Course PI: Maria Pukalchik
Course TA: Dmitrii Shadrin

Skoltech
Skolkovo Institute of Science and Technology

Introduction to Digital Agriculture

Term 3, 2020-2021

Course structure

Skoltech
Skolkovo Institute of Science and Technology

Block 1

- Lecture 01. Introduction to Digital Agriculture

Block 2

- Lecture 02. Statistic in Environmental sustainability cases
- Lecture 03. Advanced machine learning for Environmental sustainability
- Lecture 04. Crop yield simulation models and sensitivity indexes

Block 3

- Lecture 05. Plants and greenhouses
- Lecture 06. Advanced ML for plants grow prediction
- Lecture 07. Computer vision for plants
- Lecture 08. Remote sensing

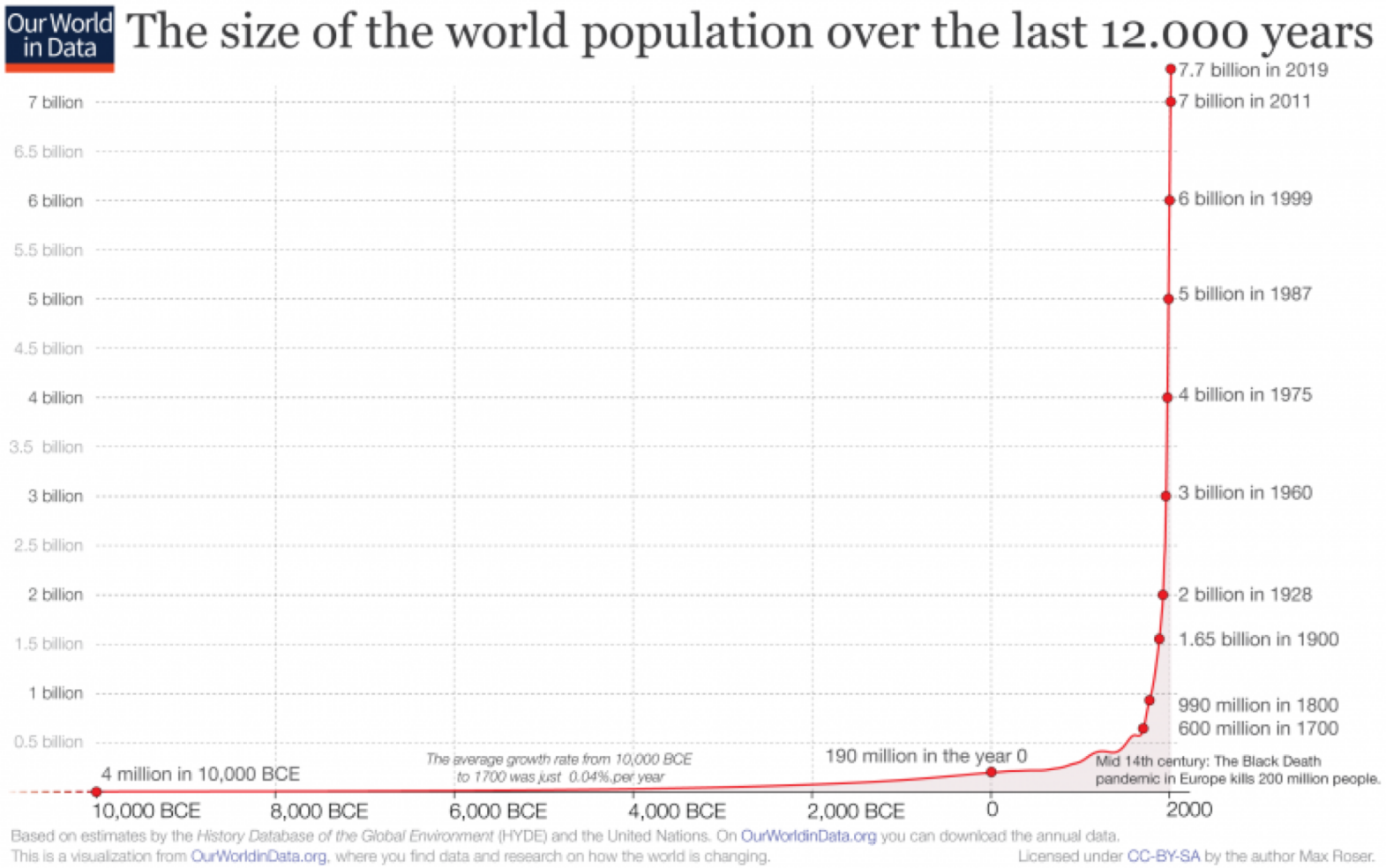
Grade system

60%	**20%**	**10%**	**10%**
HomeWorks	Final project	Personal activity	Attendance

Lecture 01 focuses on:

- Why agriculture is so important?
- Where is the place of Data Science in Agro?
- Key topics of Digital Agriculture
- Where is the glory and the money?

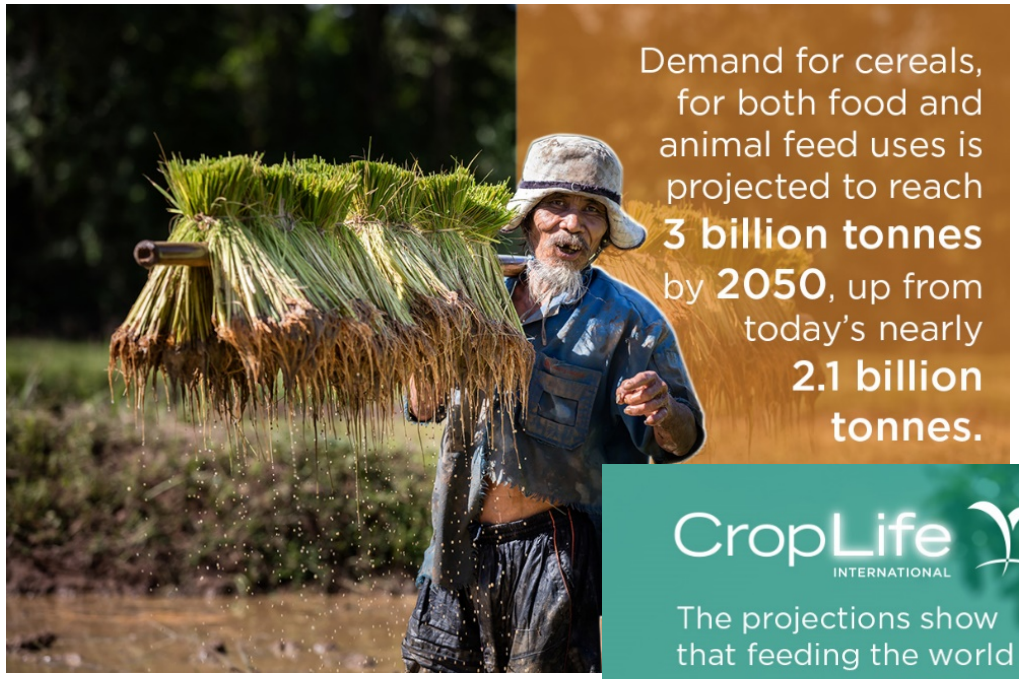
World Population: Past, Present, and Future



35-fold has increased human population over the last 1600 years

10 bln World population projected to reach in 2050

Production to Meet Population



Agriculture technologies changed during the Human hystory

10 000 b.c.

1915 *

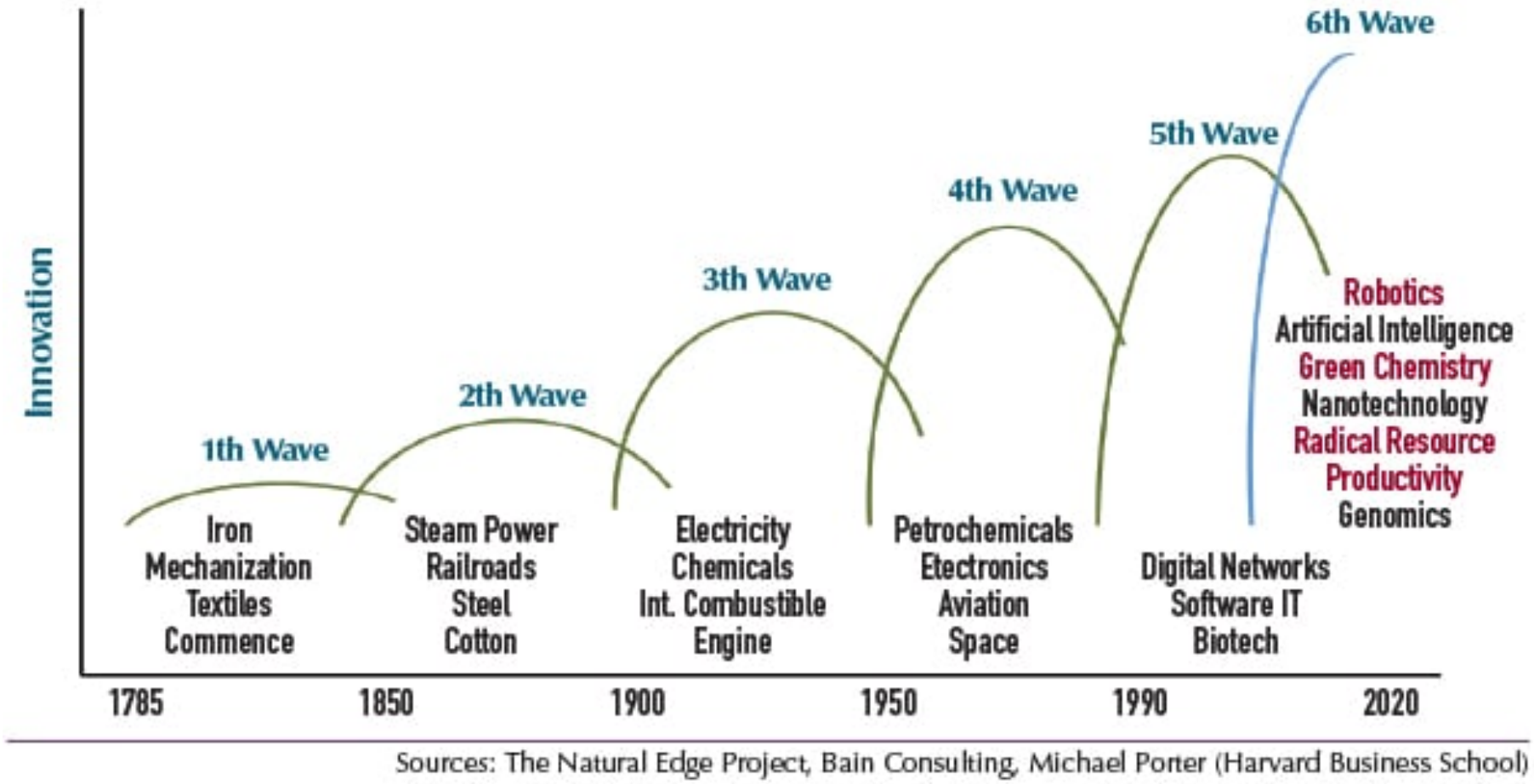
2018 **

*Sugar beat workers, USA, Colorado. Photograph by Lewis Hine, July 1915.

**Sugar beet harvest, Michigan, Amity Harvester, USA https://www.youtube.com/watch?v=ovL2xQ4V6Lo

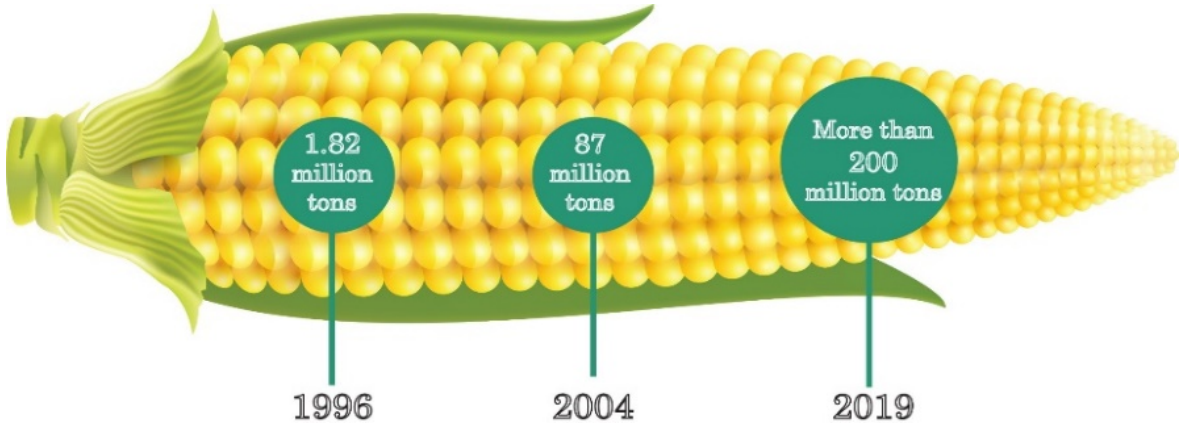
Technological Innovations is the crucial reason of agriculture (R)evolutions

…new technologies requires modifications of other elements of the technological complex, continued technological change requires a dynamic economy constantly adjusting to changing circumstances.*



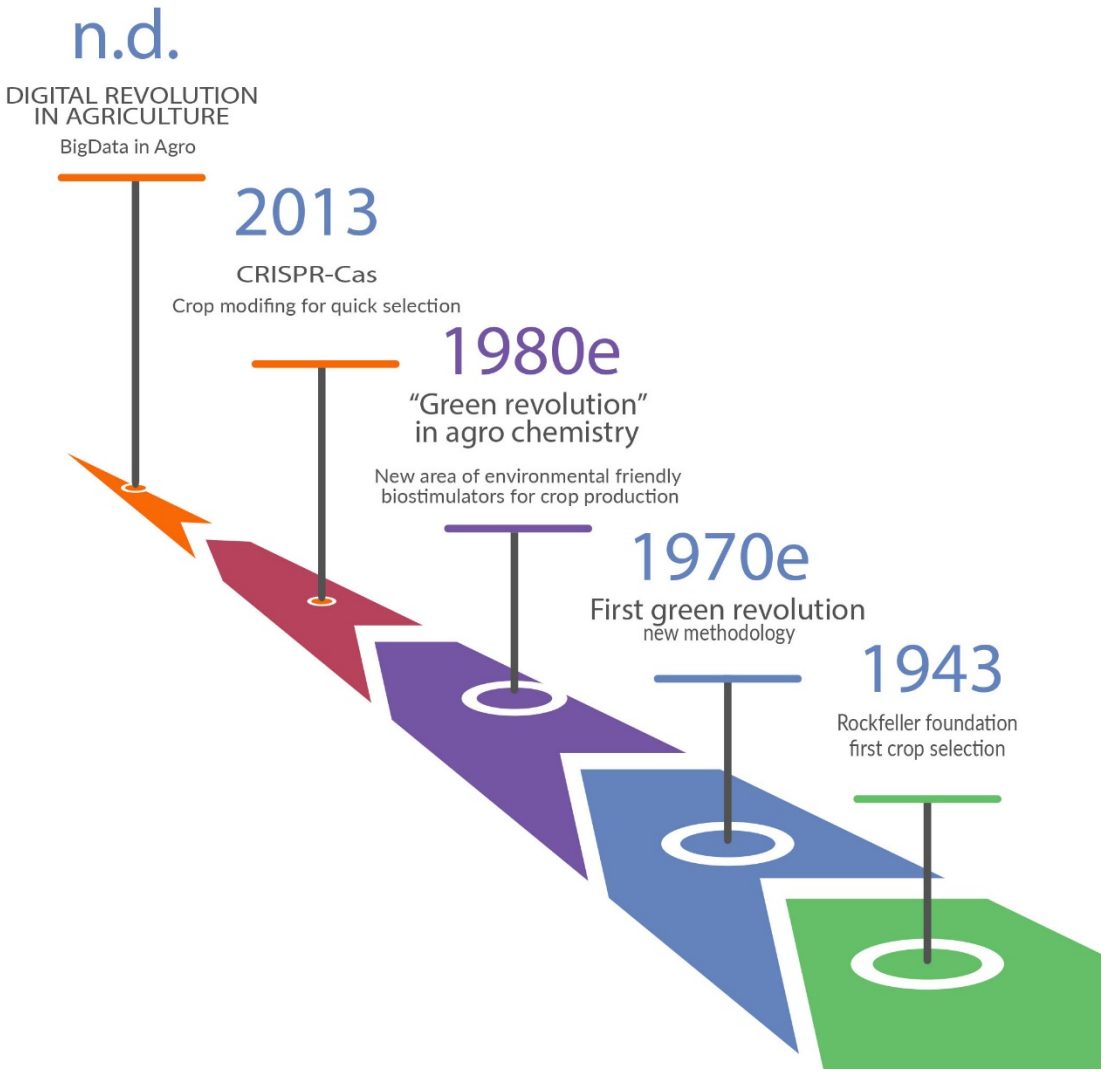
*Thomas R. De-Gregory, review of the Transfer of Technology to Developing Countries, in Technology and Culture, 1968

(R)evolutions in Agriculture



198 %

Increased the volume of corn production from 1996-2019

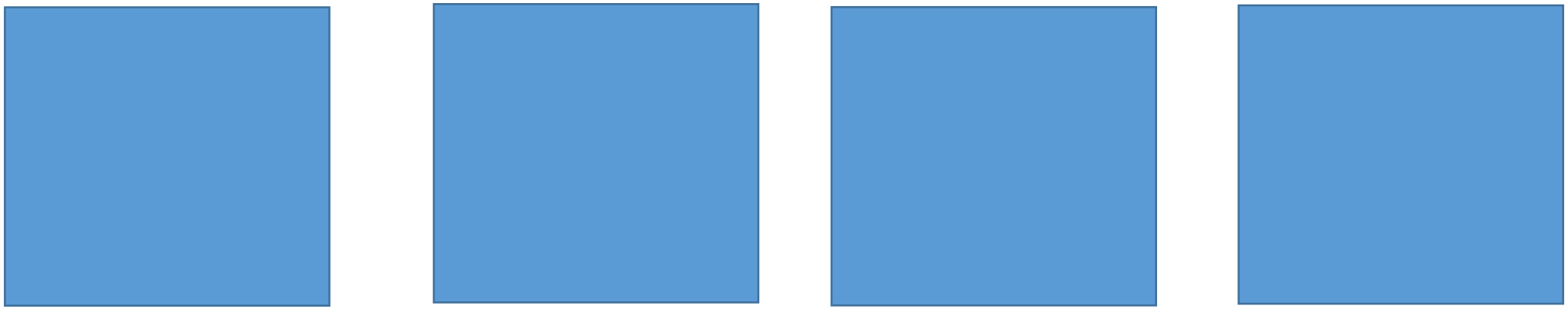


Source: https://accessmentoffoodandwater.wordpress.com/

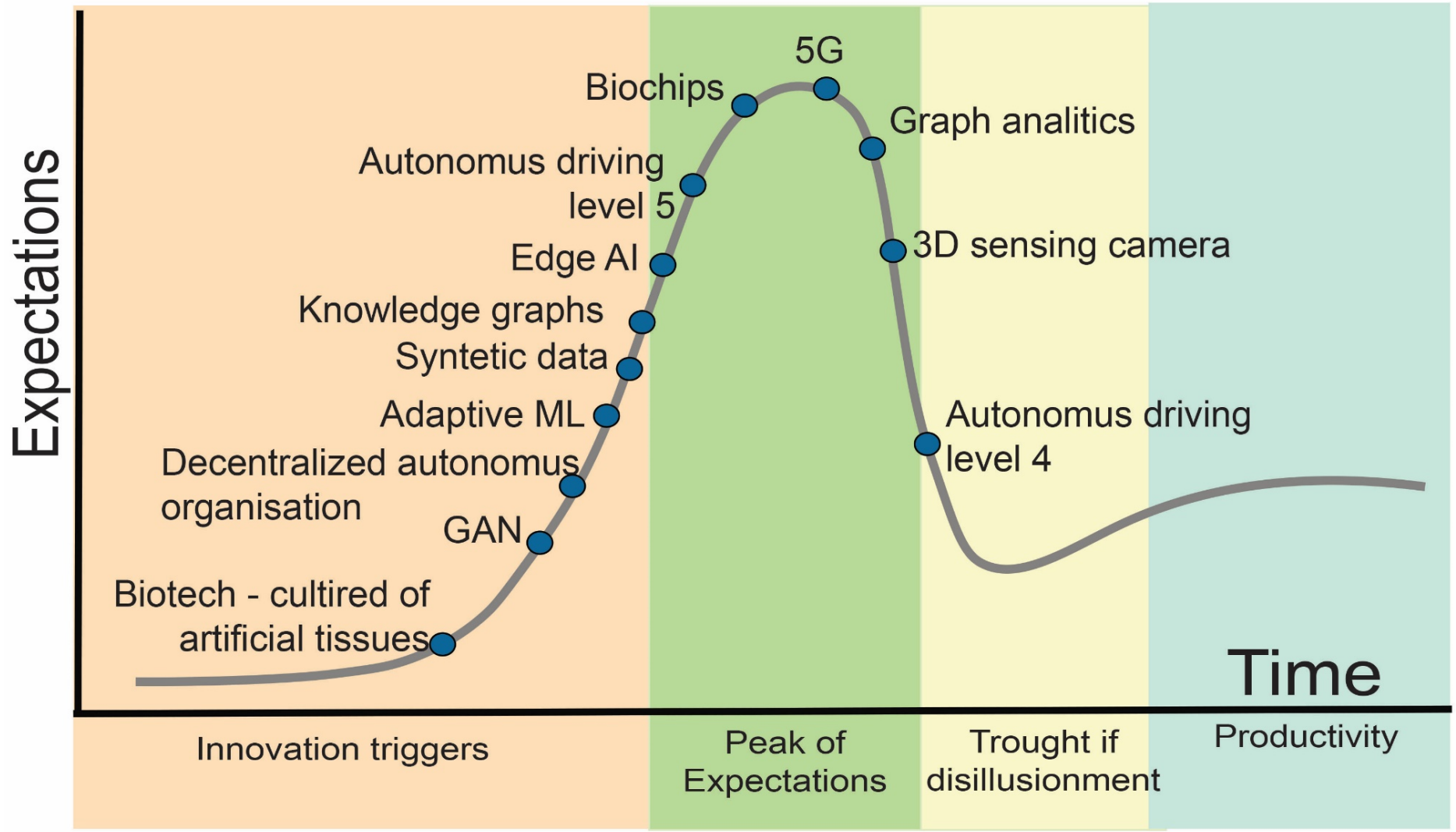
Agriculture has ‘many faces’ but the same demands

Agriculture - the utilization of biological processes on farms to produce food and other products useful and necessary to man

Specific agricultural activities and what is produced determine the type of farming



Gartner Hype Cycle for Emerging Technologies 2020
Focus on AgTech-applicable categories



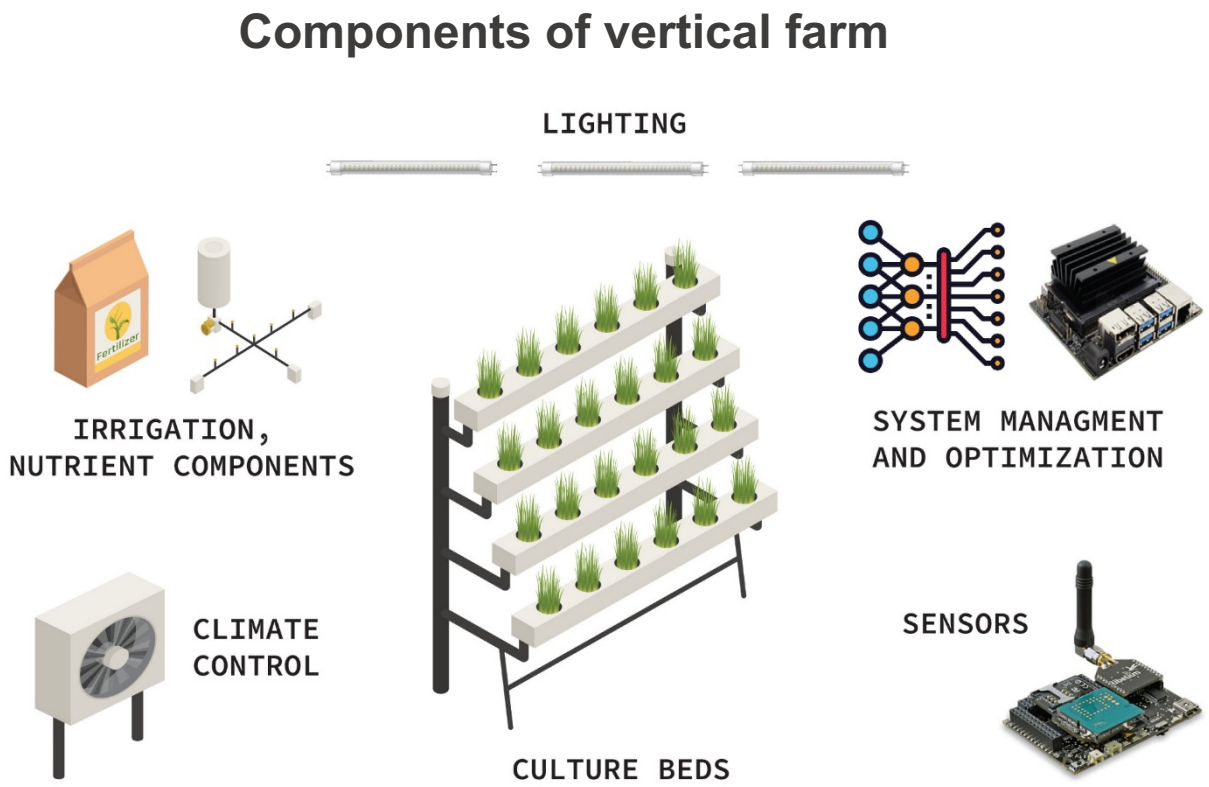
Source: adapted from Gartner, 2019

We focus on the eight most popular and promising Data Science application for Agro

Vertical farming is one of the decade's hottest trends

VERTICAL FARMING

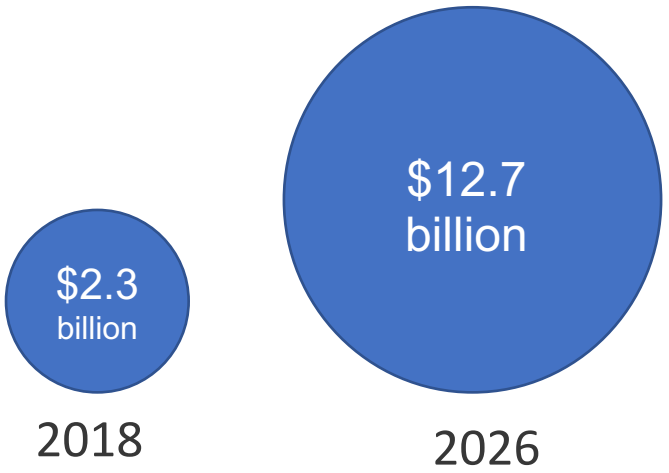
Vertical farm - is a method of cultivating various types of produce in vertically arranged layers, in unused vertical spaces of warehouses, skyscrapers, shipping containers, etc.



Vertical farming is one of the decade's hottest trends

One universal trend is that modern greenhouses and vertical farms are moving closer to metropolitan areas, universities and large transportation hubs

Global vertical farming market size[1]



Benefits and marketing concept:

- Cost-effectiveness
- Scalability
- Environmental sustainability
- High-tech engineering
- Food 'freshness'

Source: 1- Report Bayer. 2019 Vertical Farming Market by Component, Structure and Growth Mechanism: Global Opportunity Analysis and Industry Forecast, 2019-2026

Benefits and marketing concept: Scalability

An in-store farm of Infarm in the Metro's store in Paris, France

Picture Credit: Metro

A container farm of Agricool in France

Picture Credit: Agricool.

An appliance farm of Click & Grow

Picture Credit: Click & Grow.

Benefits and marketing concept: Environmental sustainability

Water usage may be drastically reduced because the same water can be recycled time and again through the same hydroponic system

Fertilizer use can be greatly reduced and herbicides and pesticides for weed and pest control are unnecessary

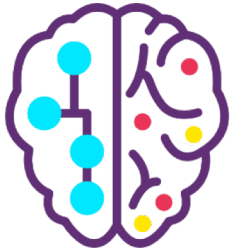
43 food miles* in transportation instead of 2000 food miles for open field production and 500-1000 food miles for greenhouses

Barbosa, G.L., Gadelha, F.D.A., Kublik, N., Proctor, A., Reichelm, L., Weissinger, E., Wohlleb, G.M., Halden, R.U. (2015). Comparison of land, water, and energy requirements of lettuce grown using hydroponic vs. conventional agricultural methods. International journal of environmental research and public health, 12(6), 6879-6891.

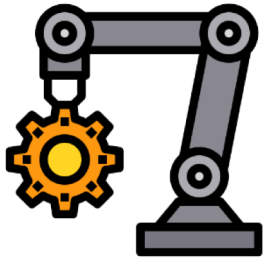
Benefits and marketing concept: High-tech engineering

The key technologies in vertical farming include

Perception technologies
cameras and other sensors which can monitor for color and other factors, such as disease detection, identifying plants ready for harvest and harvesting, etc.

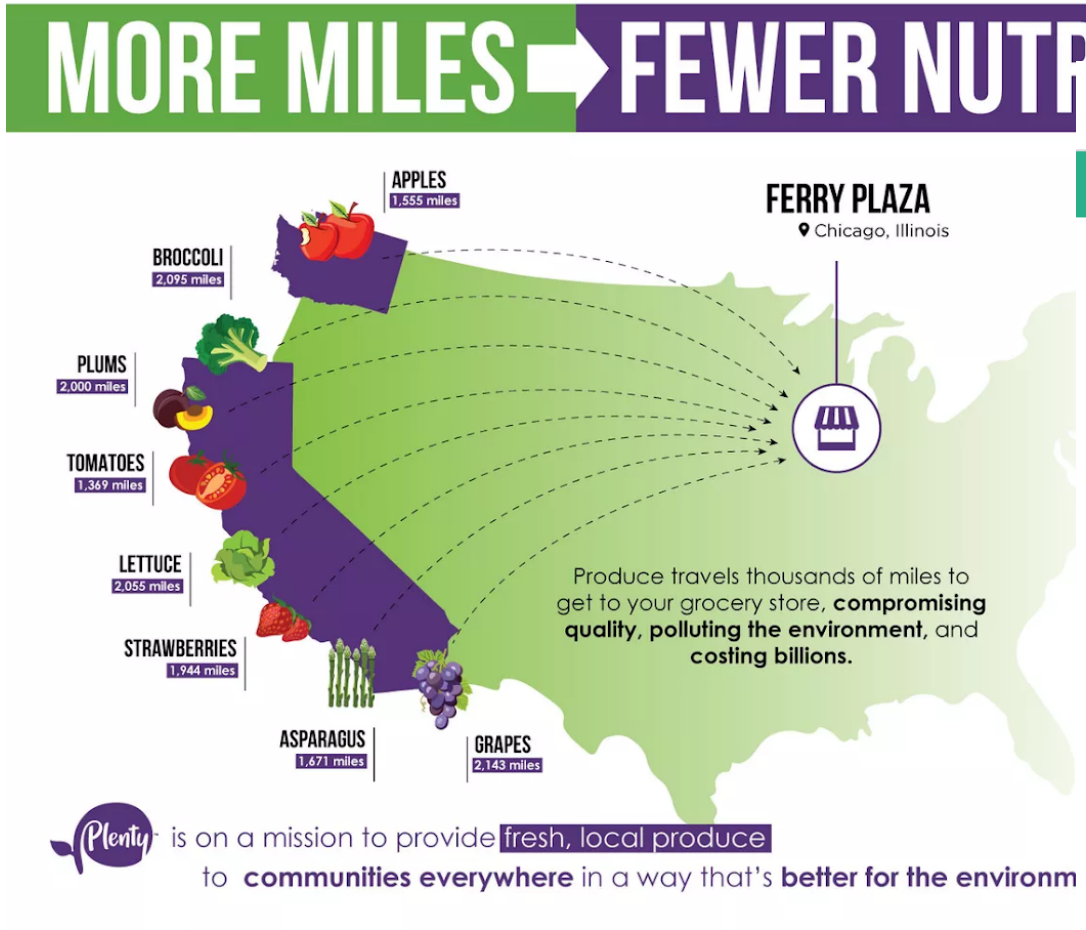


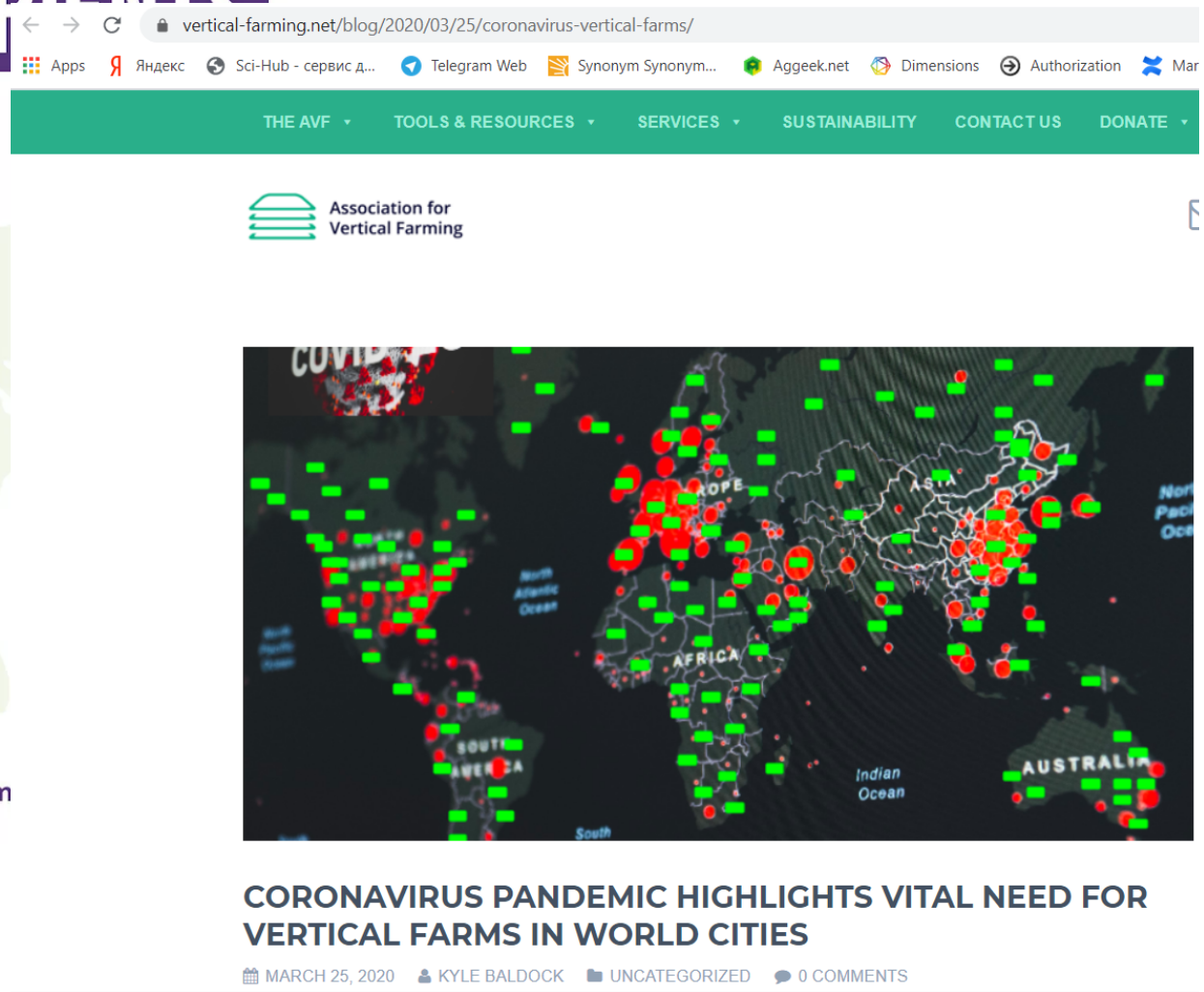
Artificial intelligence
which can process the data from the sensors and formulate solutions



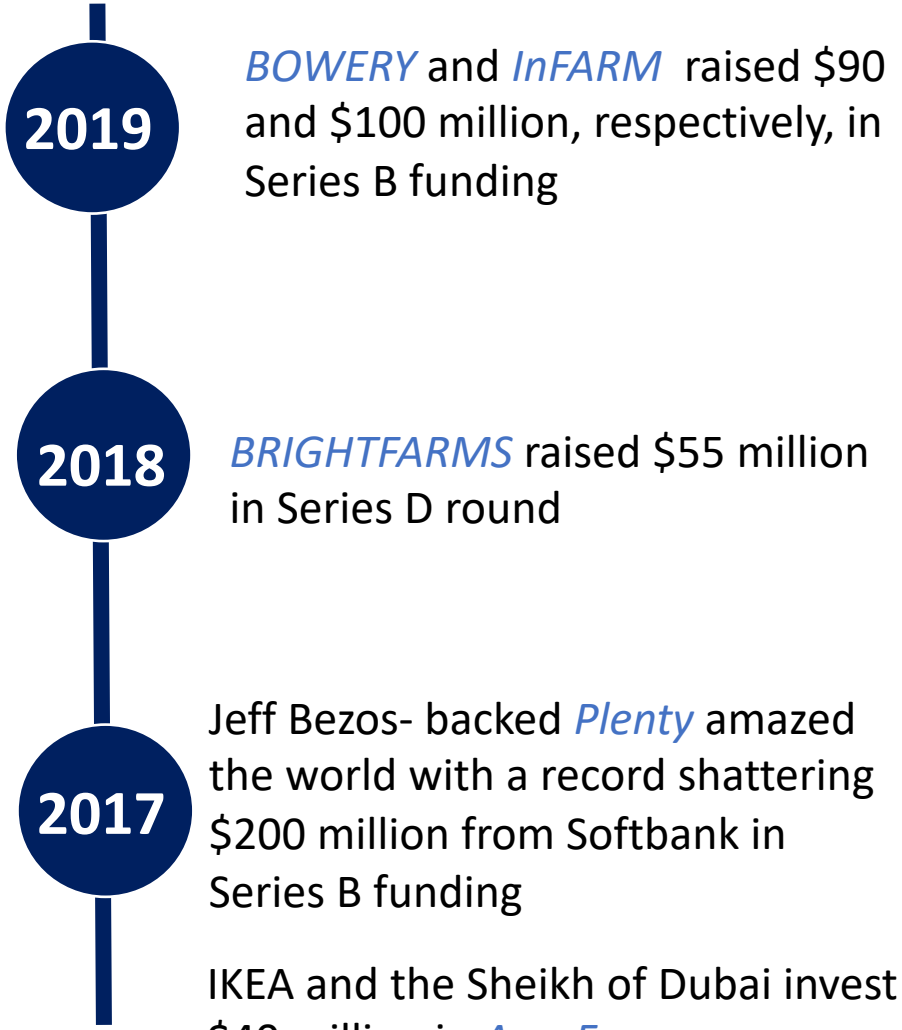
Automated and even autonomous mechatronics
robots and other automated machines which pick the produce when it is ready for market, or apply cures to ailments during their growing

Benefits and marketing concept: Food freshness



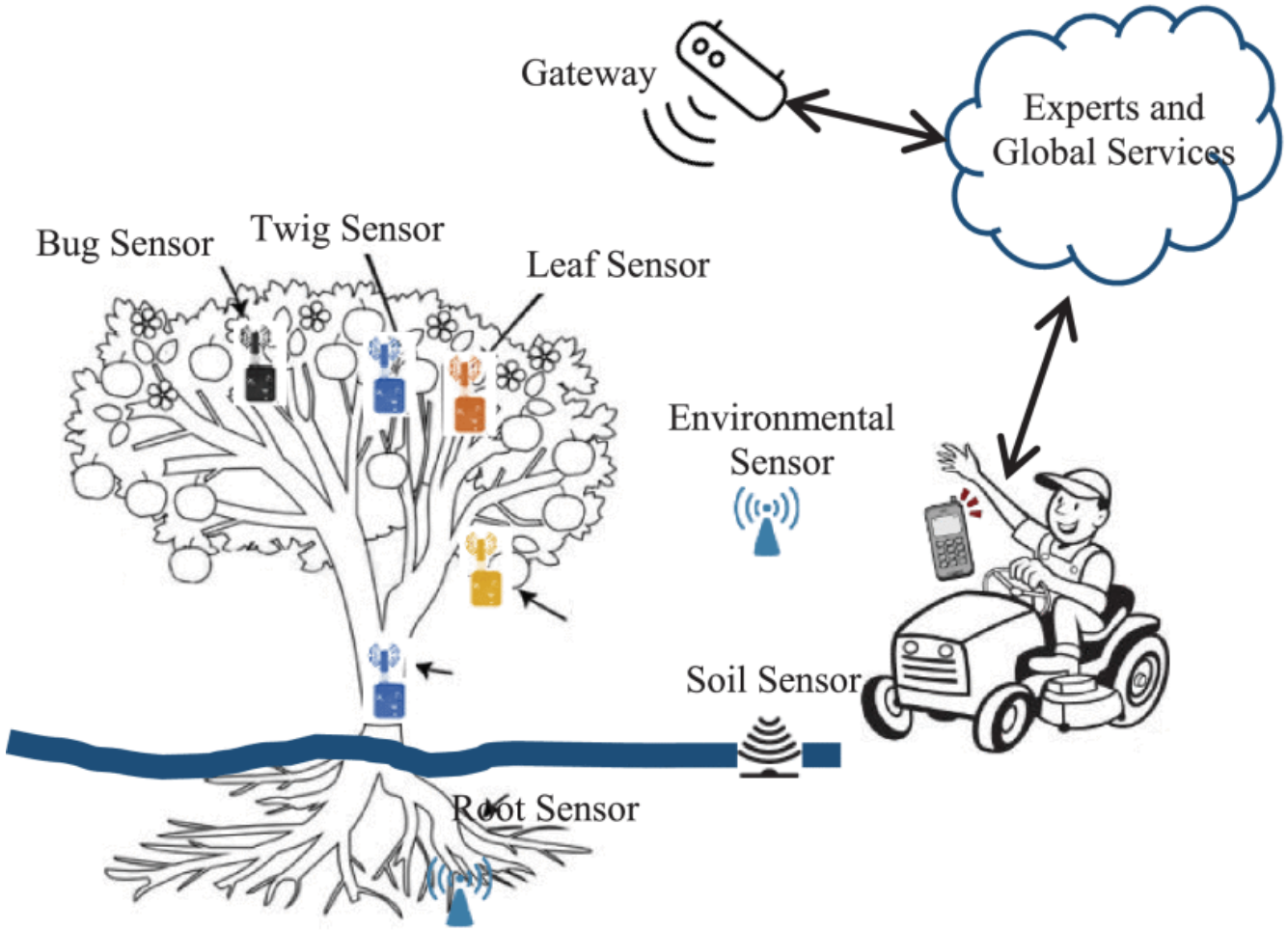


Funding for vertical farming startups is increasing

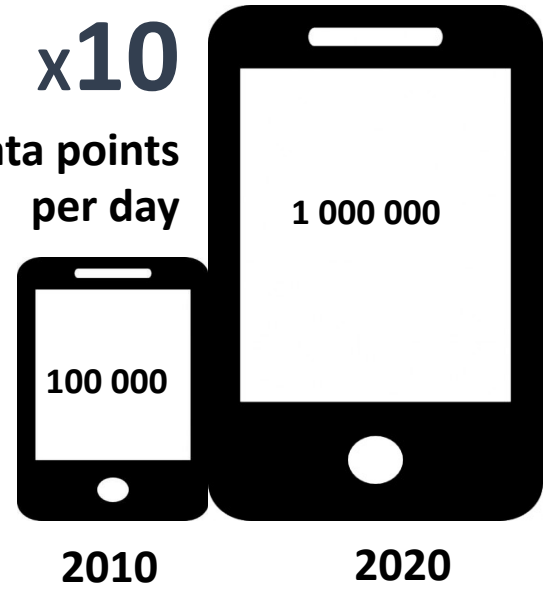


The vertical farming industry is a market full of potential, but it is not without its risks.

Wireless Sensors and Internet of Things for Agro



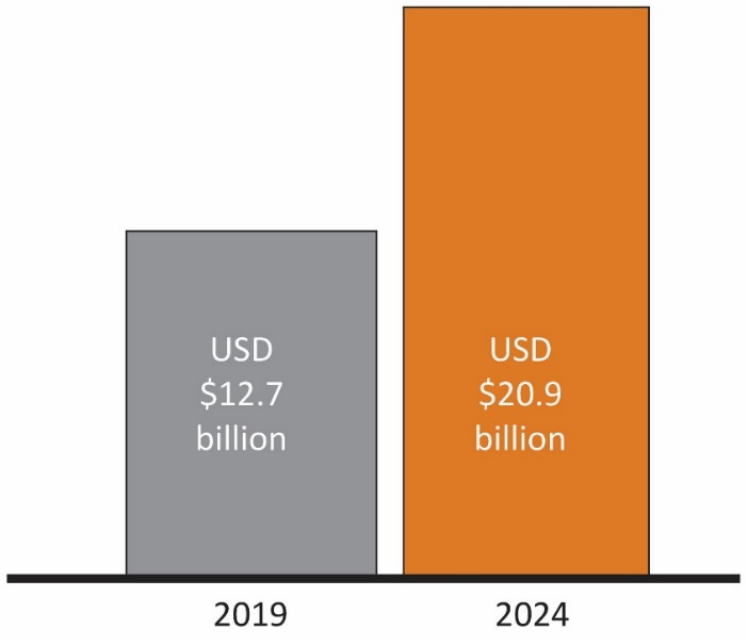
Amount of Data Generated by the Average Farm per day



Picture source: M. Ayaz, M. Ammad-Uddin, Z. Sharif, A. Mansour and E. M. Aggoune, "Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk," in IEEE Access, vol. 7, pp. 129551-129583, 2019.

Wireless Sensors and Internet of Things for Agro

The agriculture IoT market is expected to be worth $20.8 bln by 2024



IoT-based products could be used to solve major Agriculture problems

1. Disease identification & Diagnosis
2. Fertilizer Calculator
3. Soil Study
4. Water Study
5. Need of Crop Needs Estimation
6. Analysis of Crop Produce Readiness
7. Identification Temperature and Humidity (for Horticulture crops)

Picture source: M. Ayaz, M. Ammad-Uddin, Z. Sharif, A. Mansour and E. M. Aggoune, "Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk," in IEEE Access, vol. 7, pp. 129551-129583, 2019.

IoT-based architectures

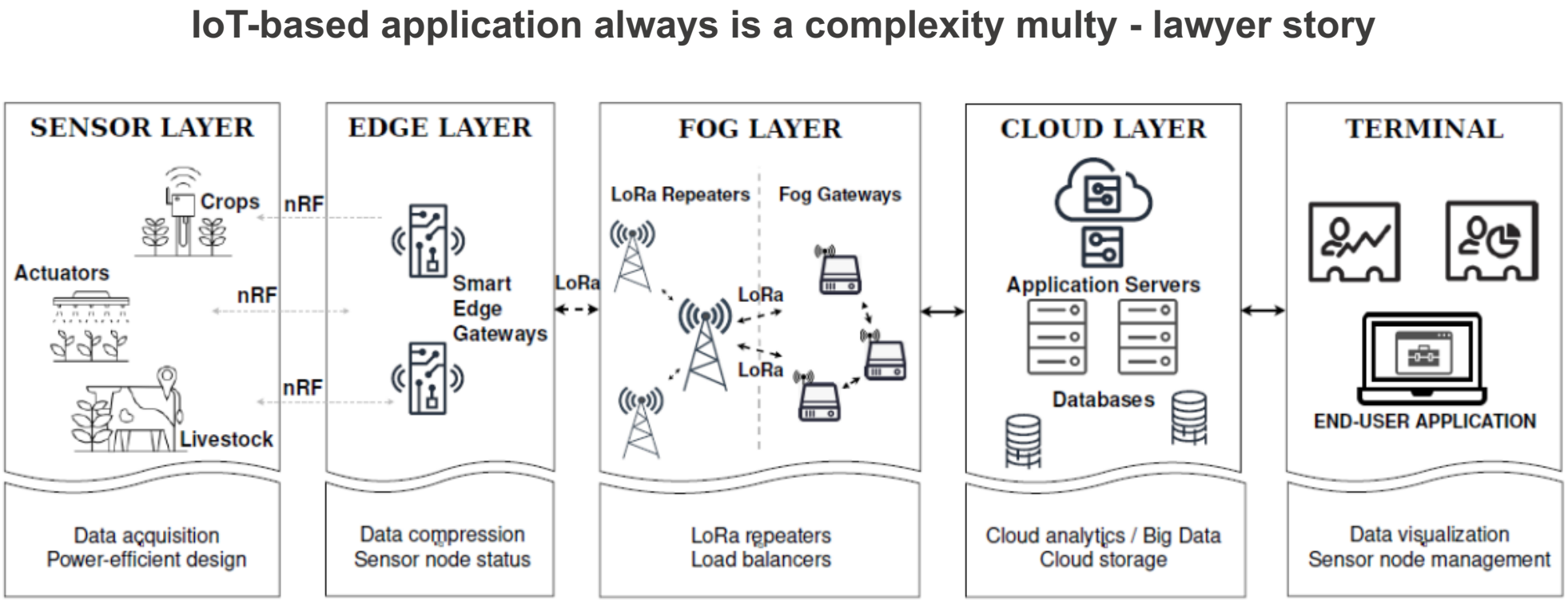
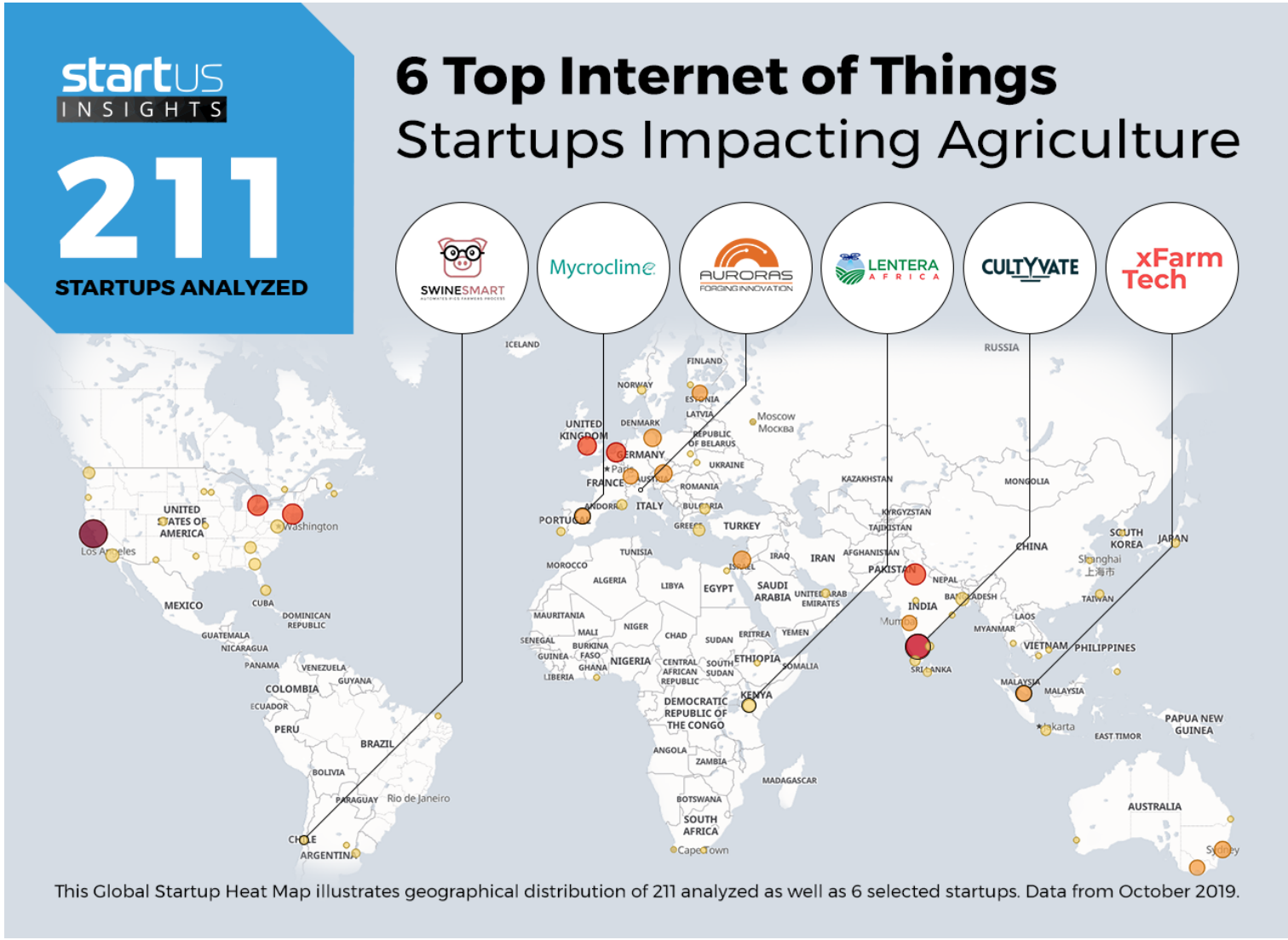


Fig. Possible 5-layers IoT system for Agriculture*

* Source: Nguyen gia, Tuan & L., Qingqing & Peña Queralta, Jorge & Zou, Z & Tenhunen, Hannu & Westerlund, Tomi. (2019). Edge AI in Smart Farming IoT: CNNs at the Edge and Fog Computing with LoRa.

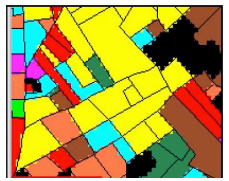
Agro-IoT startups



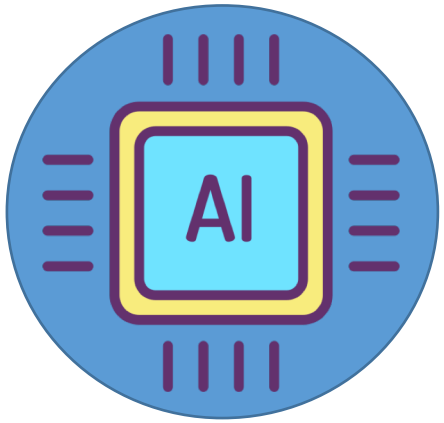
https://www.startus-insights.com/innovators-guide/6-top-internet-of-things-startups-impacting-agriculture/

5 Ways how AI benefits to agriculture

Receiving useful data to help fight food scarcity for small farmers

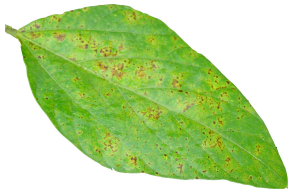


Crops and Land classifications



Tackle climate changes

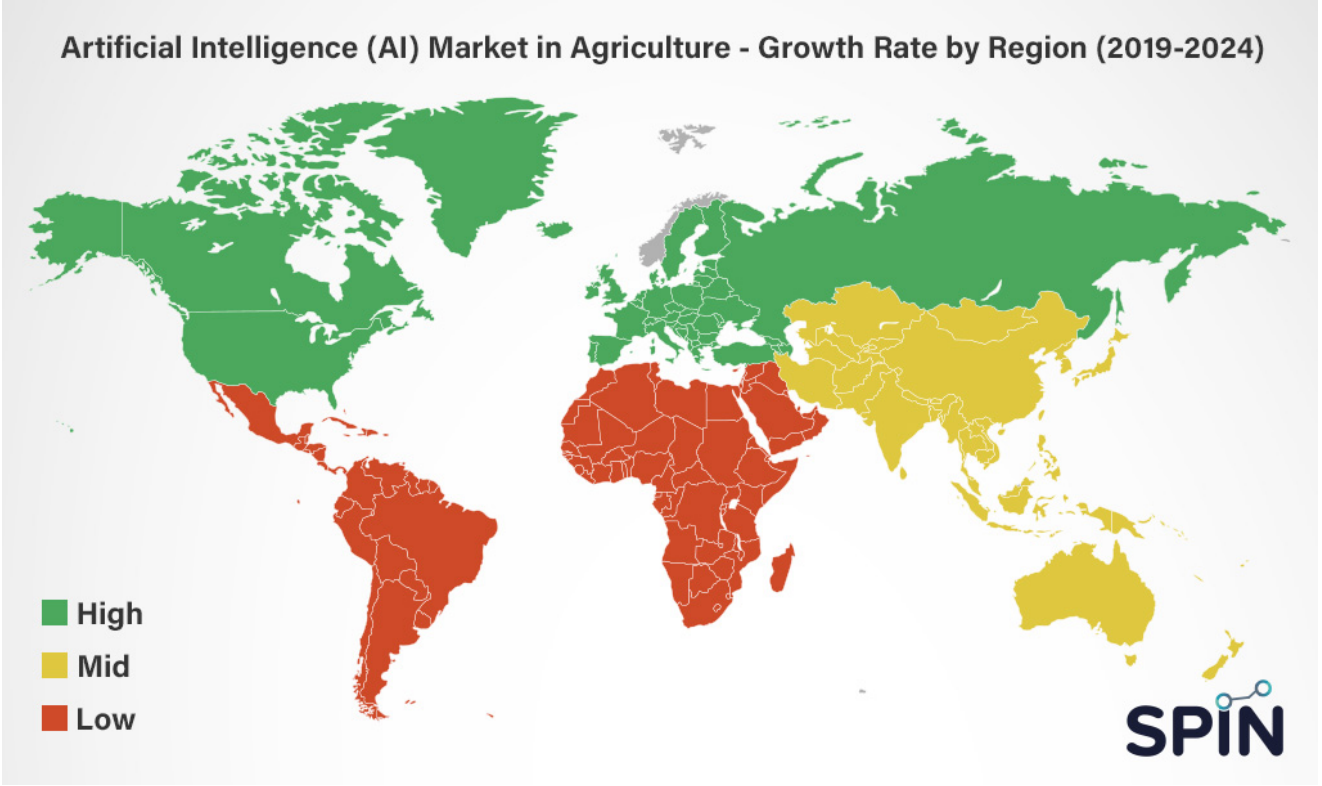
Yield predictions



Managing crop diseases and pests

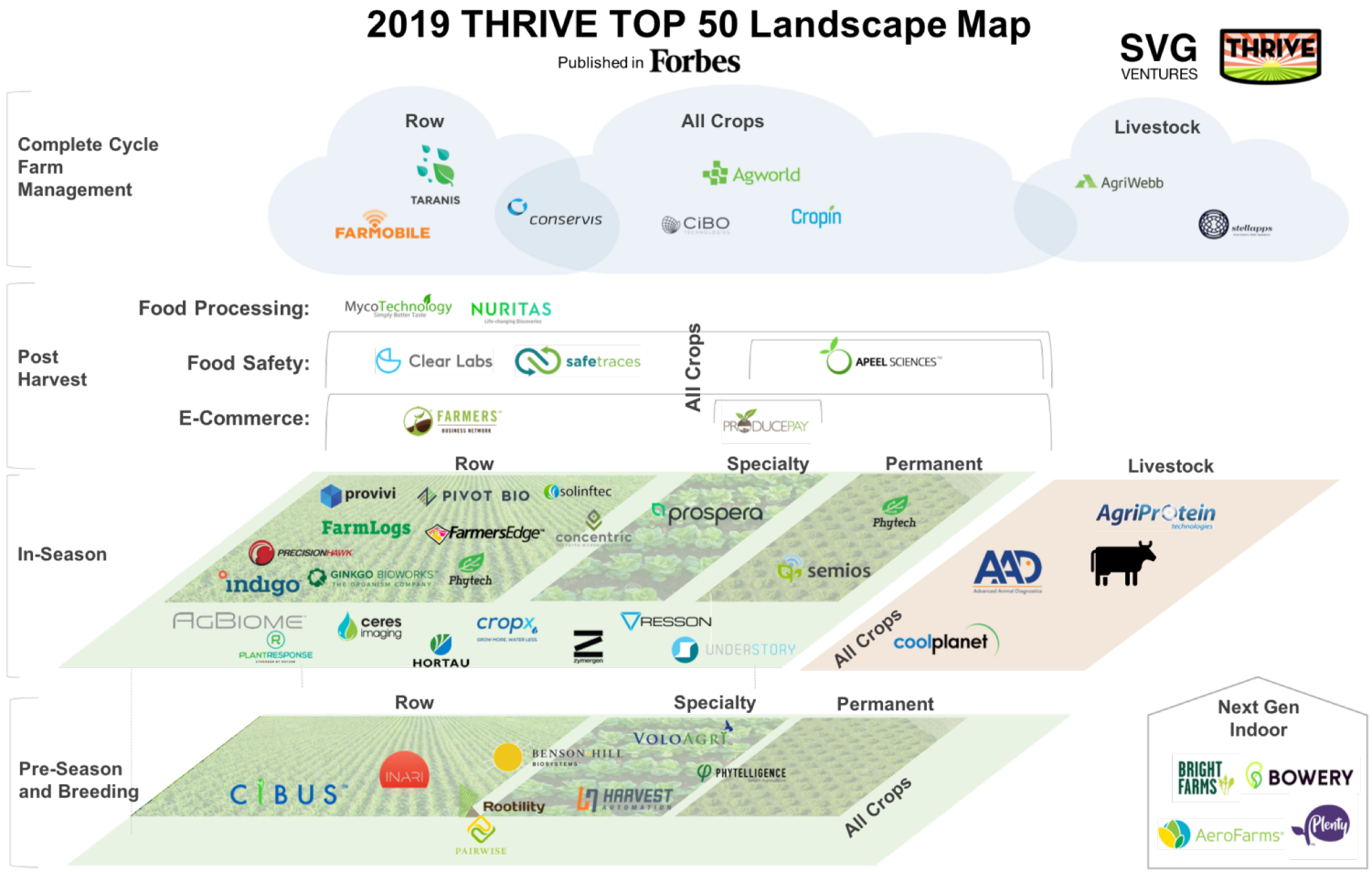
AI in Agriculture Market

The global AI in agriculture market was valued at $671.6 million in 2019 and is projected to reach $11,200.1 million in 2030



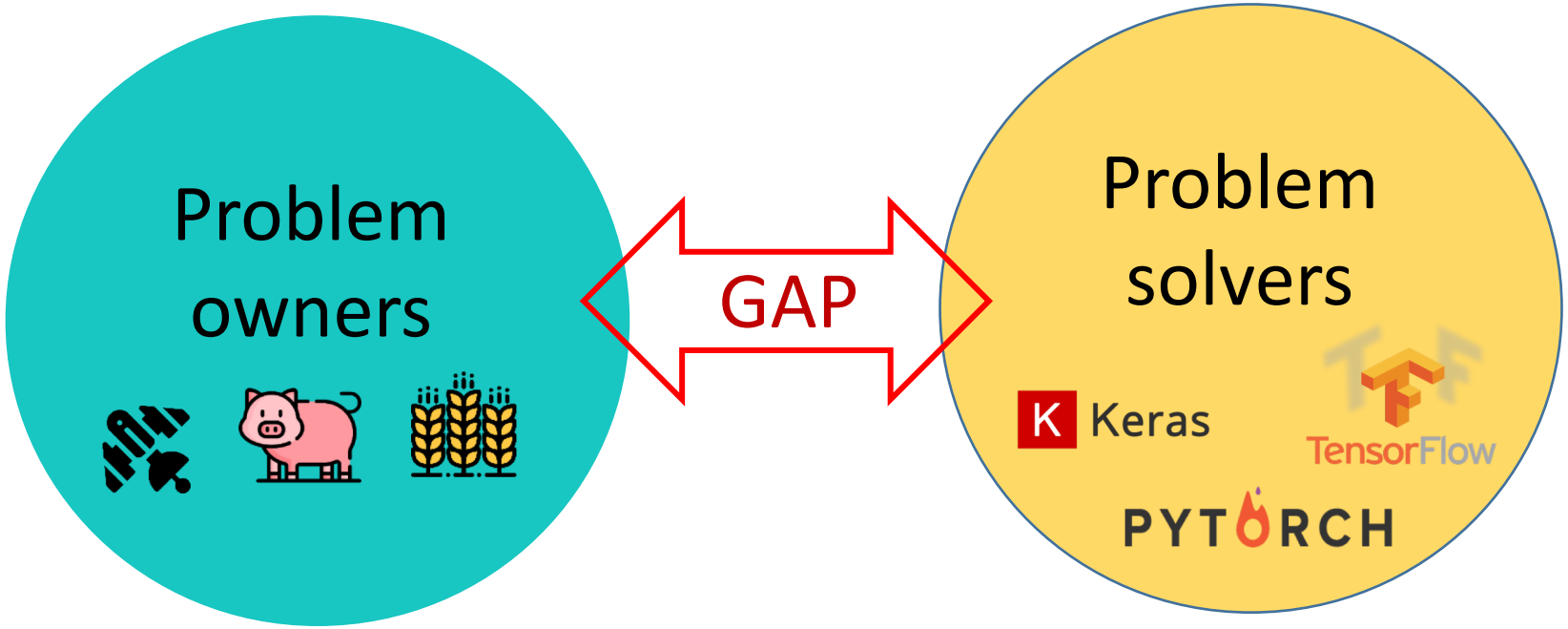
Source: Artificial Intelligence (AI) in Agriculture Market Research Report: By Type (Product, Service), Technology (Machine Learning, Predictive Analytics, Computer Vision), Application (Precision Farming, Agriculture Robots, Livestock Monitoring, Drone Analytics) – Global Industry Analysis and Growth Forecast to 2030

The majority of startups in agriculture are adapting AI-enabled approach



Source: https://thriveagrifood.com/thrive-announces-2019-top-50-report-highlighting-leading-growth-stage-companies-unicorn-predictions-in-food-and-agtech/

Why agriculture is still not AI-native?



Source: ICML 2019, keynote presentation *AI Commons* from Yoshua Bengio, Jun 15, 2019

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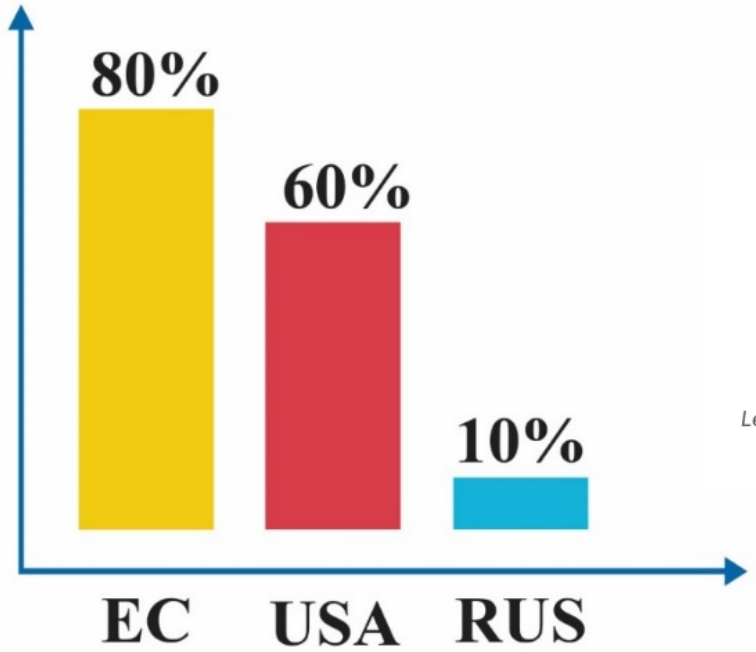
Why agriculture is still not AI-native?

AI is taking over the connected world

… but the farm is not yet connected!

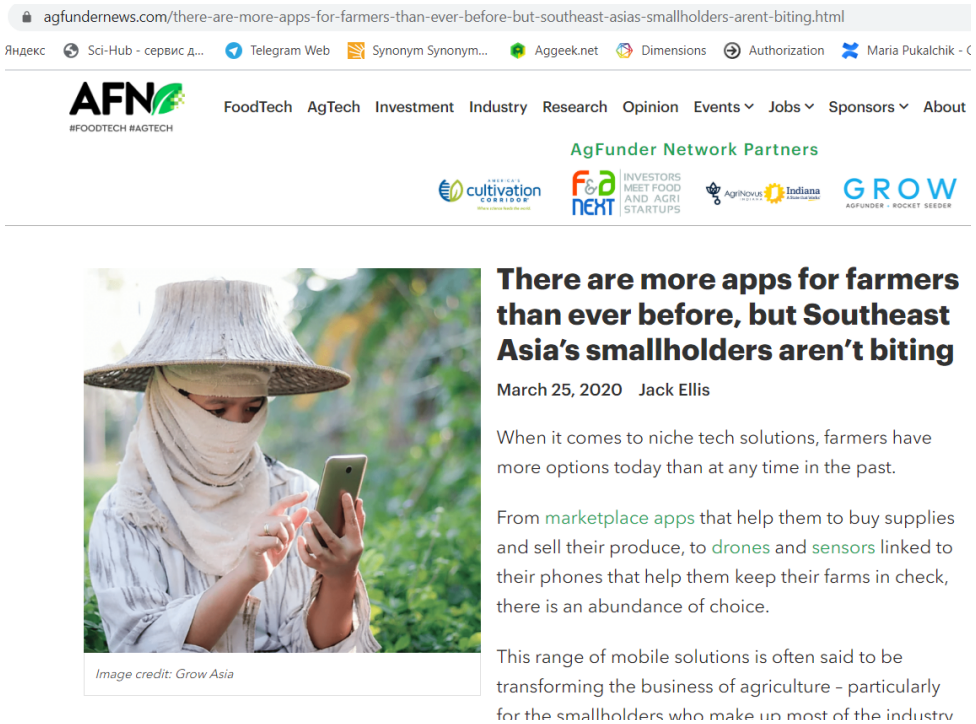
Percentage of households and farmers with broad internet connections[1]

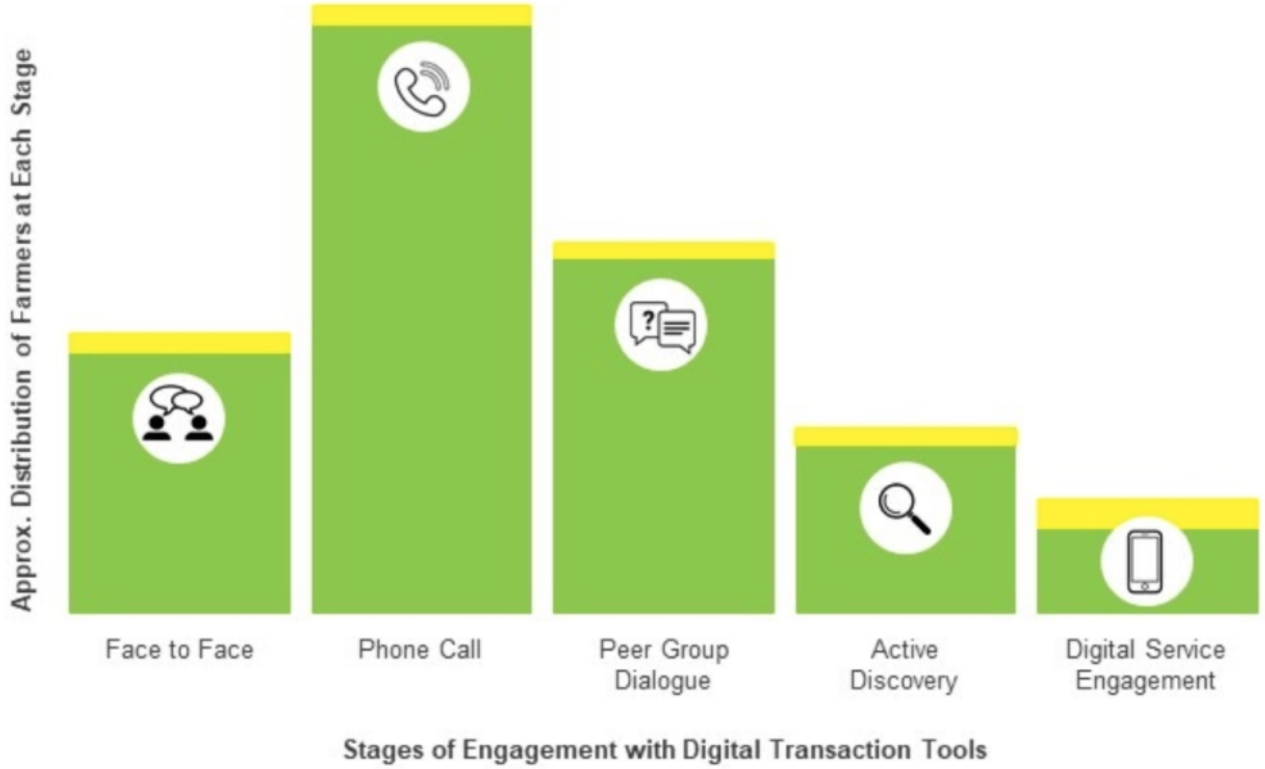


Ageing workforce on EC farm managers [1]

Source: https://www.euractiv.com/wp-content/uploads/sites/2/2016/11/CEMA-18102016-EN-V02-3-FINAL.png

Why agriculture is still not AI-native?

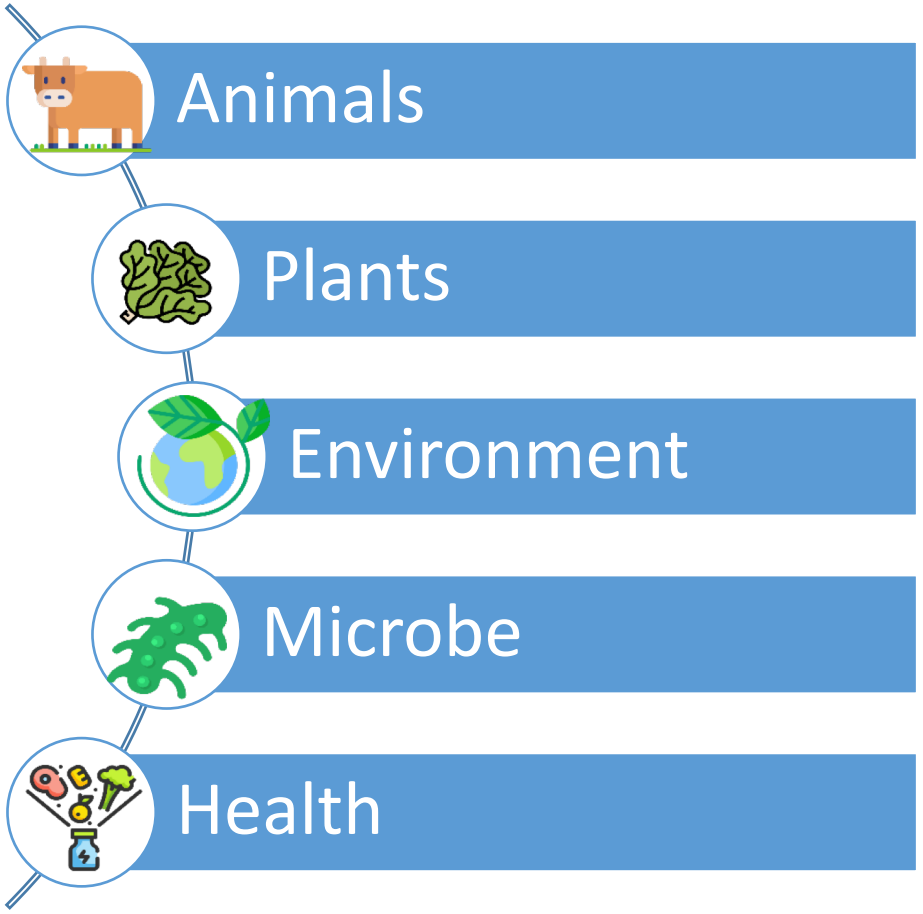




Source: https://agfundernews.com/there-are-more-apps-for-farmers-than-ever-before-but-southeast-asias-smallholders-arent-biting.html
Image credit: Grow Asia

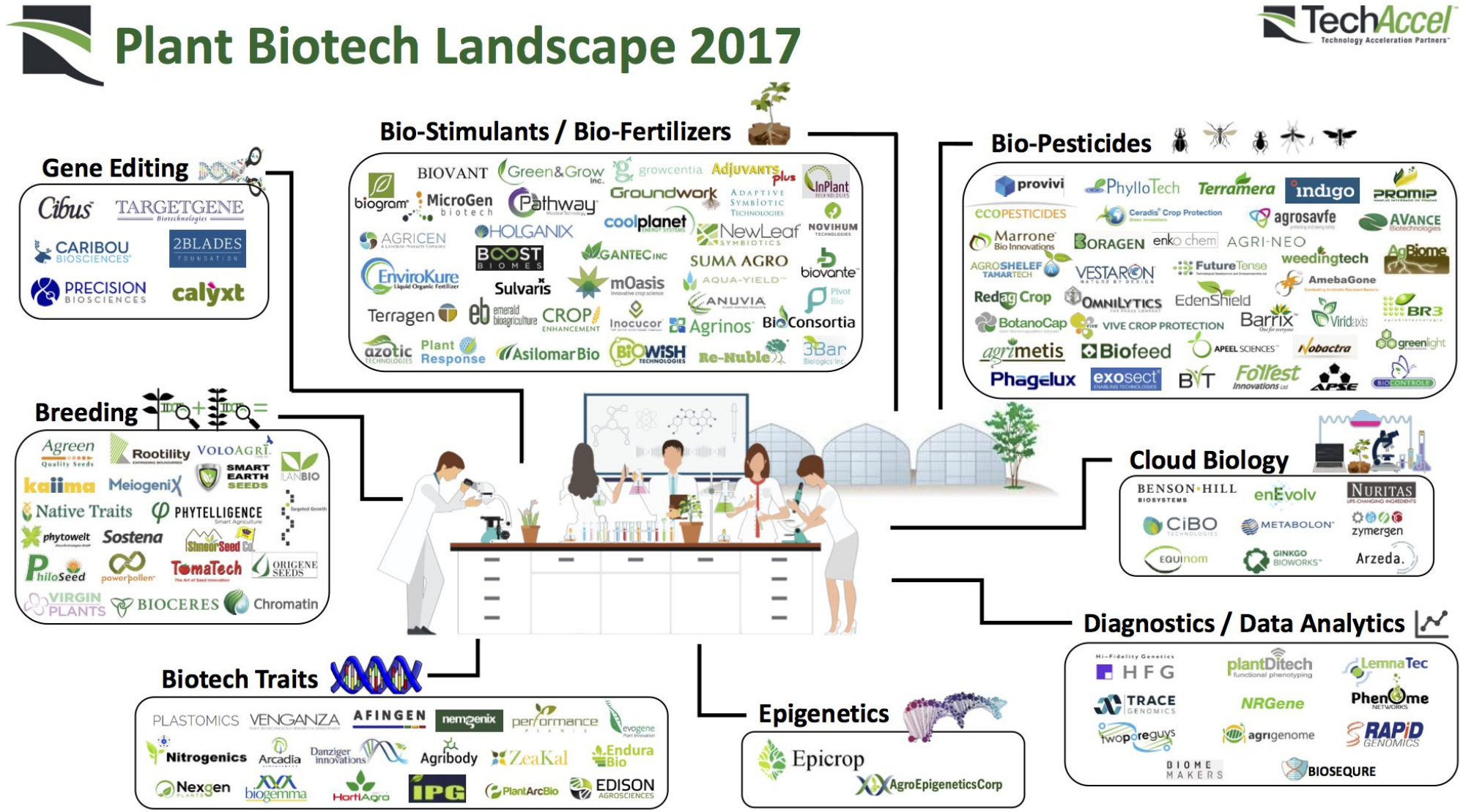
Biotech for Agriculture

Agricultural Biotechnology - a range of tools, including traditional breeding techniques, that alter living organisms, or parts of organisms, to make or modify products; improve plants or animals; or develop microorganisms for specific agricultural uses[1]



Source https://archive.bio.org/articles/glossary-agricultural-biotechnology-terms

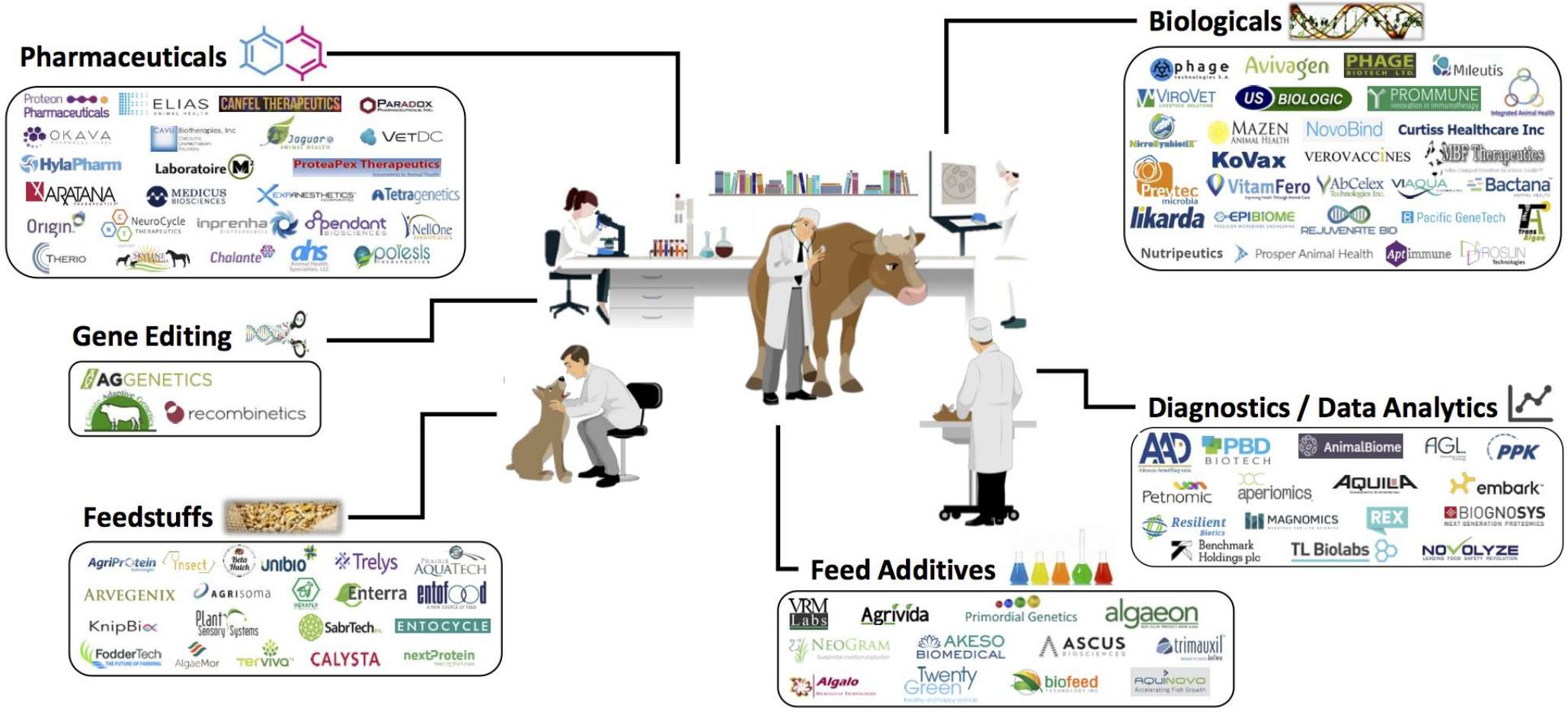
Biotech for Plants



Picture credits: https://agfundernews.com/ag-biotech-market-map.html

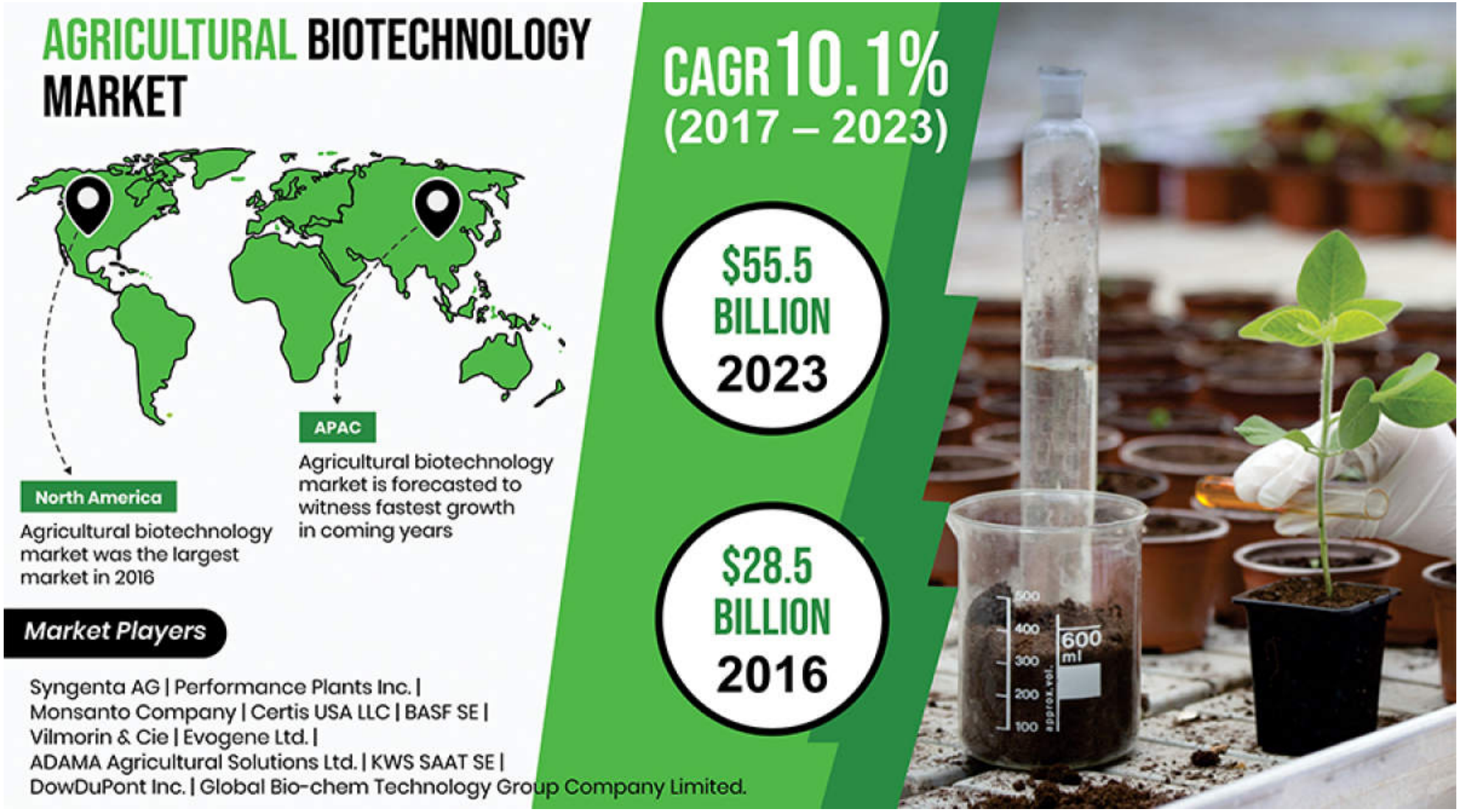
Animal Biotech Landscape 2017

TechAccel
Technology Acceleration Partners



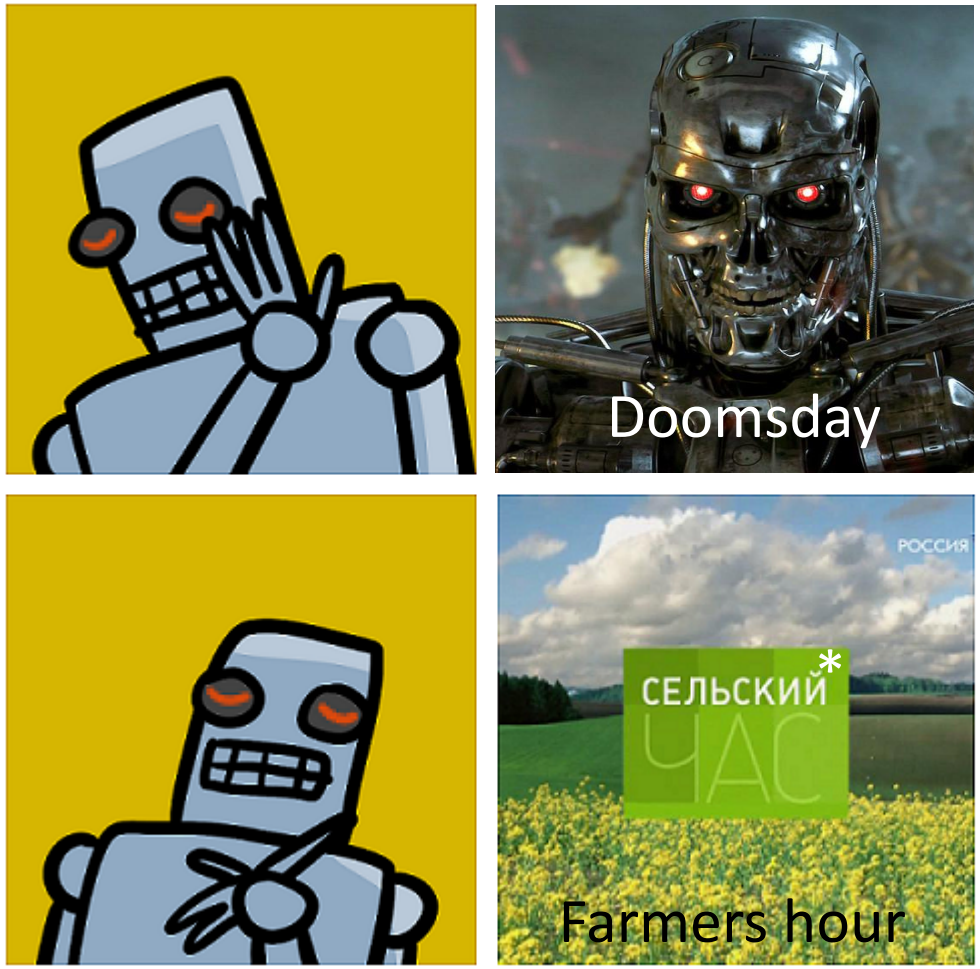
Picture credits: https://agfundernews.com/ag-biotech-market-map.html

AgBiotech market



Picture credits: https://www.whatech.com/market-research/agriculture/637086-new-release-global-agricultural-biotechnology-market-report

Robots and Drones for agriculture

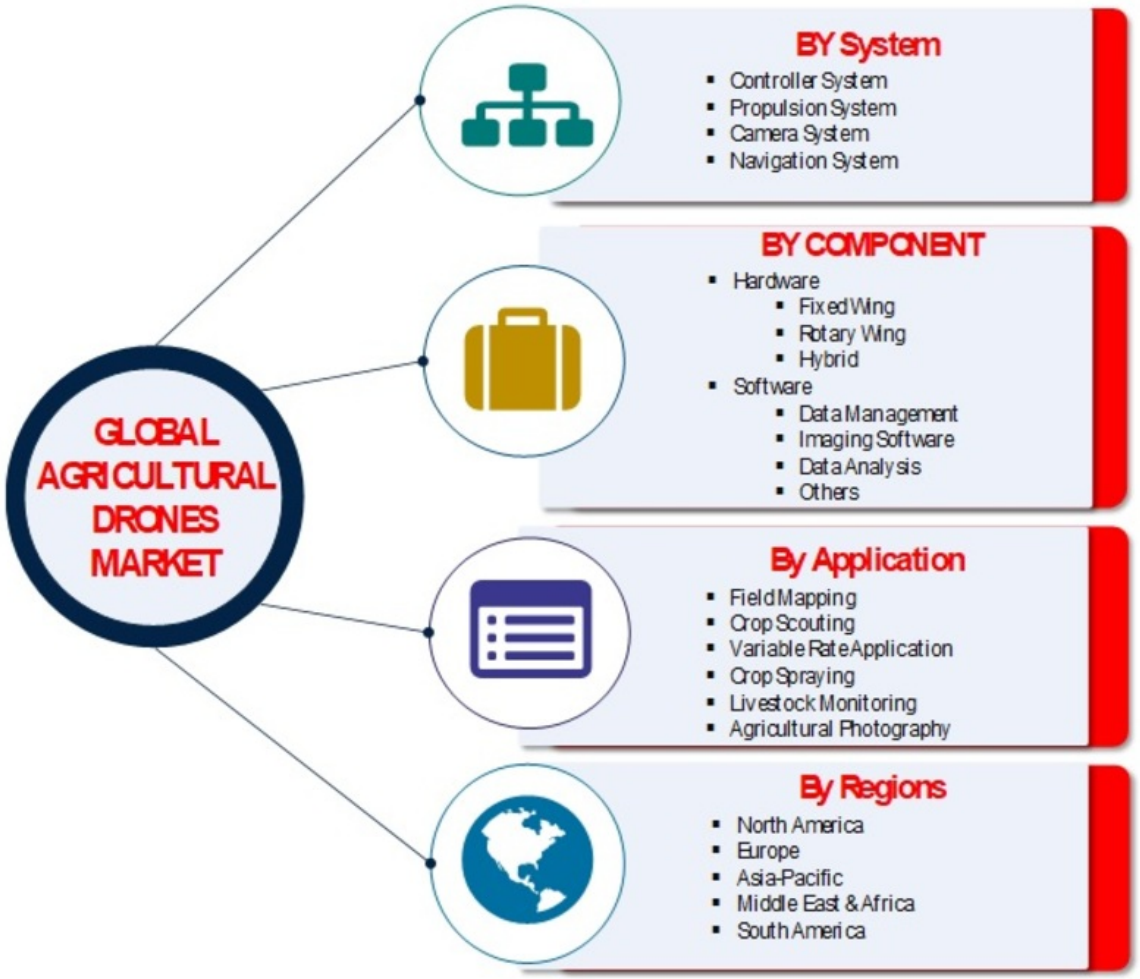


Picture credits: https://habr.com/ru/company/cloud4y/blog/460129/

Robots and Drones for agriculture

Video: https://www.youtube.com/watch?v=Qmla9NLFBvU

Agricultural drones market



Key Players*

AeroVironment™ | PROCEED WITH CERTAINTY

dji THE FUTURE OF POSSIBLE

Parrot

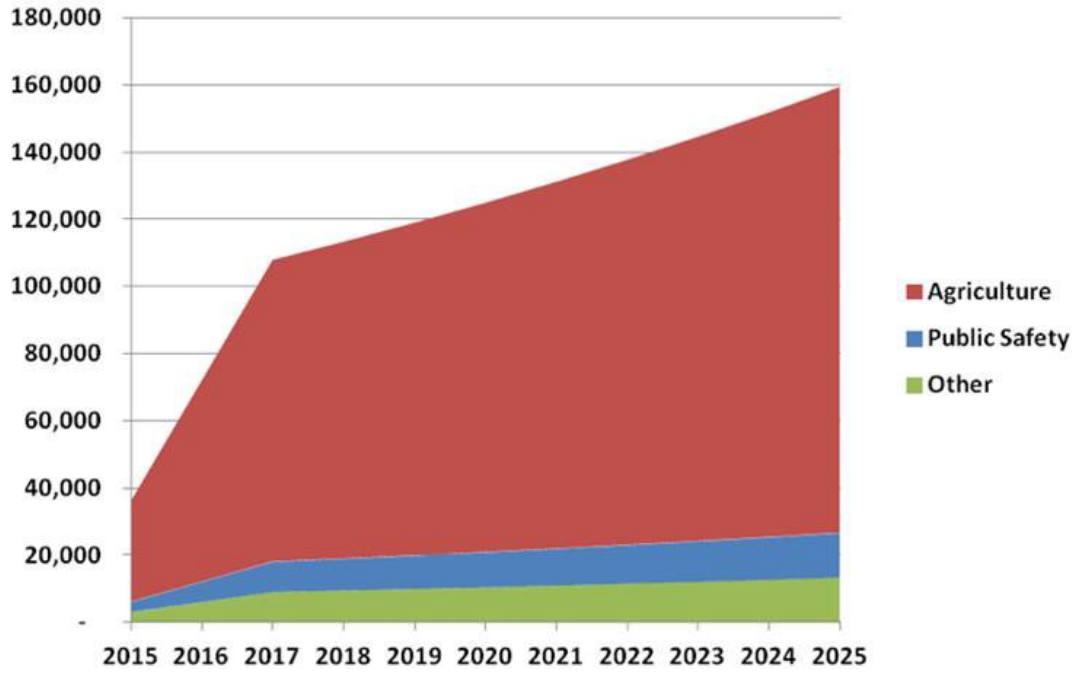
YAMAHA Revs Your Heart

draganfly INC

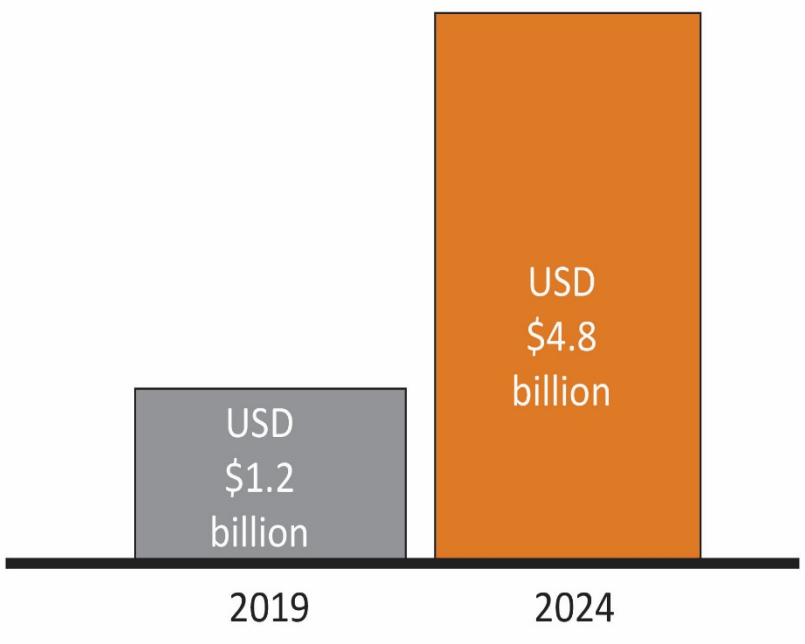
Source: Agricultural Drones Market Research Report - Global Forecast till 2025

Agricultural drones market

Annual Drones Sales in USA market[1]



The World Agriculture Drones market is expected to be worth $4.8 bln by 2024[2]



Source : 1 – AUVSI; 2 -https://www.marketsandmarkets.com/Market-Reports/agriculture-drones-market-23709764.html

There are still many restrictions in place for the commercial use of drones

Blockchain for agriculture

Blockchain - is a technology that allows users to transfer value or assets between other without the need for a trusted intermediary

* Video source: youtube https://www.youtube.com/watch?v=3xGLc-zz9cA

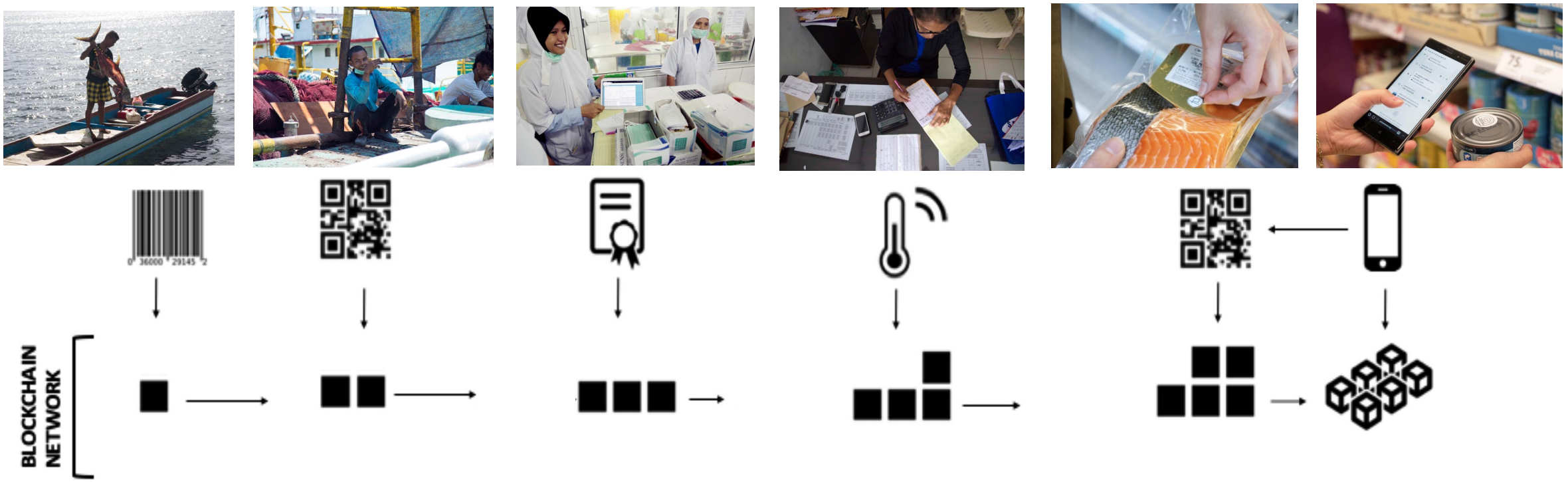
Blockchain to tracing food from source to table

- Open and shared ledger system will trace product origin with immutable provenance data from farm to table
- Retails can verify easily that the product they are receiving is exactly what they paid for

* Picture credit: https://medium.com/tokenasia/from-farm-to-plate-blockchain-technology-in-agriculture-supply-chain-611cf856b458

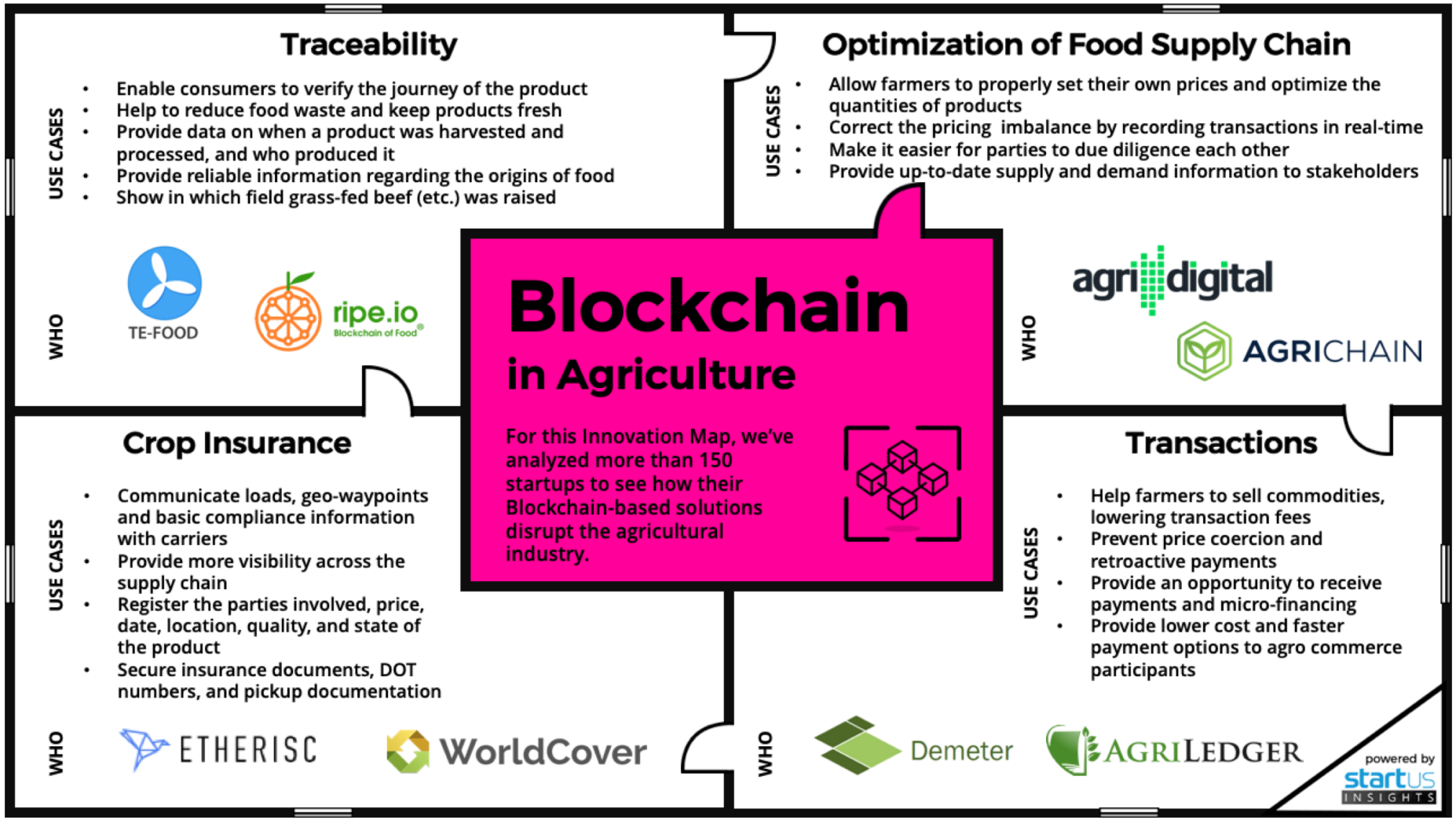
Blockchain to tracing food from source to table

Real example of technology: Tracking tuna on the blockchain

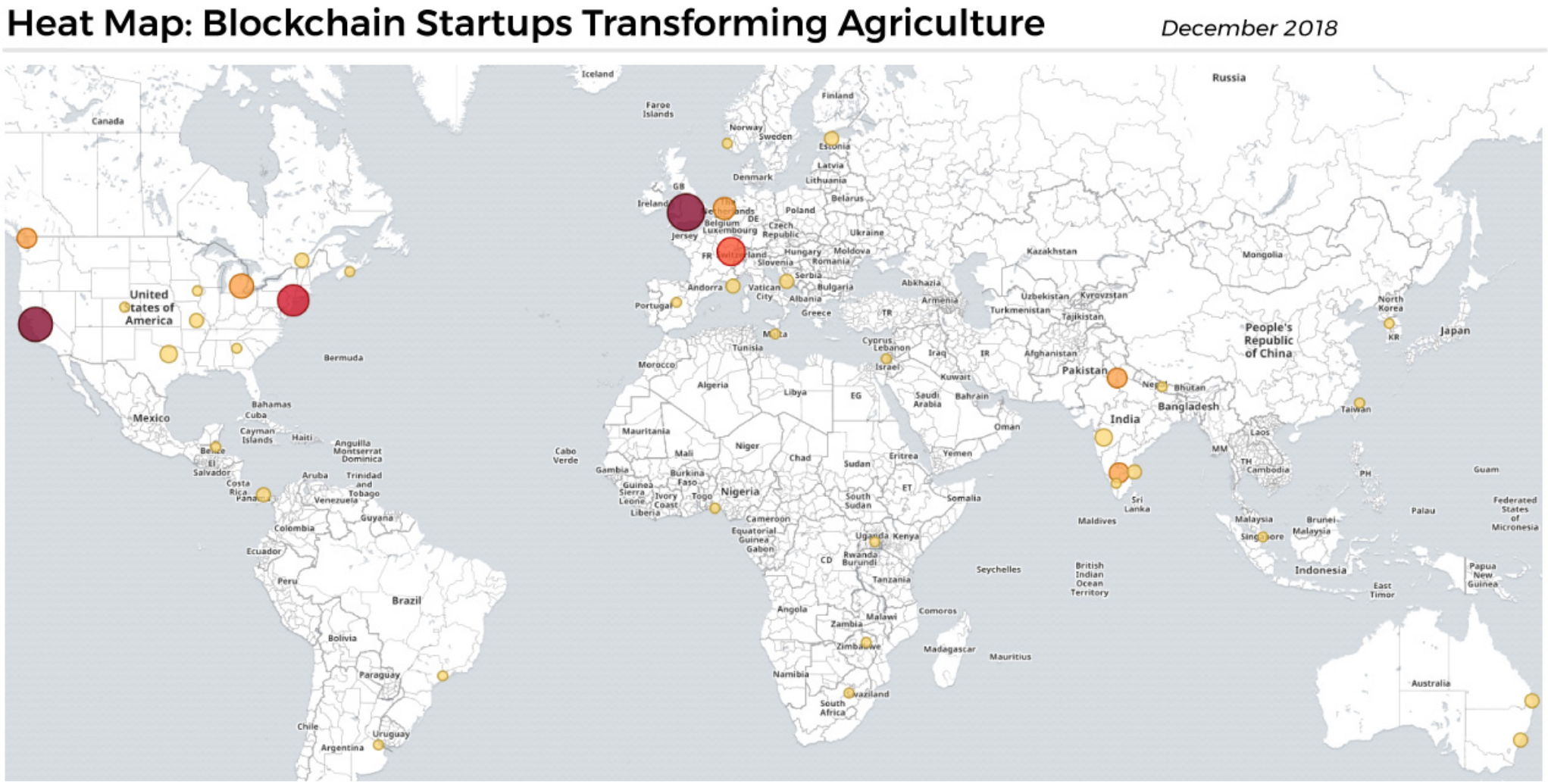


* Pictures credit: https://www.provenance.org/tracking-tuna-on-the-blockchain

Blockchain for agriculture



Blockchain for agriculture



This Heat Map illustrates the geographical distribution of over 150 Blockchain startups disrupting agriculture.

DS application to agriculture is becoming a trend in top-ranking conferences

Events		Topics
ICLR | 2021 International Conference on Learning Representations	Workshop on Computer Vision for Agriculture	CV Crop decease Multispectral imaging
	The 1st International Workshop AGRICULTURE-VISION: CHALLENGES & OPPORTUNITIES FOR COMPUTER VISION IN AGRICULTURE	Computer vision New benchmarks for CV in agro
ICCV 2021 International Conference on Computational Vision		Remote sensing applications Smart sensors

Next lectures

Skoltech
Skolkovo Institute of Science and Technology

Block 1

- Lecture 01. Introduction to Digital Agriculture

Block 2

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