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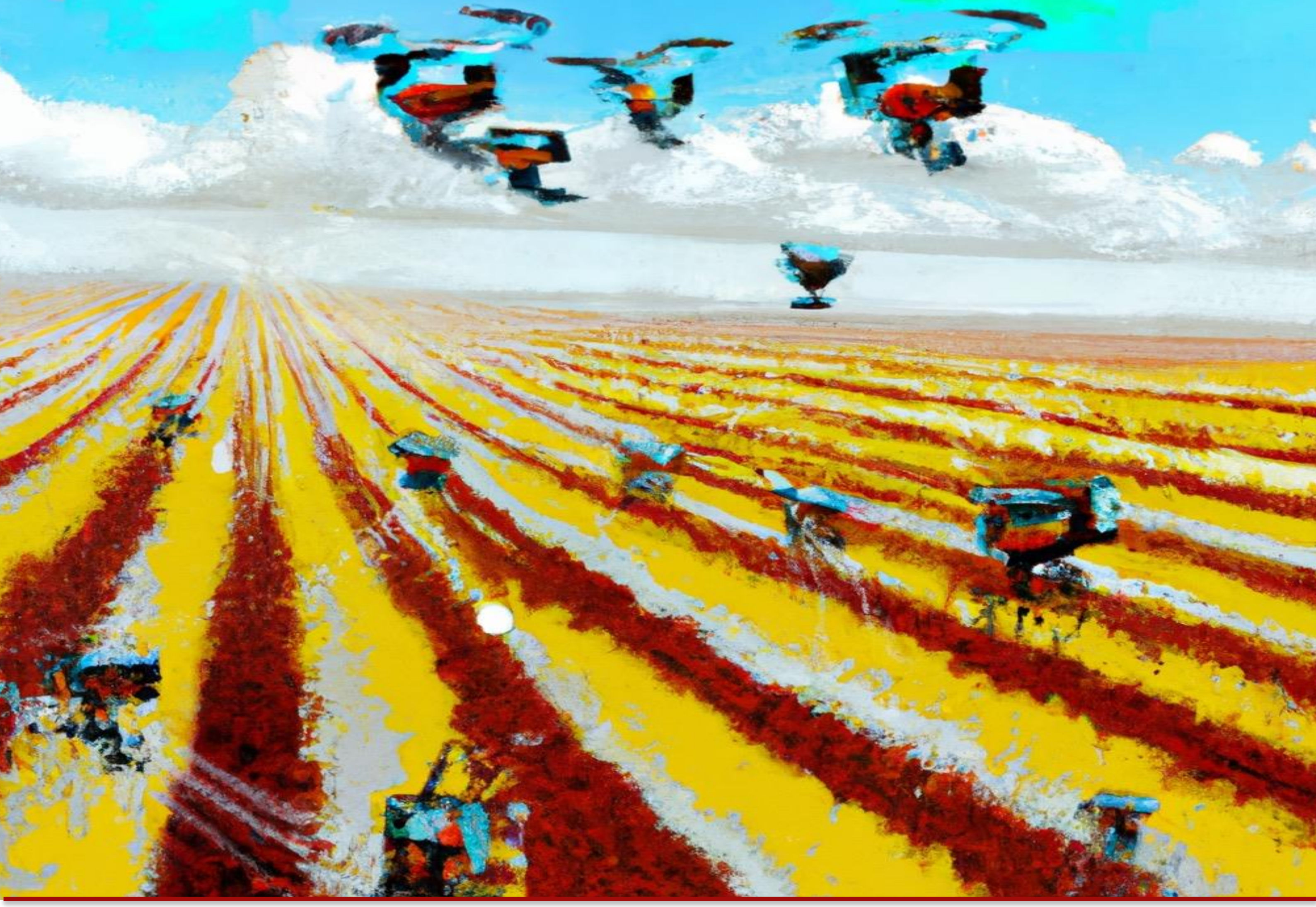

DIGITAL AGRICULTURE

AN UPDATED & COMPREHENSIVE OVERVIEW

Author: **Marco Brini**

Date: June 2023

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ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to the entire community of people working in agriculture and digital agriculture. Your unwavering commitment, open sharing of experiences, and collaboration have been instrumental in shaping this book and the broader understanding of sustainable food production.

The continuous exchange of knowledge and ideas has fostered a spirit of innovation, propelling the field of digital agriculture forward. Your collective efforts are making a tangible impact on the lives of farmers and the environment, paving the way for a more sustainable and efficient food production system.

Thank you for your dedication and contributions to this vital cause. Your passion and perseverance inspire not only the content of this book but also the progress of the entire agricultural community.

Together, we can continue to work towards a sustainable future, ensuring food security and environmental preservation for generations to come.

Marco Brini

June 2023

CHAPTER 1 Introduction to Digital Agriculture

INDEX NEXT

DIGITAL AGRICULTURE: WHAT IS IT?

How to implement it?

Download free ebook

https://lnkd.in/em38Bk4H

What is it?

Digital Agriculture, also known as AgTech or smart farming, is a rapidly evolving field that uses technology to enhance agricultural practices, aiming to increase the efficiency, productivity, and sustainability of food production systems.

Incorporating Digital Technology

Digital Agriculture involves incorporating digital technology and data-driven methodologies into farming practices. This can involve everything from GPS guidance for machinery and satellite imagery for field analysis, to robotics for labour-intensive tasks and predictive analytics for assessing crop health and yield potential.

Transforming the Agricultural Landscape

Digital Agriculture is transforming the agricultural landscape in several ways:

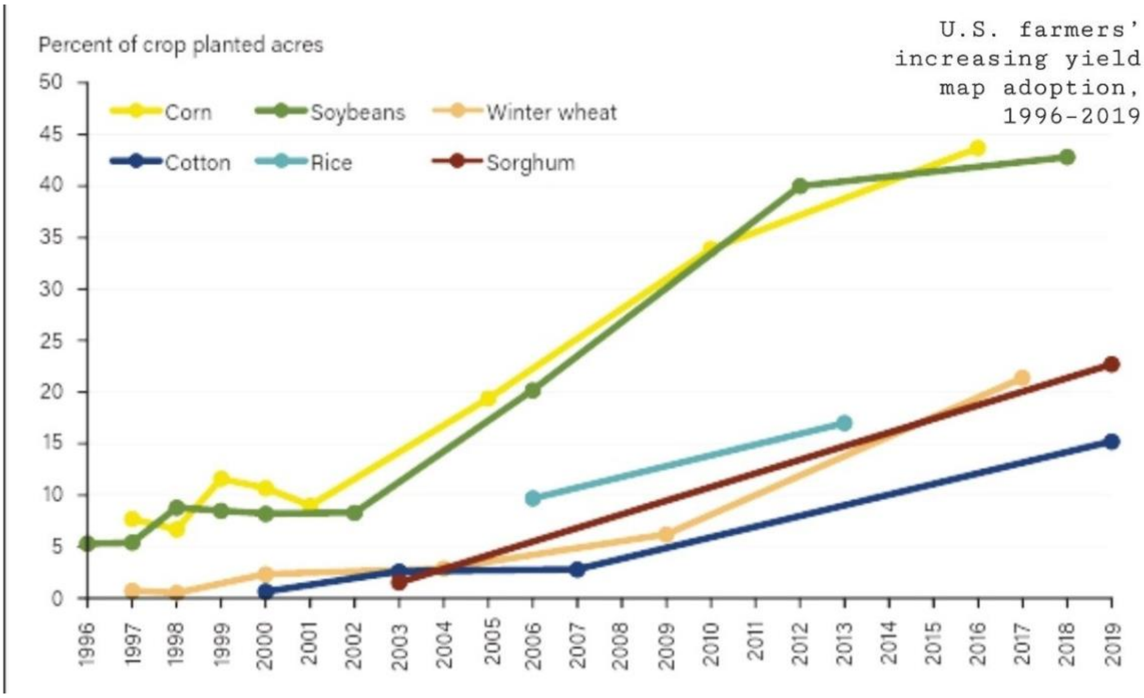
- Efficiency:
  Digital Agriculture technologies can help farmers optimize resource use, reducing inputs like water, fertilizer, and labour, while maximizing crop yield.
- Productivity:
  Real-time monitoring and predictive analytics can improve decision making, leading to increased crop productivity and quality.
- Sustainability:
  By optimizing resource use and reducing waste, Digital Agriculture contributes to more sustainable farming practices, crucial in our effort to mitigate climate change and ensure food security.
- Traceability:
  Digital tools can also improve traceability along the food supply chain, increasing transparency and aiding in food safety measures.

Embracing the Future

While the adoption of Digital Agriculture is not without its challenges – including data privacy concerns, high upfront costs, and the need for digital skills – it represents an exciting opportunity. As we embrace the future, we have the potential to revolutionize the way we grow food and manage our land, contributing to a more sustainable and food-secure world.

Video source: https://lnkd.in/eSpKyCsE

OPTIMIZING INPUTS



What are: yield maps & soil maps?

How do they enable VRT (variable rate technologies)

WHAT ARE YIELD MAPS? (in simple terms)

Think of a geographical map where the different colors tell you how much has been harvested in that specific area.

WHAT ARE YIELD MAPS? (better definition)

Are maps that show the variation in crop yields across a field, generated by collecting data using yield monitoring equipment and processing it into a graphical representation.

WHY DO WE NEED THEM?

These maps help farmers identify areas of consistent high or low yields and adjust their management practices accordingly.

HOW ARE THEY CREATED?

Yield maps are generated using yield monitors, which were once usually mounted on combine harvesters or other forms of auto-guidance systems but are now standard on new equipment.

YIELD MAPS ADOPTION (see chart)

They have been available since the early 1990s and are primarily used by agricultural producers to quantify and characterize within-field production variability.

Image from USDA Economic Research Service illustration

Report: https://lnkd.in/efAJe4pX

By Jonathan McFadden, Eric Njuki, and Terry Griffin

ENERGY SAVING

🔻 20-30% less energy → 🔻 7.2B kWh/y saved → ✅ $8.3 B/y saved (in US alone)

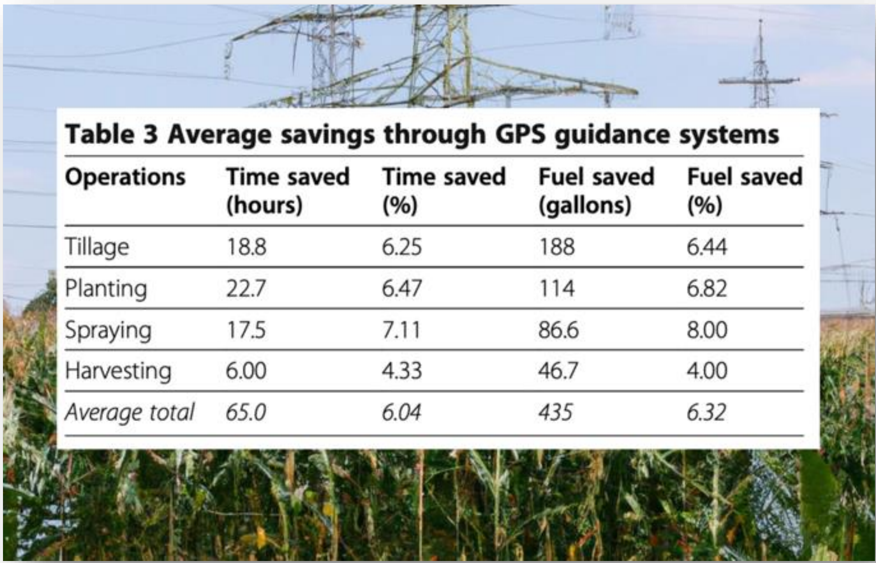


Table 3 Average savings through GPS guidance systems

Operations	Time saved (hours)	Time saved (%)	Fuel saved (gallons)	Fuel saved (%)
Tillage	18.8	6.25	188	6.44
Planting	22.7	6.47	114	6.82
Spraying	17.5	7.11	86.6	8.00
Harvesting	6.00	4.33	46.7	4.00
Average total	*65.0*	*6.04*	*435*	*6.32*

▶ KEY FIGURES

✓ Precision agriculture can save 20-30% energy per farm.

✓ Potential TOTAL ENERGY SAVING: 7.2B kWh/year (in US alone)

✓ Potential TOTAL ECONOMIC BENEFITS: $8.3 B/year (in US alone)

▶ ENERGY SAVING ESTIMATION

▪ Precision agriculture techniques can lead to significant energy savings in crop production, compared to conventional methods.

▪ According to this study (*) precision agriculture techniques can reduce energy use in crop production by 20-30% on average.

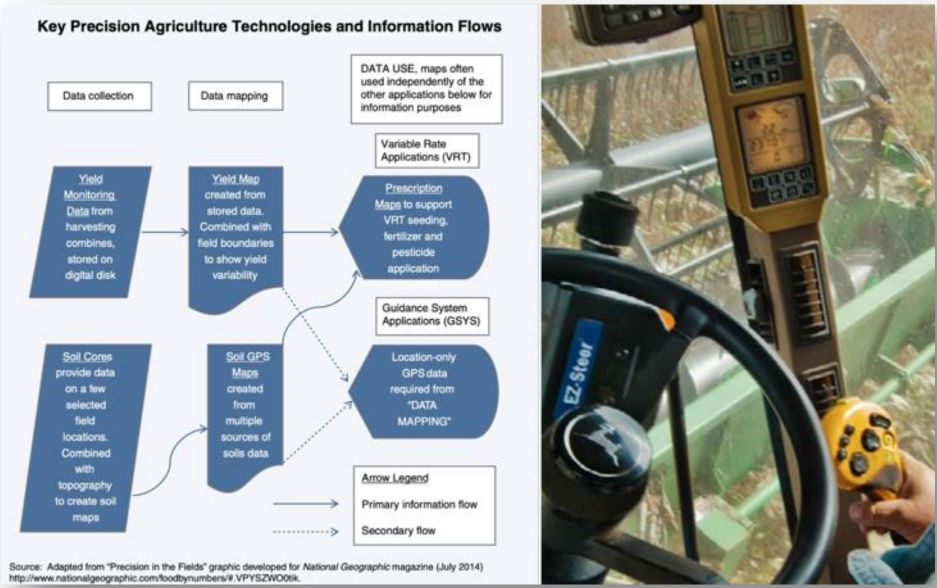
▶ HOW IS ENERGY SAVED?

▪ WATER: The largest energy savings are achieved through the use of precision irrigation systems, which can reduce water use and pumping energy by up to 50%.
▪ VRT: Other precision agriculture technologies that can contribute to energy savings include variable-rate seeding, fertilizer application, and pesticide application.

▶ TOTAL ENERGY SAVED

▪ Precision agriculture practices could result in a total energy savings of 7.2 billion kWh per year in the United States.
▪ This would translate into a reduction in greenhouse gas emissions of 6.4 million metric tons per year.
▪ The adoption of precision agriculture practices could therfore result in economic benefits of $8.3 billion per year in the United States, through reduced energy costs, increased crop yields, and other factors.
(*) Study: "Energy savings by adopting precision agriculture in rural USA"
Authors: Ganesh C Bora, John F Nowatzki and David Roberts, PhD
Link: https://lnkd.in/dgTGAQ_D

DIGITAL AGRICULTURE: ADOPTION & SAVINGS



DATA JOURNEY: 1. collect 2. map 3. optimise inputs

1. collect

▶ Yield Monitor

2. map

▶ Yield Monitor + GPS/GNSS = Yield Map

3. optimise inputs

▶ Yield Map + Automatic steering & VRT= Input optimise

Here is how it works and a description of the required technologies.

⏩ ⏩ DATA JOURNEY ⏪ ⏪

1 - COLLECT --

▶ Yield Monitor

device installed on a combine harvester that measures the crop yield (amount of harvested crop) in real-time as the combine moves through the field. This data is collected along with other information, such as moisture content and the combine's location.

▶ GPS/GNSS

The global navigation satellite systems (GNSS) (historically GPS: Global Positioning System) provides accurate location information to the yield monitor. This location data is crucial for creating accurate yield maps and guiding other precision agriculture technologies.

2 -- MAP --

▶ Yield Mapping

With the data collected by the yield monitor and the GPS/GNSS, a yield map is created showing spatial variations in productivity helping farmers identify high-performing and underperforming areas, allowing them to make informed decisions about resource allocation and management practices.

3. -- OPTIMISE INPUTS --

▶ Automatic Steering System

these technologies use GNSS/GPS data to automatically control tractors and harvesters improving the accuracy and efficiency of field operations, reducing overlap, saving fuel, and minimising soil compaction.

▶ Variable Rate Technology (VRT)

After analysing the data from yield maps and other sources, farmers can use VRT to optimise the use of inputs (seeds, fertilisers, and pesticides) at different rates across the field, based on the specific needs of each area, enhancing crop productivity and reducing waste and environmental impacts.

⏩ ⏩ Larger the farm ▶ higher the adoption ⏪ ⏪

There is a positive correlation between farm size and precision/digital agriculture solutions adoption due to the potential for increased profits, the need for better management of complex operations, greater access to financial resources, and a desire to maintain a competitive advantage in the market.

SOURCE

Report: Farm Profits and Adoption of Precision Agriculture

link: https://lnkd.in/e6fks-5F

Author: David Schimmelpfennig

from US Department of Agriculture (USDA) Agricultural Research Service (ARS)

Digital agriculture: + YIELD, — WATER, — NITROGEN

INTEGRATED STRATEGY: ↑ EFFICIENCY, ↓ ENVIRONMENTAL IMPACT

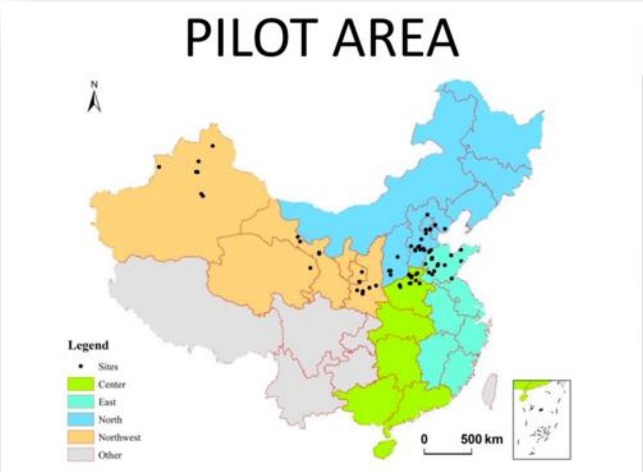


FIGURE 1 | The geographical coverage of the studies used in the meta-analysis. Sites indicate studies' location included in the current study. Refer to the details of regions classification in section "Literature Selection and Data Extraction".

▶ KEY BENEFITS:

- ✅ 5.5% more wheat yield
- ✅ 18.3% less water use
- ✅ 17.6% less nitrogen use
- ✅ Reduced environmental impact

▶ WHAT:

An integrated water & nitrogen management strategy was applied to optimise wheat yield, water, and nitrogen use efficiency.

The strategy included site-specific nitrogen management, variable rate irrigation, and the use of crop sensors.

▶ **HOW:**

- Researchers employed site-specific nitrogen management, variable rate irrigation and crop sensors to monitor plant growth and development.
- The data collected was used to adjust water and nitrogen inputs to optimise crop performance.

▶ **WHERE:**

The study took place in various wheat-growing regions in China.

ARTICLE:
"Optimizing Wheat Yield, Water, and Nitrogen Use Efficiency With Water and Nitrogen Inputs in China: A Synthesis and Life Cycle Assessment"

Zhou Li, Chao Chen (Guizhou University)

Song Cui (Middle Tennessee State University (MTSU))

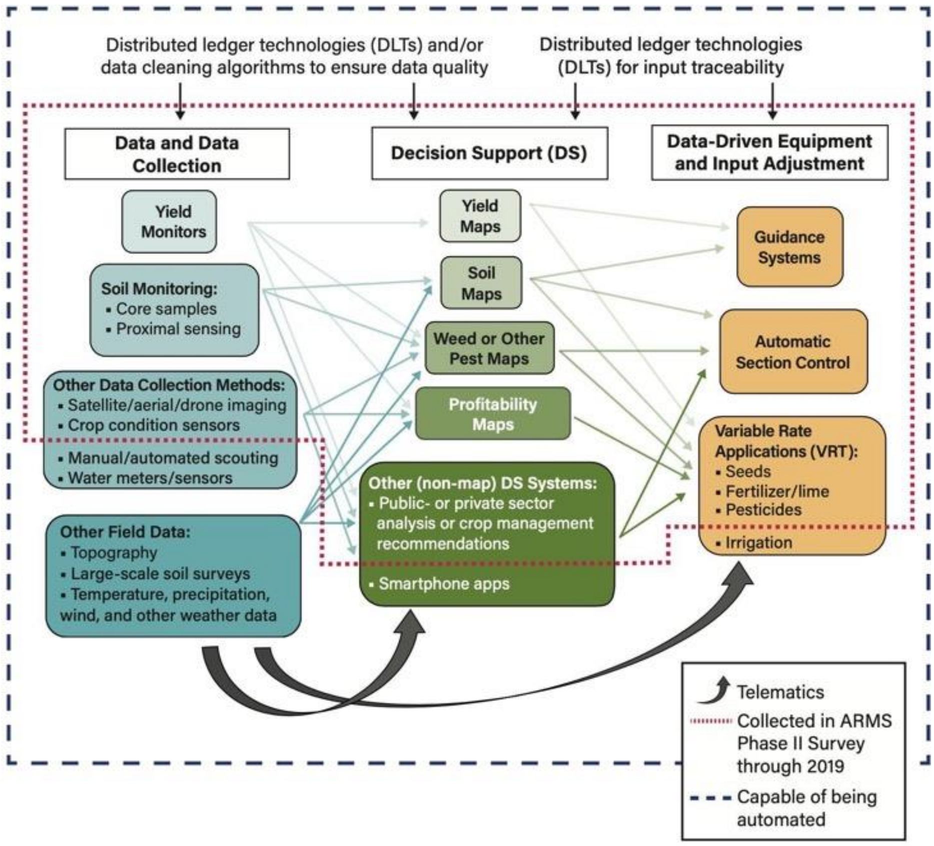
Qingping Zhang (Linyi University)

Gang Xu, Qisheng Feng, Yuan Li (Lanzhou University)

LINK Frontiers

https://lnkd.in/eSq_cyW8

Components of Digital Agriculture



In simple terms is... LISTEN, THINK, ACT

In digital agriculture terms it translates into...

1. Data Collection
2. Decision Support (DS)
3. Data-Driven Equipment and Input Adjustment

1. DATA COLLECTION:

▪ Yield Monitor

▪ Soil Monitoring: Core samples, Proximal sensing

▪ Other Data Collection Methods: Satellite/aerial/drone imaging, Crop condition sensors, Manual/automated scouting, Water meters/sensors

▪ Other Field Data: Topography, Large-scale soil surveys, Temperature, precipitation, wind, and other weather data

2. Decision Support (DS):

▪ Yield Maps

▪ Soil Maps

▪ Weed or Other Pest Maps

▪ Profitability maps

▪ Other (non-map) DS Systems: Public- or private sector analysis or crop management recommendations, Smartphone apps

3. Data-Driven Equipment and Input Adjustment:

▪ Guidance Systems

▪ Automatic Section Control

▪ Variable Rate Applications (VRT): Seeds, Fertiliser/lime, Pesticides, Irrigation

Image from USDA Economic Research Service illustration

Report: https://lnkd.in/efAJe4pX

By Jonathan McFadden, Eric Njuki, and Terry Griffin

Thanks to Dr. Jeanne E. Tomaszewski (World Food System Center, ETH Zurich) to have shared it with me.

TECH EVOLUTION IN PERSPECTIVE

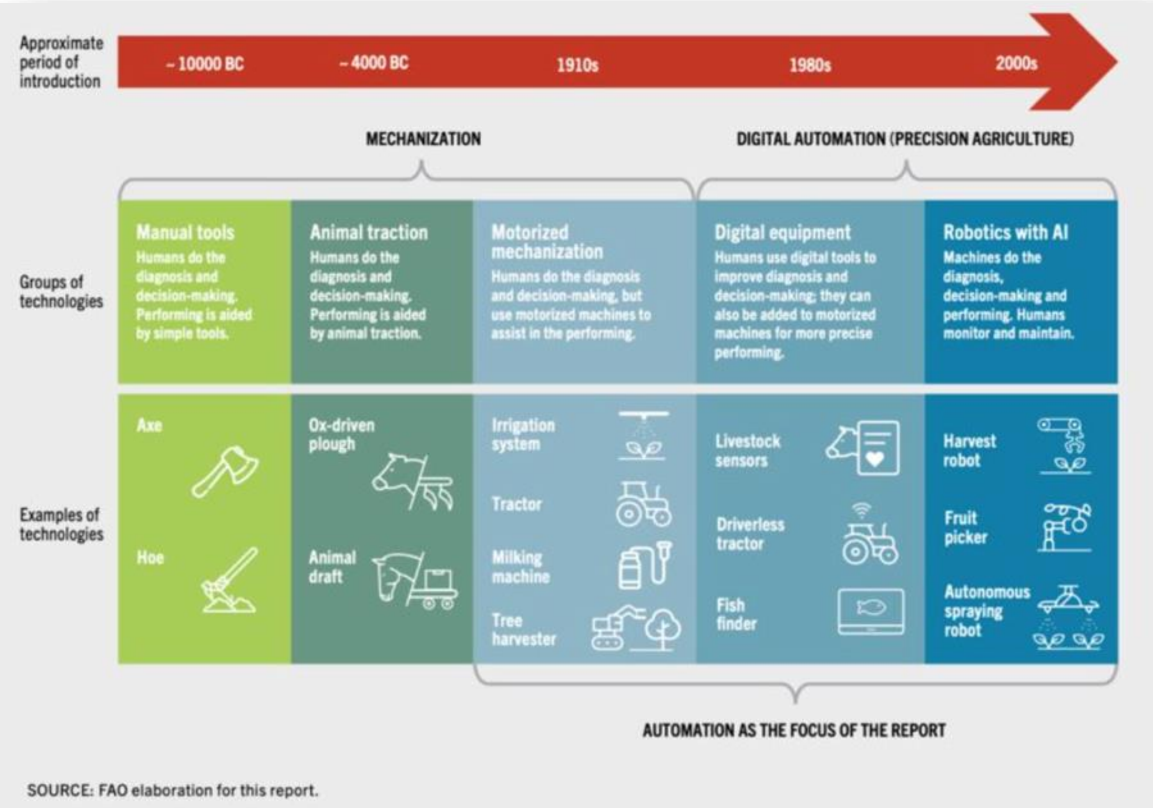
WHAT IS AGRICULTURAL AUTOMATION?

▶ The 3 phases of Agricultural operations:

1 diagnosis (DI)

2 decision-making (DM)

3 execution (E)



▶ DEFINING AUTOMATION

Any technology that automates at least one of the three phases may be classified as an automation technology.
For instance: motorised mechanisation using engine power focuses essentially on the last of the three phases: performing. It automates agricultural operations such as ploughing, seeding, fertilising, milking, feeding, harvesting and irrigating, among many others.

▶ DIGITAL

With the rise of digital technologies and automated equipment such as sensors and robots that rely on machine learning and AI, the automation of diagnosis and decision-making becomes possible.

▶ ALL 3 IN 1

The most advanced automation technologies allow indeed the three phases to be entirely automated. Fruit-harvesting robots are a case in point. These robots carry out all three phases sequentially and automatically, while agricultural producers simply monitor the sensors and maintain the equipment.

▶ MACHINES + DIGITAL = PRODUCTIVITY

Motorised machines are increasingly complemented, or even superseded, by new digital equipment that automates diagnosis and decision-making. For example, a conventional tractor can be converted into an automated vehicle capable of sowing a field autonomously.
Therefore, while mechanisation eases and reduces hard and repetitive work and relieves labour shortages, digital automation technologies further improve productivity by allowing

more precise implementation of agricultural operations and more efficient use of resources and inputs.

▶ TECH EVOLUTION

The technological evolution may be summarised through the following technology categories:

1 Manual tools ⏩ human DI, DM, E

2 Animal traction ⏩ human DI & DM; human & animal E

3 Motorised mechanisation ⏩ human DI & DM; human & motor E

4 Digital equipment ⏩ digital DI, human DM; human & motor E

5 Robotics with AI ⏩ digital DI, DM, E

More on the FAO study:

"THE STATE OF FOOD AND AGRICULTURE LEVERAGING AUTOMATION IN AGRICULTURE FOR TRANSFORMING AGRIFOOD SYSTEM"

https://lnkd.in/eZhkBNgQ

HISTORICAL TRENDS: A SELECTION OF MILESTONES

Year	Technology or activity	Company or organization	Country	Reference
1974	Electronic ID for livestock	Montana State University	United States of America	Hanton and Leach, 1974[50]
1983	Executive order allowing civilian use of GPS	US Government	United States of America	Brustein, 2014[51] Rip and Hasik, 2002[52]
1983	Drone fertilizer and pesticide application	Yamaha	Japan	Sheets, 2018[53]
1987	Computer-controlled VRT fertilizer	Soil Teq	United States of America	Mulla and Khosla, 2016[54]
1992	Milking robot	Lely	Netherlands	Lely, 2022[55] Sharipov *et al.*, 2021[56]
1997	GNSS agricultural equipment guidance	Beeline	Australia	Rural Retailer, 2002[57]
1997	N-Sensor	Yara	Norway	Reusch, 1997[58]
2006	Automated sprayer boom section controllers	Trimble	United States of America	Trimble, 2006[59]
2009	Planter row shut-offs	Ag Leader	United States of America	Ag Leader, 2022[60]
2011	Weeding robot	Ecorobotix Naïo Technologies	Switzerland France	Ecorobotix, 2022[61] Naïo, 2022[62]
2013	Combine harvester operator assistance system	Claas	Germany	Claas, 2022[63]
2017	First fully autonomous field crop production	Harper Adams University	United Kingdom	Hands Free Hectare, 2018[64]
2018	Autonomous chaser bin	Smart Ag	United States of America	Smart Ag, 2018[65]
2022	Autonomous large-scale tractor	John Deere	United States of America	John Deere, 2022[66]

NOTES: GPS – global positioning system; VRT – variable rate technology; GNSS – global navigation satellite system.
SOURCE: Lowenberg-DeBoer, 2022.[48]

The image presents selected milestones in digital automation in agriculture, listing the first mover of each technology.

▶ AUTOMATION ADOPTION

Adoption varies by agricultural commodity, capital cost, wage rate and other economic factors. In any case, adoption by small-scale agricultural producers is negligible…

1 FIRST MOVER: LIVESTOCK SECTOR

Some of the first digital automation technologies emerged in the livestock sector.
Precision livestock farming is made possible by attaching sensors to animals... electronic identification (EID) tagging allow cows to be milked without direct human involvement...
More recently farms with over 1.000 cows have joined medium-sized farms in adopting robotic milking systems due to labour shortages.
Demand is driven by lack of rural labour, coupled with a generational shift.

More:
- automated feeding
- egg count
- computerised control of ventilation (temperature and humidity)

2 MOST ADOPTED TECH: GNSS & VRT

GNSS (*) and VRT (Variable Rate Technology), matched with motorised machinery, are the most widely used in crop production to enable auto-steer and on-the-go application of inputs (fertilisers, herbicides, pesticides).

3 NEXT (COMING): ROBOTS + AI

In the most advanced automation category, autonomous crop robots entered commercial use only very recently. They appear mostly in high-income countries.
A review of 18 cases found that autonomous crop robots used for HARVESTING, SEEDING and WEEDING were economically beneficial in certain circumstances.

4 AUTONOMOUS MACHINES (TRACTORS)

In some countries, autonomous crop machines require on-site human supervision at all times, in which case the farmer may be better off using conventional equipment.
NEEDED:

- greater AI capacity to enable the autonomous machine to resolve more issues without human intervention

- REGULATIONS

(*) Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. Examples of GNSS include Europe's Galileo, the USA's NAVSTAR Global Positioning System (GPS), Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) and China's BeiDou Navigation Satellite System.

More on the FAO study:

"THE STATE OF FOOD AND AGRICULTURE LEVERAGING AUTOMATION IN AGRICULTURE FOR TRANSFORMING AGRIFOOD SYSTEM"

https://lnkd.in/eZhkBNgQ

IMPACT ON TOTAL AGRI-PRODUCTION

Technology	Impact on agriculture
Biotechnology	Genetic modelling to increase the production while decreasing the volatility of the yield and the usage of pesticides.; laboratory-grown meat
Synthetic biology	Crops with higher nutritious values with less resources, and resistant to more variable climates. [16]
Internet of Things (IoT)	IoT to collect and publish information on the production processes and the farm.
Automation and Robotization	Increased productivity by reducing the need for human workforce.[17]
Artificial Intelligence (AI)	Contribute in agricultural robotics (e.g. automatization of farm equipment), soil and crop monitoring (e.g. identify plant diseases), and predictive analytics (e.g. detect pest infestation).[18] [19]
Big Data	Contribute in the decision-making process to increase efficiency in crop planning, intelligent irrigation systems development, pest control, weather alerts implementation.[20]
Global Navigation Satellite System (GNSS)	Improve crop yield and reduce environmental impact through the application of for example farm machinery guidance, automatic steering, variable rate applications, yield and soil condition monitoring.[21]
Drones	Soil, field and crop analysis and monitoring, variable rate applications, e.g. crop spraying and irrigation.[22]
Blockchain	Enhance transparency, accountability and efficiency in agricultural insurance, land registration, and agricultural supply chains.[23]
Augmented Reality	Optimization of the farming process.[24]

Source: VVA

Agri-digital adopted ▶ agri-production in 2050 ▶ 30% yields increase

The usage of new technologies in the agri-food sector can generate numerous benefits:

▶ Technological innovation could potentially increase production more than land expansion. Innovation can boost the Total Factor Productivity (TFP) of the agricultural industry, i.e. it can increase crop and livestock output without an increase of input (e.g. use of land, labour and capital). Technologies have the potential to enable the development of precision agriculture solutions, which overall are expected to increase yields by 30%.

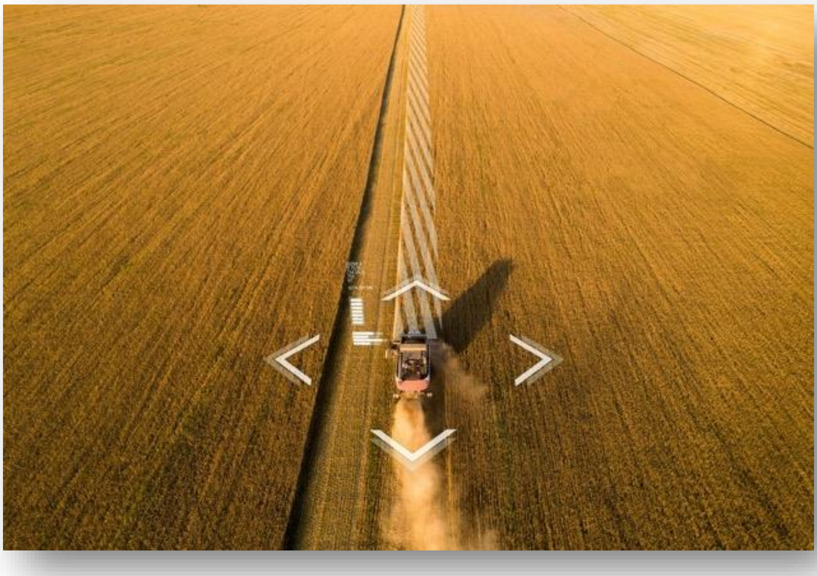
▶ The introduction of new technologies in the agri-food processes can enhance ecological efficiency, considering that agriculture is one of the main causes of the emission of greenhouse gasses (GHGs) and is thus a major factor of climate change. FAO estimates that agriculture is responsible for 21% of total GHG emissions.

Technology improvements can for example be the used for new land and water conservation techniques, improved biodiversity preservation technologies, enhanced production technologies (such as agroforestry, organic agriculture, agroecology) and integrated pest management.

▶ Technological solutions will not only modernise agriculture, increasing the efficiency of its processes, but also create new business models while fostering innovation (e.g. Mobile applications to rent tractors).

More on the European Parliament study:
"Megatrends in the agri-food sector: global overview and possible policy response from an EU perspective"
https://lnkd.in/eE7R_73T

DIGITAL AGRICULTURE GROWTH ESTIMATIONS



AgFunder https://lnkd.in/embTyrup

☑ ERP (Farm Management Systems)

the adoption of farm management systems has been growing steadily over the years, with a compound annual growth rate (CAGR) of around 7.6% from 2016 to 2022. In 2022, the global farm management software market was valued at approximately $1.8 billion, and it's projected to reach around $4.3 billion by 2027.

☑ Data Collection:

technologies for data collection in agriculture, such as remote sensing, drones, and IoT devices, have also seen increasing adoption. The global market for precision agriculture was valued at around $5.9 billion in 2022 and is expected to reach $13 billion by 2027, with a CAGR of 13.1% from 2023 to 2027. Data collection technologies are a significant component of the precision agriculture market.

Decision Support (DS):

Decision support systems, including yield maps, soil maps, and other data-driven tools, have been gaining traction as more farmers recognize their potential to improve decision-making and optimize resource use. The market for agriculture analytics, which includes decision support systems, was valued at around $1.1 billion in 2022 and is projected to reach $1.7 billion by 2025, growing at a CAGR of 14.5% during the forecast period.

Data-Driven Equipment & Input Adjustment:

The adoption of data-driven equipment, such as guidance systems, automatic section control, and variable rate applications, has been on the rise as well. The global market for precision farming technologies, which encompasses data-driven equipment and input adjustment, was valued at around $4.7 billion in 2022 and is expected to reach $10.4 billion by 2025, with a CAGR of 12.3% from 2022 to 2025

More on AgFunder

https://lnkd.in/embTyrup

CHAPTER 2 Technologies for Digital Agriculture

PREV INDEX NEXT

REMOTE SENSING: WHAT, WHY, WHO

IN SIMPLE TERMS

Remote sensing = looking at crops from the sky to make better decisions.

TECHNICALLY

It refers to the use of satellite or aerial imagery, drones, and sensors to collect data on various aspects of crop health, soil conditions, and environmental factors. This information is then analyzed to make informed decisions on crop management, irrigation, and fertilizer application, ultimately leading to optimized agricultural practices and increased productivity.

1. Crop Monitoring

▪What is it: Continuous observation of crop health and growth stages using remote sensing data and imagery.

▪Benefits for farmers: Timely identification of issues, efficient crop management, and increased yield.
▪Benefits for the environment: Targeted interventions reduce resource waste and minimize negative environmental impacts.
▪Market solutions: CropX, Taranis, Farmers Edge, SatSure, Orbital Insight.

2. Soil Moisture Monitoring

▪What is it: Measurement of soil water content using remote sensing techniques and sensors.
▪Benefits for farmers: Optimal irrigation scheduling, reduced water waste, and improved crop health.
▪Benefits for the environment: Conserved water resources and reduced runoff pollution.
▪Market solutions: Sentek, AquaSpy, Irrometer, METER Group, Arable Labs.

3. Nutrient Management

▪What is it: Assessment of soil nutrient levels using remote sensing data to inform precise fertilizer application.
▪Benefits for farmers: Improved crop yield, reduced fertilizer costs, and optimized resource use.
▪Benefits for the environment: Minimized nutrient runoff and reduced environmental pollution.
▪Market solutions: Yara, AgroCares, Cropnuts, TerrAvion, Agrology.

4. Weed Detection

▪What is it: Identification and mapping of weeds in agricultural fields using remote sensing imagery.
▪Benefits for farmers: Targeted weed control, reduced herbicide costs, and increased crop yield.
▪Benefits for the environment: Decreased herbicide use and minimized impact on non-target species.

▪Market solutions: Blue River Technology, ecoRobotix, Green Atlas, Bilberry, AgEagle.

5. Yield Estimation

▪What is it: Prediction of crop yield using remote sensing data and advanced analytics.

▪Benefits for farmers: Improved decision-making, supply chain management, and market planning.

▪Benefits for the environment: Enhanced resource management and waste reduction.

▪Market solutions: Descartes Labs, Geosys, Agrivi, OneSoil, Gro In

Video from Geospatial World:

https://lnkd.in/eMhC5YD3

DIGITAL TECHNOLOGIES TRANSFORMING THE FOOD VALUE CHAIN

Addressing key challenges across segments and subsegments

Food Value Chain: digital technologies

Segment	Subsegments	Key Challenges	Digital Technologies	Acceleration Strategies
Production	Large farms (> 1,000ha)	Resource optimization, labor shortage, environmental impacts	Precision agriculture, IoT, drones, remote sensing	Government incentives, capacity building, R&D, infrastructure development, public-private partnerships
	Middle size farms	Financial constraints, technical knowledge, access to technology	Precision agriculture, IoT, farm management software	Capacity building, financial support, infrastructure development, technology transfer
	Smallholder farmers (< 2ha)	Limited resources, lack of technical knowledge, market access	Mobile apps, digital platforms, remote sensing	Tailored capacity building, affordable financing, technology transfer, public-private partnerships
	Indoor intensive production	Energy consumption, waste management, scalability	IoT, sensors, controlled environment agriculture (CEA) technologies	R&D, energy-efficient technologies, waste management solutions, collaboration with research institutions
Processing	Primary processing	Quality control, traceability, energy efficiency	Automation, sensors, IoT, AI, machine learning	Investment in R&D, training programs, collaboration with technology providers, energy-efficient technologies
	Secondary processing	Customization, automation, reducing waste	Robotics, AI, machine learning, 3D printing	R&D, collaboration with research institutions, technology transfer, public-private partnerships
Distribution	Transportation	Reducing food waste, energy efficiency, traceability	IoT, sensors, GPS tracking, AI-driven analytics	Investment in infrastructure, collaboration between stakeholders, innovative business models
	Warehousing	Inventory management, reducing waste, energy efficiency	IoT, sensors, AI, robotics, automated storage and retrieval systems	Energy-efficient technologies, collaboration with technology providers, capacity building
Retail and Food Service	Supermarkets and grocery stores	Personalization, inventory management, waste reduction	AI, machine learning, IoT, mobile apps, digital signage	Capacity building, investment in infrastructure, partnerships with technology providers, data-driven insights
	Restaurants and institutional caterers	Order management, waste reduction, personalization	AI, IoT, mobile apps, digital menu boards, smart kitchen equipment	Technology integration, training programs, innovative business models, data-driven insights
Consumption	Food purchase	Promoting healthy and sustainable diets, reducing waste	Mobile apps, digital platforms, AI-driven recommendations	Consumer education, marketing campaigns, collaborations with food industry stakeholders
	Food consumption	Encouraging sustainable eating habits, reducing food waste	IoT, smart appliances, food tracking apps	Consumer education, behavioral change campaigns, collaborations with food industry stakeholders

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🚀 Develop digital infrastructure and connectivity
🚀 Encourage public-private partnerships
🚀 Strengthen policy frameworks and regulatory systems

By leveraging digital technologies across the food value chain, we can address key challenges, improve resource management, and ensure a more sustainable, efficient, and resilient food system.

LoRaWAN: MOVING DATA FROM FIELD TO CLOUD

1 What is LoRaWAN?

It's a communication infrastructure.
Think about the communication infrastructure allowing our mobile phones to communicate. Translate it for sensor and you have LoRaWAN.

2 What PROBLEM does LoRaWAN address?

Sensors need to communicate data to the cloud, therefore they need an internet connection. LoRaWAN provides it.

3 Why can't we use the mobile phone network?

It works, but it's not convenient. It's like going shopping with a truck, you can do it, but a bicycle or a small car would certainly be more convenient (and cheaper).
The mobile phone network has been conceived to allow us to send our vocal messages and receive them. That means real time communication of large amount of data. It's like a truck.
While agri-sensors mostly need to communicate few data and receiving them with some second of delay is in the majority of the cases acceptable.

4 Some leading countries:

▶ The Netherlands
Lorawan has been widely adopted in the Netherlands, with a significant deployment in rural areas, including agriculture and livestock management.

▶ **Switzerland**

Swisscom (Swiss telco operator) has already covered the majority of the country with LoRa service. In most of the part of the country a farmer can just buy a LoRa sensor and receive its data without the need of further equipment.

▶ **Germany**

There have been initiatives to extend Lorawan coverage in rural areas of Germany, especially in the agriculture sector.

▶ **France**

Lorawan has been deployed in rural areas of France, with a focus on smart agriculture and rural connectivity.

▶ **United States**

Lorawan has been deployed in rural areas of the United States, with a focus on agriculture, asset tracking, and environmental monitoring.

▶ **United Kingdom**

Lorawan has been deployed in rural areas of the United Kingdom, with a focus on agriculture and rural connectivity.

5 Main OEM vendors:

Actility,

Siemens,

Senet,

Helium,

NNNCo (National Narrowband Network Co),

kerlink ,

ThingsIO.AI,

LORIOT,

WAVIoT – IoT solutions for AMI, Energy & Utilities, Industrial automation and Monitoring

RAKwireless,

adeunis,

Telit IoT Solutions,

Rohde & Schwarz,

MULTITECH,

TE Connectivity

Hardware investments to implement LoRaWAN all over INDIA

LoRaWAN in **ALL RURAL INDIA?**
USD 36M (total infrastructure direct costs – *rough estimation*)

LORA GATEWAY RANGE (assuming rural flat areas):
15-20 Km (circle ray) -> area = **706** Km^2 **- 1250** Km^2 *(maximum distance ever reached: 702 km)*

INDIA RURAL SURFACE:
1.4M km² (140 MILLION hectares according to FAO)

HOW MANY GATEWAY FOR RURAL INDIA? LoRa Gateways number for the entire rural Indian area
12.000 Gateways
(assuming minimum gateway distance performances and considering an increasing factor of about 600% due to orography irregularity and disconnected area)

POTENTIAL SENSORS SERVED:
120 Million of agri-sensors

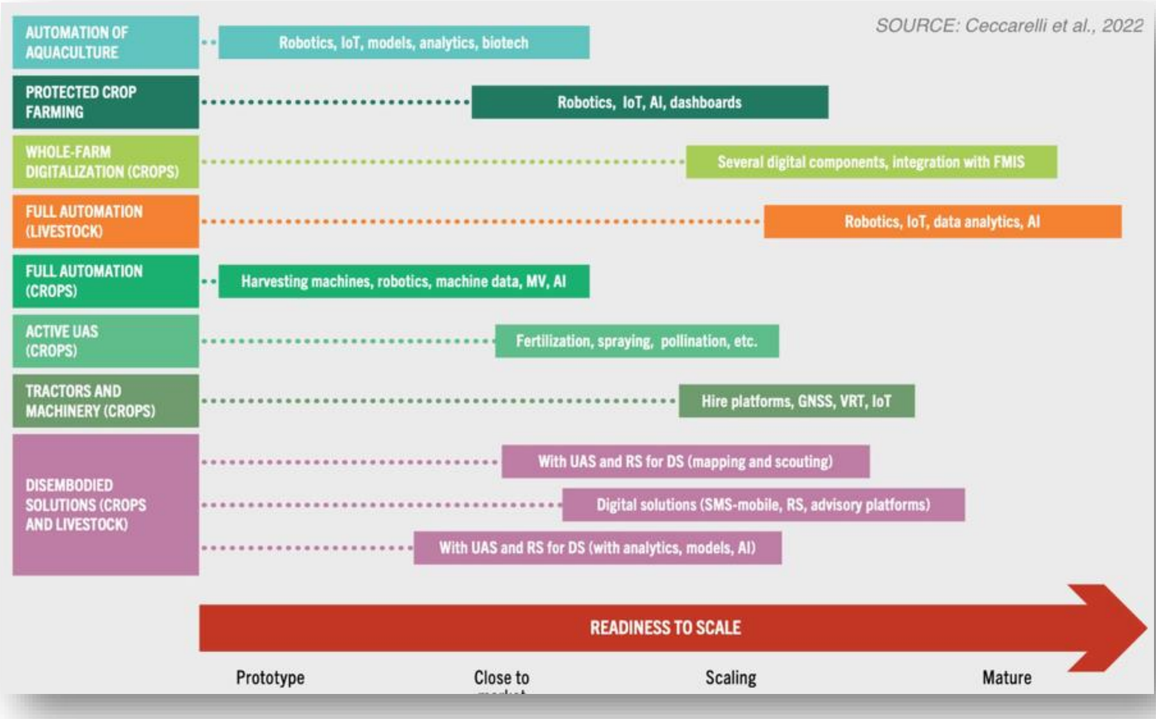
- One eight-channel gateway can support a 250.000 (probably more) messages per day
- Sensors for Agriculture should normally send 1 message per hour, so 24 messages per day;
- One eight-channel gateway can support 10.000 sensors in its area

TOTAL COST:
USD 36 Millions

UNITARY COSTS:
USD 1.000 LoRa Gateway cost (assuming an order of 12.000 Gateways)
USD 2.000 Installation cost (leveraging installation points WITH INTERNET made available by the rural communities)

TECHNOLOGIES READINESS

What is ready to be adopted? What's ahead?



While working to have fully integrated solutions for farms (still far away), let's have a look at the readiness of each sub-sector within the (extremely) diversified Agriculture sector.

⏩ LIVESTOCK has been driving automation in agriculture.

(more here: https://lnkd.in/ernfgjAg)

⏩ ERP comes second: it's the "innovation" that each farm should have: farm software management. Such software have been adopted in every other sector so far, significantly increasing processes efficiency.

(more about this here: https://lnkd.in/eWvfbZW7)

⏩ ADVISORY SERVICES come third; that include agronomic recommendations (when seeding, disease identification, lack of fertilisers assessment, but also pricing, financial...)

What are the readiness stages?

1 PROTOTYPE:
concept has been tested and demonstrated in limited trials;

2 CLOSE TO MARKET:
solution functions under real production settings, and the service provider is investigating one or more business models to reach clients;

3 SCALING:
the solution has been adopted by several end users/clients, and one or more business models are profitable;

4 MATURE:
the solution has a dedicated client base, one or more business models are profitable, and demand is growing.

Acronyms:
UAS: uncrewed aerial system (for instance drones)
IoT: internet of things;
AI: artificial intelligence;
FMIS: farm management information system (ERP);
MV: machine vision;
GNSS: global navigation satellite system;
VRT: variable rate technology;

RS: remote sensing;

DS: decision support.

More on the FAO study:

"THE STATE OF FOOD AND AGRICULTURE LEVERAGING AUTOMATION IN AGRICULTURE FOR TRANSFORMING AGRIFOOD SYSTEM"

https://lnkd.in/eZhkBNgQ

SATELLITES for Digital Agriculture.... WHICH ONES?

LIST of ACTIVE satellites for digital agriculture

▶ **AVHRR**

SENSOR: MS

SPATIAL RES.: 1.1 km

TEMP. RES.: 1 day

AGRI-APP: Biomass , crop yield & growth

▶ **Landsat 7**

SENSOR: MS & Thermal

SPATIAL RES.: SWIR 30m / Thermal 100 m

TEMP. RES.: 16 days

AGRI-APP: Crop growth

▶ Landsat 8

SENSOR: MS & Thermal

SPATIAL RES.: SWIR 30m / Thermal 100 m

TEMP. RES.: 16 days

AGRI-APP: Crop yield, soil properties, nutrient management, ET estimation

▶ LiDAR

SENSOR: VIS

SPATIAL RES.: 10 cm

TEMP. RES.: 1–6 days

AGRI-APP: Crop yield & growth, water management

▶ Terra/Aqua MODIS

SENSOR: MS (SpectroRadiometer)

SPATIAL RES.: 250–1000 m

TEMP. RES.: 1–2 days

AGRI-APP: Disease , crop yield, crop growth, water management

▶ Terra-ASTER

SENSOR: MS & Thermal

SPATIAL RES.: 15 m (V, NIR), 30 m (SWIR), 90 m (TIR)

TEMP. RES.: 16 days

AGRI-APP: LAI and biomass, nutrient management, crop growth

▶ KOMPSAT-2

SENSOR: MS

SPATIAL RES.: 4 m

TEMP. RES.: 5.5 days

AGRI-APP: Crop growth

▶ **Radarsat-2**

SENSOR: C-band SAR

SPATIAL RES.: 1–100 m

TEMP. RES.: 3 days

AGRI-APP: Crop yield, N management

▶ **RapidEye**

SENSOR: MS

SPATIAL RES.: 6.5 m

TEMP. RES.: 1–5.5 days

AGRI-APP: Disease

▶ **GeoEye-1**

SENSOR: MS

SPATIAL RES.: 1.65 m

TEMP. RES.: 2.1–8.3 days

AGRI-APP: Crop yield, water management

▶ **WorldView-2**

SENSOR: MS

SPATIAL RES.: 1.4 m

TEMP. RES.: 1.1 days

AGRI-APP: Crop growth

▶ **Pleiades-1A**

SENSOR: MS

SPATIAL RES.: 2 m

TEMP. RES.: 16 days (repeat)

AGRI-APP: ET

▶ **Pleiades-1B**

SENSOR: MS

SPATIAL RES.: 2 m

TEMP. RES.: 1.4 days

AGRI-APP: Crop growth

▶ **VIIRS Suomi-NPP**

SENSOR: MS (IR Radiometer)

SPATIAL RES.: 375 m and 750 m

TEMP. RES.: 1 day

AGRI-APP: Nutrient management

▶ **VIIRS-JPSS-1**

SENSOR: MS (IR Radiometer)

SPATIAL RES.: 375 m and 750 m

TEMP. RES.: 1 day

AGRI-APP: Crop growth

▶ **KOMPSAT-3**

SENSOR: MS

SPATIAL RES.: 2.8 m (V, NIR), 5.5 m (SWIR)

TEMP. RES.: sub-daily

AGRI-APP: Crop management (NDVI)

▶ **Spot-6**

SENSOR: MS

SPATIAL RES.: 6 m

TEMP. RES.: 1–3 days

AGRI-APP: Crop growth

▶ **Spot-7**

SENSOR: MS

SPATIAL RES.: 6 m

TEMP. RES.: 2–5 days

AGRI-APP: Crop yield

▶ **SkySat-1**

SENSOR: MS

SPATIAL RES.: 1 m

TEMP. RES.: 1.4 days

AGRI-APP: Disease

▶ **SkySat-2**

SENSOR: MS

SPATIAL RES.: 1 m

TEMP. RES.: 2–3 days

AGRI-APP: Crop growth

▶ **Worldview-3**

SENSOR: SS

SPATIAL RES.: 1.24 m

TEMP. RES.: 1 day

AGRI-APP: Crop yield, water management

▶ **Sentinel-1**

SENSOR: C-band SAR

SPATIAL RES.: 5–40 m

TEMP. RES.: 1–5 days

AGRI-APP: Crop growth [128]

▶ **Sentinel-2**
SENSOR: MS
SPATIAL RES.: 10 m (V, NIR), 20 m (Red edge, SWIR),
60 m (2 NIR)
TEMP. RES.: 5 days
AGRI-APP: ET

▶ **KOMPSAT-3A**
SENSOR: MS
SPATIAL RES.: V, NIR - 2.2 m; SWIR - 5.5 m
TEMP. RES.: sub-daily
AGRI-APP: Crop growth

▶ **TripleSat**
SENSOR: MS
SPATIAL RES.: 3.2 m
TEMP. RES.: 1 day
AGRI-APP: Crop growth
Source: "Applications of Remote Sensing in Precision Agriculture: A Review"
https://lnkd.in/eS6mEHmv

CHAPTER 3 Solutions for Digital Agriculture

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DIGITAL AGRICULTURE: PLAYERS

Farm Management Systems	Data Collection	Decision Support (DS)	Data-Driven Equipment/Input Adjustment
Granular	Farmers Edge	aWhere	John Deere (Precision Ag)
Conservis	Taranis	Proagrica (Sirrus)	AGCO Corporation (Fuse Technologies)
Agworld	The Climate Corporation	Agrible (Morning Farm Report)	CNH Industrial (PLM Software)
Trimble Ag Software	Semios	Nutrien Ag Solutions (Echelon)	Raven Industries (Precision Agriculture Solutions)
FarmLogs	Arable	xarvio (Digital Farming Solutions)	Topcon Agriculture
Farmers Business Network (FBN)	CropX	Agro.Club	DJI Agriculture
Farmbrite	Pessl Instruments (iMetos)	Agronow	Smart Ag (Autonomous Tractor Technology)
AGRIVI	Sentera	Growers Edge	Blue River Technology (See & Spray)
AgriWebb	SatSure	FARMWAVE	Kubota (AgriRobo)
Cropio	Orbital Insight	Farm-Trace	ecoRobotix
Agri-Data Solution	SkySquirrel Technologies	Farmobile	Precision Planting
Croptracker	TerrAvion	Iteris ClearAg	Trimble Inc.
farm-file	Pix4D Agriculture	MyAgData	Claas (EASY)
Farmflo	Ceres Imaging	FieldNET Advisor	360 Yield Center
Farmplan	FluroSat	Precision Planting (PTI)	Ag Leader Technology
AgSquared	Hummingbird Technologies	Ag-Analytics	SST Software (Sirrus)
Fieldmargin	Scanit Technologies	SoilCares	Jacto
GeaCompass	AgEagle Aerial Systems	CropIn	Lindsay Corporation (FieldNET)
SoftAgro	BioCarbon Engineering	DecisionNext	Tule Technologies
Agrimap	AgroScout	Plantix	Bosch (Deepfield Robotics)
Agrinavia	Gamaya	Greenlight Guru	Valmont Industries (Valley Irrigation)
AgOS	Aerobotics	Phytobiotics	Reinke Manufacturing
EffiCrop	Solvi	Smart Yields	TeeJet Technologies
FarmFact	UrtheCast	Agrivi Analytics	Yara International (N-Sensor)
FarmWizard	MicaSense	FieldClimate	Horsch (iBox)
FarmRexx	Skycision	OneSoil	Pöttinger
			@Marco Brini

This table lists some of the most relevant AgTech players conveniently grouped according to the criteria proposed in my recent book about efficiently implementing digital agriculture in a farm: https://lnkd.in/erkK6kNx
(Chapter: COMPONENTS OF DIGITAL AGRICULTURE: SUMMARY TABLE)
Although this list is far from being exhaustive, checking these companies may help the reader to better understand digital agriculture and eventually choose some of their solutions to be implemented.

Link to free ebook for efficiently implement digital agriculture:

https://lnkd.in/eBMJYA8E (ResearchGate)

https://lnkd.in/e7qN264W (Academia.edu)

CROP MONITORING SOLUTIONS

Adoption Rates by Region

Farms adoption of crop monitoring solutions

	Large Farms (>1000 ha)	Medium Size Farms	Smallholder Farms (<2 ha)	Indoor Intensive Production
North America	High	Moderate	Low	Moderate
Central America	Moderate	Moderate	Low	Low
South America	High	Moderate	Low	Low
North Africa	Moderate	Low	Very Low	Low
Sub-Saharan Africa	Low	Low	Very Low	Very Low
Western Europe	High	High	Moderate	High
Eastern Europe	Moderate	Moderate	Low	Moderate
Middle East	Moderate	Low	Very Low	Moderate
Asia	High	Moderate	Low	High
Oceania	High	Moderate	Low	Moderate

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1. North America:

Crop monitoring solutions are widely adopted in this region, particularly in the United States and Canada. Farmers are increasingly utilising advanced technologies such as satellite imagery, drones, and data analytics to optimise crop health and yield.

2. Europe:

European farmers are also embracing crop monitoring technologies, driven by strong innovation ecosystems and supportive policies. Countries like the Netherlands, Germany, Switzerland and the United Kingdom are leading the way in crop monitoring adoption.

3. Asia-Pacific:

In this region, crop monitoring adoption varies significantly between countries. Countries like Australia, New Zealand, and Japan have high adoption rates, while other countries, especially those in Southeast Asia, face challenges such as limited access to technology and infrastructure.

4. Latin America:

Crop monitoring adoption in Latin America is growing, with Brazil and Argentina as frontrunners. Factors such as increasing demand for food, a growing middle class, and supportive government policies are driving the adoption of innovative crop monitoring technologies.

5. Africa:

Crop monitoring adoption in Africa is generally lower than in other regions, mainly due to infrastructure limitations, access to technology, and financial constraints. However, there is a growing interest in crop monitoring solutions, particularly mobile-based technologies that can empower smallholder farmers.

As crop monitoring solutions continue to advance, there is an opportunity for more regions and countries to benefit from innovative solutions that can help optimise food production, reduce waste, and promote sustainability.

COUNTING, MONITORING & HERDING cattle…

WHAT FOR?

1. Cattle Counting and Monitoring
2. Drones for Farm Security
3. Herding Cattle With Drones
4. Drones for pasture monitoring

WHY?

Automated cattle counting with drones saves time and is more accurate.
“In the past, counting cattle required 4-6 people and probably 15-20 hours a week,” he says. “Now we can do it in much less time.”

WHO? (SOLUTIONS)

- BeeFree Agro

https://beefreeagro.com/

1. Open the app

2. select the field to analyse
3. activate the drone
4. receive detailed report & images

autonomous livestock management system that locates and counts cattle on large pastures or feedlots, providing essential information in minutes letting the farmer focus on solving problems rather than looking for cattle.

▸ CattleQuants

https://lnkd.in/e6TPsjKi

collects aerial images via drone, runs them through our AI-powered counting software and gives a detailed inventory report.

“CattleQuants is a great tool and really easy to use. There is nothin’ like it! It saved me a lot of time and made my life a lot easier!”

▸ HeadCount and Crop Quest, Inc.

Simply turn on your drone and press “PLAY” on your flight app. The drone takes off and executes the flight plan on its own. Images of each selected pen are automatically captured. The drone will automatically return back to its take off point once it has completed its flight plan.

▶ Do It Yourself

Hackster.io

Thanks to 🐄 Faan Basson (ACG) 🌱 for his request

Video from: BeeFree Agro

Digital Ag solutions for soil health (for large farms)

Digital/Precision Agriculture Solution	Market Solution & Provider	Short Description	Benefits	Disadvantages/Limits
Soil Sensors	Wireless Soil Moisture Sensor SOIL SCOUT	Wireless underground soil sensors providing real-time data.	Access to real-time and continuous data, even from below the surface.	High initial investment, requires technical knowledge to interpret data.
	AgroCares F Series Scanner agrocares	Handheld soil scanner providing real-time nutrient analysis.	Portable and easy to use, provides immediate results.	Limited to surface soil samples, requires purchase of analysis credits.
	Smart Soil Sensors teralytic	Sensors providing detailed soil quality data including NPK.	Offers comprehensive soil health data, easy-to-use platform.	High initial investment, requires cellular or LoRa connectivity.
Precision Fertilizer Application	GreenSeeker Trimble.	Handheld crop sensor for real-time fertilizer application.	Reduces over-application, improves nutrient use efficiency.	May require additional Trimble equipment for full functionality.
	OptRx Crop Sensors Ag Leader	Crop sensors that direct variable rate application in real-time.	Can be used day or night, and in a variety of crop types.	Requires integration with other Ag Leader technology.
	Yara N-Sensor YARA	Real-time sensor for variable rate nitrogen application.	Proven yield and quality improvements, reduces environmental impact.	Designed specifically for nitrogen, not other nutrients.
Cover Cropping and Crop Rotation Decision Support Tools	Granular (Corteva)	Farm management software offering crop rotation planning.	Comprehensive farm management tool, user-friendly interface.	Subscription-based, may offer more features than needed for some farmers.
	Adapt-N YARA	Nitrogen recommendations taking into account previous crop and cover crop.	Tailored nitrogen advice, considers effect of cover crops.	Only covers nitrogen, not other nutrients or aspects of rotation planning.
	Sirrus	Field-level decision support for crop management.	Allows for in-depth analysis and planning, customizable.	May require other SST Software products for full functionality.
Remote Sensing Technologies	FarmSight JOHN DEERE	Integrated suite of remote sensing and equipment management tools.	One integrated system for equipment and field monitoring.	Requires investment in John Deere equipment.
	FieldAgent sentera	Drone and satellite field imagery and analytics.	High-resolution imagery, wide range of analyses available.	Cost of drone and software may be high for some farmers. Requires technical skills to operate drones and analyse data.
	Planet planet.	Satellite imagery service providing daily, global coverage.	Frequent updates, wide coverage, different imagery types (RGB, thermal, NDVI).	Subscription service, data analysis requires technical skills.

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Soil Health Challenges

Large farms often practice monoculture, which is the agricultural practice of growing a single crop or plant species over a wide area and for many consecutive years. This practice is common due to its economic benefits: it simplifies management and improves the efficiency of planting, pest control, and harvesting.

However, monoculture farming can lead to severe soil degradation and loss of fertility over time. This is because each crop type has a specific nutrient requirement and continuous planting of the same crop depletes those specific nutrients from the soil. Furthermore, monoculture farming does not allow for the natural replenishment of soil nutrients that typically occurs in more diverse cropping systems. This nutrient depletion can lead to poor soil structure, decrease in organic matter, and reduced soil microbial activity, all of which are critical for maintaining healthy soils.

If this challenge is not addressed properly, it can result in numerous negative impacts:

· **Declining Crop Health and Yield:** as soil fertility decreases, crops may become less healthy and yields may decline, impacting the productivity and economic viability of the farm.

· **Increased Dependence on Fertilizers:** to compensate for the loss of soil fertility, farmers may become increasingly reliant on synthetic fertilizers, which can lead to further soil degradation, groundwater contamination, and increased costs.

· **Environmental Impacts:** soil degradation can result in increased erosion, loss of biodiversity, and contributes to climate change through the release of stored carbon.

· **Food Security:** in the long term, a decline in soil health can threaten food security by reducing the land's productive capacity.

Therefore, it's critical to implement sustainable farming practices that maintain and enhance soil health, especially in large-scale farming operations.

Soil Health Digital/Precision Agriculture solutions

To mitigate the effects of this issue several digital and precision agriculture solutions can be adopted:

· **Soil Sensors:** these devices are placed in the field to provide real-time data on soil moisture, temperature, and nutrient content. This information can guide farmers to apply water, fertilisers, and other inputs only when and where they are needed, reducing excessive use and soil degradation.

· **Precision Fertiliser Application:** GPS-guided equipment can apply fertilisers with high precision, reducing over-application and ensuring nutrients are delivered where they are most needed. This can improve soil health and reduce nutrient runoff into nearby waterways.

· **Cover Cropping and Crop Rotation Decision Support Tools:** these digital tools help farmers to plan and manage crop rotations and cover cropping, which can improve soil health and reduce the need for synthetic fertilisers. They use data on local conditions, crop characteristics, and other factors to provide recommendations.

· **Remote Sensing Technologies:** satellite or drone-based imagery can provide a larger-scale view of the farm and reveal patterns and issues such as soil erosion or nutrient deficiency that might not be visible at ground level.

The ideal scenario would be a combination of these solutions to achieve a comprehensive approach to soil health management. Soil sensors and remote sensing technologies would provide continuous monitoring of soil conditions across the entire farm. This data would feed into decision support systems for precision application of water and fertilisers, as well as for planning crop rotations and cover cropping. This would ensure that all actions taken are data-driven and specifically tailored to the needs of the soil and crops at any given time, leading to improved soil health, reduced environmental impact, and potentially increased yields. The challenge would be to manage the initial investment and the complexity of integrating these systems, but the potential benefits in terms of improved soil health and farm sustainability can be significant.

Solutions:

Soil Scout

AgroCares

Teralytic

Trimble Inc.

Ag Leader Technology

Yara International

Granular (Corteva Agriscience)

@sirrus

John Deere

Sentera

Planet

GRAINS QUALITY ANALYSIS

Company	Solution	Technology	Parameters Measured	How & When	Website
FOSS	Infratec Series	Near-Infrared Spectroscopy (NIR)	Moisture, protein, oil, and other constituents	Benchtop analyzer; **used in the lab** during post-harvest quality control	www.fossanalytics.com/
PerkinElmer	DA 7250 NIR Analyzer	Near-Infrared Spectroscopy (NIR)	Moisture, protein, oil, starch, and other parameters	Benchtop analyzer; **used in the lab** during post-harvest quality control	www.perkinelmer.com/category/grain-analyzers
agrocares	Lab-in-a-box	NIR and X-ray fluorescence	Nutrient content in grains and soil samples	Portable device; **used in the field** and lab for on-the-spot analysis	www.agrocares.com/
GrainSense	GrainSense	Near-Infrared Spectroscopy (NIR)	Protein, moisture, oil, and carbohydrate content	Handheld device; **used in the field** during harvest for real-time analysis	www.grainsense.com/
DICKEY-john	GAC 2500-UGMA	Radio Frequency (RF) Technology	Moisture, temperature, and test weight	Benchtop analyzer; **used in the lab** during post-harvest quality control	www.dickey-john.com/
SATAKE	REACH	Advanced imaging technology	Color, shape, size, and other quality parameters	Sorting machine; used in **processing plants** for post-harvest quality control	satake-group.com/
zeltex	ZX-101XL	Near-Infrared Spectroscopy (NIR)	Moisture, protein, oil, fiber, and other parameters	Portable device; **used in the field** and lab for on-the-spot analysis	www.zeltex.com/
BÜHLER	MYTA	Optical spectroscopy	Protein, moisture, ash, wet gluten, and other parameters	Online analyzer; integrated into the **processing line** for real-time monitoring	www.buhlergroup.com/
Next Instruments	CropScan	Near-Infrared Spectroscopy (NIR)	Protein, moisture, oil, starch, and other parameters	Mounted on a combine harvester; used **in the field** during harvest for real-time analysis	www.nextinstruments.net/
Seedburo Equipment Company	DICKEY-john Mini GAC Plus	Radio Frequency (RF) Technology	Moisture and test weight	Handheld device; **used in the field and lab** for on-the-spot analysis	www.seedburo.com/

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DIGITAL IMPROVING EFFICIENCY & EFFECTIVENESS

Grain quality analysis is a vital aspect of the food value chain, ensuring that the final products meet safety, nutritional, and quality standards. This process is important across various stages of the value chain, from production and harvesting to processing, transportation, and consumption. By understanding the significance of grain quality analysis in each phase, stakeholders can make informed decisions and contribute to providing consumers with high-quality food products.

https://lnkd.in/eBPWkx6m

CHAPTER 4 Indoor (digital) Farming

PREV INDEX NEXT

VERTICAL FARMING

HIGHER ENERGY COST WILL HELP TO IDENTIFY THE RIGHT MARKET NICHE

Vertical farming is best positioned to be fully automatized, but.... sun is free while electric light is not!

How does vertical farming work?
Where are its ideal market niches?
What does the future of vertical farming look like?

Find the answers and more in the article below.

Vertical Farming: Present & Future

"...The Vertical Farming industry is expected to grow to $9.7bn worldwide by 2026.
In 2022, Walmart announced an investment in Plenty® as part of its $400m Series E funding round. The retail giant will source leafy greens for all of its California stores from Plenty's new 95,000 sq ft flagship farm in Compton, California, which will open early next year.
Plenty will also be growing Driscoll's strawberries indoors at their Laramie, Wyoming, research and development farm as part of a new agreement.
But critics say the massive energy costs needed to run vertical farms..."

IN SHORT

Vertical Farming is currently under scrutiny for its energy consumption.
Vertical Farming makes use of Aeroponics & Hydroponics/Aquaponics allowing intensive production and total automatization; but that comes at cost... ENERGY.

Why is energy considered only now?

While the energy cost has always been there, the hype of the past years just covered it with a lot of (over)enthusiasm.

Sun is free and whatever the cost current of energy (higher or lower according to the cycles), sun is always winning.

The current higher energy costs compensate for the over-enthusiasm finally allowing us to have a more rational attitude toward these interesting technologies and growing approaches.

Over-enthusiasm shouldn't become over-criticism, because these growing methods are here to stay and will cover specific market niches where the benefits overcome the higher costs.

The players that will focus (and are focusing) on the right market niche(s) on vertical farming (regardless if hydro/aero/aqua...ponics) will win the race.

MARKET NICHE

Given the high cost of energy, it is advisable to focus on crops that have high yields and short growth cycles, so as to minimize the energy input required for their growth.

WELL POSITIONED PLAYERS: Retailers!

The food supply chain is rapidly changing and retailers are already sizing the opportunity and testing it. Why add delivery time cost to highly perishable food when you can automatically grow it locally, in the supermarket?
Let's have a deeper look.

VERTICAL FARMING: ...PONICS

Vertical Farming adopts one or more of the following growing methodologies:

- Aeroponics
- Hydroponics
- Aquaponics

Hydroponics is a method of growing plants without soil, using mineral nutrient solutions in water.

Aeroponics is a form of hydroponic growing that uses a mist environment to deliver nutrients and oxygen to the roots of plants.

Acquaponics hydroponics for growing plants and fish farming creating a symbiotic system (circular system) where the fishes eat the waste of plants and the plants get nutrients from... the waste of fishes.

Vertical Farming Aeroponics, in many aspects more advanced than hydroponic, although the latter is often simpler and can also be combined with fish (aquaponics).

...PONICS: current market niches

Let's considering the OVERALL current market niche for each single growing method:

HYDROPONICS:

- urban agriculture,
- commercial farming,
- indoor gardening.

AEROPONICS:

- space and vertical farming,
- research,
- high-tech indoor gardening.

AQUAPONICS:

- sustainable agriculture,
- organic farming,
- urban agriculture,
- and home gardening.

Given the impact of the cost of energy, it is advisable to focus on crops that have high yields and short growth cycles, so as to minimize the energy input required for their growth.

...PONICS ideal crops include:

- microgreens, young greens that are packed with flavor and nutrition, and are a popular choice for aeroponic systems
- strawberries, Tomatoes, Cucumbers
- Spinach, Lettuce, Radicchio, Arugula, ...
- Peppers, basil, mint, cilantro, parsley...
- and other high-value specialty crops with high yields per unit area and fast growth cycles;

This is just a small selection of the many crops that can be grown using ....ponics systems. The ideal crops for ....ponics systems will depend on the specific requirements of the grower, including the available space, desired yields, and local market demands.

Aquaponics' recommended fishes are:

- Tilapia
- Trout
- Catfish
- Carp

In addition, to be considered that aquaponics resonates with sustainable agriculture, organic farming, and urban agriculture, where the focus is on sustainable and environmentally friendly practices.

Vertical Farming, RETAILERS & new food system

There are a number of retailers that have already integrated hydroponic, aeroponic, and aquaponic production technologies or are planning to do so. Here are some of the notable ones:

Walmart: The retail giant has been experimenting with various forms of indoor agriculture, including hydroponic and aeroponic systems, in its stores and distribution centers to increase the availability of fresh produce year-round.

Amazon: The e-commerce giant has also shown interest in indoor agriculture and has been investing in the development of new technologies, such as vertical farms, to increase its ability to produce fresh produce.

Whole Foods Market: As a leading retailer of natural and organic foods, Whole Foods has been at the forefront of the push to integrate sustainable and environmentally-friendly farming practices into its supply chain. They have been testing and incorporating hydroponic and aquaponic systems into their stores.

METRO AG: The German retailer has been experimenting with hydroponic systems in its stores and has plans to expand the use of indoor agriculture technologies in the future.

Carrefour: The French retailer has been experimenting with vertical farms and hydroponic systems in its stores and has plans to expand their use in the future.

These retailers are just a few examples of the many companies that are exploring the use of indoor agriculture technologies in their supply chains. The trend is expected to continue to grow as the demand for fresh, locally-sourced produce continues to increase. Some automatic ...ponics farms

Hydroponics

Iron Ox: A fully-automated hydroponic farm that uses robots to plant, care for, and harvest crops.

Farm.One: A vertical farm that uses robots to plant, maintain, and harvest a variety of crops.

BrightFarms: A company that operates a network of high-tech greenhouses that use robots to plant and care for crops.

Aeroponics

AppHarvest: A company that operates a large-scale aeroponic farm that uses robots to plant and maintain crops.

AeroFarms: A company that operates a large-scale aeroponic farm that uses robots to plant, maintain, and harvest crops.

Aquaponics

Nelson and Pade, Inc.: A company that offers automated aquaponic systems that use robots to plant, maintain, and harvest crops.

Intelligent Growth Solutions (IGS): A company that offers automated aquaponic systems that use robots to plant, maintain, and harvest crops.

These are just a few examples of the many fully-automated hydroponic, aeroponic, and aquaponic systems that make use of robots.

What is the future of Vertical Farming? Trends

The future of hydroponics, aeroponics, and aquaponics technologies looks promising, as there is growing demand for fresh, locally-grown produce and sustainable agriculture practices. Here are some trends and potential developments in the field:

Expansion of indoor agriculture: As urban populations continue to grow, the demand for locally-grown produce is likely to increase, and indoor agriculture is likely to play a larger role in meeting that demand.

Advances in automation and robotics: The use of robots and automation in indoor agriculture is likely to continue to increase, as the technology becomes more sophisticated and cost-effective. This will lead to increased efficiency and scalability in the industry.

Increased focus on sustainability: As consumers become increasingly concerned about the environmental impact of their food choices, hydroponics, aeroponics, and aquaponics are likely to become more popular, as they are more sustainable than traditional agriculture methods.

Growth in vertical farming: Vertical farming is likely to continue to grow, as companies look for ways to maximize production in limited urban spaces.
Increased use of renewable energy: As the cost of renewable energy decreases and the impact of climate change becomes more evident, the use of renewable energy sources, such as solar and wind power, is likely to increase in the indoor agriculture industry.

Overall, the future of hydroponics, aeroponics, and aquaponics technologies is likely to be shaped by the growth of urban populations, advances in automation and robotics, and a growing focus on sustainability. As these technologies continue to evolve and mature, they will play an increasingly important role in meeting the world's food needs.

LEADING COUNTRIES

Countries with higher penetration of hydroponics, aeroponics, and aquaponics;
Hydroponics:

- Netherlands
- Japan
- United States
- Germany
- Canada

Aeroponics:

- United States
- Canada
- Germany
- Netherlands
- Japan

Aquaponics:

- United States
- Canada
- Australia
- Netherlands

- Germany

...PONICS OPERATIONAL COSTS

Equipment costs: This includes the cost of the aeroponic system itself, including the misting systems (if aeroponics) / pomps (if hydro/aquaponics), grow lights, climate control systems, sensors, and any other necessary equipment. The cost can range from a few thousand dollars for a small home system to hundreds of thousands of dollars for a commercial-scale operation.
Energy costs: Energy costs are one of the largest ongoing expenses for an aeroponic operation. The cost of electricity to run the grow lights, climate control systems, and other equipment can be substantial.
Labor costs: Labor costs can include the cost of hiring employees to manage the aeroponic system, including monitoring and adjusting the growing conditions, harvesting the crops, and maintaining the equipment.
Nutrient costs: Aeroponic systems typically require a steady supply of nutrients, either in the form of a commercial nutrient solution or a homemade mixture, which can add to the operational costs.
Water costs: Although aeroponic systems use less water than traditional agriculture, they still require a steady supply of water, which can add to the operational costs.
Seed and planting material costs: The cost of seeds and other planting materials will depend on the types of crops being grown and their source.

Most relevant technologies for ...ponics

Hydroponics:

- Grow lights
- Water pumps and aeration systems
- Nutrient delivery systems
- pH and EC sensors
- Climate control systems (heating, cooling, ventilation)
- Automated irrigation systems

Aeroponics:

- High-pressure misting systems
- Grow lights
- Climate control systems (heating, cooling, ventilation)
- pH and EC sensors
- Automated nutrient delivery systems

Aquaponics:

- Recirculating water systems
- Aquaculture systems for fish culture
- Grow lights
- Biofilters and nitrification systems
- pH and water quality sensors
- Automated nutrient delivery systems
- Climate control systems (heating, cooling, ventilation)

Technologies providers

Grow lights:

- Philips Lighting
- OSRAM
- ge LIGHTING

Water pumps and aeration systems:

- EHEIM GmbH & Co. KG
- TTV FLUVAL
- JBL Professional

Nutrient delivery systems:

- General Hydroponics
- Dutch Masters
- Advanced Nutrients Pty Ltd

pH and EC sensors:

- Milwaukee Instruments Europe

- Bluelab
- Hanna Instruments

Climate control systems (heating, cooling, ventilation):

- Quest Dehumidifiers
- Portacool, LLC
- Thermal Aircon Solutions Corp.

Automated irrigation systems:

- Netafim
- Rivulis Irrigation
- Jain Irrigation Systems Ltd.

High-pressure misting systems:

- HydroMist
- Hydro Dynamics

Aqua Dynamics

- Grow Flow
- ECOLIFE Conservation
- Aquaculture and Integrated Aquaponic Commercial Systems

Systems for fish culture:

- Nelson and Pade, Inc.
- AquaVerti Farms
- Backyard Aquaponics

Biofilters and nitrification systems

- Aqua Biofilter
- Biofit Engineering
- Nitrate Elimination Technology

DIGITAL TECHNOLOGIES IMPACT on FOOD SYSTEMS

"The digital agriculture revolution is simultaneously emanating from multiple links along the food value chain, rather than spreading sequentially from innovations adopted on farms (as in the previous agri-revolutions)"

DIGITAL AGRICULTURE REVOLUTION WILL BE DIFFERENT

Digital technologies promise to accelerate transformation of the agri-food system in ways not previously seen. The earlier revolutions increased agricultural productivity, increased food supply, reduced real food prices...the digital agriculture revolution builds on the outcomes of the preceding revolutions, but the new revolution is profoundly different in that it is SIMULTANEOUSLY EMANATING FROM MULTIPLE LINKS ACROSS THE FOOD VALUE CHAIN, rather than spreading sequentially from innovations adopted on farms.

AGRI-FOOD SYSTEM IS DEEPLY CONNECTED WITH...

The interconnectedness of the agri-food system with the economy, health, and the environment takes place in the context of the system's vast complexity, high transaction costs, and pervasive information asymmetries. The system involves many actors exchanging vast amounts of information (see picture).

FOOD SYSTEMS are:

➞ LOCAL: an essential feature in communities

➞ GLOBAL: linked through trade and sophisticated financial and insurance markets

COMPLEXITY & INTRICACY

The complexity of the agri-food system is vexing.
Every decision and transaction in one direction almost invariably produce an equivalent shift in another.

EXAMPLE: RISING FOOD PRICES

They are GOOD for net food producer farmers (many of whom are poor), while they are BAD for net food consumers (especially those who are close to the poverty line).
These same rising food prices have positive & negative effects on nutrition, where both low and high prices are blamed for problems of obesity and undernutrition.
Rising food prices encourage investment in land, labor, and technology, while they also encourage deforestation and environmental degradation.

DIGITAL

Digital technologies, with their rapid development and deployment, can overcome long-standing market and policy failures and accelerate food system transformation if an enabling environment and complementary investments are put in place.

More on FAO report:
"What's Cooking: Digital Transformation of the Agri-food System"

Many thanks to Hans Jöhr that shared with me the report.

URBAN FARMING

GROWING FOOD ON CITY'S ROOFS

✅ KEY BENEFITS:
✔️ Sustainable urban farming solution
✔️ Reduction in food miles and carbon footprint
✔️ Fresh, locally-grown produce
✔️ Efficient use of resources and space

✅ WHAT:
✔️ Citiponics is pioneering a vertical aquaponics system to grow fresh produce in urban environments.
✔️ The innovative farming method utilizes a multi-layered structure, allowing for the efficient use of limited urban space.
✔️ Their system combines hydroponics and aquaculture, creating a closed-loop system that uses less water and generates less waste compared to traditional agriculture.

✅ WHY:

✔️ As the demand for fresh, locally-sourced produce grows, innovative urban farming solutions like Citiponics can provide a sustainable alternative to traditional agriculture.

✔️ By reducing food miles and lowering the carbon footprint of food production, Citiponics contributes to a more environmentally-friendly and efficient food supply chain.

✅ HOW:

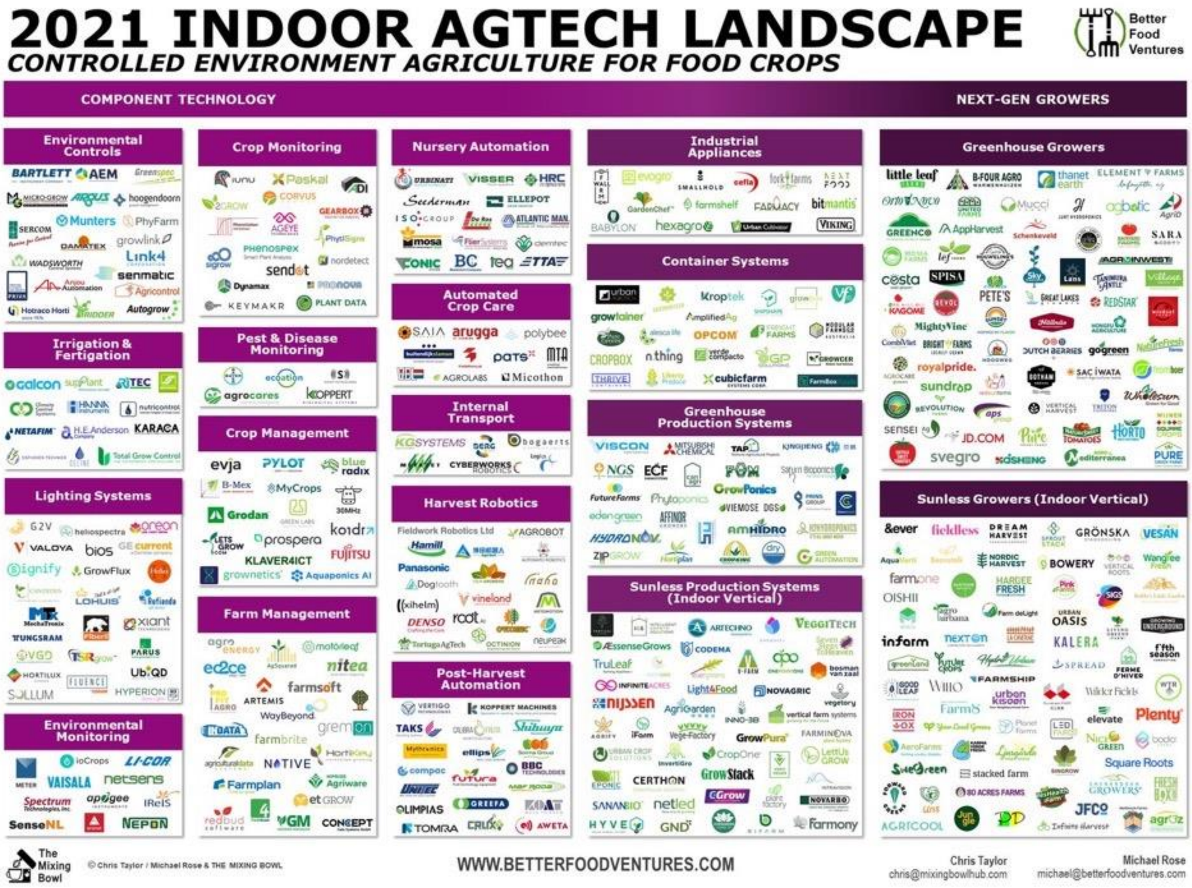
✔️ Citiponics' vertical aquaponics system circulates nutrient-rich water from fish tanks to the plants, which in turn filter the water before it returns to the fish tanks.

✔️ The efficient use of water and space allows for high-density farming in urban areas, promoting a more resilient and sustainable food system.

✅ WHERE:

✔️ Citiponics is based in Singapore and is focused on providing fresh produce to the local market.

INDOOR AgTech LANDSCAPE



⏩ Current AgTechologies

✅ Environmental Controls:

Optimize growing conditions, enhancing crop quality and yield while reducing waste and costs.

✅ Advanced Lighting Systems:

Energy-efficient LED lighting improves crop yield and quality while reducing energy costs.

✅ Precision Irrigation & Fertigation:
Precise water and nutrient delivery minimizes waste, improves yield, and reduces environmental impact.

✅ Automation & Robotics:
Automated tasks reduce labor costs, increase efficiency, and maintain consistent crop quality.

✅ Environmental & Crop Monitoring: Sensors and analytics enhance decision-making and early issue detection for improved crop management.

✅ Vertical Farming:
Space-efficient growing methods increase production capacity and support urban and local food production.

✅ AI & Machine Learning:
Data-driven insights optimize growing conditions and enhance crop yield and quality.
⏩ Future AgTechologies

✅ Genomic Technologies:
Develop crops with improved traits, enhancing performance and reducing chemical reliance.

✅ Circular Economy Models:
Implement waste reduction and recycling strategies, minimizing environmental impact.

✅ Decentralized Food Production:

Encourage small-scale indoor farms for reduced transportation costs and improved food security.

✅ Renewable Energy Integration:
Utilize renewables to reduce energy costs and carbon footprint.

✅ Advanced Plant Breeding:
Develop crops tailored for indoor farming environments, optimizing performance and yield.

More on my previous article
"Vertical farming: present & future"
https://lnkd.in/eWC3b9jv
More also on: better food ventures
https://lnkd.in/etVw2ueA

FARMING IN DESERT

Pure Harvest Smart Farms: FOOD SUSTAINABILITY IN THE UAE

Problem:

The United Arab Emirates, with its arid climate and scarcity of arable land, faces significant challenges in food production, leading to heavy dependence on food imports. This reliance not only affects the prices and availability of fresh produce but also raises concerns about environmental sustainability due to the carbon footprint associated with long-distance transportation of food.

Solution:

Pure Harvest Smart Farms is addressing this pressing issue by leveraging advanced greenhouse technologies and precision agriculture. Their methods enable the UAE to produce its own fresh fruits and vegetables year-round, reducing reliance on imports. Moreover, these produces are grown without the use of pesticides, resulting in healthier food options for the population.

🔗 *Key Benefits of Pure Harvest Smart Farms* 🔗

• Sustainable Practices: The advanced hydroponic systems used by Pure Harvest consume up to 90% less water than traditional farming methods. This, along with reduced transportation, significantly lowers the environmental impact of food production.

• Pesticide-Free Produce: Pure Harvest's controlled growing environment eliminates the need for pesticides, ensuring that the fruits and vegetables are not only fresh but also healthier and safer to consume.

• Tackling Food Scarcity: By enabling local production, Pure Harvest contributes to the UAE's food security, ensuring a steady supply of fresh produce regardless of global market fluctuations.

• Reducing Import Dependence: Locally grown produce means less reliance on imports, leading to more stable prices and readily available fresh produce for consumers in the UAE.

• Year-round Production: Regardless of the harsh external weather conditions, Pure Harvest's climate-controlled greenhouses allow for the continuous production of high-quality produce.

By providing a sustainable solution to the UAE's food scarcity problem, Pure Harvest Smart Farms is not only shaping the future of farming in the region but also contributing significantly to a healthier and more sustainable world.
Video link:
https://lnkd.in/emcFPYCN

DIGITAL ALLOWS BETTER HYDROPONICS

Problem:

Water Use

Traditional agriculture uses a vast amount of water, straining our precious resources.

Pesticides

Conventional farming often relies heavily on pesticides, affecting the health of consumers and the environment.

Localised Production

The need for transporting food over long distances increases costs and carbon footprint.

Labour-Intensive

Farming can be a labour-intensive practice, often facing labour shortages.

Solution: Iron Ox

Iron Ox, a pioneer in AgTech, is transforming farming with its AI-powered robotic hydroponics system, addressing the above challenges and offering a sustainable, efficient, and healthier food production model.

Benefits of Iron Ox's Approach

Water Efficiency

The hydroponic system uses 90% less water than traditional farming, promoting sustainability.

Pesticide-Free

An indoor controlled environment eliminates the need for pesticides, ensuring healthier produce.

➡️ **Localized Production**
The indoor farming model allows for local production in urban areas, reducing the carbon footprint associated with food transportation.

➡️ **Highly Automated**
Robots handle everything from seeding to harvesting, addressing labor shortages and enhancing consistency in farming operations.

➡️ **Individual Plant Care**
Iron Ox's approach to hydroponics features plants in independent groups, each treated as a small ecosystem with its own specific needs. This leads to tailored care, optimizing plant health and yield.

➡️ **AI-Driven Efficiency**
The use of AI and robotics ensures precise resource allocation and optimization, resulting in cost-efficient and high-yield farming.

Through its innovative technology, Iron Ox is not only addressing the challenges of today's agriculture but also paving the way for the future of farming.

Video from CNET

Link to full video (it deserves a view)

https://lnkd.in/ehfiZEyQ

CHAPTER 5 Robots & Automation in Agriculture

PREV INDEX NEXT

WHO'S STILL SKEPTICAL ABOUT ROBOTS…

“When” not “if”

Have a look at this video.

It's not anymore, a matter of "IF" robots will be pervasive in agriculture, it's now only a matter of "WHEN".

It doesn't matter if we like it or not, more and more robots will be growing our food.

Agri-robots-adoption will just be a copy-paste of what already happened in the manufacturing industry.

Why has Agri been left behind?

Because a farm is much more challenging than a manufacturing facility from a robot point of view.

Further technology development was required.

And.... here we are.

Robots are already weeding and harvesting in the most innovative farms.

But these are specialized robots, meaning that they execute one on more specific tasks under defined conditions.
While these robots are getting tractions (and starting to scale) a new generation of robots is under development: general purpose robots highly adaptable.

Boston Dynamics is among the leaders.

Watch this video to get an idea.
Compare it with videos of a few years ago to appreciate the speed of development and you can easily guess WHEN.

No more than 5 years from now, these robots in conjunction with AI will be able to assist and perform several farming activities.

Additional 5 years will be required to scale and make the prices affordable for the large and medium size farms.
Smallholder farmers will remain and not be substituted by robots (provided we will have found a sustainable food system for them as well).

They will wait many more years before the robots will be so affordable to help them in the fields as well.

Perhaps 30 years?
Hard to say.

HARVEST ROBOT

SWEEPER, the sweet pepper harvesting robot

▶ WHAT

SWEEPER optimises the cultivation system by simplifying the harvest through the use of a robot.

▶ WHY

In the world of greenhouse horticulture there is a great need to automate labour. The availability of employees who want to perform repetitive tasks under challenging climatic conditions is rapidly decreasing. At the same time, the robotisation of this work offers a wealth of advanced technological possibilities

▶ WHO

Wageningen University & Research

▶ DEVELOPMENT STAGE

Tested and under further development

▶ TECH DATA

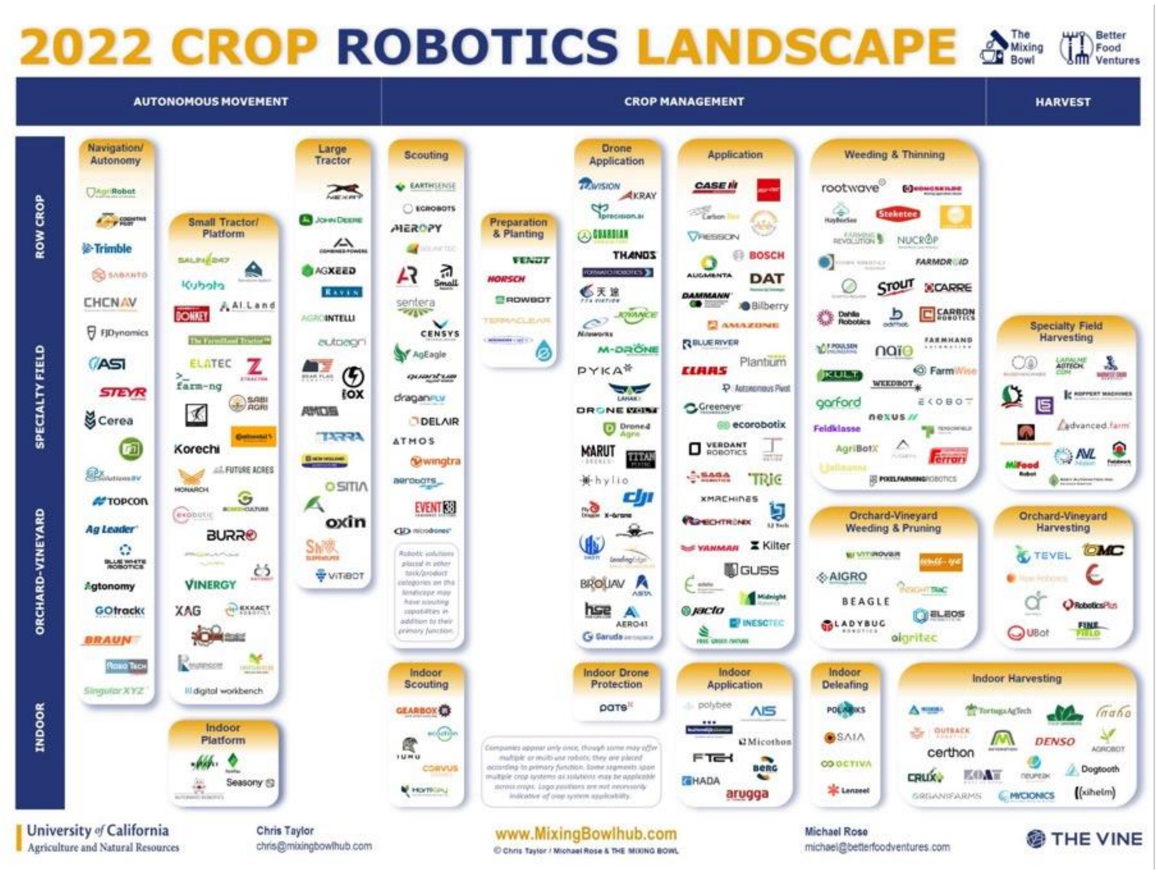
The average cycle time to harvest a fruit was 24 s. Logistics took approximately 50% of this time (7.8 s for discharge of fruit and 4.7 s for platform movements). Laboratory experiments have proven that the cycle time can be reduced to 15 s by running the robot manipulator at a higher speed. The harvest success rates were 61% for the best fit crop conditions and 18% in current crop conditions.

SWEEPER

https://lnkd.in/eGcs89ch

Video from TOP MACHINE

Crop Robotics: PLAYERS



WHAT?

✅ Autonomous movements

Agriculture robots with autonomous movement capabilities are designed to navigate fields, orchards, or indoor environments without human intervention. These robots utilize GPS, LIDAR, and various sensor technologies to map their surroundings, avoid obstacles, and efficiently perform tasks. This category of agri-robots helps farmers save time, labour, and resources, enabling them to focus on higher-level management.

✅ Crop management

Crop management robots are designed to improve crop health, monitor growth, and optimize resources. These agribots can perform tasks such as soil analysis, weed detection, and pest control, ensuring a more sustainable and efficient farming process. They use advanced AI, machine learning algorithms, and computer vision to identify issues and apply targeted treatments, ultimately increasing crop yield and reducing waste.

✅ Harvest

Harvest robots are specifically designed to automate the collection of ripe produce from the field, vineyard, or indoor environment. They use advanced imaging and sensors to identify and pick ripe fruits or vegetables without causing damage. By automating this labor-intensive task, these robots increase efficiency, reduce labor costs, and help maintain consistent product quality.

WHERE?

▶️ Indoor

Indoor agriculture robots are designed to work in controlled environments such as greenhouses, vertical farms, and hydroponic facilities. These robots can perform various tasks like seeding, watering, monitoring, and harvesting. Indoor agribots are essential in maximizing space utilization, maintaining precise environmental control, and ensuring high-quality yields.

▶️ Orchard vineyard

Orchard and vineyard robots are specifically engineered to navigate the unique challenges of fruit tree and grapevine cultivation. These robots are capable of tasks such as pruning, canopy management, and fruit thinning. Equipped with advanced vision systems and delicate manipulators, they can identify and harvest ripe fruits without damaging the plant, ensuring higher yield and reduced labour costs.

▶ Specialty field

Specialty field agriculture robots are tailored to specific crops or farming techniques that require unique skills or care. They can perform tasks like transplanting delicate seedlings, applying targeted fertilization, or managing high-value crops like medicinal plants or flowers. These robots offer greater precision and efficiency, addressing the unique challenges of each specialized field.

▶ Row crop

Row crop robots are designed for large-scale farming operations that rely on well-organized crop rows. These agri-robots can perform various tasks, including planting, cultivating, and harvesting row crops like corn, soybean, and wheat. By automating these tasks, row crop robots help farmers optimize resource usage, increase efficiency, and reduce labour costs.

▶ Autonomous movements & row crops

Market leader: John Deere

Solution: AutoTrac™ Guidance System

Benefits: Improved navigation, reduced input costs, and higher crop yield.

Ideal market niche: Large-scale row crop farms

Open challenges: High initial investment, compatibility with non-John Deere equipment

▶ Autonomous movements & specialty field

Market leader: Ecorobotix

Solution: AVO

Benefits: Reduced manual labor, lower herbicide use, and increased sustainability.

Ideal market niche: Specialty crop farmers, organic agriculture

Open challenges: Limited effectiveness in diverse fields, high initial investment

▶ Autonomous movements & orchard/vineyard

Market leader: Ecorobotix

Solution: Vitirover

Benefits: Precise mowing and weeding, reduced fuel consumption, and labor costs.

Ideal market niche: Vineyards and orchards

Open challenges: Limited effectiveness on steep terrain, high initial investment

▶ Crop management & indoor

Market leader: Iron Ox

Solution: Robotic Indoor Farming System

Benefits: Maximized space usage, reduced manual labor, increased production efficiency.

Ideal market niche: Indoor vertical farms, urban agriculture

Open challenges: High initial investment, scalability for large-scale operations

▶ Crop management & row crops

Market leader: Blue River Technology

Solution: See & Spray™

Benefits: Precise herbicide application, reduced herbicide use, improved crop health.

Ideal market niche: Sustainable row crop farmers

Open challenges: High initial investment, adapting to various field conditions and crop types, technology adoption by traditional farmers.

▶ Crop management & specialty field

Market leader: Naïo Technologies

Solution: Dino

Benefits: Autonomous weeding, reduced labor costs, and herbicide use.

Ideal market niche: Specialty crop farmers, organic agriculture

Open challenges: Limited effectiveness in diverse fields, high initial investment

▶ Crop management & orchard/vineyard

Market leader: VISION ROBOTICS CORPORATION

Solution: Intelligent Orchard/Vineyard Management System

Benefits: Pruning, thinning, monitoring crop growth, reduced labor costs, improved crop quality.

Ideal market niche: Orchard and vineyard owners

Open challenges: Adapting to different crop varieties, high initial investment

▶ Harvest & indoor

Market leader: Root AI (AppHarvest)

Solution: Virgo

Benefits: Reduced labor costs, increased efficiency, minimized crop damage during harvest.

Ideal market niche: Indoor farms, high-value produce

Open challenges: Adapting to various crop types, scalability

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image shared by: Better Food Ventures

image from: Chris Taylor UCANR The Mixing Bowl

AGRI-ROBOTS BY COUNTRY PRODUCERS

Country	Company	Robot	What it does	Benefits	Challenges
	SwarmFarm Robotics	SwarmBot	Performs autonomous spraying, seeding, and weeding	Improved efficiency, reduced labor costs, precision farming	Technology adoption, scalability
	Ripe Robotics	Eva	Harvests fruit autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	Octinion	Rubion	Harvests strawberries autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	DJI	Agras MG-1	Drone for autonomous crop spraying	Precision spraying, reduced labor costs, increased efficiency	Regulation, drone adoption
	Robotti	Agrointelli Robotti	Carries and operates various agricultural implements autonomously	Improved efficiency, reduced labor costs, precision farming	Technology adoption, scalability
	Naïo Technologies	Dino	Provides autonomous weeding in specialty crops	Reduced labor costs, reduced herbicide use, increased efficiency	Diverse fields, high initial cost
	Toposens	TS3	Provides 3D ultrasound sensing for collision avoidance in agricultural machinery	Improved safety, reduced machinery damage, increased efficiency	Integration, technology adoption
	Niqo Robotics	BrijBot	Autonomous weeding and spraying in row crops	Reduced labor costs, increased efficiency, reduced chemical use	Scalability, technology adoption
	FFRobotics	FFR Multi-Purpose Orchard Robot	Performs harvesting, pruning, thinning, and monitoring in orchards autonomously	Reduced labor costs, improved efficiency, precision operations	Crop variability, high initial cost
	Metomotion	GROWA	Harvests greenhouse tomatoes autonomously	Reduced labor costs, increased efficiency, consistent harvesting quality	Scalability, crop variability
	Tevel Aerobotics	Flying Platform	Performs autonomous orchard management & harvesting	Improved efficiency, reduced labor costs, precision operations	Technology adoption, scalability
	Kubota	Agri Robo	Operates as an autonomous tractor	Improved efficiency, reduced labor costs, precision farming	Technology adoption, scalability
	Priva	Kompano	Harvests cucumbers autonomously	Reduced labor costs, increased efficiency, consistent harvesting quality	Scalability, crop variability
	Robotics Plus	Aporo II	Harvests apples autonomously	Reduced labor costs, increased efficiency, consistent harvesting quality	Crop variability, high initial cost
	Saga Robotics	Thorvald	Provides autonomous UV treatment, harvesting, and monitoring	Improved efficiency, reduced labor costs, and chemical use	Technology adoption,
	Agrobot	E-Series	Harvests strawberries autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	Einride	T-log	Autonomous electric logging truck	Sustainable transport, reduced emissions, increased efficiency	Infrastructure, technology adoption
	EcoRobotix	AVO	Targeted spraying and weeding in row crops	Reduced chemical use, increased efficiency, reduced labor costs	Scalability, technology adoption
	Small Robot Company	Tom, Dick, and Harry	Monitoring, precision weeding, and seeding	Reduced labor costs, increased efficiency, reduced chemical use	Scalability, technology adoption
	Dogtooth Technologies	Dogtooth	Harvests soft fruit autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	Energid Technologies	CitrusBot	Harvests citrus fruits autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	Blue River Technology	See & Spray	Targeted spraying and weeding in row crops	Reduced chemical use, increased efficiency, reduced labor costs	Scalability, technology adoption
	Harvest CROO Robotics	Berry 4	Harvests strawberries autonomously	Reduced labor costs, improved yield quality, increased efficiency	Crop variability, high initial cost
	Vision Robotics	Grapevine Pruner	Autonomous grapevine pruning	Reduced labor costs, increased efficiency, consistent pruning quality	Scalability, technology adoption
	Rowbot	Rowbot System	Autonomous fertilizer application in row crops	Precision fertilization, reduced labor costs, increased efficiency	Technology adoption, scalability
	Burro	RnR	Autonomous crop transportation and data collection	Reduced labor costs, improved workflow, increased efficiency	Scalability, technology adoption
	Autonomous Tractor Corp	Spirit	Autonomous electric tractor for various agricultural tasks	Improved efficiency, reduced labor costs, precision farming, sustainability	Technology adoption, scalability
	Raven (Dot Technology Corp.)	Dot Power Platform	Carries and operates various agricultural implements autonomously	Improved efficiency, reduced labor costs, precision farming	Technology adoption, scalability
	FarmWise	Titan FT-35	Autonomous weeding and crop monitoring	Reduced labor costs, increased efficiency, reduced chemical use	Scalability, technology adoption

@Marco Brini

AU AUSTRALIA

SwarmFarm Robotics

SwarmBot

www.swarmfarm.com/

AU AUSTRALIA

Ripe Robotics

Eva

www.riperobotics.com/

BE BELGIUM

Octinion

Rubion

http://octinion.com/

CN CHINA

DJI

Agras MG-1

www.dji.com/

DK DENMARK

Robotti & Company

Agrointelli Robotti

https://lnkd.in/ehneK_cU

FR FRANCE

Naïo Technologies

Dino

www.naio-technologies.com/

DE GERMANY

Toposens

TS3

https://toposens.com/

IN INDIA

Niqo Robotics (formerly TartanSense)

BrijBot

https://niqorobotics.com/

IL ISRAEL

Fresh Fruit Robotics Ltd.

FFR Multi-Purpose Orchard Robot

www.ffrobotics.com/

IL ISRAEL

Metomotion

GROWA

https://metomotion.com/

IL ISRAEL

Tevel

Flying Platform

www.tevel-tech.com/

JP JAPAN

Kubota Corporation Agri

Robo

www.kubota.com/

NL NETHERLANDS

Priva

Kompano

www.priva.com/

NZ NEW ZEALAND

Robotics Plus

Aporo II

www.roboticsplus.co.nz/

NO NORWAY

SAGA ROBOTICS // THORVALD

Thorvald

https://sagarobotics.com/

ES SPAIN

AGROBOT

E-Series

www.agrobot.com

SE SWEDEN

Einride

T-log

www.einride.tech/

CH SWITZERLAND

Ecorobotix

AVO

https://ecorobotix.com/

GB UK

Small Robot Company

Tom, Dick, and Harry

www.smallrobotcompany.com

GB UK

Dogtooth Technologies

Dogtooth

https://dogtooth.tech/

US USA

Energid

CitrusBot

www.energid.com/

US USA

Blue River Technology

See & Spray

https://lnkd.in/eRQgbdYm

US USA

Harvest CROO Robotics

Berry 4

https://lnkd.in/eta_R6BR

US USA

VISION ROBOTICS CORPORATION

Grapevine Pruner

www.visionrobotics.com

US USA

Rowbot

Rowbot System

https://www.rowbot.com/

US USA

Burro

RnR

https://burro.ai/

US USA

Autonomous Tractor Corporation

Spirit

https://lnkd.in/e_PsMK-r

US USA

Raven Industries (Dot Technology Corp.)

Dot Power Platform

https://ravenind.com/

US USA

FarmWise

Titan FT-35

https://farmwise.io/

AUTOMATIC MACHINERY... CONVENIENT?

24% increased productivity compared to conventional machinery

	Conventional	Autonomous (Benefits Assumed)			
Scenario	Base	Base	Cost Only	Yield Only	Cost & Yield
Tractors(s)	130 hp	1 – 46 hp	1 – 46 hp	1 – 46 hp	1 – 46 hp
Planter(s)	8 row	1 – 4 row	1 – 4 row	1 – 4 row	1 – 4 row
Fertilizer App.	8 row	1 – 7.6 m	1 – 7.6 m	1 – 7.6 m	1 – 7.6 m
Sprayer	18.3 m	1 – 6.1 m	1 – 6.1 m	1 – 6.1 m	1 – 6.1 m
Input Cost Reduction	-	0%	10%	0%	10%
Yield Increase	-	0%	0%	7%	7%
Avg. Net Returns (U.S.$)	600,057	606,050	636,979	688,361	719,290
Min. Net Returns (U.S.$)	318,674	345,094	376,023	395,716	426,645
Max. Net Returns (U.S.$)	858,863	791,930	822,859	934,515	965,443
Std. Dev. Net Returns (U.S.$)	132,061	122,871	122,871	137,868	137,868
Coef. of Var. Net Returns (%)	22.01	20.27	19.29	20.03	19.17
Selected Input Costs (U.S.$)[1]	309,287	309,287	278,358	309,287	278,358
B-E Invest Price (U.S.$)[2]	-	$26,128	$160,995	$ 96,825	$ 130,737
		VALUE CREATION			
Avg. Corn Yield (kg ha^{-1})	10,293	10,150	10,150	10,972	10,972
Avg. Soybean Yield (kg ha^{-1})	4,188	4,181	4,181	4,480	4,480

KEY BENEFITS

▶ LESS COSTS: reducing inputs, fuel and hectare labor costs

▶ BETTER SOIL: autonomous machinery can be smaller & lighter (less soil compaction)

IN SUMMARY

"An increase in net returns of 24% over operating with conventional machinery is found when including both input savings and a yield increase due to reduced compaction" (using: 130 hp tractor, an 8-row planter, an 8-row fertiliser applicator, and an 18.3 meter sprayer)

KEY FIGURES (in the study)

▶ $160.000 value creation (for a 850ha farm on soya & corn)
⬇ herbicides reduction (from 10% up to 90%)
⬇ better soil conditions (estimated 7% increased productivity)
⬇ less working hours

HERBICIDES REDUCTION (ESTIMATIONS)

90% ⏩ Pendersen et al., (2007): 90% reduction in herbicide cost alone for an autonomous micro-sprayer because of its ability to recognize individual weeds and target herbicide application.
20% ⏩ Pendersen et al., (2006): reduction in input cost from autonomous machinery of 20%, and ranging from 12% to 25%.
10% ⏩ Shockley et al., 2011; Shockley et al., 2012: automated steering and section control reduce input costs by 10%.

INCREASED PRODUCTIVITY (due to better soil conditions)

7% ⏩ The University of Kentucky Extension Services: reduction in corn and soybean yields of 7% due to soil compaction (Murdock and James, 2008).

FARM SIZE

Net returns increase dramatically for smaller farm sizes probably due leasing vs. purchasing.

BENEFITS OF AUTOMATIC MACHINERY

▶ Increased productivity and efficiency due to reduced downtime;
▶ increased accuracy, and better field management.
▶ Reduced labor costs due to decreased need for human operators and reduced fatigue.
▶ Lower fuel and input costs due to optimized field management;
▶ precise application of inputs, and reduced idle time.
▶ Improved yield and crop quality due to better field management and precise application of inputs.
▶ Increased flexibility in crop management, such as variable rate application of inputs, enabling farmers to respond quickly to changing field conditions and market demands.
▶ solves the declining availability of a skilled agricultural workforce
▶ mitigate the working risks

Article:
"An Economic Feasibility Assessment of Autonomous Field Machinery in Grain Crop Production"

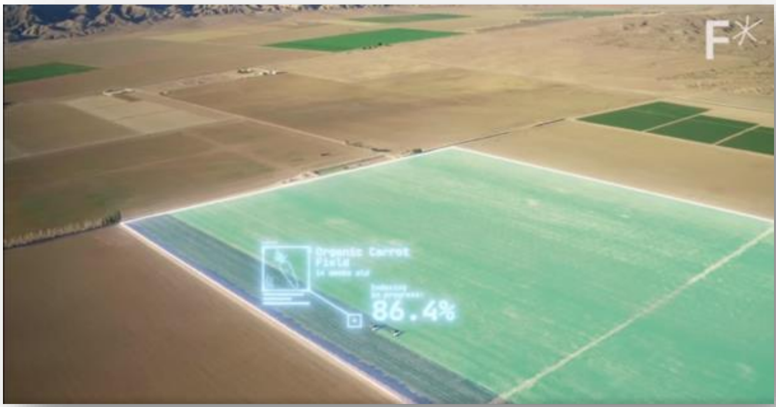
Jordan Shockley, PhD (University of Kentucky)

Carl R. Dillon (University of Kentucky)

Scott Shearer (The Ohio State University)

https://lnkd.in/eyST-8sr

SPRAY ROBOT: SAVE 95% PESTICIDES



How

1. IDENTIFIES PLANTS
2. KILLS IT IF UNWANTED
3. FEEDS IT IF WANTED

Benefits:

- Less costs
- Less pollution
- More Harvest

Who

Verdant Robotics does it in few seconds saving pesticides and fertilizer.

The robot is mounted on the tractor.

While moving on the fields, its cameras scan the crop, identify them and take decision accordingly... in few seconds.
A twin digital crop is made, allowing to aggregate data to a level impossible to conceive in the past.
Farmers can have a deeper understanding about their crop and take better decisions.

Video Freethink

https://lnkd.in/erqDn5mK

Curtis Garner

Lawrence Ibarria

Gabe Sibley

AI & more make TRACTORS AUTOMATIC

HANDS FREE TRACTORS

To use the autonomous tractor, farmers only need to transport the machine to a field and configure it for autonomous operation.
While the machine is working the farmer can leave the field to focus on other tasks, while monitoring the machine's status from their mobile device.

IF SOMETHING GOES WRONG...

In the event of any job quality anomalies or machine health issues, farmers will be notified remotely and can make adjustments to optimize the performance of the machine.

THE MACHINE...

John Deere's tractor has six pairs of stereo cameras, which enables 360-degree obstacle detection and the calculation of distance.

AI

Images captured by the cameras are passed through AI that determines within milliseconds weather the machine continues to move or stops, depending on if an obstacle is detected.

POSITION

The autonomous tractor is also continuously checking its position relative to a geofence, ensuring it is operating where it is supposed to, and is within less than an inch of accuracy.

John Deere's self-driving tractor can operate to within an accuracy of less than 1 inch.

More at John Deere:

https://lnkd.in/eRCqkzHw

Video from World Economic Forum

https://lnkd.in/eVw99Tcw

Fully automatic hydroponic is REAL & NOW

AGRI-JOBS SHIFTS: MANUAL ▶ BRAIN

Just a superficial look to the below contents allows to conclude that:

1. Hydroponics will be fully automatic (ROBOTS)
2. Hydroponics win on short cycle crops
3. Agri-Jobs will/are shifting from manual to specialized jobs (setup, maintenance and management)

HYDROPONICS FOR?

For short cycle crops such as lettuce, herbs and cabbage, hydroponic growing is the way to go!

BENEFITS?

In addition to be the perfect setting for a fully robotized farm, the hydroponic has the following benefits:

90% LESS WATER

The whole system needs roughly 7 litres in comparison to 70 litres per head in the open field.

SAFE, UNIFORM, CLEAN

The main benefit of growing hydroponically in comparison to the open field is that production takes place in a safer and more controlled environment. Cultivation in deep water causes less plant loss and results in a clean product without any dirt. Since all plants have the same water intake a uniform quality of the crop is achieved.

MORE CYCLES (PRODUCTION)

Another important benefit is the increased amount of cultivation cycles which can be produced in a year. This boosts the total yield immensely. And because the product is floating the complete system can be automated. This enables growers to scale up and cultivate at a very cost-efficient rate.

LESS FERTILIZERS

Growing in a controlled environment also saves fertilizers because the fertilizer stays in the water system and isn't being drained out in the field as occurs with the traditional growing method.

LESS PESTICIDES

Hydroponics does not need soil to grow plants, reducing the instances of soil-borne diseases. Additionally, since this farming technique is done indoors and everything is in a controlled setup, the chances of pest infestations are much lower.

DISADVANTAGES / LIMITATIONS

1. High Set-Up COST
2. Reliance On Constant Power Supply/System
3. High-Level Maintenance & Monitoring
4. Susceptibility to Waterborne Diseases
5. Requires Special Expertise

More on:

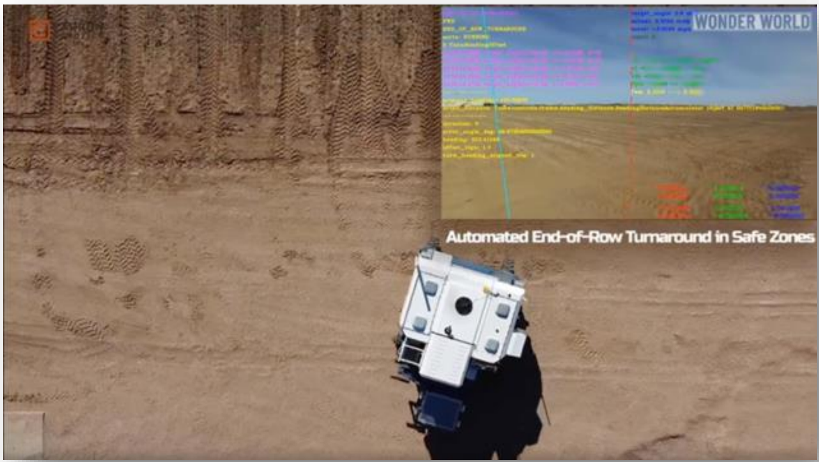
https://lnkd.in/e93DRfvW

https://lnkd.in/eDFVf_Ay

Video from: Viscon Group about

Mucci Farms

WEEDING ROBOT: 100k Weeds/h (laser, no herbicides)



✅ **WHAT**

Autonomous Weeder (robot from Carbon Robotics) uses advanced computer vision & machine learning algorithms to identify and eliminate weeds in crop fields…

✅ **WHY**

No herbicides and less manual labor for a more sustainable and cost-effective farming practices.

✅ **LASER**

Thermal energy vs. Chemical energy: Carbon Robotics' Autonomous Weeder uses high-power laser technology to eliminate weeds (thermal energy), rather than relying on chemical herbicides.

✅ Key robot figures

🔷Eliminating up to 100,000 weeds per hour

🔷Operates at a speed of about 5 miles per hour

🔷Price: not disclosed

✅ Herbicides saved

Can potentially save several kilograms of herbicides per hectare, depending on the weed density and type of crops

✅ Robot's enabling technologies

1 Advanced computer vision

Identifies and distinguishes weeds from crops

2 Machine learning algorithms

Improves weed recognition and elimination over time

3 Autonomous navigation

Allows the robot to operate independently in the field

4 High-power laser technology

Precisely targets and eliminates weeds without damaging crops

Video from wonder world

https://lnkd.in/e8rkXXGY

GRADING & PACKAGING ROBOT

Crux Agribotics: OPTIMISING PACKAGING & GRADING WITH ROBOTICS & AI

Problem:

Farmers face difficulties in delivering customers product quality consistent with their requests, maintaining efficiency in packaging and grading processes, and addressing the high costs associated with manual labor in these areas.

Solution:

Crux Agribotics offers innovative robotics and AI solutions designed specifically to address packaging and grading challenges (& more), helping farmers improve efficiency, reduce labor costs, and ensure consistent product quality.

Key Benefits of Crux Agribotics for Farmers

• Consistent Quality: AI-driven grading systems by Crux Agribotics ensure that the produce you deliver to the market is consistently high in quality, meeting the demands of today's consumers.

• Enhanced Efficiency: By automating repetitive tasks like packaging, grading, and sorting, Crux Agribotics' solutions boost the overall efficiency of your farm, allowing you to focus on more important aspects of your business.

• Labour Savings: Crux Agribotics' robotic solutions, such as their advanced packaging robots, reduce the need for manual labour, addressing labour shortages and lowering labour costs.

• Improved Sustainability: Crux Agribotics' technology reduces waste and optimises resource usage, contributing to more sustainable agriculture practices.

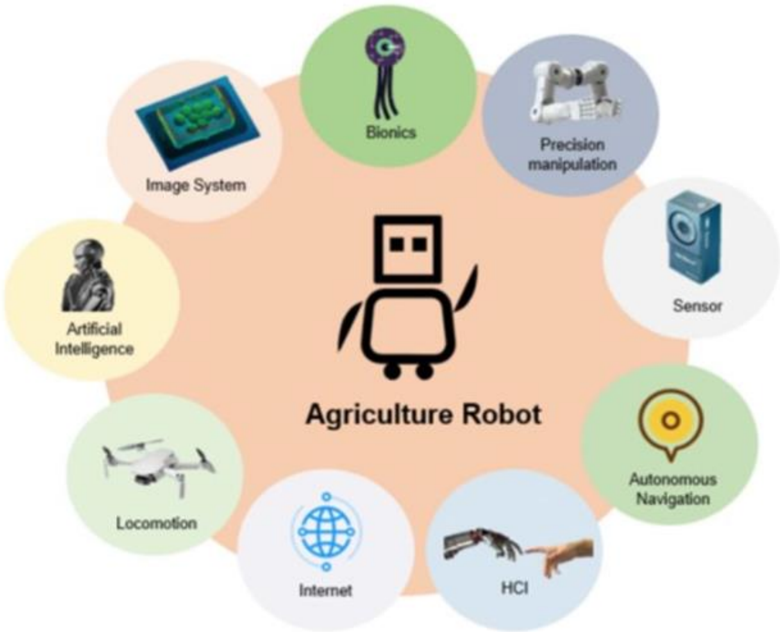
• Adaptable to Various Crops: Crux Agribotics' solutions can be tailored to various crops, such as tomatoes, peppers, and cucumbers, making it a versatile choice for diverse farming operations.

🌱 Overcome packaging and grading challenges with Crux Agribotics' cutting-edge robotics and AI solutions, designed to help you save on labor, improve efficiency, and deliver the highest quality produce to market.

Video source: Kind Technologies

https://lnkd.in/eZYrPHUi

AGRICULTURE ROBOTICS: 2023 OVERVIEW



1. FIELD ROBOTS

These robots are designed to navigate agricultural fields:

▶ planting,

▶ monitoring crop health

▶ applying fertilisers and pesticides.

Utilize GPS and sensor technology for autonomous navigation and operation, reducing the need for human labor.

Can work continuously (24/7) if required, potentially increasing productivity.

Assist in data collection for crop health analysis, improving decision-making and yield optimization.

Minimize waste by applying precise amounts of water, fertilizer, and pesticides, promoting sustainable farming practices.

2. FRUIT AND VEGETABLE HARVESTING ROBOTS

These are specialised robots designed to harvest fruits and vegetables. Equipped with advanced sensors, imaging technology, and machine learning algorithms, they are capable of distinguishing ripe fruits and vegetables from unripe ones, picking them without causing damage, and doing so at a speed that can potentially surpass human capabilities.

▶ Identify and pick ripe fruits and vegetables using AI and machine vision, leading to increased harvesting efficiency.

▶ Operate around the clock, increasing productivity and shortening the harvest time.

▶ Reduce the necessity for manual labor, addressing labor shortages during peak harvest seasons.

▶ Minimise damage to produce during the harvesting process due to their gentle handling, potentially improving product quality.

▶ Can work in varying weather conditions, ensuring consistent productivity.

3. ANIMAL HUSBANDRY ROBOTS

Improving efficiency and quality in livestock farming:

▶ Disinfection robots perform labour-intensive tasks efficiently

▶ Monitor the environment of enclosed henhouses

▶ Feeding systems reduce costs, eliminate waste, and improve animal welfare

▶ Milking robots using advanced sensing and vision systems improve milking frequency and quality

▶ Egg collecting robots improve productivity in poultry houses

CHALLENGES

Despite the progress, challenges remain, such as:

▶ High energy consumption and cost of fabrication.

▶ GNSS accuracy for precise localization.

▶ Maintenance of robots or robotic systems.

Further research is needed in human-robot interaction, agronomics, and sensor technologies to achieve full automation in agriculture.

Recent Advancements in Agriculture Robots: Benefits and Challenges

https://lnkd.in/ecDcByvu

https://lnkd.in/erMPnV9r

Chao Cheng, Jun Fu, Luquan Ren (Jilin University)

Hang Su (Jilin University & Politecnico di Milano)

CHAPTER 6 Data and AI in Agriculture

PREV INDEX NEXT

OVERVIEW of Agri-ARTIFICIAL INTELLIGENCE

PREDICTIVE ANALYTICS

What: analysing large amount of data

Benefit: make better decisions about when to plant, fertilize and harvest

PRECISION FARMING

What: monitoring crop health with the help of satellites, drones and sensors

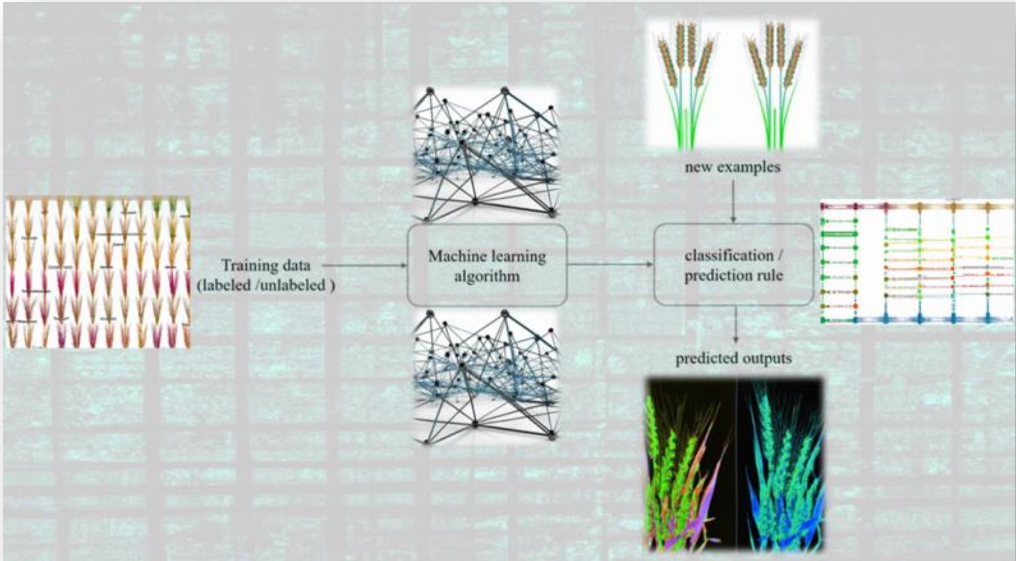
Benefit: identify area where crops are struggling and adjust the practices accordingly

AUTONOMOUS FARMING

What: AI power machines to automatically planting, harvesting and irrigation

Benefit: reduce labour cost and increase efficiency

ARTIFICIAL INTELLIGENCE for DIGITAL AGRICULTURE



WHERE can A.I. CONCRETELY HELP AGRICULTURE?

Beyond the talk, do we really have something concrete? Yes

What? In this post you will find a DETAILED and extended (but not exhaustive) list of concrete applications.

☑ **APPLICATIONS**

▶ Yield Prediction

▶ Disease Detection

▶ Weed Detection

▶ Crop Quality

▶ Species Recognition

▶ Animal Welfare

▶ Livestock Production

▶ Water Management

▶ Soil Management

☑ DATA INPUTS from...

▶ Fluorescence sensors

▶ Hyperspectral camera

▶ Spectral camera

▶ Data records

▶ NDVI

▶ Near infrared sensors

▶ Data images and colour indexes

☑ KEY BENEFITS:

▶ Enhanced crop monitoring

▶ Improved yield prediction

▶ Optimised irrigation and fertilisation

▶ Advanced pest and disease management

☑ WHAT:

▶ Machine learning applications are increasingly being used to analyse data from various sources, such as sensors, satellites, and drones.

▶ This data-driven approach enhances decision-making and supports farmers in optimising agricultural processes.

☑ WHY:

▶ Machine learning offers significant benefits for agriculture, such as:

- improved crop monitoring,

- yield prediction,

- irrigation and fertilisation optimisation,
- advanced pest and disease management.

▶ These advancements contribute to increased productivity, reduced input costs, and more sustainable farming practices.

☑ **HOW:**

▶ Machine learning algorithms (decision trees, neural networks, and support vector machines) are used to process large amounts of agricultural data.

▶ The algorithms learn from the data to identify patterns and make predictions, allowing for more accurate and timely decision-making.

☑ **WHO:**

The review was conducted by:

Konstantinos Liakos (Institute for Bio-economy and Agri-technology iBO/CERTH)

Patrizia Busato (University of Turin)

Dimitrios Moshou (Institute for Bio-economy and Agri-technology iBO/CERTH , Aristotle University of Thessaloniki (AUTH))

Simon Pearson (Lincoln Institute for Agri-Food Technology)

Dionysis Bochtis (Institute for Bio-economy and Agri-technology iBO/CERTH)

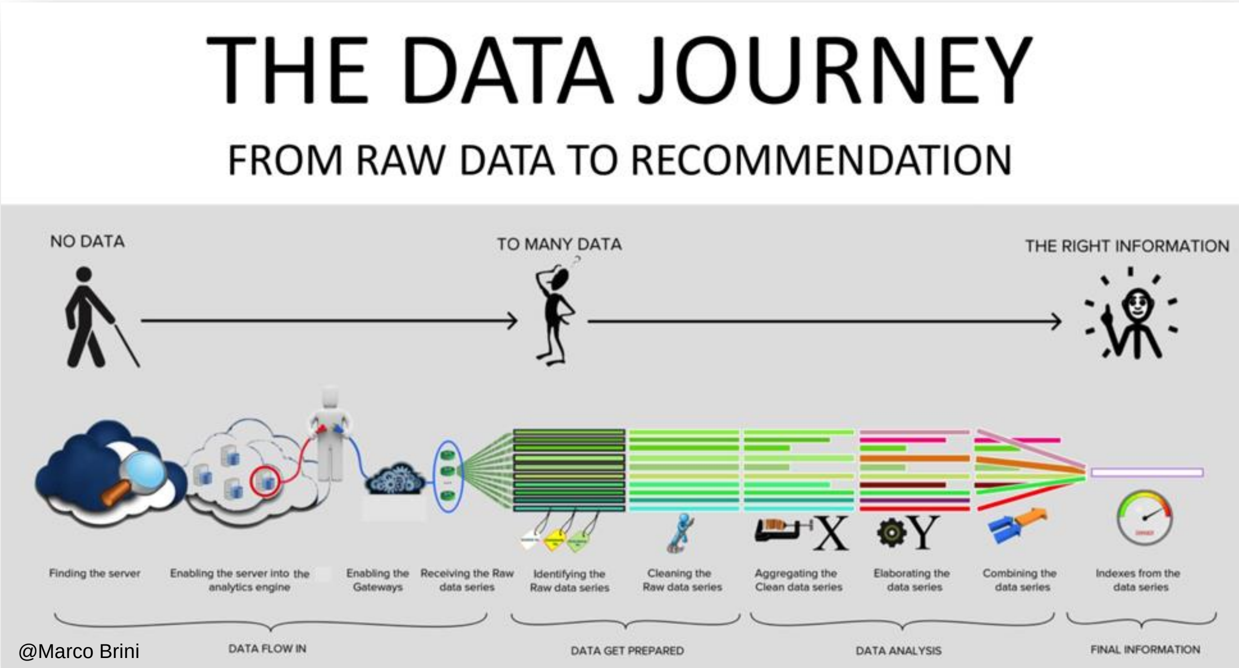
SOURCE:

"Machine Learning in Agriculture: A Review"

https://lnkd.in/dDQh-AJ5

DATA ▶ BIG DATA, AI ▶ RECOMMENDATION

There is more than "just AI" or "satellites"...



☑ METHODOLOGY:

1. collect diverse data sources (raw data)
2. uniform the data formats
3. pre-process the data (data label, cleaning, filing, ...)
4. integrate various data sources (seeing from different perspectives)
5. apply advanced data analysis techniques (AI, machine learning,…)
6. derive valuable insights ... optimise the agri production and minimise the inputs

KEY BENEFITS:

- Improved crop yield and productivity
- Efficient resource management
- Enhanced decision-making through data-driven insights
- Climate-smart agriculture

more concretely:

- selecting optimal crop varieties,
- designing efficient irrigation systems,
- managing pests and diseases.

... (and much more)

DIGITAL TOOLS

- Data Fusion
- GIS
- Time-Series Analysis (ARIMA, VAR,…)
- machine learning,
- data mining,
- other AI techniques (NLP, CNN, RNN,...)

USE CASES (from below paper)

- Data-driven agronomic research framework
- Vegetation indices from satellite data
- Crop and water stress detection using satellite data
- Estimated green-up date for rice-growing regions
- Interactive predictive analytic platform to predict yield
- Comparison of different time-series forecasting models for wheat production in India

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SOURCE

personal experience + paper "Application of Big Data Analytics and Artificial Intelligence in Agronomic Research" by K.V. Ramesh, @V. Rakesh, and E.V.S. Prakasa Rao

PREDICTING DISEASES: example COFFEE RUST

(a) (b)

1. SETUP

SENSORS ▶️ HYSTORICAL DATA ▶️ AI TRAINING or ALGORITHM DEFINITION (`f`: see section below)

2. OPERATION

SENSORS ▶️ DATA GATHERING ▶️ AI / ANALYTICS USE ▶️ RISK LEVEL
OK, that's in general, but.... how does it really look like? Here is an example.
This paper describes the process and the variables involved in the coffe rust risk using regression model / machine learning taking into account microclimate variables.
❓Coffee Rust Incidence = f(Temperature, Precipitation, Relative Humidity, Time of Insolation)`

Where:

☑ \`f\` is the function or model that describes the relationship between the meteorological variables and coffee rust incidence. This could be a regression model or a machine learning model that has been trained on historical data.

☑ \`Temperature\` includes maximum, minimum, and average temperature

☑ \`Precipitation\` is the amount of rainfall.

☑ \`Relative Humidity\` is the amount of water vapor present in the air expressed as a percentage of the amount needed for saturation at the same temperature.

☑ \`Time of Insolation\` is the duration of sunshine.

✅ The specific form of the function \`f\` would be determined by the regression or machine learning model used, and it would be based on the patterns found in the historical data.

Paper:

Coffee Rust Forecast Systems: Development of a Warning Platform in a Minas Gerais State, Brazil

Autors:

@Edson Ampélio Pozza
@Éder Ribeiro dos Santos
@Nilva Alice Gaspar
@Ximena Maira de Souza Vilela
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Universidade Federal de Lavras
Cooperativa Reg.Cafeic. Guaxupé
IHARA Defensivos Agrícolas

CHAPTER 7 Blockchain in Agriculture

PREV INDEX NEXT

BLOCKCHAIN REVOLUTIONISING AGRICULTURE

Solutions Providers	Solution Description	Benefits	Potential
IBM Food Trust™	A blockchain platform for creating a transparent food supply chain, tracking products from farm to table	Improved traceability, transparency, and trust; increased efficiency	Reduction of food fraud and contamination risks; better supply chain management
Provenance Blockchain	Blockchain-based platform for supply chain transparency and product verification	Enhanced trust and transparency; verified sustainability and ethical claims	Strengthening consumer confidence; promoting sustainable and ethical practices
ripe.io Blockchain of Food	IoT and blockchain-enabled platform for tracking food quality and safety throughout the supply chain	Real-time monitoring of food quality; improved traceability	Ensuring fresher, safer food products; reduction of foodborne illnesses
TE-FOOD	End-to-end food traceability solution using blockchain and IoT technologies	Traceability from farm to table; improved supply chain efficiency	Combating food fraud; optimizing food waste and distribution
Ambrosus	Combining IoT and blockchain to create a transparent and secure food supply chain	Real-time data sharing; tamper-proof data storage	Enhanced food safety and quality assurance; preventing product recalls
origintrail	Decentralized, blockchain-based platform for transparent supply chain data exchange	Interoperability between supply chain participants; enhanced trust	Improved collaboration between stakeholders; fostering sustainability
vechain	Blockchain platform for supply chain management, quality control, and data verification	Enhanced data integrity and transparency; reduced manual errors	Facilitating smarter, more efficient supply chains; fraud prevention

@ Marco Brini

✅ **BLOCKCHAIN (easily explained)**

▪ Imagine a shared notebook with multiple pages, where each page contains a list of transactions.

▪ Once a page is filled with these transactions, it is sealed with a unique lock and key, then added to the notebook in a way that can't be altered or removed.

▪ The notebook is shared among a network of computers, and every computer has a copy of it.
▪ Whenever there's a new transaction, all the computers in the network verify and agree on its validity before adding it to the latest page.
▪ When a new page is full, a new lock and key are created, linking it to the previous page.
▪ This chain of locked pages ensures that no one can tamper with the notebook without breaking the links between the pages.

🔵 In this analogy:

▶ the pages are called "blocks,"
▶ the locks and keys are the "cryptographic security,"
▶ the notebook is the "chain."

The blockchain securely records transactions without needing a central authority, like a bank, to oversee it.

This technology can be used for various purposes, such as tracking products in a supply chain, managing digital currencies, or verifying data.

🔶Companies & Solutions for FOOD & AGRICULTURE🔶

1. IBM Food Trust

A blockchain-based platform that connects farmers, processors, distributors, and retailers to create a transparent and secure food supply chain.

2. Ambrosus

A blockchain and IoT platform that ensures the quality, safety, and origins of food and pharmaceutical products throughout the supply chain.

3. TE-FOOD International

A farm-to-table food traceability solution that provides real-time data on food origin, processing, and transportation.

4. Provenance

A platform that empowers brands to be transparent about their products' origins, ingredients, and impact through blockchain technology.

5. ripe.io

A blockchain-powered platform that enables real-time tracking of food from farm to fork, ensuring quality, safety, and sustainability.

🔶Key Benefits🔶

🔷 Transparency: Blockchain enhances visibility across the entire food value chain, allowing consumers to access information about the origin and quality of their food.

🔷 Efficiency: The technology streamlines processes by automating transactions and reducing intermediaries, leading to cost savings and improved productivity.

🔷 Data Security: Decentralized data storage ensures data integrity, minimizing the risk of fraud and manipulation.

🔷 Sustainability: Blockchain promotes responsible resource management and sustainable practices by enabling greater accountability in the food supply chain.
Blockchain solutions have the potential to transform the agriculture and food industries, creating a more secure, transparent, and sustainable food system for all.

PRICE VOLATILITY: CAN BLOCKCHAIN HELP?

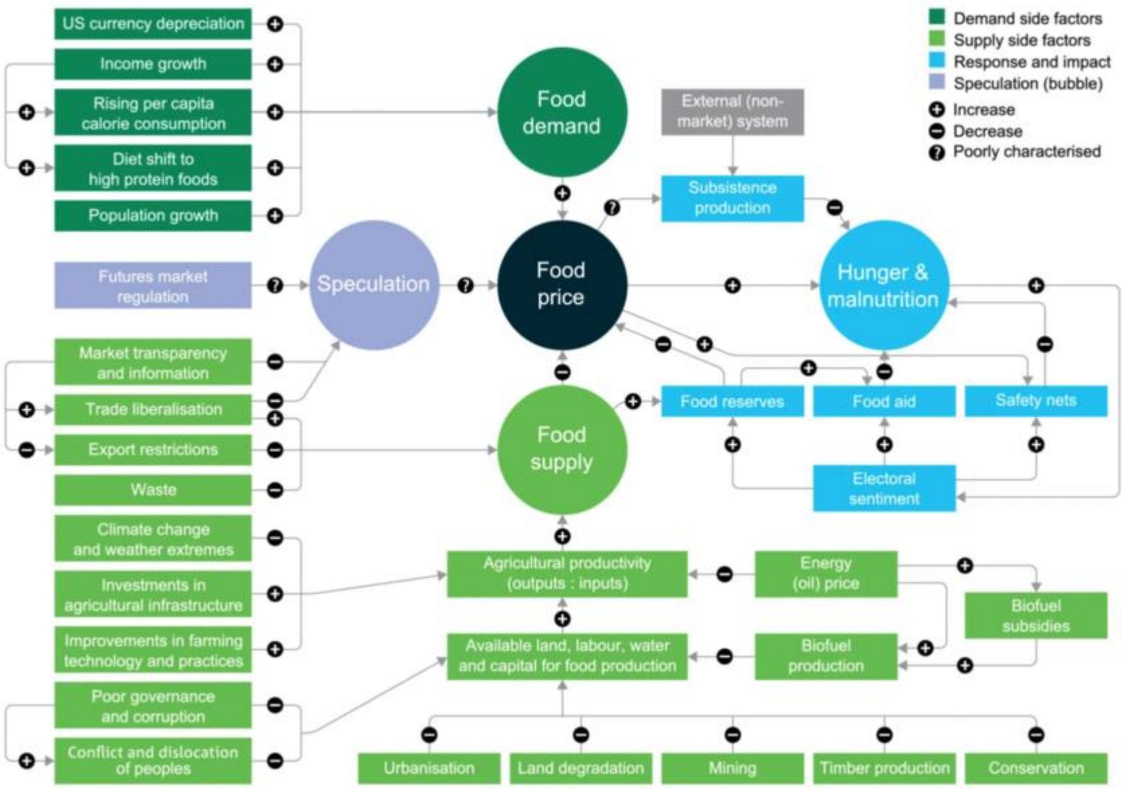


Image from: Food price volatility and hunger alleviation – can Cannes work?

FOOD PRICE VOLATILITY

The fluctuation of food prices over time can have significant impacts on both consumers and smallholder farmers as producers.

CAUSES

Causes of food price volatility:

1. Climate change: Changes in weather patterns can affect the production of crops and cause supply shocks that can lead to price spikes.

2. Increased demand: Rapid population growth and changes in dietary habits have led to increased demand for food, which can drive up prices.
3. Trade policies: Changes in trade policies, such as export restrictions or import tariffs, can affect the availability of food and lead to price volatility.
4. Speculation: Speculators in commodity markets can drive up food prices by buying and selling contracts without ever taking physical delivery of the goods.
5. Energy prices: As food production relies heavily on fossil fuels, changes in energy prices can affect the cost of production and transportation, leading to changes in food prices.

CONSEQUENCES

Consequences for developing countries:

1. Consumer vulnerability: Food price spikes can push many people below the poverty line, making it difficult for them to access sufficient and nutritious food. This is particularly problematic in developing countries, where a large proportion of household income is spent on food.
2. Malnutrition: High food prices can lead to undernutrition, particularly in children, which can have long-term impacts on their health and development.
3. Instability: Food price spikes can lead to political instability and social unrest in developing countries, particularly in countries that are heavily reliant on food imports.
4. Smallholder farmer vulnerability: Smallholder farmers may struggle to cope with price volatility, particularly if they lack access to finance, technology, or information. If they are unable to pass on higher prices to consumers, they may suffer from reduced incomes and food insecurity.

Food price volatility can have significant impacts on both consumers and smallholder farmers as producers in developing countries. Addressing the causes of price volatility and implementing measures to mitigate its consequences is crucial to ensure food security and promote sustainable development in these countries.

POSSIBLE SOLUTIONS

1. Promoting sustainable agriculture practices: Encouraging the adoption of sustainable agriculture practices such as agroforestry, crop diversification, and water conservation can help increase agricultural productivity and reduce supply shocks that can drive up food prices.
2. Investing in rural infrastructure: Improving rural infrastructure, including transportation, communication, and energy systems, can help reduce the costs of production and distribution, making food more affordable and accessible to consumers.
3. Developing social safety nets: Implementing social safety nets such as food assistance programs, targeted subsidies, and income support measures can help protect vulnerable populations from the impact of price volatility.

TECHNOLOGY OPPORTUNITIES

1. Adoption of precision agriculture: Precision agriculture technologies such as satellite imagery, weather sensors, and drones can help farmers improve their yields and reduce the risk of crop failure due to weather patterns and climate change.
2. Adoption of blockchain technology: Blockchain technology is a distributed ledger system that can help enhance transparency, traceability, and accountability in the food system. It can help reduce price volatility by enabling farmers to track the production of their crops from farm to fork, ensuring that they receive a fair price for their products. It can also help reduce transaction costs and improve market efficiency by facilitating direct trade between farmers and consumers.

BLOCKCHAIN TECHNOLOGY

Blockchain technology has the potential to revolutionise the way that smallholder farmers in developing countries engage with the food system. By using blockchain, farmers can create a tamper-proof record of their crop production, which can be used to verify the quality and authenticity of their products. This can help to reduce the risk of fraud and ensure that farmers receive a fair price for their crops. Additionally, blockchain can facilitate direct trade between farmers and consumers, eliminating intermediaries and reducing transaction costs. This can help to increase the incomes of smallholder farmers and improve food security for consumers.

SOME BLOCKCHAIN SOLUTIONS

1.AgriDigital: AgriDigital is an Australian blockchain-based platform that enables farmers to manage their grain deliveries, contracts, and payments. By using blockchain, AgriDigital provides farmers with greater transparency and traceability in the grain supply chain, helping to reduce price volatility and improve the efficiency of the market.

2. Provenance: Provenance is a UK-based blockchain platform that enables food producers to track the provenance of their products from farm to fork. By using blockchain, Provenance provides consumers with greater transparency and traceability in the food supply chain, helping to reduce the risk of fraud and ensure that farmers receive a fair price for their products.

3. IBM Food Trust: IBM Food Trust is a blockchain-based platform that enables food producers, retailers, and consumers to track the provenance of their products. By using blockchain, IBM Food Trust provides greater transparency and traceability in the food supply chain, helping to reduce price volatility and improve the efficiency of the market.

CHAPTER 8 Open-Source Agriculture solutions

PREV INDEX NEXT

BEST ADOPTION STRATEGY? GO OPEN.... SOURCE!

DIGITAL AGRICULTURE PROBLEMS:

❌ lack of interoperability,

❌ data privacy

❌ data quality

❌ difficulty in attracting talent from a population increasingly disconnected from agriculture.

☑ THE SOLUTION

The common thread of all these problems is that their solution can be found in open source culture.

❓WHAT DOES OPEN SOURCE REALLY MEAN?

"Open-source culture" does not mean "make all private agricultural data publicly available."

OPEN SOURCE refers instead to a method of software development in which the source code is made available publicly without requiring a licensing fee.

The DATA, which the software handles, REMAINS as PRIVATE as the owner wishes it to be. ONLY THE CODE IS OPEN, not necessarily the data.

Of course, once open source code makes people masters of their own data, they are EMPOWERED to make their data available as they see fit, be they researchers, industry, and even farmers.

✳ Open source democratizes innovation

When the keys of innovation are held by only a select few, this evolution toward “better” is handicapped because fewer people trying fewer alternatives means that fewer ideas are born.

Open source democratizes this process. Anybody with an idea, passion, and talent anywhere in the world can contribute to the innovation evolution. More minds mean more ideas and more creativity

✳ Open source reduces the barriers to building on others’ work

Open-source software promotes collaboration by making the source code freely available allowing anyone to modify, enhance, or build upon existing work without needing to start from scratch. For example, if a developer creates an open-source data visualization tool, another developer could add new features or adapt it for a specific use case, like visualizing climate data. This accelerates innovation and reduces duplication of effort, as developers can leverage and contribute to the collective knowledge of the open-source community.

✳ Open source builds bigger markets

Agriculture is currently experiencing the problem of small proprietary markets. Many companies have dedicated themselves to making their own proprietary internet instead of working together to build an ag internet. Some companies restrict how people are allowed to use their data across platforms. Some argue with farmers about who owns the data. Some treat ideas that originated outside their company, or in the academic world outside their research group, as useless at best or usually problematic. Unless open-source collaboration can be brought to bear in industry and academia, we will all continue to lament the limited utility and limited size of the ag data market. Open-source streamlines talent discovery and attraction.

https://lnkd.in/eX6U2kyc

Open-Source ROBOT: grow your food at home!

▶ WHAT

FarmBot Inc grows food at home fully automatically

Currently focusing on home growing, FarmBot Inc is a great example of combining open source with robotics and agriculture.

▶ HOW

Farmbot it's the IKEA of your home grown food. You buy the components online and assemble them in 1h. Then Farmbot will work for you to grow your food (indoor or outdoor).

▶ A FIRST STEP

Although FarmBot Inc isn't for professional growers, it shows us the ideal way to go. FarmBot Inc proves that open source is viable in agriculture also on the robotics level.

▶ APP

Through FarmBot app you can move & operate farmbot, take photos of your veggies, turn the lights on for a night time harvest... from everywhere. You can also monitor the automatic tasks automatically performed by Farmbot such as watering a group of plants.

▶ INTEROPERABLE

It can also be easily integrated with other systems through simple API.

▶ OPEN SOURCE: HW & SW

FarmBot Inc is completely open source, they share all instructions to build it and the code to operate it

https://lnkd.in/e28y6p7e

INTEROPERABILITY & OPEN SOURCE

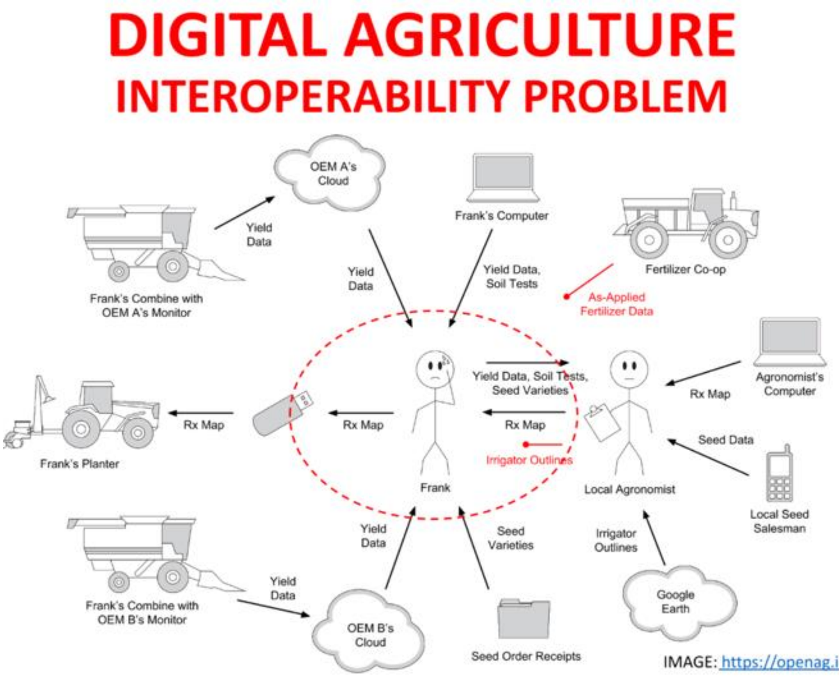


IMAGE: https://openag.io/principles/#use-case

Farmers are currently overwhelmed with incompatible data generated by their DIGITAL

AGRICULTURE SOLUTIONS

Farmer's want SUCH SOLUTIONS to interoperate – that is, to share information and be able to adequately rely on each other to help support decision-making.
Several attempts at solving data sharing & compatibility have revolved around creating monolithic standards that are licensed commercially and selectively.
Farmers require an open solution that works with existing standards, adheres to clear privacy and security policies, and doesn't require farmers to pay to access their own data.

Open Ag Data Alliance (https://openag.io/)

Partners:

- 360 Yield Center
- AgReliant Genetics, LLC
- AgSpace
- AgriCircle AG
- ApRecs
- Ayrstone Productivity
- CNH Industrial
- Centricity
- Climate
- GROWMARK, Inc.
- Granular
- Monsanto Company
- ONFARM
- Purdue University
- Tierra
- Agri-Valley Irrigation (AVI)
- Wilbur-Ellis Agribusiness
- WinField United

Open Ag Data Alliance Principles

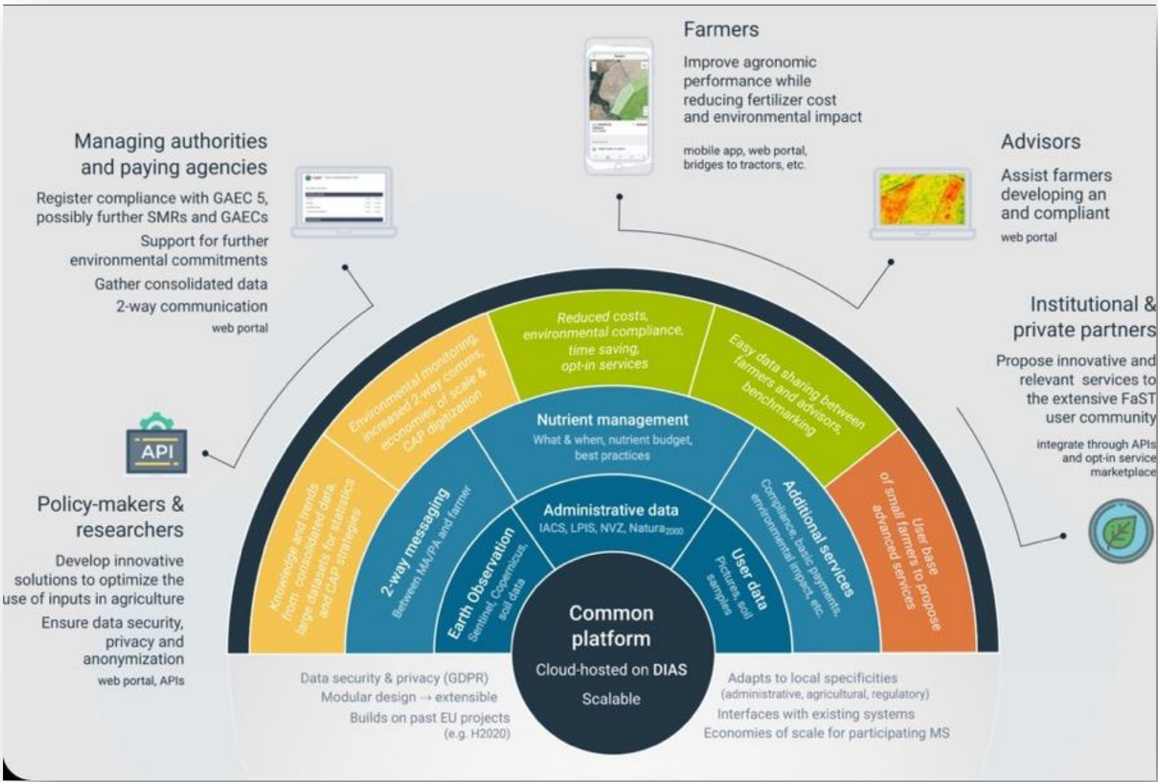
https://lnkd.in/eME9_WKE

Open Ag Data Alliance code on GitHub

https://github.com/OADA

OPEN PLATFORM

(EU) FaST Platform: open source + many services + interoperable +...



▶ WHAT?

farmers' APP ➕ CLOUD service(s)

▶ TO WHOM? (Benefits)

1. Farmers (fertilizer optimization & data sharing with... ⬇️)
2. Authorities (payments & public register)

3. Agronomists (better recommendations to farmers)
4. Policy makers (better policies)

▶ **SERVICES**

1. Nutrient optimization ▶ costs reduction + environmental compliance)
2. Administrative data sharing ▶ saving time
3. data aggregation ▶ better policy making

▶**FERTILIZERS? HOW?**

Satellites ▶ Copernicus/sentinel (RGB+NDVI)

▶ **APPROACH**

✔Open source
✔Modular
✔Interoperable
✔Customizable
✔Cloud-based

▶ **WHO**

European Commission

Copernicus

isa2

Galileo

Claudia Muresan, Ph.D.

Isidro Campos Rodriguez

Elena Cristina Cosma

PwC France

▶ **DEVELOPMENT STAGE**

✅ (done) Stage 1 (released in 4 EU regions)

🔷 (now) Stage 2 (project expansion)

Website

https://fastplatform.eu/

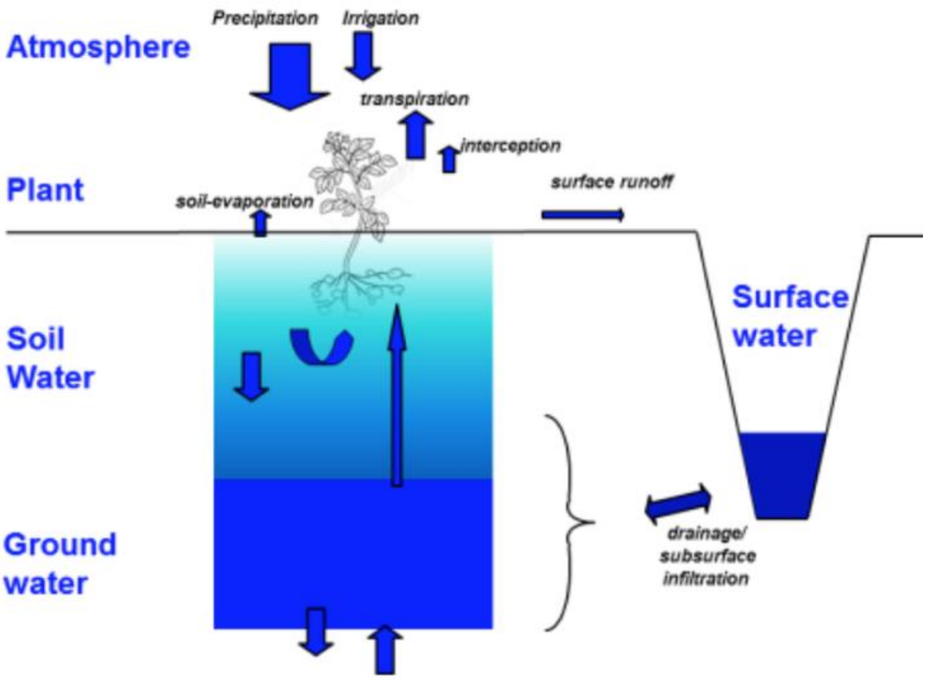
Video

https://lnkd.in/etMkJPYD

https://lnkd.in/e4PYSiMX

Optimise IRRIGATION… for free!

SMART IRRIGATION...with FREE and VALIDATED software



Full list here: https://lnkd.in/e6YDVDC3

FREE ?

Digital Agriculture doesn't necessarily has to be expensive.

Numerous projects promoted by universities and NGOs have produced interesting free software that any farmer can download and adopt.

DO-IT-YOURSELF

Many are already used by farmers.

Others...can be adopted by farmers with a Do It Yourself (DIY) attitude and some digital skill.

AVAILABLE OPTIONS

Farmers, developers and researchers can choose one of the following: (complete list and details here: https://lnkd.in/e6YDVDC3)

▶ AquaCrop

https://lnkd.in/eFcZbtCM

▶ CROPWAT

https://lnkd.in/ehVUzA-S

▶ NIAZAB software

▶ WATER METER CALCULATOR APP

https://lnkd.in/ee2T2h5f

▶ IrrigatePump + IrrigateCost

https://lnkd.in/eKKCJxCE

▶ IrrigatorPro

https://irrigatorpro.org/

▶ OpenSprinkler

https://opensprinkler.com/

▶ AquaCrop-OS

https://lnkd.in/ehqEmQSh

▶ DSSAT

https://dssat.net/

▶ SWAP

https://lnkd.in/eB4GmXPs

▶ EPIC

https://epicapex.tamu.edu/

CHAPTER 9 Digital Agriculture for Smallholders

PREV INDEX NEXT

DIGITAL SOLUTIONS FOR SMALLHOLDERS

Company	Solution	Description	Benefits for Smallholder Farmers	Benefits for Consumers and the Environment	Challenges
Granular	Farm Management Software	Suite of farm management tools to optimize operations and resources	Data-driven decisions, optimized resources	Improved food quality, reduced waste and environmental impact	Limited access to technology and connectivity, learning curve
Taranis	Farm Management Software	AI-powered aerial imagery and precision agriculture technology for crop management	Improved crop management, early detection of issues	Enhanced food security, reduced pesticide use and environmental impact	Costs of technology, adoption barriers
PrecisionHawk	Precision Agriculture	Drone and remote sensing technology for data collection and analysis in agriculture	Better resource management, crop monitoring	Sustainable farming practices, reduced environmental footprint	Costs, regulatory restrictions for drone usage, data analysis expertise
CropX	Precision Agriculture	Soil monitoring technology and data-driven irrigation solutions	Optimized water usage, improved crop yields	Water conservation, better quality produce	Initial investment, understanding data-driven solutions
Farmdrop	Online Marketplace	Connects local farmers and producers directly with consumers	Access to wider markets, higher profit margins	Fresh, locally-sourced produce, reduced carbon footprint	Trust-building between consumers and producers, logistical challenges
Provenance	Traceability Platform	Blockchain-based supply chain transparency and traceability for food and consumer goods	Enhanced product value, consumer trust	Assurance of product authenticity and sustainability, informed purchasing decisions	Complexity of technology, scalability
Kiva	Crowdfunding Platform	Allows individuals to lend money to smallholder farmers and other entrepreneurs in developing countries	Access to financial resources, investment opportunities	Supporting sustainable development and ethical businesses	High demand for loans, repayment risk, financial management
FarmDrive	Financial Services	Kenyan fintech company providing credit and financial services to smallholder farmers using data analytics	Access to credit, improved financial management	Encouraging sustainable growth in agriculture	Limited access to banking services, credit risk, digital literacy
AgroCenta	Mobile Services	Ghanaian agritech company providing market information, financial services, and agricultural best practices via mobile tech	Access to information, improved farm practices	Support for local farmers, sustainable agriculture practices	Limited access to mobile devices and connectivity, regional limitations
Plantix	Mobile App	AI-powered app to diagnose crop diseases and provide crop management recommendations	Improved yields, reduced crop losses	Lower pesticide use, healthier and safer produce	Access to smartphones, internet connectivity, technology adoption
AeroFarms	Vertical Farming	Urban vertical farming using aeroponic technology and data-driven approaches	Resource optimization, potential for urban farming	Reduced environmental impact, fresh and local produce	High setup costs, energy consumption, urban space constraints
Blue River Technology	Precision Agriculture	AI-driven equipment for targeted weed elimination and herbicide application	Reduced herbicide use, cost savings	Reduced chemical exposure, healthier produce, decreased environmental impact	High costs of equipment, training, and maintenance
aWhere	Weather Information	Weather data and agricultural intelligence for informed decision-making	Improved planting, irrigation, and pest management strategies	Enhanced food security, reduced crop losses and environmental impact	Access to technology, understanding and interpreting data

PROBLEM

Over the next decade, many smallholder farmers will face challenges that may lead to the abandonment of their farms. Factors such as financial constraints, an ageing population, urbanisation, climate change, and the increasing competition from large-scale commercial agriculture will contribute to this trend.
In order to remain in business, smallholder farmers will need to adapt and innovate.

CONSEQUENCES

The challenges faced by smallholder farmers and the potential increase in large-scale commercial farming can have significant implications for the resilience of the world food system and the environment. Promoting sustainable and diversified agricultural practices among both smallholder and large-scale farmers is essential to ensure global food security and minimise environmental impacts.

SOLUTIONS

One possible avenue is to focus on organic, permaculture, and regenerative agriculture practices. By rediscovering and cultivating autochthonous (native) plants, farmers can preserve local biodiversity and cater to a growing market of environmentally conscious consumers who prioritise healthy food choices.

DIGITAL TOOLS

Digital technologies can play a crucial role in supporting smallholder farmers as they transition to these new practices. Some key technologies that can help include:

🌟 Mobile Apps & Platforms 🌟

1. AgroCenta Technologies, Inc (Techstars 22)

This Ghana-based digital platform connects smallholder farmers directly with buyers, offering fair prices and eliminating middlemen. AgroCenta also provides farmers with access to financial services and real-time market information.

2. Wefarm

WeFarm is a peer-to-peer knowledge-sharing platform that enables smallholder farmers to share information, ask questions, and access advice on sustainable farming practices via SMS.

🌟 IoT & Precision Agriculture 🌟

3 Hello Tractor

Hello Tractor is an innovative solution that connects smallholder farmers with tractor owners, allowing them to rent equipment on-demand. This platform makes mechanisation more accessible and affordable for small-scale farmers.

4 FarmBeats for Students

Developed by Microsoft, FarmBeats is an AI-driven platform that collects and analyses data from low-cost sensors, drones, and satellite imagery to provide smallholder farmers with actionable insights for optimising their agricultural practices.

🌟 Financing & Insurance 🌟

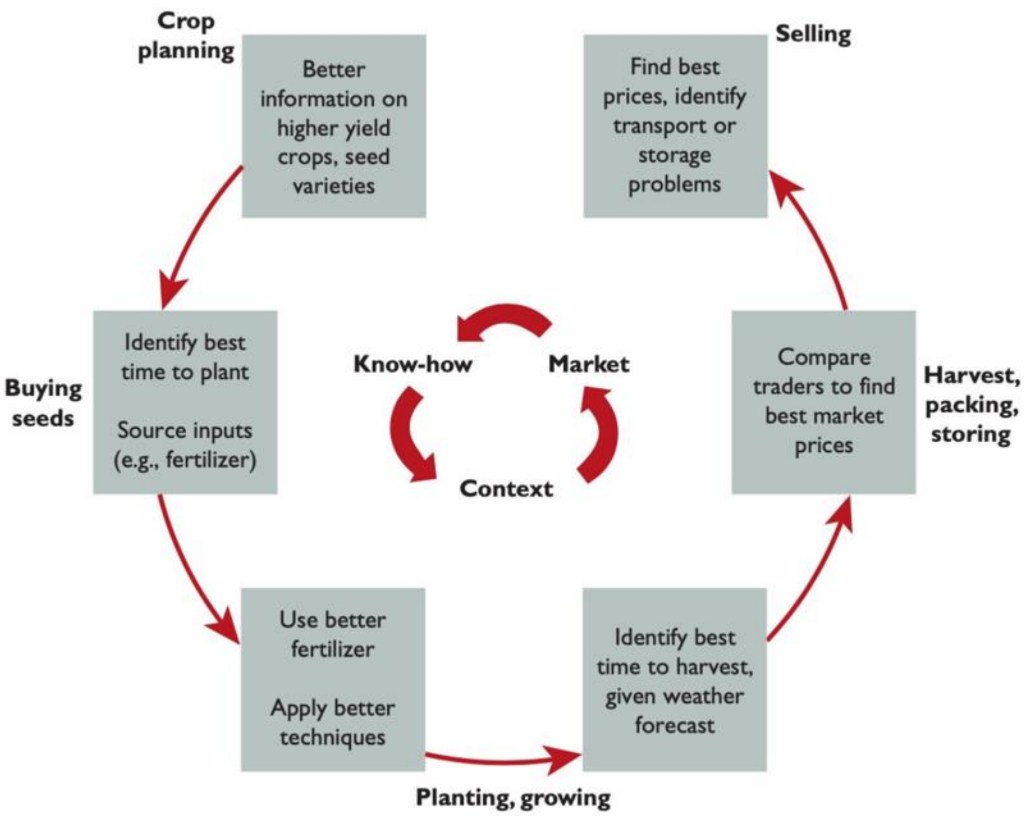
5 PULA

Pula is an insurtech company that offers affordable insurance products and digital solutions to smallholder farmers in Africa. By leveraging data and technology, Pula helps farmers manage risks and improve their productivity.

MORE ON THE ARTICLE: https://lnkd.in/etQHXC7F

Farmer's Seed-to-Sell: key choices

WHAT INFORMATION FARMERS NEED? WHERE SHOULD DIGITAL TOOLS FOCUS?



Source: Adapted with permission from Mittal, Gandhi, and Tripathi 2010.

The SEED-TO-SELL FARMER'S PROCESS imposes & offers choices.
Often the digital agriculture provider gets lost into tech details missing the key farmer's needs. That is slowing down digital agriculture adoption and creating market inefficiency.

MAIN PHASES & CROSSING POINTS

The digital tools should focus on to help farmers in increasing food production efficiency:

1 SET

🔙 Crop planning (which crop, which genotype)

🔙 Seeding time (when is the best time to seed)

🔙 Soil preparation (practices & fertilizers)

2 DO

🔛 Ongoing agronomic practice (water efficiency, pest & diseases)

🔛 Harvest (when is the best time, how to anticipate or postpone)

3 GET

🔜 Selling (traders' selection, market prices, stocking costs & risks)

✅ Digital technologies should close the efficiency gap by reducing the farmer's informational hurdles supporting farmers' decision-making through the acquisition and leveraging of granular data about fields and animals in combination with accurate, timely, and location-specific weather and agronomic data.

Digital Agriculture as a Service (DAAS) for smallholders

DAAS: WHAT?

DAAS (Digital Agriculture as a Service) presents several opportunities for smallholder farmers.
Today, with the rapid pace of mobile phone penetration (ranging between 50% and 95% throughout the developing world), smallholder farmers can adopt digital agriculture innovations, gaining access to real-time agricultural advice, market trends, weather forecasts, and other vital information.

WHAT FOR?

Enhanced Learning and Sharing
DAAS can facilitate the sharing of knowledge and best practices among the farming community, leading to improved farming techniques and strategies.

WHY?

▫Increased Yield and Income

The use of DAAS could potentially catalyze a $1 billion increase in yields annually among 100 million smallholder farmers, leading to increased income.

▫Access to Financial Services and Markets Digital platforms can connect farmers to markets more efficiently and provide access to financial services.

FUNDING (USAID)

"Devoting a small percentage (~2%–5%) of USAID's agricultural aid budget to DAAS and other digital agriculture innovations... "

USAID's agricultural budget is around $2 billion, therefore:

2% of $2 billion would be $40 million.

5% of $2 billion would be $100 million.

FUNDING's expected impact

This investment is expected to catalyze $1 billion in increased yields annually among 100 million smallholder farmers. To provide exact figures in million USD, we would need to know the total amount of USAID's agricultural aid budget.

More on this interesting article Federation of American Scientists

https://lnkd.in/eUrFe43b

Farmers' Peer2Peer AI supported

TOP-DOWN

Digital agriculture standardise & package product & solutions for the market. While this approach produces good results in developed countries it has significant limitations for smallholder farmers:

(1) AFFORDABILITY: solutions produced in developed countries tend not to be affordable to smallholder farmers;

(2) HETEROGENEITY: smallholder farmers are extremely diversified in: genotypes, climate conditions, different practices, different budgets, …

BOTTOM-UP

In the Peer-to-Peer (P2P) approach each farmer can be the protagonist, becoming a source of information, service, training.

This approach is particularly effective on knowledge sharing & training.

"Farmers need clear and simple explanations…it's thus much more relevant if the training is based on a peer-to-peer approach: successful farmers act as protagonists and showcase their achievements. In addition, this project's ambassador is able to describe his own pathway up to full scale adoption that will sound even better in other farmers' ears: 'If he has been able to do this, and as I'm similar to this guy, thus I'm also able to perform the same and maybe I can do even better".

Issoufaly Hatim

FARMERS' KNOWLEDGE + DIGITAL P2P + AI

The final ingredient is AI that can help routing the information among farmers, filtering spam, learn from farmers previous messages and therefore being able to become an "artificial farmer" built on the farmers' shared knowledge.

2P2 INITIATIVES

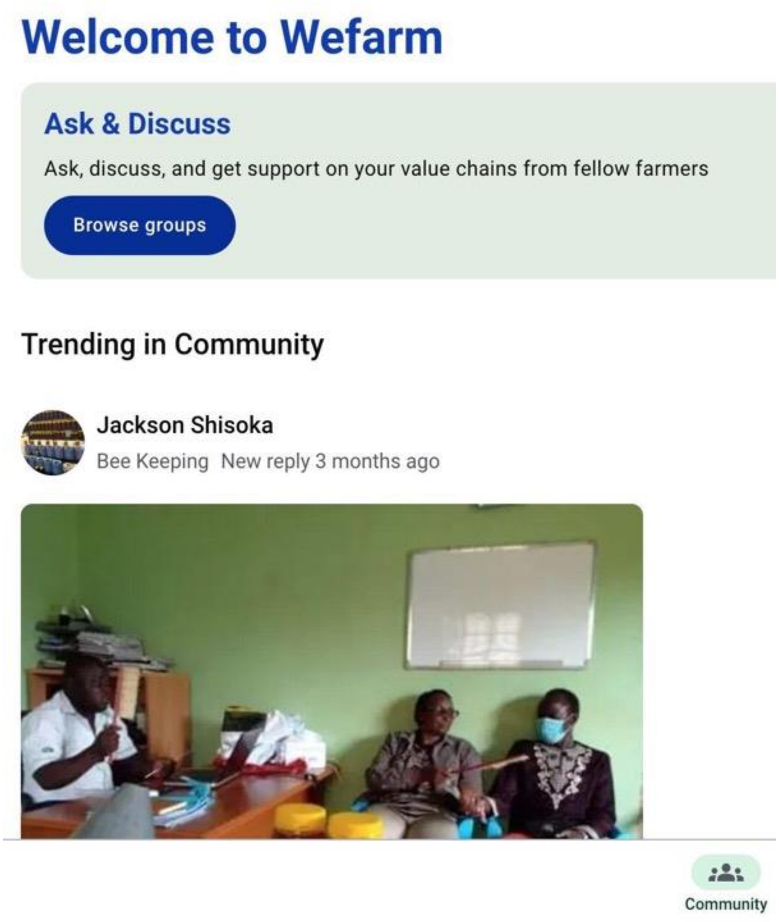
NEFERTITI (EU)

https://lnkd.in/euFG8kPA

The overall objective of NEFERTITI is to establish an EU-wide highly connected network of demonstration and pilot farms designed to enhance knowledge exchanges, cross fertilisation...through peer-to-peer... in Europe.

***Wefarm* (Kenya, Uganda and Tanzania)**

Free peer-to-peer service that enables small-scale farmers to share information via SMS about anything related to agriculture, then receive crowdsourced bespoke content and ideas from other farmers around the world within minutes. Machine-learning algorithms then match each question to the best suited responder within the network, based on analysis of the content and intent.

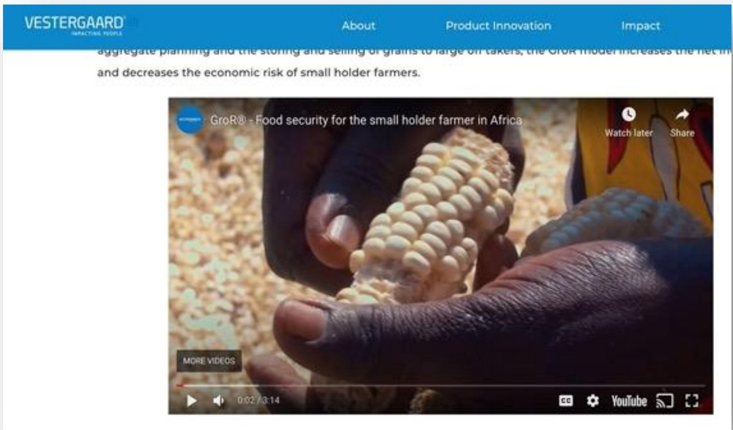


OTHERS P2P INITIATIVES

GroR Vestergaard

https://lnkd.in/ejz6TSqY

Rural, decentralized, community-based Peer-to-Peer micro-warehouse and trading platform for commodities, implemented in Kenya.



P2P certification program (Thai Organic Agriculture Foundation)

Peer-to-peer system for farmers to test and certify (ORGANIC) each other's produce.

The Greater Mekong Subregion

CHAPTER 10 Digital Agriculture & Sustainability

PREV INDEX NEXT

DIGITAL AGRICULTURE helps OLD (good) PRACTICES

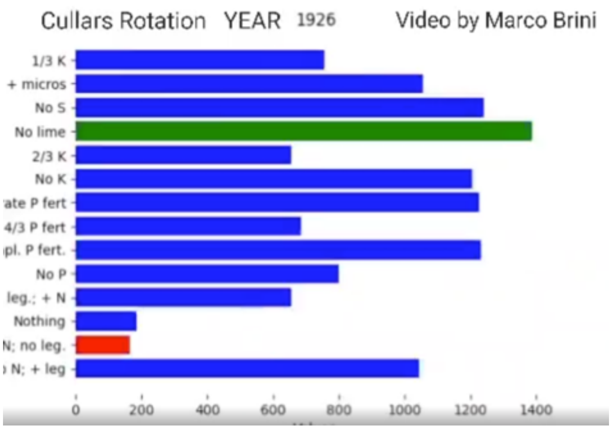
Digital tools help to do better and more efficiently, but good old practices shouldn't be forgotten, on the contrary, should benefit from the new tools.

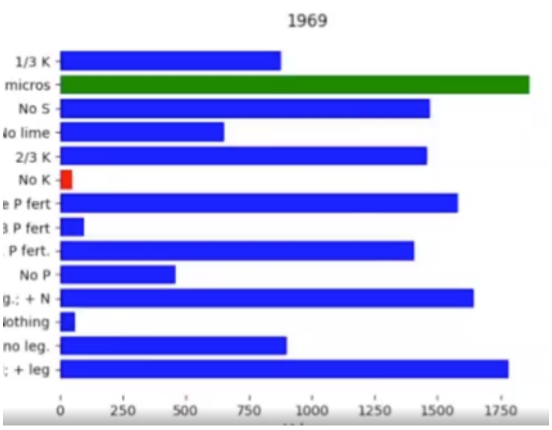
Robert Mikkelsen shared the extremely interesting "**cullars rotation experiment**".

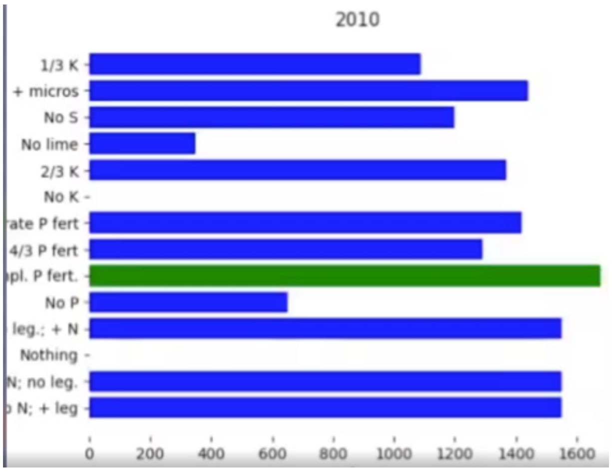
More than 100 years of accumulated experience that give guidance.

Digital tools can help to introduce efficiency in such fundamental experiments reducing the overall management costs while making the results easily available to everyone.

Below screenshots (years 1926, 1969, 2010) from a video showing the performances over time from different parcels that received different treatments over time. Refer to Robert Mikkelsen post for more info and find below more material about this valuable experiment that is our duty to continue for the future.







Cullars Rotation: in short

Video data sources:

https://lnkd.in/eqDikW4z

Centennial of Alabama's Cullars Rotation, the South's Oldest, Continuous Soil Fertility Experiment C. C Mitchell, D. P. Delaney, and K. S. Balkcom

College Auburn University hosting the testing area

https://lnkd.in/eczpqcAx

Paper by Charles C. Mitchell, Dennis Delaney, and Kipling S. Balkcom

https://lnkd.in/ezhXzHqz

Cotton Research Report No. 36 March 2010

Interesting paper containing a lot of info

https://lnkd.in/emNebJKV

Site coordinates

https://lnkd.in/evPVhvdh

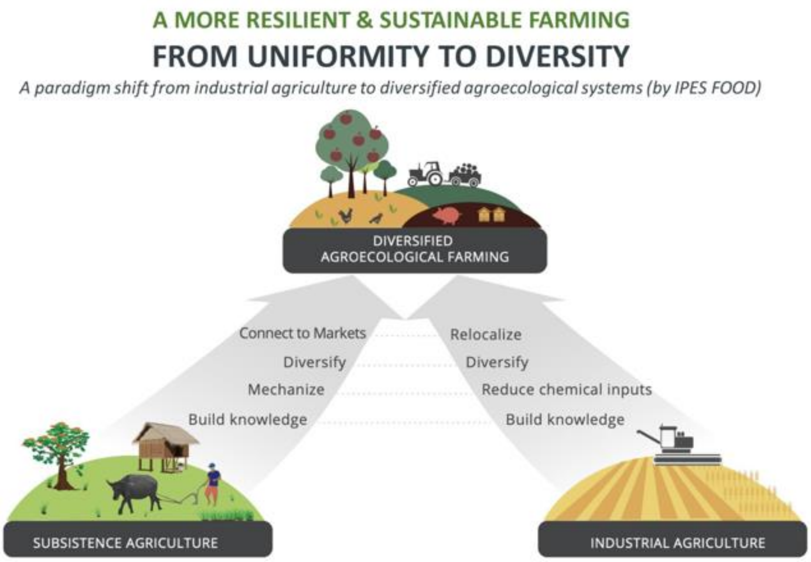
Wikipedia:

https://lnkd.in/eDJdVXMD

Thanks also to Steve Noffsinger and Marius Monen to share more info

ENABLING AGROECOLOGY

A MORE DIVERSIFIED, RESILIENT & SUSTAINABLE FARMING...HOW?



▶ INDUSTRIAL AGRICULTURE = SPECIALISATION

Is the 'conventional' agriculture often corresponding to the industrial model:

- monocultures
- CAFOs (Concentrated Animal Feeding Operations)
- genetically uniform varieties
- intensive use of external inputs

▶ AGROECOLOGY = DIVERSIFICATION

Intends to offer an alternative to industrial agriculture

- temporal & spatial crops diversifications
- uniform, locally-adapted varieties/breeds
- Low external inputs (circular)

IF WE TRANSITION... WILL WE FEED WORLD?

Yes... provided efficiency is introduced.

Digital tools can indeed help over the key actions required:

- Connect to Markets ▶ integrated supply chain
- Diversify = more complexity ▶ ERP (Farm management systems)
- Reduce chemical inputs ▶ Agronomic recommendation systems
- Build (& share) knowledge...▶ that's the final goal of the digital tools!!!

More on IPES-Food report: https://lnkd.in/dPhsW6Fy

DIGITAL AGRICULTURE makes INDOOR SUSTAINABLE

A POWERFUL MIX TO SUPPLY FRESH VEGETABLE TO URBAN AREA

Have a look at AppHarvest, as for a future more sustainable food system we need more companies like this (especially for large urban areas).

AppHarvest combines conventional agriculture with cutting-edge technology focusing on sustainable, controlled-environment farming

AppHarvest Overview:

▶ among the largest single-site greenhouses in the world

▶ 2.6 million square feet of indoor growing

▶ 45 million pounds of tomatoes/year

▶ focus on non-GMO, sustainably grown produce

Environmental Impact:

▶ Reduces water usage by 90% compared to traditional farming

▶ Rainwater recycling system eliminates the need for groundwater

▶ Eliminates the use of harmful chemical pesticides and fungicides

Food System Benefits:

▶ High-yield production of fresh, nutritious produce

▶ Consistent year-round availability of crops

▶ Reduced dependence on imported produce, leading to lower food miles and carbon emissions

▶ Enhanced food security through local, resilient production$

Sustainable Infrastructure:

▶ Massive, state-of-the-art greenhouse facilities

▶ Climate-controlled environment for optimal plant growth

▶ Utilizes energy-efficient LED lighting for lower energy consumption

Economic and Social Impact:

▶ Supports local economies by creating new job opportunities

▶ Encourages investment in sustainable agriculture and innovation

▶ Promotes education and training in sustainable farming practices

Future Prospects:

▶ Scalable model with potential for expansion to other crops and regions

▶ Ongoing research and development to further optimize sustainability and productivity

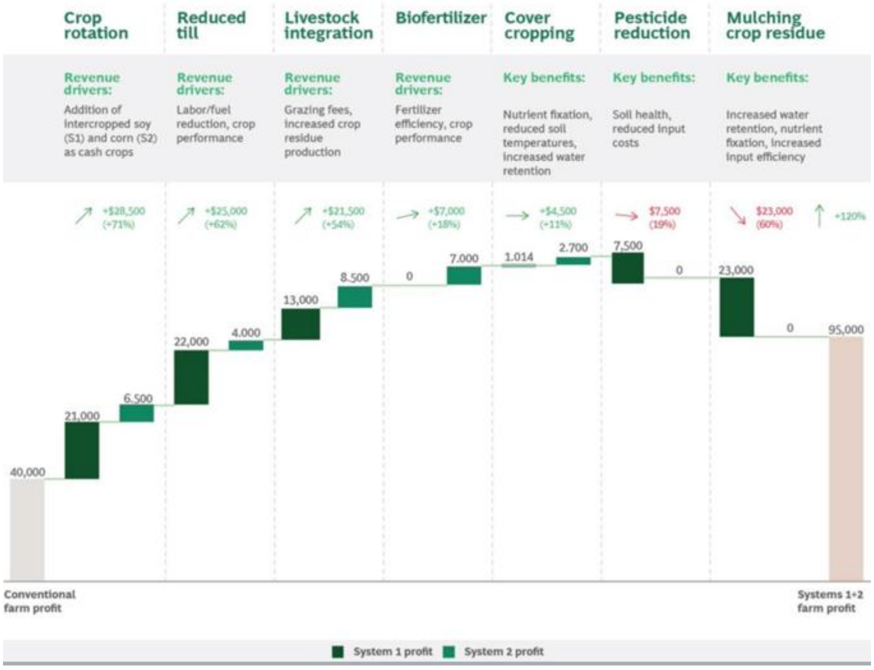
▶ Pioneering a new era of environmentally friendly, high-tech agriculture

Video from insider business https://lnkd.in/et86qDKt

Featuring: @Jonathan Webb

Featuring: Jonathan Webb, Jackie Roberts

DIGITAL & REGENERATIVE AGRICULTURE



CONVENTIONAL vs. REGENERATIVE

Report suggests economic superiority for regenerative agriculture, while facing initial losses transitioning from conventional agriculture.
DIGITAL AGRICULTURE tools support key regenerative agriculture's strategies:

■ Crop Rotation

Tools for soil analysis and yield prediction aid in planning crop rotation (Farmers Edge, Granular,...)

■ Reduced Till (& Soil Health):

Soil sensors and AI tools optimise irrigation and reduce tillage, improving soil health (Teralytic, SoilOptix Inc,CropX Technologies,...)

■ Livestock Integration:
IoT devices monitor livestock health, and digital platforms guide rotational grazing practices (AgriWebb, PastureMap,...)

🗒️ **Report's summary**

🔍 Focus:
- The analysis focuses on Kansas (USA) wheat farmers.
- The transition to regenerative agriculture involves a shift from monoculture wheat to rotations that integrate corn and soy, which can increase revenue.

🌿 Productivity:
▶ After the initial transition period, farmer profitability under a regenerative system consistently outperforms the conventional case under favourable climate conditions.
▶ Key profitability drivers for regenerative systems:
♻️ crop rotation (increasing revenue from diversifying cash crops);
🚜 reduced till (lowering fuel and labor needs),
🐂 livestock integration (grazing systems for external cattle).

🔻 Losses:
▶ The transition to regenerative agriculture involves an initial decline in profits (relative to the conventional farm) within the first 3-5 years following transition.
▶ The total profit loss in the transition period can be anywhere from $15-$45+ per acre annually (the profit losses could be higher, the transition period longer).

💰 **Targeting short term Economic Sustainability:**

▶ The transition period is full of uncertainty and risks, which cannot be borne exclusively by farmers.

▶ Support is needed in the form of consolidated financial, technical, and educational systems.

▶ The financing landscape for the transition to regenerative agriculture is fragmented and complex. Farmers need to navigate many disconnected stakeholders to obtain information on available programs, complete application processes, and keep stock of award eligibility requirements.

📓 **Report:**

Cultivating farmer prosperity: Investing in Regenerative Agriculture

🖋 Authors:

OP2B: Doug Petry , Stefania Avanzini, Alain Vidal (AgroParisTech)

Boston Consulting Group (BCG): Francesco Bellino, Jack Bugas, Helena Conant, Sonya Hoo, Shalini Unnikrishnan, Matt Westerlund

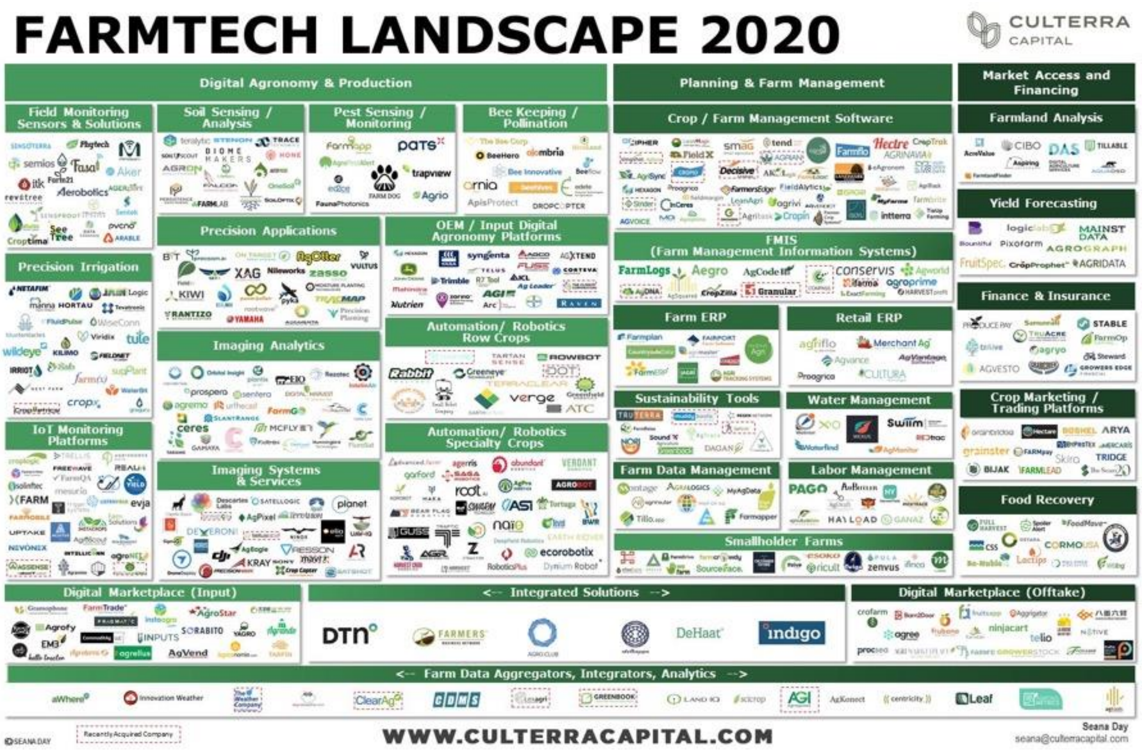
🌐 link:

https://lnkd.in/e-C3U47k

CHAPTER 11 Digital Agriculture adoption & landscape

PREV INDEX NEXT

LANDSCAPE SEGMENTATION, SOLUTIONS, LAYERS



The digital/tech agriculture solutions landscape can be segmented in many ways, in this post I'm sharing this inspiring infographic made by Culterra Capital segmenting the farm-tech sector's solution into:

1. Three layers:

▶ Vertical solutions (see point 2)

▶ Digital marketplaces

▶ Farm data aggregators

2. Three main categories:

▶ Digital agronomy & production

▶ Planning & farm management

▶ Market access & finance

Seana Day

Culterra Capital

INDIAN AgTech LANDSCAPE

AgFunder's free report

"India 2023 AgriFoodTech Investment Report"

🌐 https://lnkd.in/eDdvsSC4

Report's summary

The report provides an overview of the investment landscape in India's AgriFoodTech sector for the year 2023:

▶ key insights

▶ investment highlights

▶ investment by category.

‣ startup: Ecozen, Loopworm, Varaha, Agrizy, S4S Technologies ...

▶ category definitions, sources, and methodology.

Key figures:

▶ Total funding in billions of USD for Farmtech investments from 2018 to 2022:
- 2018: $0.2 billion
- 2019: $0.3 billion
- 2020: $0.4 billion
- 2021: $1.3 billion
- 2022: $1.1 billion

▶ Total number of deals for Farmtech investments from 2018 to 2022:
- 2018: 83 deals
- 2019: 96 deals
- 2020: 102 deals
- 2021: 137 deals
- 2022: 87 deals

▶ 37% decrease in the number of deals from 2021 to 2022, suggesting higher deal values and more mature startups tackling chronic inefficiencies in the value chain.

DIGITAL AGRICULTURE: SEGMENTATION & ADOPTION

Application Solution	Large Farms (> 1000 ha)	Middle Size Farms	Smallholder Farmers (< 2 ha)	Indoor Intensive Production
Yield Improvement & Crop Quality				
Variable Rate Technology (VRT)	High	Moderate	Low	Low
Precision Planting	High	Moderate	Low	High
Integrated Pest Management	High	Moderate	Low	High
Crop Health Monitoring	High	Moderate	Low	Moderate
Plant Phenotyping	Moderate	Moderate	Low	Moderate
Crop Breeding Optimization	High	Moderate	Low	Moderate
Yield Prediction	High	Moderate	Low	Moderate
Post-harvest Loss Monitoring	High	Moderate	Low	High
Resource Efficiency & Environmental Sustainability				
Smart Irrigation Systems	High	Moderate	Low	High
Soil Mapping & Analysis	High	Moderate	Low	Low
Weather-based Decision Support	High	Moderate	Low	Moderate
Precision Livestock Feeding	High	Moderate	Low	Moderate
Adaptive Grazing Management	Moderate	Moderate	Low	N/A
Nutrient Recycling	High	Moderate	Low	High
Carbon Farming & Sequestration	High	Moderate	Low	Low
Pollination Optimization	Moderate	Moderate	Low	N/A
Farm Energy Management	High	Moderate	Low	High
Controlled Environment Agriculture	N/A	N/A	N/A	High
Real-time Labor Management	High	Moderate	Low	Moderate
Waste Reduction & Recycling	High	Moderate	Low	High
Monitoring, Analytics & Decision Support				
Drone-based Field Scouting	High	Moderate	Low	Low
Satellite-based Crop Monitoring	High	Moderate	Low	Low
Livestock Monitoring & Management	High	Moderate	Low	Moderate
Food Quality Assessment	High	Moderate	Low	High
Crop Insurance Analytics	High	Moderate	Low	Low
On-farm Experimentation	High	Moderate	Low	Moderate
Farm Management Platforms	High	Moderate	Low	Moderate
Digital Extension Services	High	Moderate	Moderate	Moderate
Biotechnology & Gene Editing	High	Moderate	Low	High
Agroecology Management	Moderate	Moderate	Moderate	Moderate
Automation, Robotics & Labor Efficiency				
Autonomous Machinery	High	Low	Very Low	Low
Robotic Harvesting	High	Low	Very Low	High
Vertical Farming Automation	N/A	N/A	N/A	High
Greenhouse Automation	Low	Low	Very Low	High
Virtual Fencing	Moderate	Moderate	Low	N/A
Precision Beekeeping	Moderate	Moderate	Low	N/A
Aquaculture Management	High	Moderate	Low	High
Market Access & Supply Chain Management				
Supply Chain Management	High	Moderate	Low	Moderate
Traceability & Food Safety	High	Moderate	Low	High
Digital Marketplaces	High	Moderate	Moderate	Moderate

Digital agriculture adoption (picture) by FARM SEGMENT (below)
Food production system can be divided into four main categories, each playing a unique role and serving distinct purposes:

Large Farms (>1,000ha)

- ▶ Focus on producing staple crops and livestock products
- ▶ Highly mechanised and efficient
- ▶ Contribute significantly to the global food supply
- ▶ Main commodities produced:
    - Grains: wheat, corn, rice, and barley
    - Oilseeds: soybeans, rapeseed, and sunflower seeds
    - Sugar crops: sugarcane and sugar beet
    - Livestock: cattle, pigs, and poultry
    - Dairy products: milk and cheese

Middle Size Farms

- ▶ Produce a variety of different foods
- ▶ Specialise in particular regions or markets
- ▶ Size ranges from a few dozen to several hundred acres
- ▶ Essential role in providing diverse and regionally-specific food products
- ▶ Support local economies and preserve traditional agricultural practices
- ▶ Examples of products:
    - Fruits, vegetables, specialty grains
    - Artisanal dairy and meat products

Smallholder Farmers (<2ha)

- ▶ 608 million farmers worldwide
- ▶ Produce 28-31% of total crop production and 30-34% of food supply on 24% of gross agricultural area

▶ Predominantly in developing countries

▶ Cultivate to support their families and local communities

▶ Often lack access to advanced technologies and resources

▶ Play a critical role in local food security, biodiversity, and traditional agricultural knowledge

▶ Production includes:

- Staple crops, fruits, vegetables
- Small-scale livestock

Indoor Intensive Production

▶ Methods: greenhouses, hydroponics, aquaponics, aeroponics, and vertical farming

▶ Controlled environments and innovative technologies

▶ Maximize yield, reduce resource consumption, and minimize environmental impacts

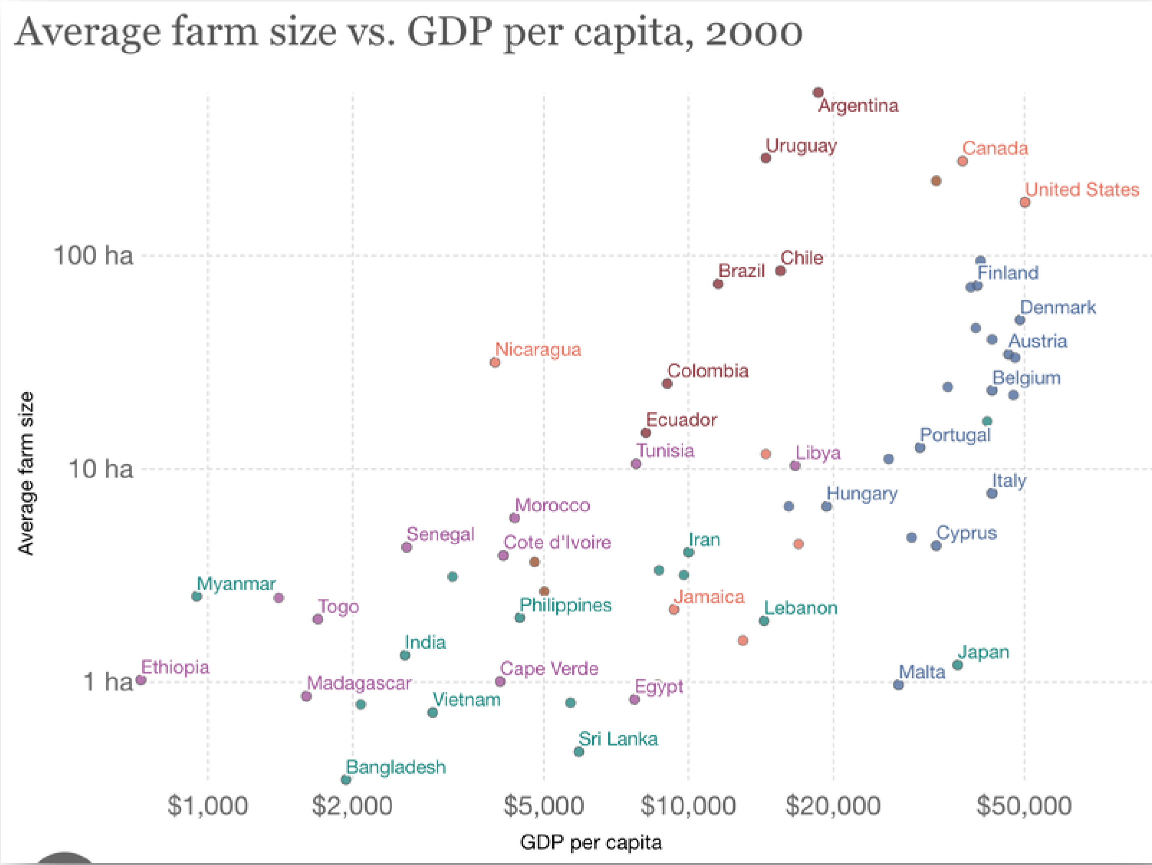
▶ Produce a wide variety of crops, including leafy greens, herbs, fruits, and fish (aquaponics)

▶ Significant role in providing fresh, locally-grown produce in urban areas

▶ Reduce the need for long-distance transportation

▶ Offer a more sustainable approach to food production

ADOPTION by SEGMENTS & PHASES



☑ AGTECH ADOPTION ACROSS FARM SEGMENTS:

1. Large farms:

EARLY ADOPTERS, driven by efficiency and optimisation

2. Medium size farms:

MODERATE ADOPTION, influenced by financial capabilities and market demands

3. Smallholder farmers:

LOWER ADOPTION, limited by financial constraints and access to technology

4. Indoor intensive production:

HIGH ADOPTION, focused on controlled environments and precision agriculture

☑ DIGITAL TECHNOLOGIES IN FARMING PHASES:

🌾 Planning and preparation:

Assess land suitability, predict weather patterns, and analyze market demand

🌾 Sowing or planting:

Precision agriculture technologies for accurate seed placement and optimal planting density

🌾 Crop management and animal husbandry:

Real-time data for monitoring crop health and livestock well-being

🌾 Harvesting and animal production:

Automation technologies for improved efficiency and reduced labor costs

🌾 Post-harvest handling and storage:

Digital tools to maintain product quality and minimize spoilage

🌾 Marketing and distribution:

E-commerce platforms, better supply and demand matching, and efficient logistics

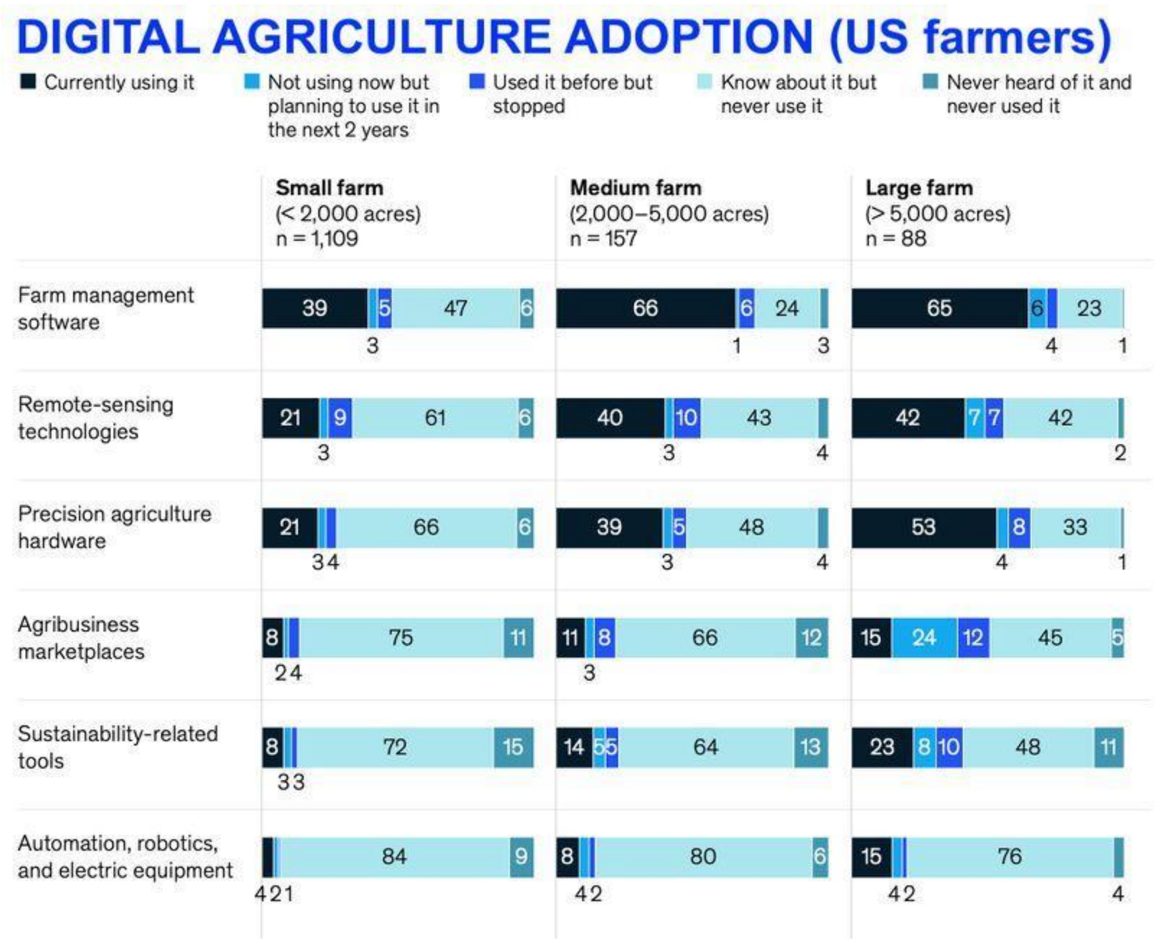
Much more here:

https://lnkd.in/eMDmtBUm

"AgTech adoption by farm's segment and production phase"

DIGITAL AGRICULTURE ADOPTION by FARM'S SIZE

Survey of over 1.300 US farmers (May 2022)



¹Figures may not sum to 100%, because of rounding.
Source: McKinsey US Farmer Insights 2022–23 (n = 1,354)

AgTech Adoption:

▶ farmers are using agriculture technology to support more farming operations;

▶ tools that might have seemed niche just a few years ago have gained more acceptance;

▶ nearly 55 percent of large farms today use farm management systems, and 50%+ large farms use some form of precision agriculture hardware.

Adoption of Precision Agriculture Hardware & Other Technologies:

▶ Nearly a quarter of small farms use precision agriculture hardware or intend to use it over the next two years.

▶ Automation, robotics, and electrification are also gaining interest, especially among larger operations.

Growth in Agribusiness Marketplaces:

▶ most growth in adoption between now and 2024;

▶ 15% of large-scale farmers currently use these digital ecosystems to enhance their commodity-trading capabilities;

▶ 25%+ plan to start engaging in agribusiness marketplaces to sell outputs over the next two years.

Suppliers' Role in Supporting Farmers:

▶ suppliers could use data & analytics to refresh their value proposition and market segmentation;

▶ they could employ omnichannel (*) approaches to engage more with farmers and be proactive across offline and online channels;

▶ suppliers could invest in the design of programs that make it easier for farmers to try new products and services;

▶ they could use contextual farmer and field data to facilitate the personalisation of field teams.

Farmers' Approach to Profitability:

▶ growers with more than 5.000 acres are far more likely than those with smaller holdings to lean on technology to give them a marketplace edge;

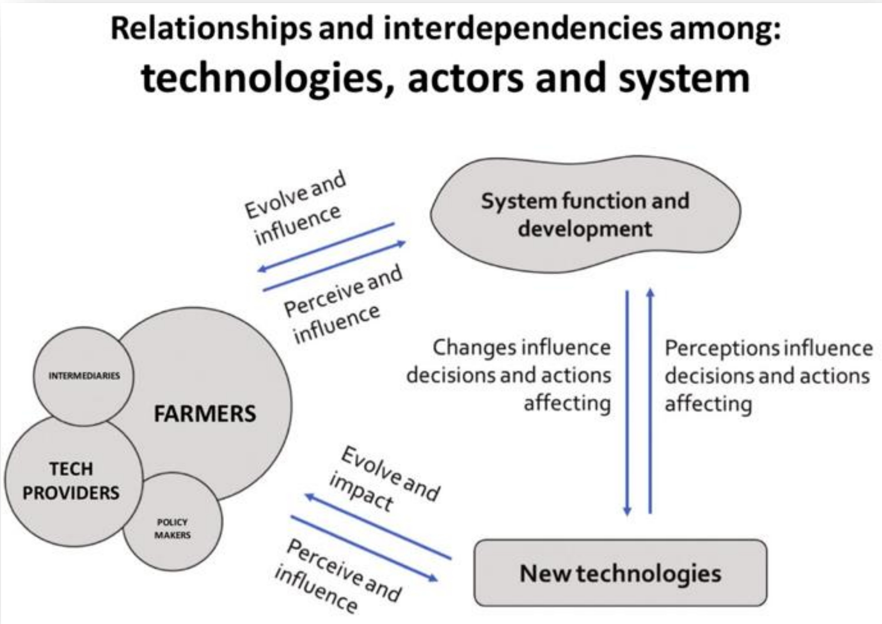
▶ 30% say that they will purchase innovative equipment over the next two years, and 27% say that they will invest in technology that can help them improve their ability to trade their crops;

▶ small growers are more likely to embrace product-based innovation. Just 50%+ say that they will invest in products designed to increase yield, and 38% will try new crop protection products.

(*) OMNICHANNEL
DEFINITION: multichannel approach to sales that seeks to provide customers with a seamless shopping experience, whether they're shopping online or in a physical store.
EXAMPLE: A customer browses products on a retailer's website, checks reviews on their mobile app, then purchases the item in the physical store.

McKinsey & Company's report presents the results of a survey of over 1.300 US farmers conducted in May 2022.
"Voice of the US farmer in 2022: Innovating through uncertainty"
https://lnkd.in/eUKX-Yij

How is digital agriculture PERCEIVED?



HOW TO FACILITATE DIGITAL AGRICULTURE ADOPTION?

❓ What factors influence the slow adoption of Precision Agriculture Technologies (PATs) and how can a systemic approach using Group Concept Mapping (GCM) help facilitate their adoption?

✔ Very interesting article discussing the slow adoption of Precision Agriculture Technologies (PATs) and the role of collective perceptions of actors (FARMERS, INTERMEDIARIES, TECH PROVIDERS, POLICYMAKERS) involved in the innovation system (focus on Switzerland and Germany).

IN SHORT:

▶ Precision agriculture technologies (PATs) use INTRA-FIELD VARIABILITY to improve efficiency, yields, and reduce environmental impact.

▶ PATs require collaboration, coordination, and shared perceptions among actors to transform agriculture through innovation.

▶ The ADOPTION of PATs remains low in Germany and Switzerland, especially for advanced technologies such as variable rate application.

▶ MULTI-STAKEHOLDER ENGAGEMENT is necessary to address the challenges facing the precision agriculture innovation system.

▶ The PERCEPTION of different actors of the technology itself, as well as the role of actors and their actions inside this system, are important for an effective innovation system around precision agriculture to take shape.

▶ Group Concept Mapping (GCM) is a mixed-method approach that combines qualitative and quantitative methods to integrate input from multiple sources with different backgrounds.

▶ The GCM method identified ten clusters of factors that influence PAT adoption, with many relating to system structures and functions rather than the technology itself.

▶ ENHANCE EFFICIENCY through precision was considered the most important driver for PAT adoption, while economic gains were rated as less important.

▶ POLICYMAKER rated all clusters to be of lower importance when compared with other groups, especially farmers.

Article:
"Exploring actors' perceptions of the precision agriculture innovation system – A Group Concept Mapping approach in Germany and Switzerland" from:

Debora Monteiro Moretti (The University of Bonn)

Chad M. Baum (The University of Bonn, Aarhus University)

Melf-Hinrich Ehlers (ETH Zürich, Agroscope)

Robert Finger (ETH Zürich)

Stefanie Bröring (Ruhr University Bochum)

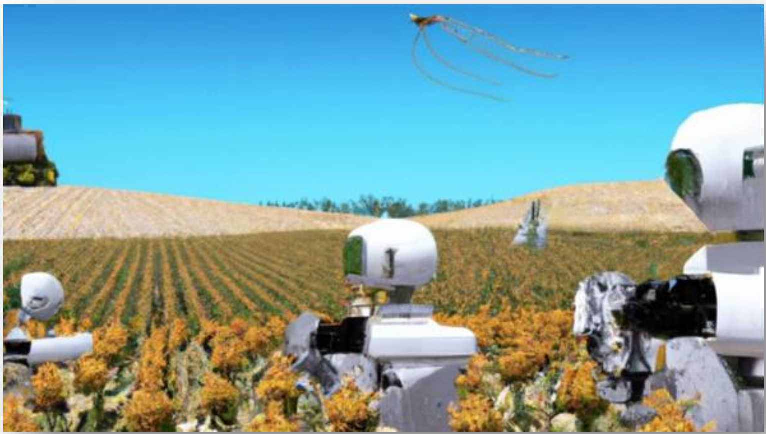
https://lnkd.in/eCA9e2J4

https://lnkd.in/eAMQJvcd

CHAPTER 12 The Future of Digital Agriculture

PREV INDEX NEXT

A TYPICAL HYPOTETICAL FARMER'S DAY IN 2030



John stared out at the sprawling fields that stretched out before him, the sun just beginning to crest over the horizon. He couldn't help but feel a sense of pride and satisfaction as he surveyed the land that had been in his family for generations. But he also knew that the farming industry was changing rapidly, and he needed to adapt in order to stay ahead of the curve.

That's why he had invested in a precision agriculture platform, John Deere Operations Center. With this cutting-edge technology, he was able to keep a watchful eye on his entire operation, from the health and location of his animals to the growth and yield of his crops. He could check on his herd in real-time, monitor their movements and activity, and ensure that they were always in the best possible condition. This not only improved the welfare of his livestock, but also reduced the risk of disease, leading to higher productivity and profits.

But John didn't stop there. He was determined to revolutionise the way he farmed, and so he adopted a blockchain-based platform, ripe.io . This technology allowed him to track his produce from the farm to the consumer, increasing transparency in the food supply chain and building direct relationships with customers. With this solution, he could ensure that his customers knew exactly where their food came from, and that they were getting the freshest, highest-quality produce available.

John also adopted the use of drones, DJI Matrice 600, to survey and map his land and crops with high resolution, this helped him to identify areas that required attention, detect crop stress, and monitor crop growth, he also used them to inspect and count his livestock. This resulted in a 15% reduction in labor costs and a 20% increase in crop yields.

In addition, he implemented a weather forecasting and prediction system, AgriWeather, that helped him to optimise his planting and harvesting schedule, this way he saved more than 30% on inputs costs and avoided crop losses due to weather-related issues.

But even with the help of these technologies, John knew that he couldn't do it all on his own. That's why he turned to Artificial Intelligence tools, such as IBM Watson Studio, to analyze the vast amount of data that he collected every day. He used this data to make more informed decisions about crop management and resource usage, optimizing crop growth, reducing inputs, and improving yields. With the help of AI, he was able to cut down on waste and increase efficiency, leading to even greater profits.

Finally, John knew that he needed a way to sell his produce directly to customers. That's why he turned to digital marketplace, LocalHarvest, which allowed him to connect with consumers all over the country, and increase revenue. With this platform, he could build direct relationships with customers, allowing him to sell his products at a premium, and truly reap the rewards of his hard work.

As John settled down for the night, he couldn't help but feel a sense of satisfaction. He knew that the future of farming was bright, and he was excited to be a part of it. With the help of these digital technologies, he was able to revolutionise the way he farmed, reducing labor costs by 20%, increasing crop yields by 30% and increasing revenue by 25%. He was able to ensure that his family's land would continue to thrive for generations to come.

But John didn't stop here, he also knew that he needed to automate some of the most labor-intensive tasks, that's why he decided to implement robots into his farm. He purchased two robots, Blue River Technology Lettuce Bot and AGROBOT SW 6010, the first one was used to thin out lettuce seedlings, reducing
How hypothetical is this story?
How far do you think we are from it?
Or...is it perhaps too conservative?

FEARS & AUTOMATION

"Common fears that automation leads to growing unemployment, although understandable, are questionable and generally not supported by historical realities. Overall, automation alleviates labour shortages and can make agricultural production more resilient and productive, improve product quality, increase resource-use efficiency, promote decent employment, and enhance environmental sustainability....
Furthermore, automation is expected to reduce jobs that involve routine tasks, such as planting and harvesting, but increase skilled jobs requiring, for example, secondary education. In countries with a large rural workforce, this shift in employment can risk deepening inequalities. Overcoming these challenges requires reducing barriers to adoption – faced in particular by small-scale producers, women and youth – to ensure that automated solutions become scale-neutral, that is, accessible to all scales of agricultural producers from small to large. This can be achieved through technological innovations that tailor automation to the conditions of small-scale producers."
FAO

"THE STATE OF FOOD AND AGRICULTURE LEVERAGING AUTOMATION IN AGRICULTURE FOR TRANSFORMING AGRIFOOD SYSTEM"
https://lnkd.in/eZhkBNgQ

FARM OF THE FUTURE?

Digitally driven regenerative agriculture ▶ SUSTAINABLE FOOD & ENVIRONMENT

▶ Regenerative farming adds complexity: digital manages it ◀

Digital technologies have an important role to play in enabling regenerative agriculture and in supporting the farming operations that go with it.
With each growing season, farmers who practice regenerative agriculture are providing more proof of the benefits of sustainable farm practices. The signs of progress include healthier soil, savings of fuel and other resources, and better water quality.

Trey Hill CEO of https://lnkd.in/enawCheY (13.000 Acres)
is approaching traditional practices with creativity and innovation.
From management software to precision equipment, integrating GPS systems to managing resources and environmental impact, if there's an edge from technology, Trey will try it.

While others might confine themselves in boxes like “environmentalist” or “technologist” or “traditionalist,” Harborview is all three and more, pioneering new techniques for totally new kinds of farms that can bring all of these priorities together.

One challenge of regenerative farming is that it adds complexity—more scheduling, more variables, more data—to an already complex business. Harborview has invested in a comprehensive farm management system to keep its operations running smoothly throughout the annual cycle of planting, harvesting and cover cropping.

That system includes:

▶ Farm-management software to track planting and harvesting schedules, costs and inventory, while organizing notes and images gathered during field scouting

▶ GPS-guided farm equipment for precise, variable-rate application of seeds and fertilizers

▶ Satellite imaging for “intra-field” management of crops down to the square meter

▶ A solar array-powered grain system capable of loading and storing more than one million bushels

“The more you can utilize digital technology to sense, predict and prescribe specific protocols on the farm, the more scalable and affordable regenerative farming becomes,”

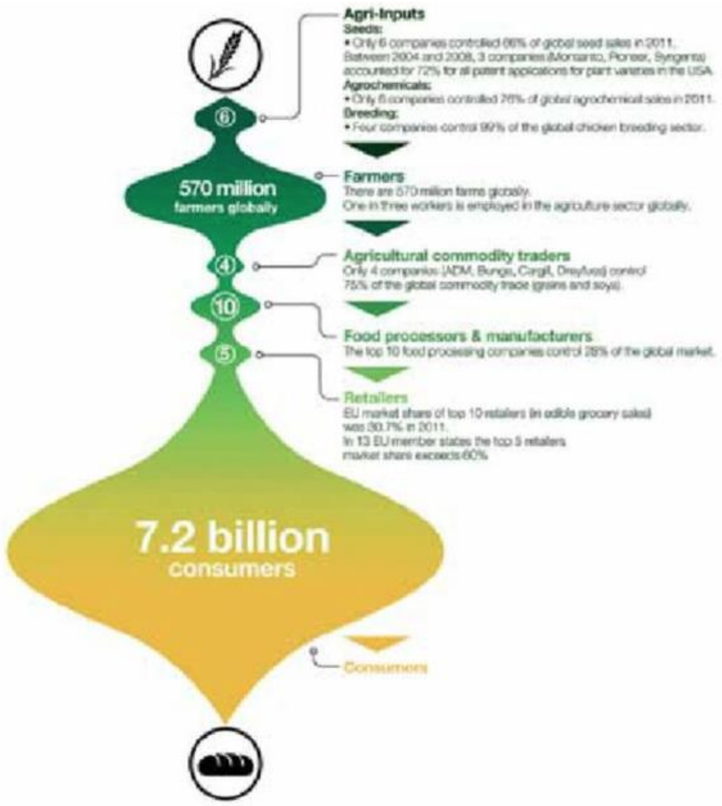
Greg Meyers

Trey Hill

John foley Syngenta Group news service

Video from: Brent Loken

DIGITAL AGRICULTURE IN 10 YEARS from now



■ **FARM LEVEL:** consolidation of few leaders in the digital agriculture vertical solutions (machinery (VRT,,..), smart (fert)irrigation, agronomic recommendation systems...).

◆ **ERP at FARM LEVEL:** consolidation of few leaders in the farm management systems (ERP) will be the farm data collectors (the first local star) interoperating will all farms vertical solutions on one side (see above) and with the entire food system (on the other side).

◆ **FOOD SYSTEM LEVEL:** consolidation of few leaders in the digital food system: it will be based on block-chain-like technology with smart contracts, RF-ID, ... and connect seed to fork allowing full traceability and transparency (with some risk of data monopoly that should be avoided).

Data aggregators at farm level

The key players for the entire consolidation scheme are the **DATA AGGREGATORS AT FARM LEVEL**, integrating with the other special purposes solutions (ALL IN ONE) and allowing the farm to be integrated with the rest of the value chain.
The best positioned are ERP providers.

Three consolidation waves

Three consolidations waves will impact the digital agriculture & food system sectors: These waves will re-shape the food sector leveraging digital technologies and the existing startups ecosystem while consolidating the leading agribusiness & food corporations.

1. Digital agriculture vertical solutions
   The current agribusiness companies have to adjust or totally reinvent their business model in order to fully embrace digital agriculture. The best and fastest will be the market leader in 5 to 10 years. The shift in market share will be dramatic.

2. Horizontal consolidation at farm level (2 waves)
   Farm Management Systems (ERP) are the core of the farm.
   They should make the effort to integrate to all major APIs of the major vertical solutions (machinery, smart fertigation, agronomic recommendation systems, supply chain management,...). If the ERP providers try to cover themselves in one or more of these verticals they will fail.

3. Digital food system consolidation

The third (major) wave can also expect FUSIONS among corporations operating at different level of the value chain in order to facilitate the integration & control of the entire food system (or at least at key points)

(more on this article).

13 TRENDS THAT WILL SHAPE FOOD PRODUCTION

PRODUCE MORE & MORE SUSTAINABLE

Precision Agriculture Technologies (PAT):

▶ 4% increase in crop production,

▶ 7% increase in fertilizer placement efficiency,

▶ 9% reduction in herbicide and pesticide use

▶ 6% reduction in fossil fuel use.

USE LESS WATER: Optimization of water use

Precision Agriculture:

▶ 4% reduction in water use.

...Closed-loop system:

▶ 40% savings of irrigation water daily and

▶ retained 35-54% more nutrients

MORE PROTEINS: Increased global demand for protein

annual meat production (FAO):

▶ 72% increase in 2030

non-dairy alternatives (almond, soy, coconut, oat) raising:

▶ ...non-dairy milk sales grew 61% from 2012-2017.

▶ ... Plant-based meat alternatives CAGR 19.3% from 2022-2030.

SHORTER FOOD SUPPLY CHAIN:

▶ “farm to fork"

▶ "buy local": local edible farm products in 2017 had a 35% increase

▶ Vertical farming selling directly to retails

CLIMATE CHANGE -> Geographic shifts in production

▶ farmers: ...change to what a farmer plants and harvests....

▶ supply chain: change in markets and supply chain infrastructure

TRACEABILITY: Advanced food traceability helps maintain consumer trust

▶ 81% of shoppers believe food transparency is important, ⬆ 12% from 2 before

CO2 REGULATIONS: Farmers adjust in response to emission regulation

▶ Farmers will use more alternative energies (biofuel, battery/solar, hydrogen fuel cells) to power machinery.

▶ “Policy will be a driver of adoption”

CO2 REGULATIONS: create adjacent economies

▶ carbon offsets market

MORE CONNECTED: Connectivity gap narrows

▶ LORA, LEO (low earth orbit) satellites, 5G, 6G enabling digital-agri

AI (& ROBOTICS):

▶ skilled workforce shortage drives AI (data analysis, operating machinery,...)

▶ reducing "in field" food-waste: 70% of food product loss results from something other than decay, such as improper packaging or harvesting. Auto-harvesting robots can detect 90% of harvestable fruit and harvest it in just 16 seconds

CYBERSECURITY

▶ modern farming becomes increasingly automated, equipment becomes vulnerable to hacking

LAND OWNERSHIP SHIFT (ownership concentration)

▶ In US 370M acres of farmland will be transitioned over the next 10 years

NEW BUSINESS MODELS

▶ Equipment as a Service (EaaS)

▶ Custom farming

▶ outcome-based pricing models.

Association of Equipment Manufacturers (AEM)

Full report available at:

https://lnkd.in/e8qF6SFh

The Future of farming

▯ CONCEPT

Digital Agriculture = integration of digital technologies into the farming process (& throughout the supply chain, from seeds or farm animals to the consumer).

▯ COMPONENTS

1. DATA GATHERERS: Hardware Tools (in field or out of the field) that constantly gather digital data

2. DATA: are the central commodity of digital agriculture.

3. PROCESSING TOOLS (ANALYTICS & AI): combine data to extract Information (and actions) out of data

4. ACTUATORS (ROBOTS, Drones, Valves,...): take action

💠 ENDGAME: optimise farming practices.

? REVOLUTION

The digital age is a disruptive phase in farming bringing a significant transformation in agriculture and playing a pivotal role in the entire food systems.

? FACTS (CASE STUDIES)

It's not anymore, an "IF" but a "HOW".
Several successful implementations of Digital Agriculture around the world serve as excellent examples of its potential highlighting the benefits of digital farming and how it can transform the agricultural industry.

? SUSTAINABILITY

Digital Agriculture contributes significantly to sustainable development, representing the set of tools that can help farmers to transition to more sustainable and respectful practices while increasing food production, optimizing resources and reducing waste.

? ECONOMIC BENEFITS

The economic benefits of Digital Agriculture are substantial. By increasing efficiency and productivity, it can lead to higher profits for farmers and lower prices for consumers.

? CHALLENGES

- initial cost of technology,
- correct implementation
- need for digital skills,
- need to integrate solutions that require working in concert to deliver the maximum value
- data privacy & ownership
- data security

▯ POLICY & REGULATIONS

Policy & regulation play a crucial role in promoting or hindering digital agriculture. Policies that support the adoption of digital technologies in farming can help accelerate the digital agricultural revolution.

▯ FUTURE

Digital has completely changed several sectors, increasing their efficiency dramatically. If the current challenges will be properly addressed, we can expect similar benefits in the entire food system.

Photos: John Deere , Rémi Minart , BASF Agricultural Solutions

UNMANNED FARM

CHINA'S FULLY AUTOMATED FARM

Located in northeast China, the Beidahuang Seven Stars Farm (Beidahuang group corporation) is an advanced unmanned farm where staff can operate the entire farm with just a mouse.

There are unmanned trains to transport crops. Rice planting is also automated and unmanned.

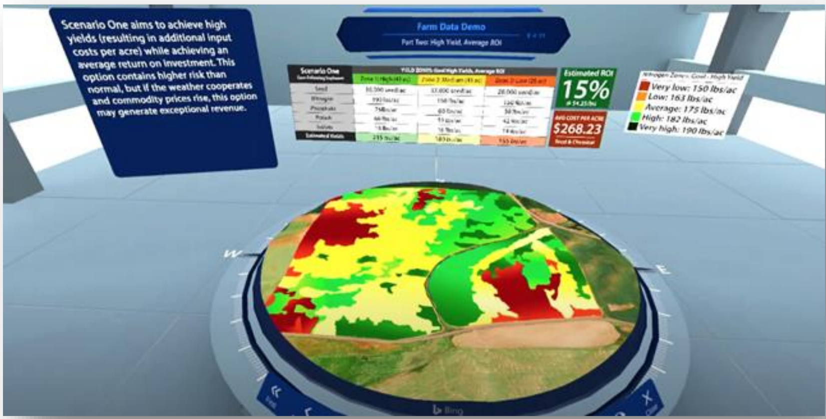
Intelligent systems and satellites work together to manage the farm simultaneously.

In the harvest season, there are unmanned harvesters to harvest the grain.

Look the automation process at the Video:

https://lnkd.in/eGr3cWyQCGTN

AGRI INTERFACE OF THE FUTURE: VIRTUAL REALITY



PROBLEM

How to combine all data to make a farm decision?

Multiple data, information and solutions can confuse farmer even more than help.

SOLUTION

Solutions integrating them all in a holistic way leveraging all data, are an important piece of the new digital agriculture time.

A GLIMPSE IN OUR FUTURE

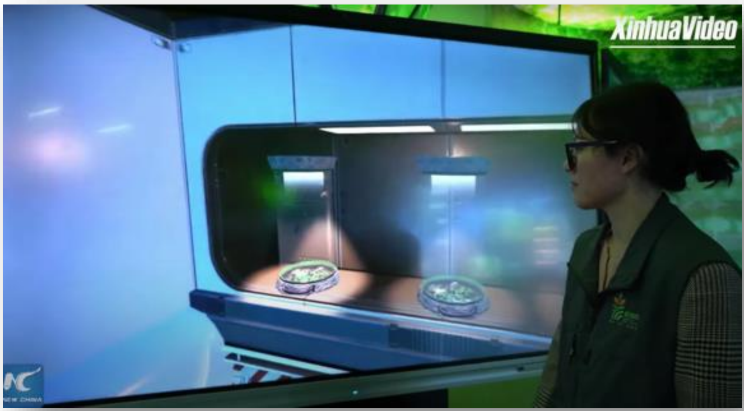
This short video provides a glimpse in the future.

Similar solutions will help farmers to take informed decisions during all crop phases.

Video from Taqtile

https://lnkd.in/emdxFfnx

AUGMENTED REALITY in AGRICULTURE?



Augmented Reality (AR) is set to revolutionise the agricultural sector in various ways:

✅ **Precision Farming**
AR can assist farmers in monitoring crop growth and identifying diseases or pests. With AR glasses or smartphone apps, farmers could scan their fields to see real-time digital information, like soil health or moisture content.

✅ **Training & Skill Development**
AR can provide interactive training for farmers, showing them exactly how to operate machinery or implement techniques, which can greatly improve efficiency.

✅ **Maintenance & Repair**
AR can facilitate real-time guidance for machinery repair and maintenance. A farmer can use AR glasses to scan a tractor engine, for example, and the AR system can guide them through a step-by-step repair process.

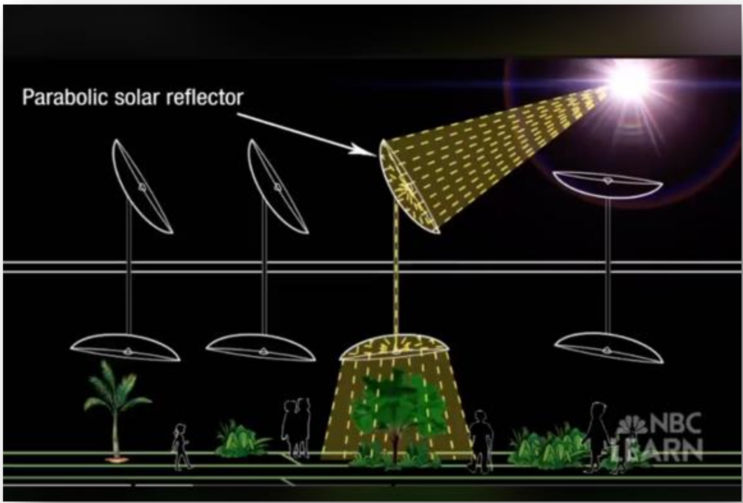
✅ **Supply Chain Transparency**

AR can also be used to offer consumers a better understanding of where their food comes from. By scanning a QR code with an AR app, consumers could see the journey of their food from farm to table, boosting transparency and trust.

✅ **Oculus + augmented reality**
In the future, Oculus devices combined with Augmented Reality (AR) will revolutionise farming by providing farmers with real-time, data-driven insights into their fields directly in their field of view. They will enable precise pest and disease identification by overlaying digital information on physical crops, facilitating swift and accurate treatment. This technology will also assist in effective resource management, optimizing irrigation, fertilization, and harvesting based on real-time data, significantly enhancing decision-making and operational efficiency in farming, contributing to improved yields and sustainability.

Video from @New China TV
https://lnkd.in/eWdY_Dvr

SUNLIGHT HARVEST?



Can vertical farm be more sustainable adding to leds harvested sunlight?

VERTICAL FARMS' PROBLEM:

SUN ▶️ (solar panel) ▶️ Electricity ▶️ SUN

❌ NOT efficient ❌

Greenhouses capture sunlight from the sun, but vertical farm rely on leds (light from electricity), while sun is free.

That's one of the major problems in vertical farming.

❓ IS THERE A WAY TO CAPTURE AND BRING SUNLIGHT TO VERTICAL FARMS?

✅ YES!

The use of parabolic solar reflectors and fiber optic cables to harvest solar light for vertical farming can be economically convenient under certain circumstances.
but a cost-benefit analysis should be conducted before making a decision.

1 - AMOUNT OF SUNLIGHT AVAILABLE...

... in the location where the vertical farm is located. If there is ample sunlight, using parabolic solar reflectors to concentrate the light can increase the efficiency of the system and reduce the number of solar panels needed to generate the same amount of electricity.

2 - COST OF THE MATERIALS...

... used to build the system. Parabolic solar reflectors and fiber optic cables can be expensive, so the initial investment may be high. However, if the system is designed and built efficiently, it can lead to long-term cost savings in terms of energy consumption and maintenance.

3 - VERTICAL FARM SIZE & LIGHTING REQUIREMENTS

If the vertical farm is small and the lighting requirements are low, the cost of the parabolic solar reflectors and fiber optic cables may outweigh the potential benefits. However, for larger farms and plants with higher lighting requirements, the use of this technology could result in significant energy savings and increased crop yields.

Video from NBC News

https://lnkd.in/erZSt68y

HOW TO DEVELOP FUTURE USEFUL SOLUTION?

Producing 20 times more with 75% less water proven by World Horti Center in Netherland.

"if you produce tomatoes in an open field in Spain you will end up at the end of the growing season with 4 kg of tomatoes / square meter, if you do this in a hight tech greenhouse in the Netherlands you'll end up with 80 kg of tomatoes / square meter ... using 75% less water....so high tech offers really a possibility of producing a lot of food per square meter in a sustainable way" .

Ernst van den Ende

"...the future of the Netherland shouldn't to be the producer for the rest of the world, we should be the developer for the rest of the world....we are the country that will export our knowledge on creating production facilities all over the world".

Erwin Cardol

World Horti Center in Netherland

https://lnkd.in/ep6vcHj9

Video from Freethink :

https://lnkd.in/exr4NehF

MORE FREE MATERIAL

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https://lnkd.in/dgDmPx2k

VIDEO

(from Inter-American Development Bank)

"What is precision agriculture? Why is it a likely answer to climate change and food security?"

https://lnkd.in/e4Hk997b

DIGITAL AGRICULTURE

AN UPDATED & COMPREHENSIVE OVERVIEW

June 2023

The free e-book is an intriguing exploration of the intersection of technology and agriculture. Authored by Marco Brini, a thought leader in the field, this comprehensive is divided into several chapters, each focusing on a different aspect of digital agriculture. With over 200 pages of insightful content, this book is a must-read for anyone interested in the future of farming and the role of technology in shaping it.

Clicking on book's links, you can easily navigate through the book and connect to external material. (click here to go to the INDEX)

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