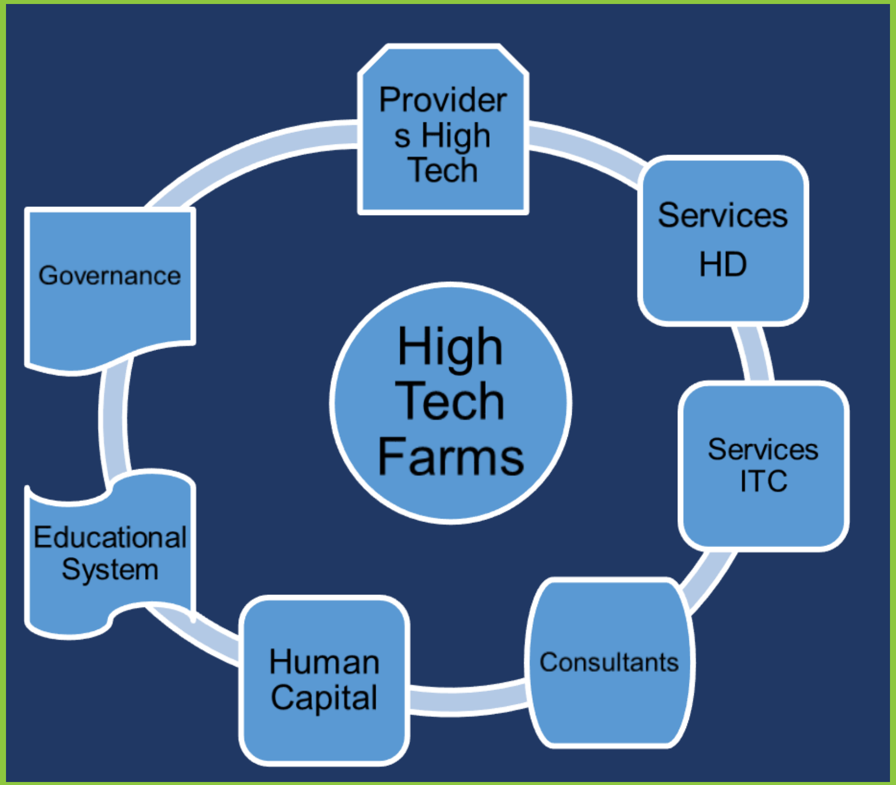



Providers High Tech
Services HD
Services ITC
Consultants
Human Capital
Educational System
Governance
High Tech Farms

3. Holistic vision in introducing innovation

- Introducing technology must well defined in the Business Model with reference to the Key Activities, Key Resources, Key Partners.
- Introducing technology must be supported by a specific Territorial Ecosystem that guarantees the best use and efficiency: learning, consultancy, services.





DEVELOPMENT OF THE COURSE: 4 AREAS

	SPA OVERVIEW
	TECH-ING
	BE SITUATED
	MANAGE IT

12 LESSONS

SPARKLE

1. Introduction to SPA
2. Variables and systems
3. Positioning systems
4. Proximal Sensing
5. Remote Sensing
6. Variables Rate Technology
7. Robotics
8. Data Analysis
9. Communications
10. Policy & Management
11. Entrepreneurship in SPA
12. Toolkit for Agripreneurs 4.0

Thank you for your attention

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