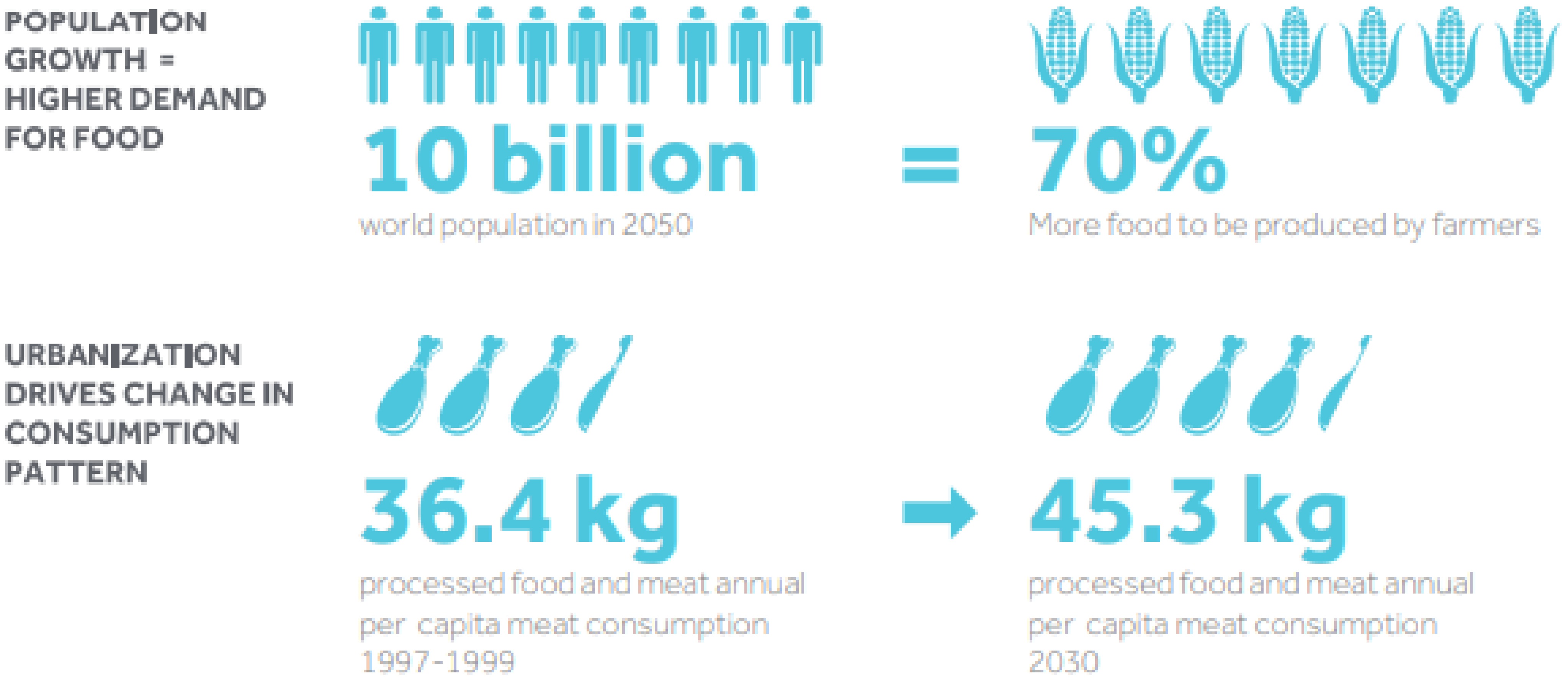
Data Analytics in Precision Agriculture

SARITH DIVAKAR M | GITHUB.COM/SARITHDM

Population growth and Urbanization



Source: https://www.oliverwyman.com/our-expertise/insights/2018/feb/agriculture-4-0--the-future-of-farming-technology.html

Natural Resources

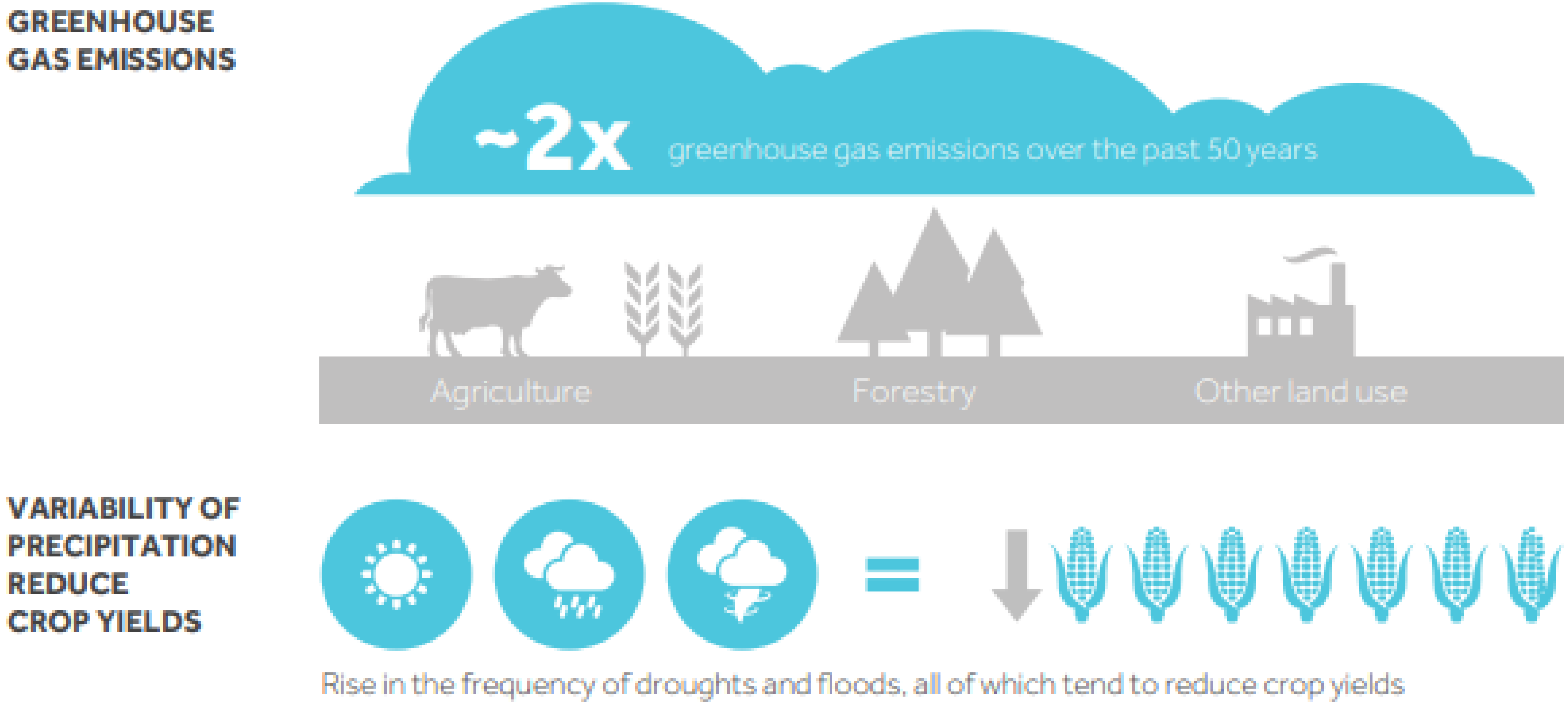
25% of all farmland is already rated as highly degraded

~80% global deforestation driven by agricultural concerns

$1 trillion investment necessary until 2050 for irrigation water management in developing countries alone

Source: https://www.oliverwyman.com/our-expertise/insights/2018/feb/agriculture-4-0--the-future-of-farming-technology.html

Climate Change



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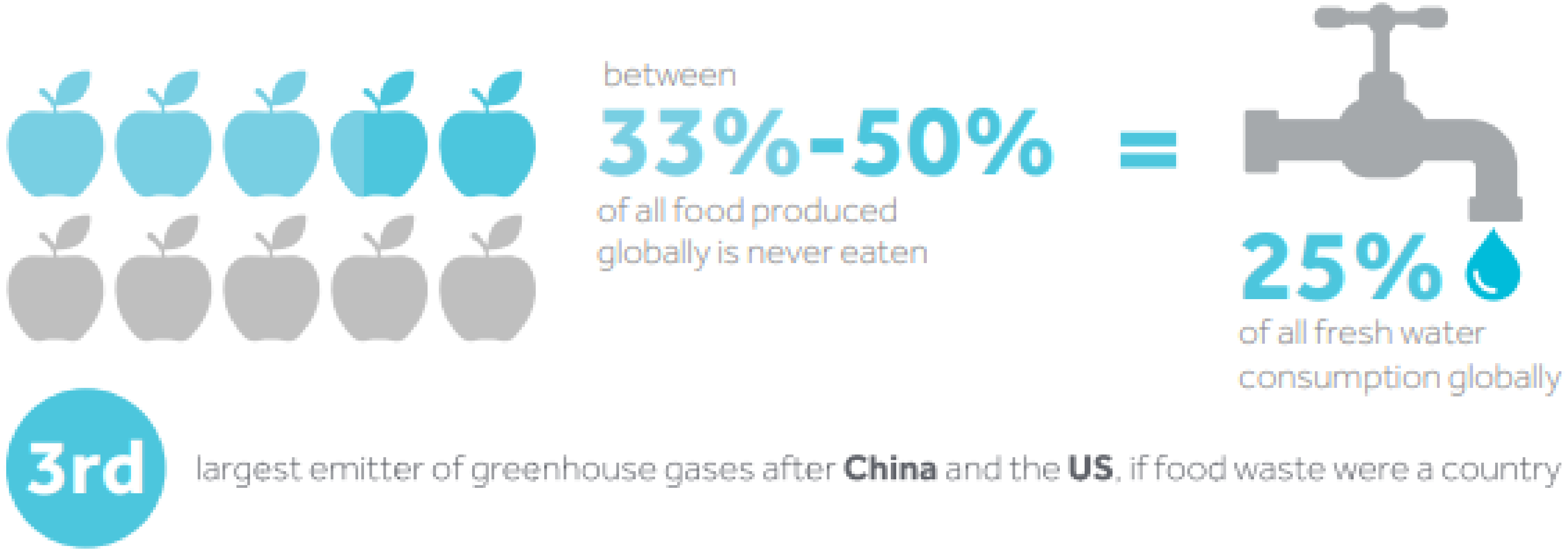
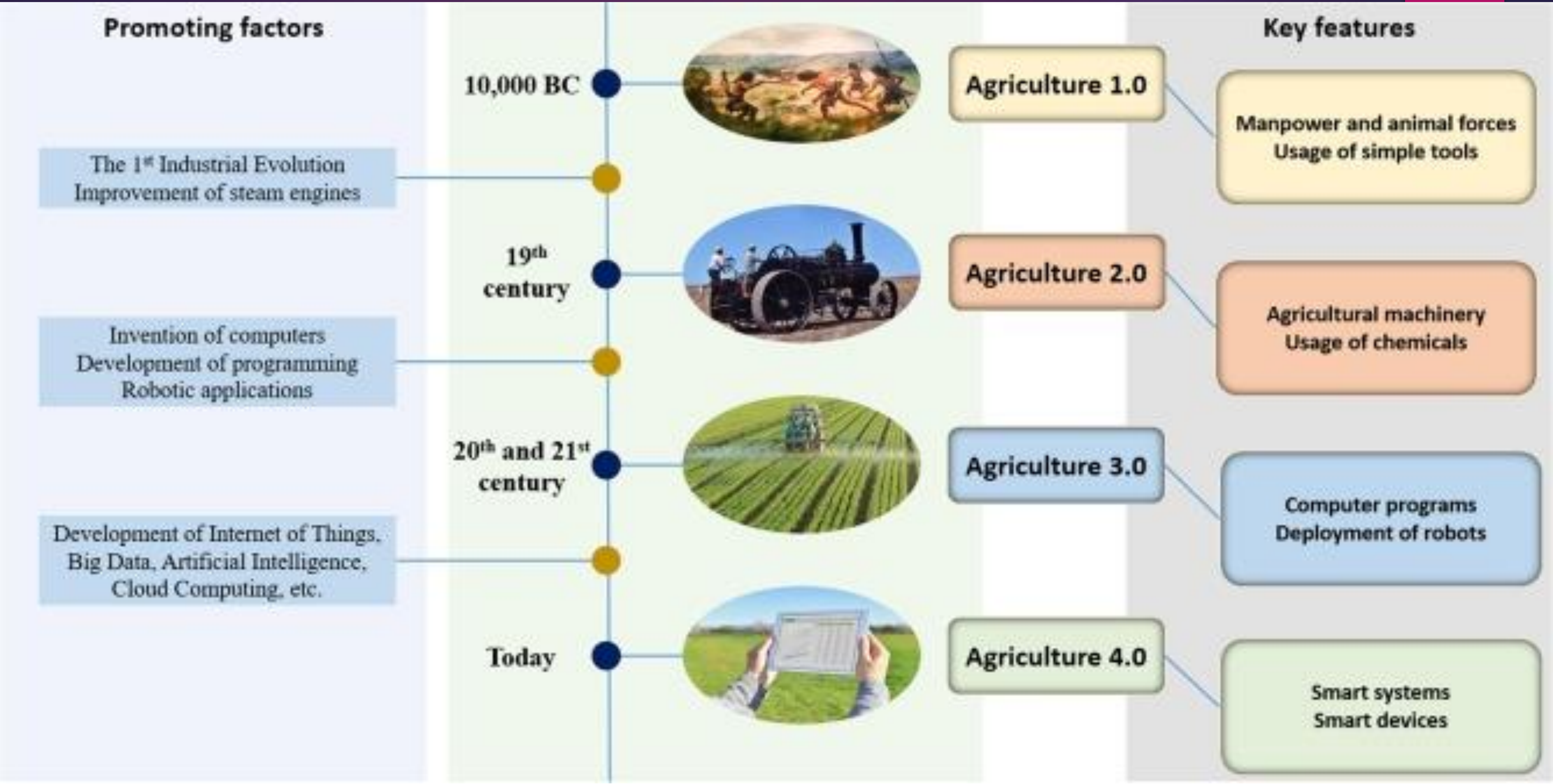
Food Waste



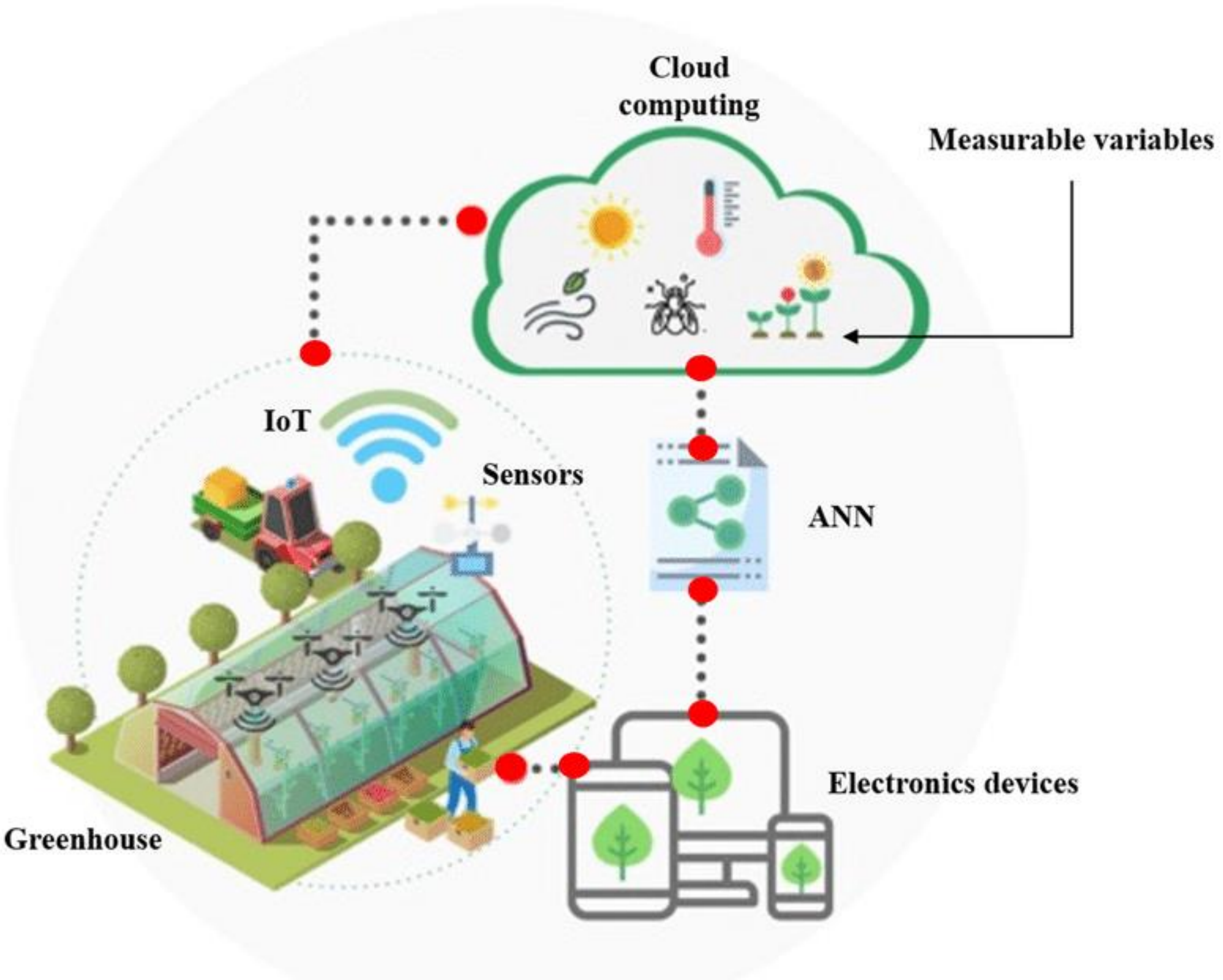
Source: https://www.oliverwyman.com/our-expertise/insights/2018/feb/agriculture-4-0--the-future-of-farming-technology.html

Solution: Agriculture 4.0

Agriculture 4.0

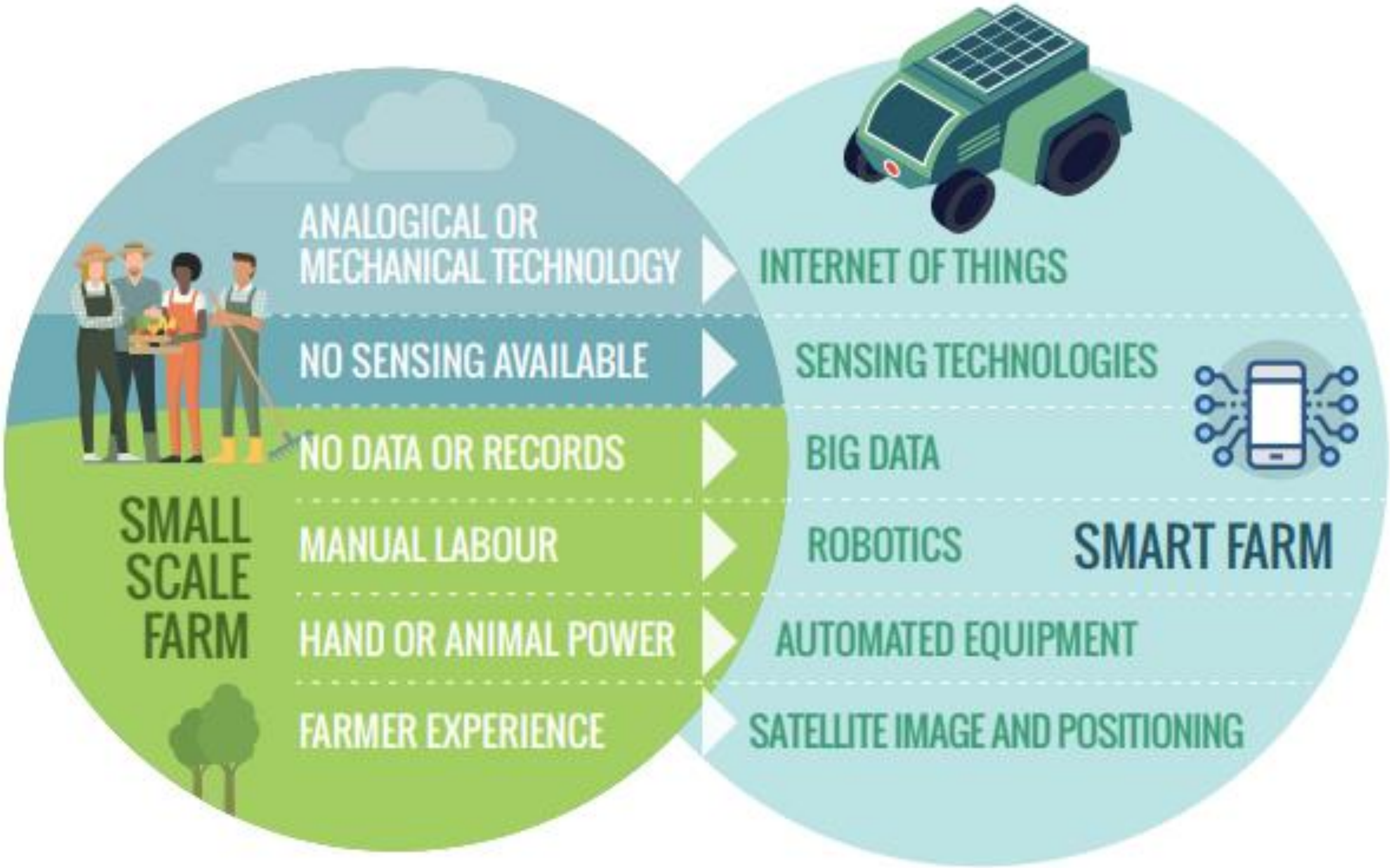


Source: Zhaoyu Z. et al. Decision support systems for agriculture 4.0: Survey and challenges, Computers and Electronics in Agriculture(2020)



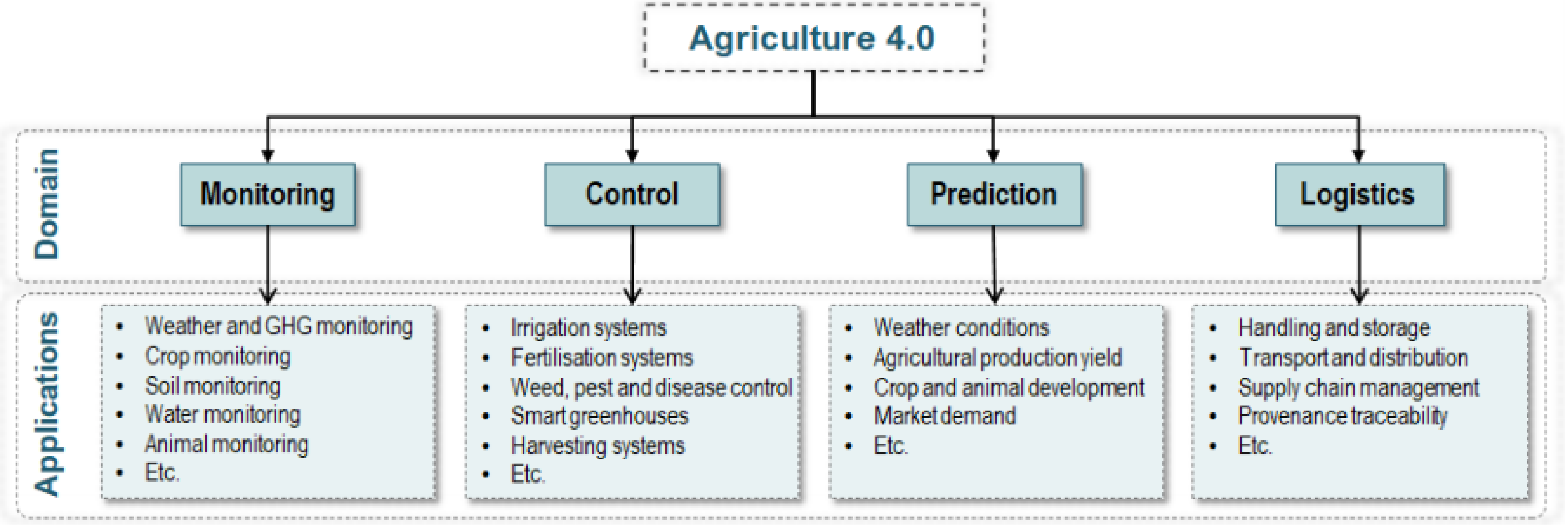
Source: E-G, Axel et al. 2020. "Applications of Artificial Neural Networks in Greenhouse Technology and Overview for Smart Agriculture Development" *Applied Sciences* 10, no. 11: 3835. https://doi.org/10.3390/app10113835 https://www.austrade.gov.au/agriculture40

Precision Agriculture/Smart Farming

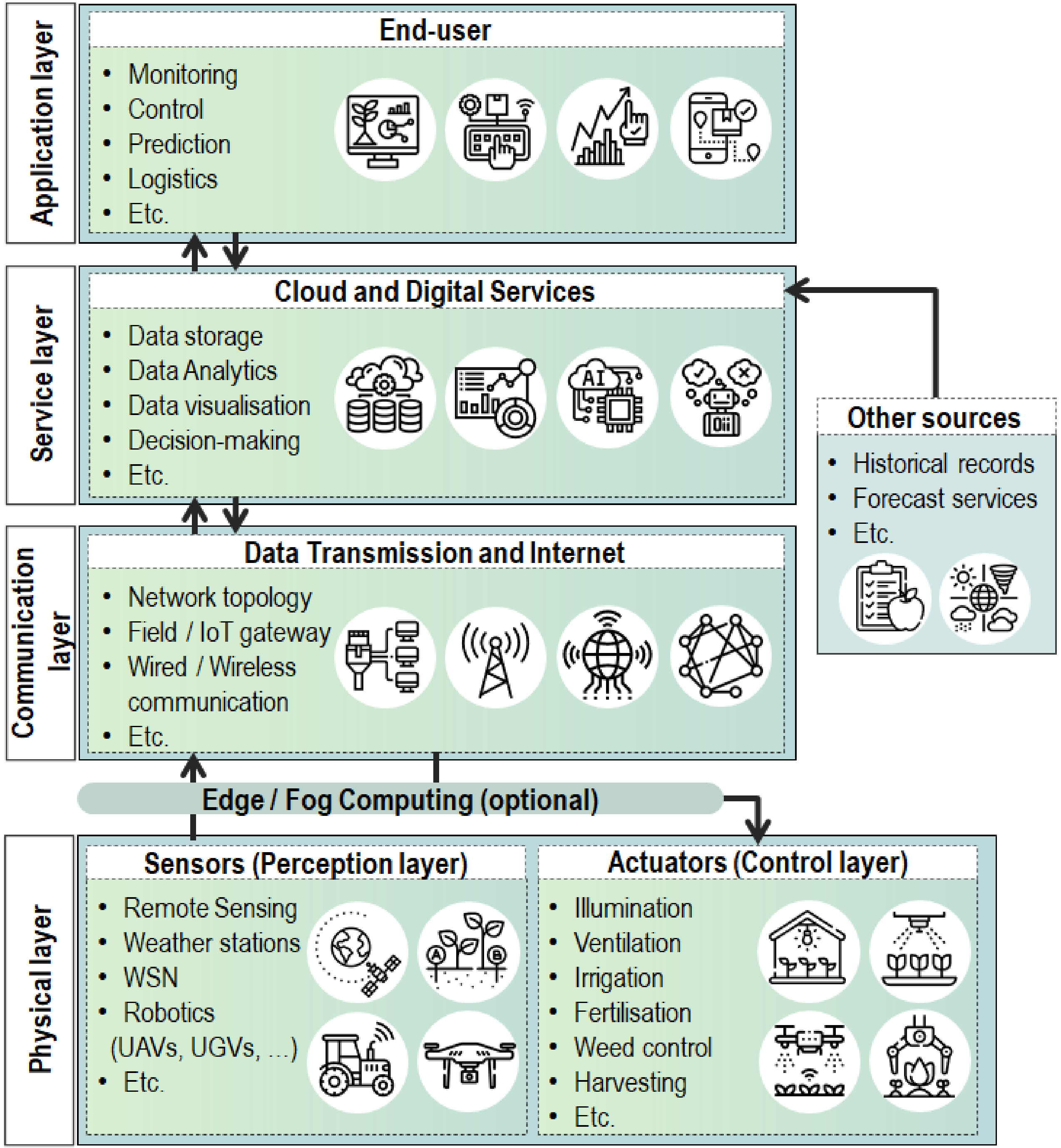


http://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1365039/

Applications



Source: Araújo, S. O.et al. 2021. "Characterising the Agriculture 4.0 Landscape—Emerging Trends, Challenges and Opportunities" *Agronomy* 11, no. 4: 667. https://doi.org/10.3390/agronomy11040667



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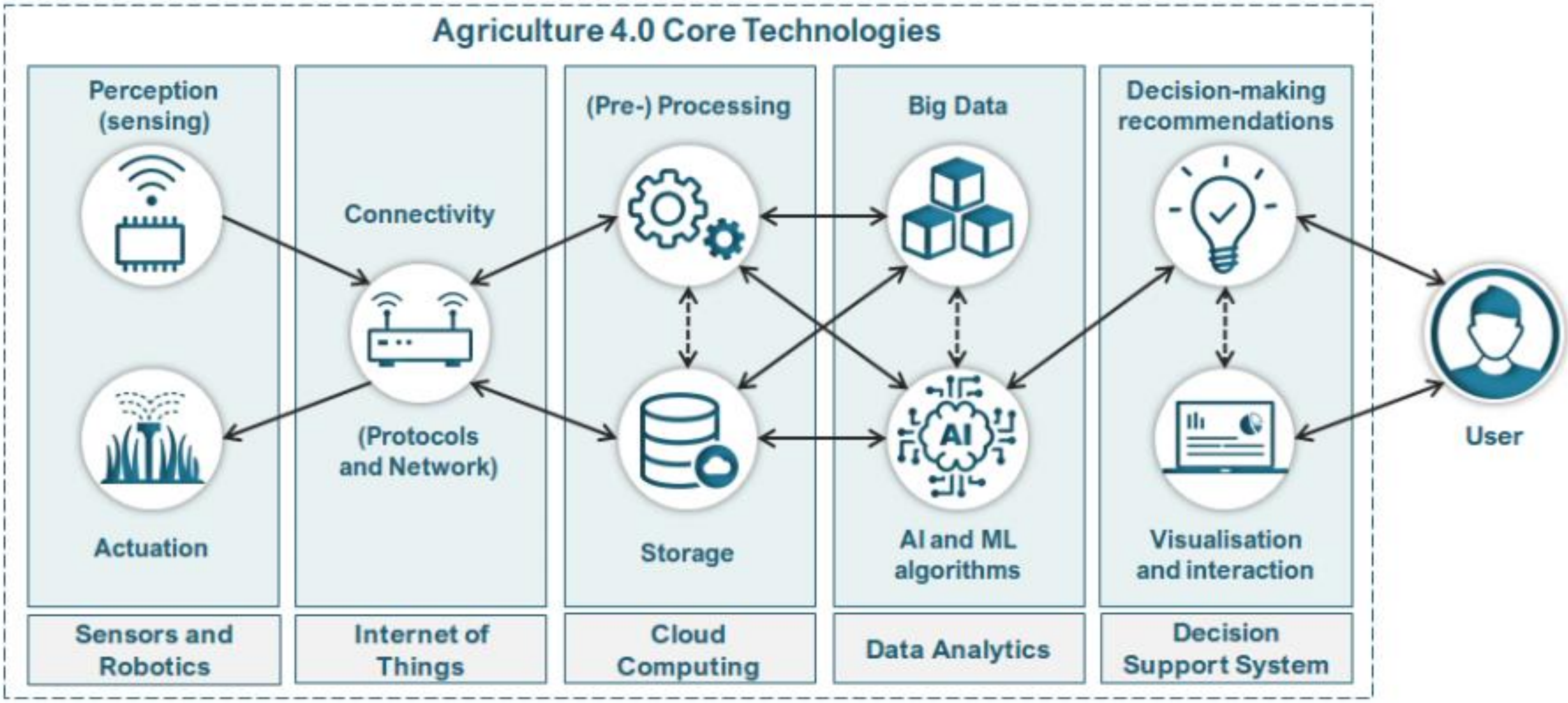

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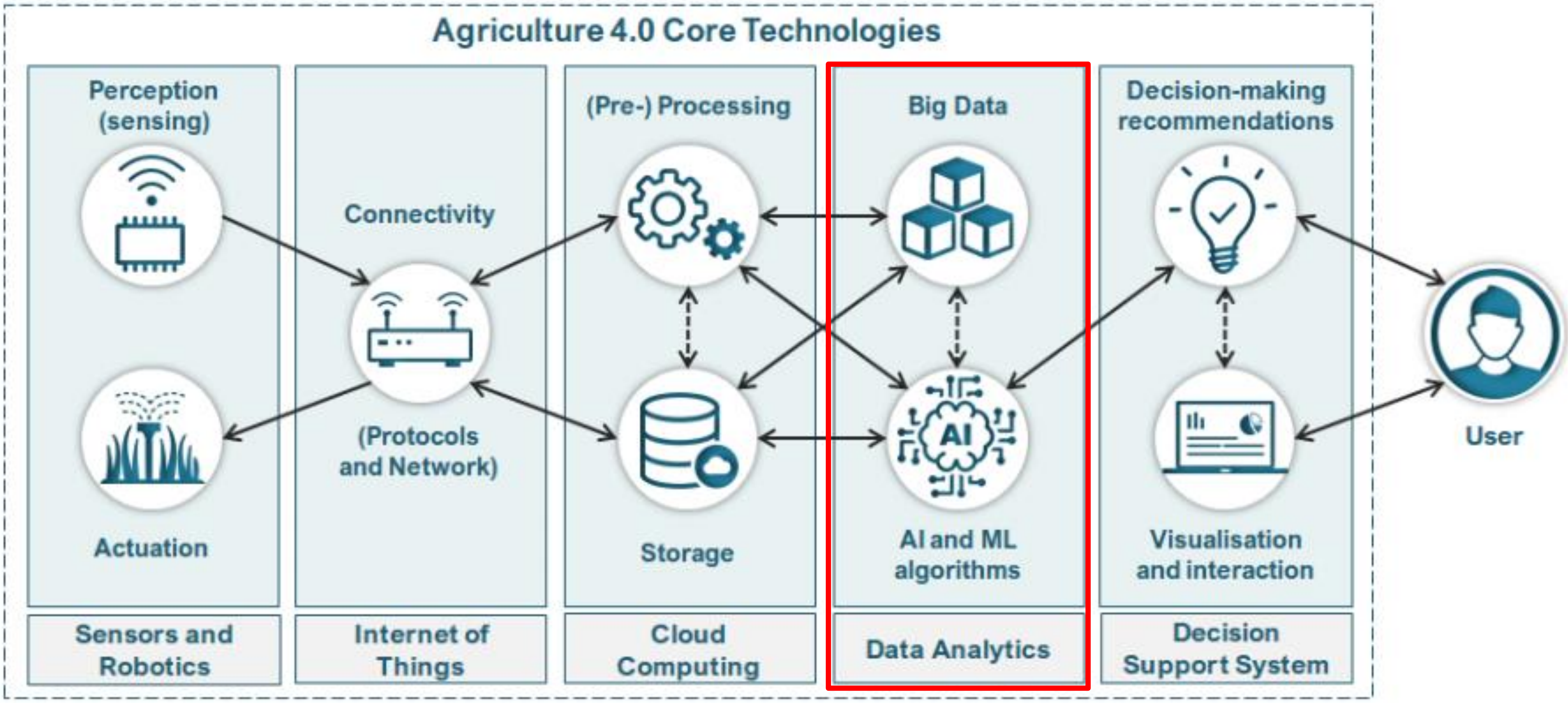

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AI/ML Algorithms

An algorithmic way of **making sense** (learning) from data.

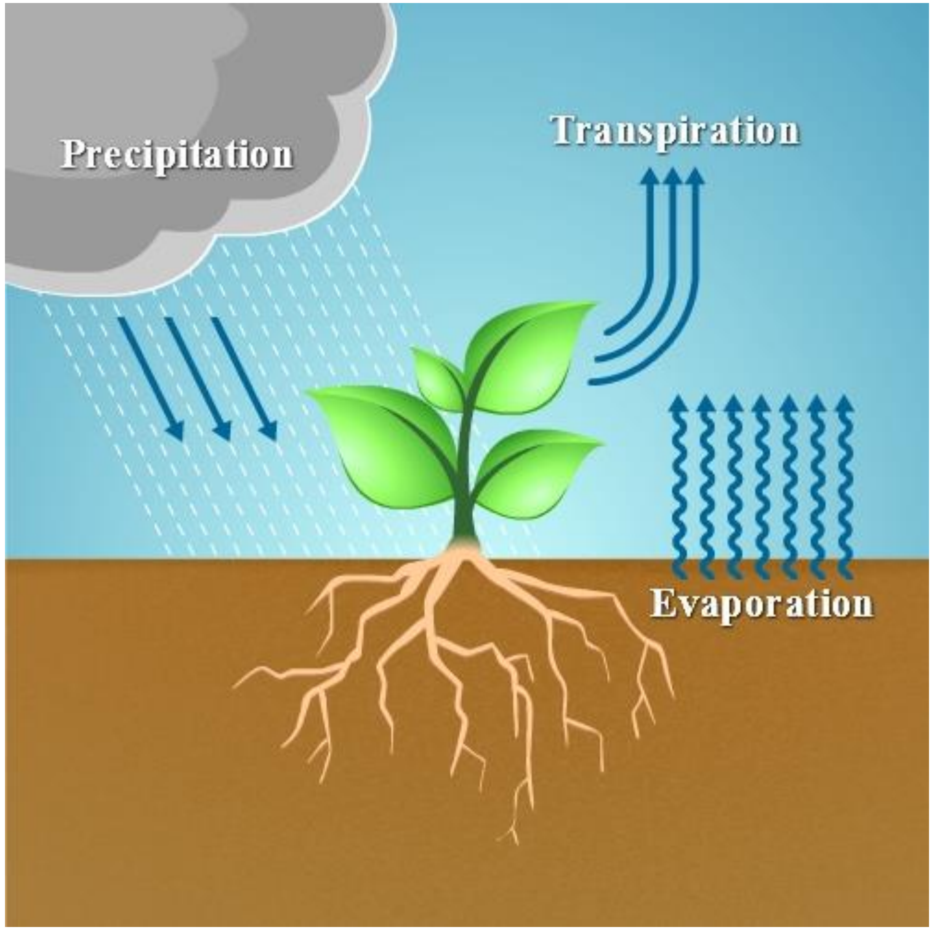
Learning means Improving with Experience at some Task

Tom M. Mitchell: A computer program is said to learn from Experience E with respect to some Task T and some Performance measure P, if its performance on T, as measured by P, improves with experience E.

T: Estimate Evapotranspiration rate

E: Learning from Evapotranspiration dataset

P: Accuracy of the Evapotranspiration rate

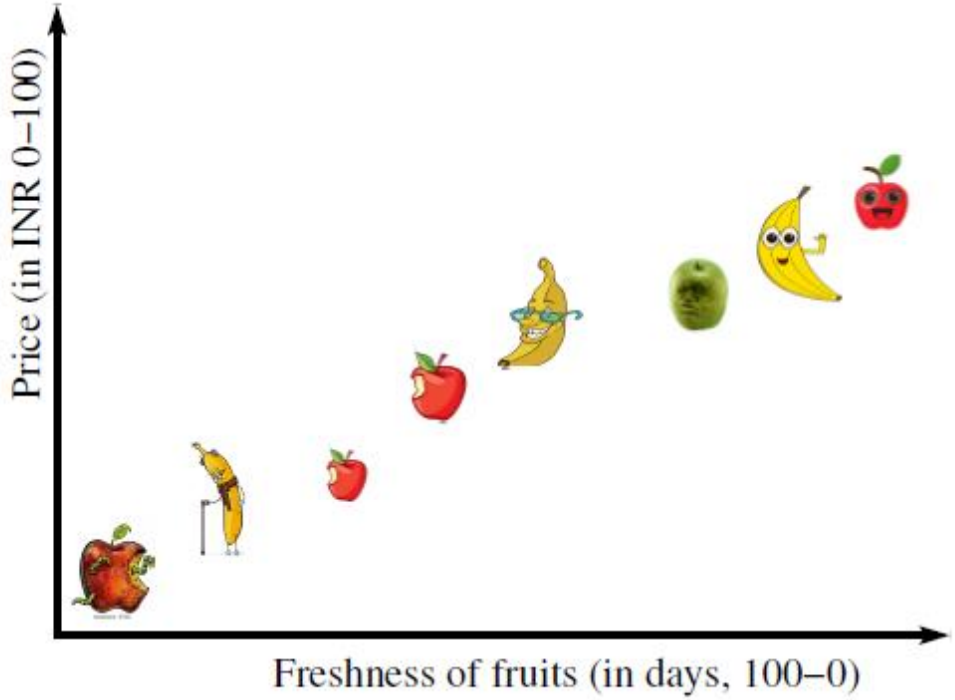


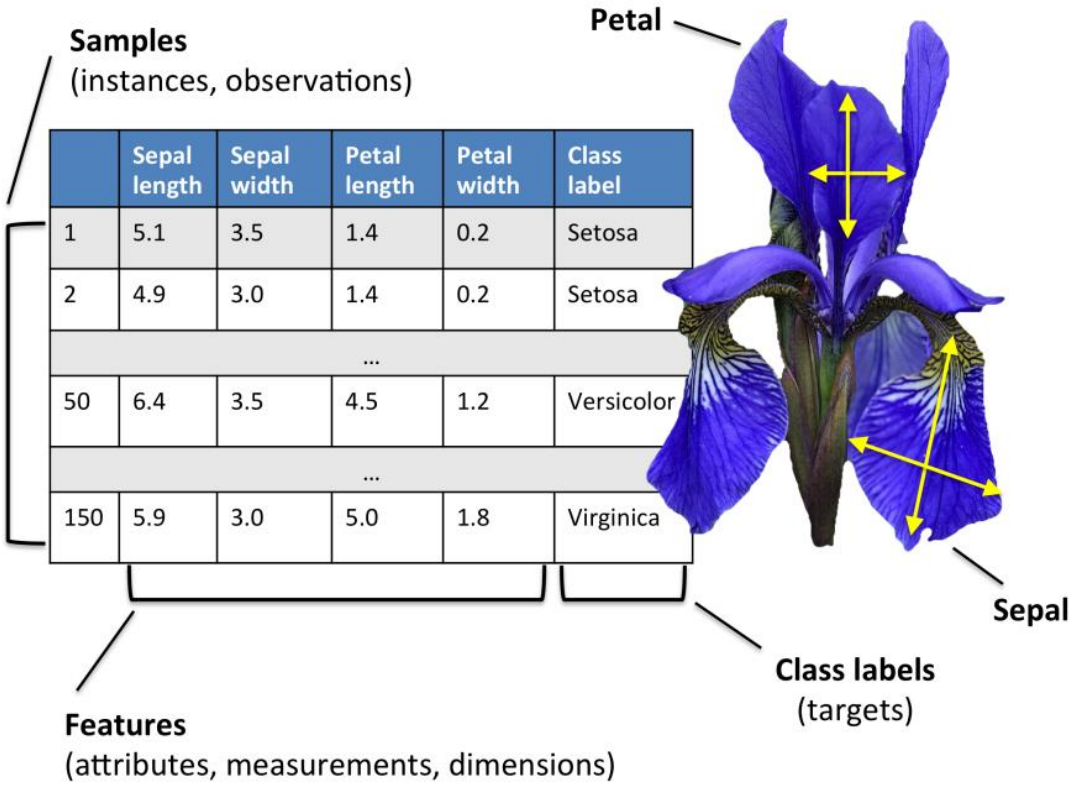
Decision: Irrigation Scheduling

Predictive Analytics/ Supervised learning

Build an analytical model predicting a target measure of interest

Example: Predict Price based on freshness



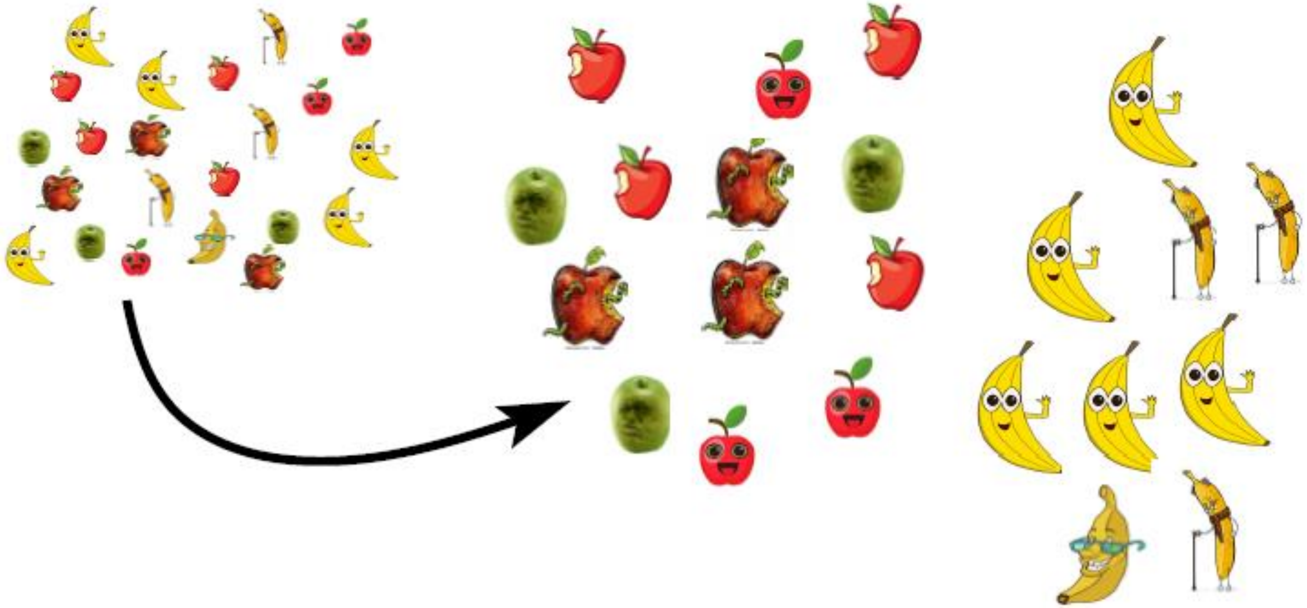


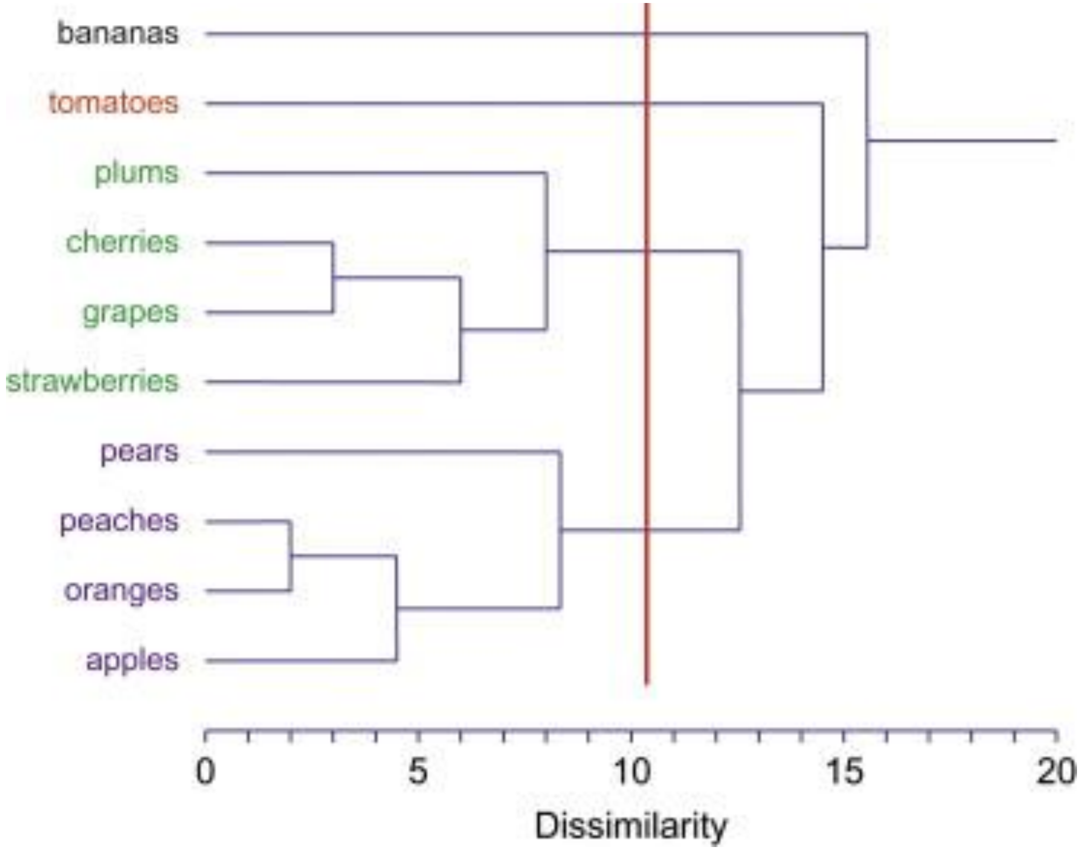
	Sepal length	Sepal width	Petal length	Petal width	Class label
1	5.1	3.5	1.4	0.2	Setosa
2	4.9	3.0	1.4	0.2	Setosa
			...		
50	6.4	3.5	4.5	1.2	Versicolor
			...		
150	5.9	3.0	5.0	1.8	Virginica

Descriptive Analytics/Unsupervised learning

Describe patterns from the data

Example: Group fruits into two groups





Deep Learning

Neural Networks are considered universal function approximators

They can compute and learn any function

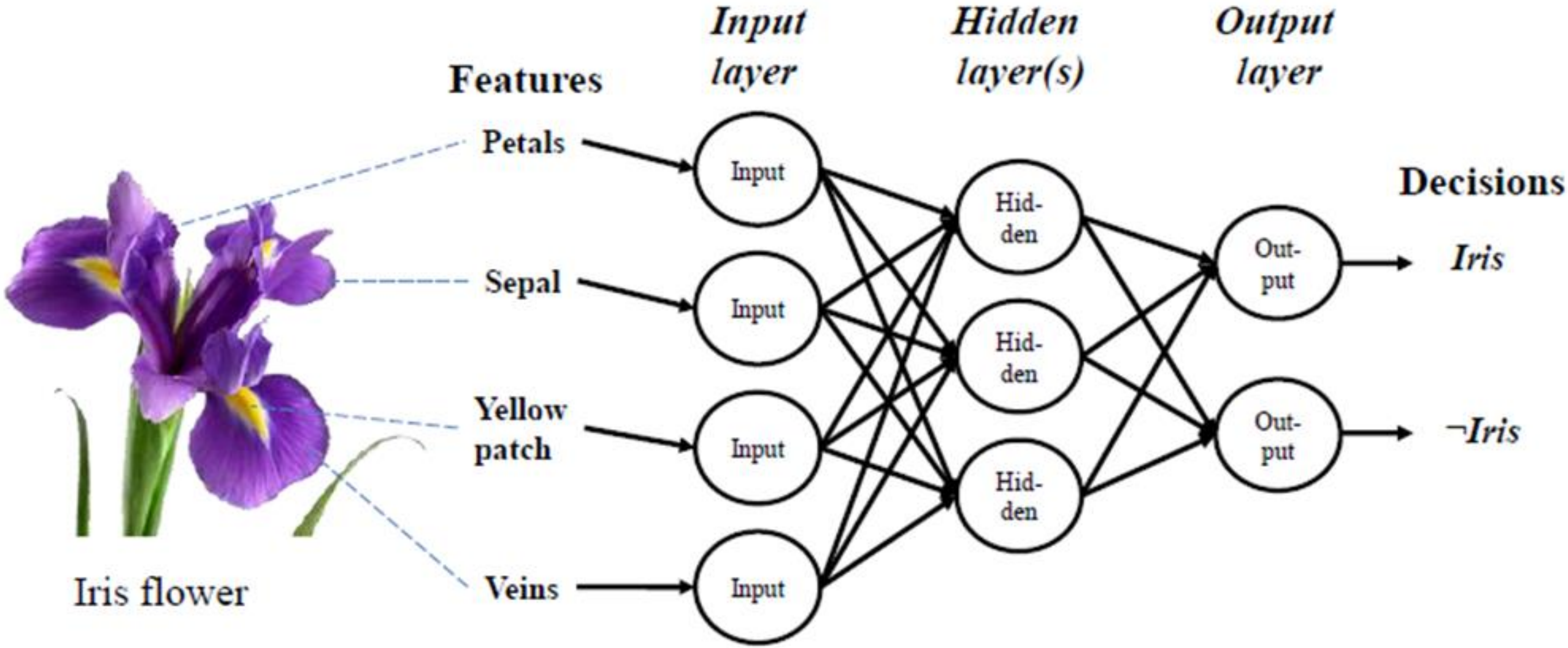
The neuron count has risen over the years to express more complex models.

More parameters efficiently learned using high computing powers.

More connections means that our networks have more parameters to optimize, and this required the explosion in computing power that occurred over the past 20 years.

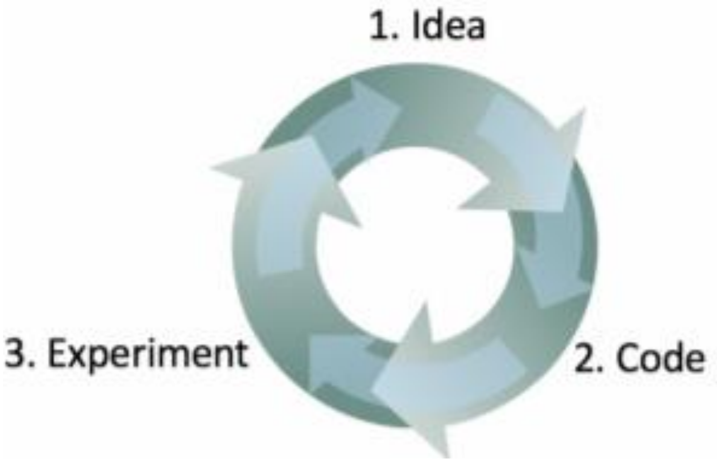
Core components

- Parameters
- Layers
- Activation functions
- Loss functions
- Optimization methods
- Hyperparameters


Features
Input layer
Hidden layer(s)
Output layer
Decisions
Petals
Sepal
Yellow patch
Veins
Input
Input
Input
Input
Hid-den
Hid-den
Hid-den
Out-put
Out-put
Iris
¬Iris
Iris flower

ML/DL is an iterative process:
Don’t expect it to work first time

Andrew Ng (Co-Founder of Coursera and a former head of Google Brain) states that his approach to building machine learning/deep learning software is threefold:



1. Start off with an idea
2. Implement the idea in code
3. Carry out an experiment to conclude how well the idea worked

The faster you can go around this loop, the quicker progress will be made!

How to solve an agricultural problem?

Is it a ML task? Are you sure ML is the best solution?

- Hard: X is independent of Y: X , Y=?
- Easy: X is a set with limited variations. Configure Y=F(X)

Appropriate ML scenario?

- Supervised learning
- Unsupervised learning

Appropriate model?

- Data size (small data -> linear model, large data -> consider non-linear)
- Imbalanced data (special treatment of the minority class required)

Enough training data?

- Investigate how precision improves with more data

Model overly complicated?

- Start simple first, increase complexity and evaluate performance
- Avoid overfitting to training set

Feature quality

- Have you identified all useful features?
- Use domain knowledge of an expert to start
- Include any feature that could be found and investigate model performance

Feature engineering

- The best strategy to improve performance and reveal important input
- Encode features, normalize [0:1], combine features

Combine models

- If multiple models have similar performance there is a chance of improvement
- Use one model for one subset of data and another model for the other

Model Validation

- Use appropriate performance indicator (Accuracy, Precision, Recall, F1, RMSE, MSE, etc.)
- How well does the model describe data? (AUC)
- Data typically divided into Training and Validation
- Evaluated accuracy on disjoint dataset (other than training dataset)
- Tune model hyper parameters (i.e. number of iterations)

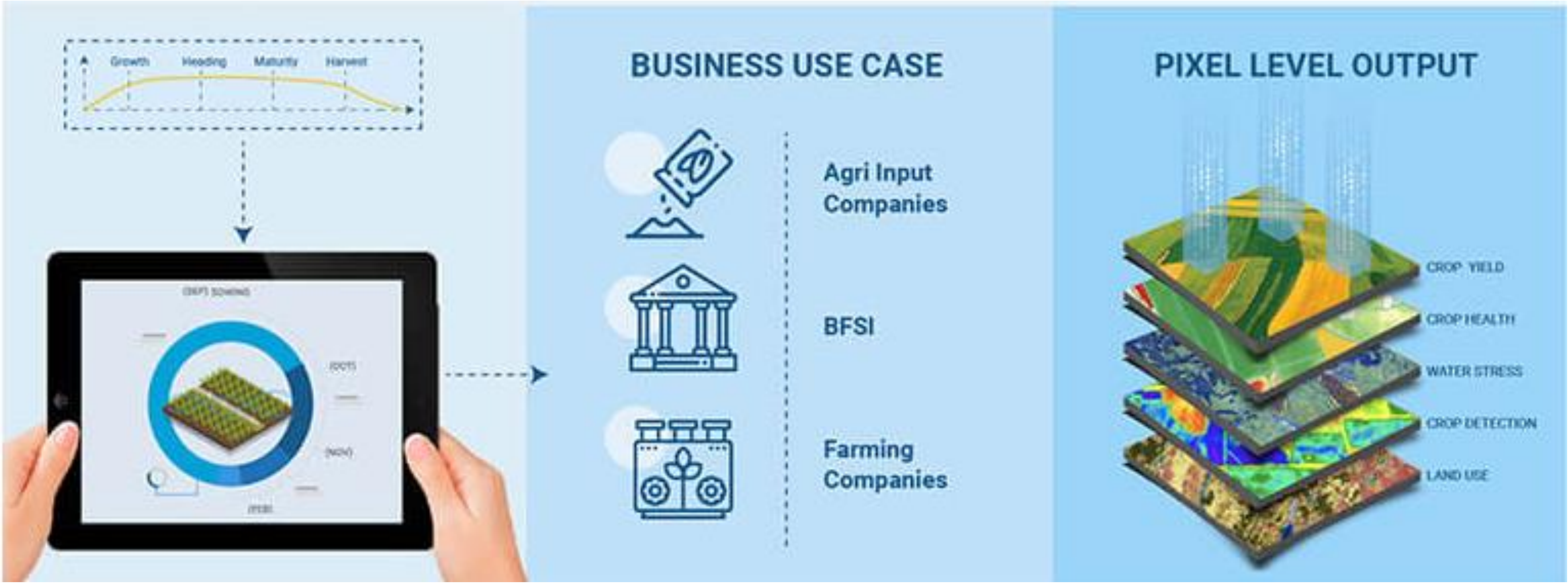
Use Cases


The Smart Agriculture market is expected to reach $18.45 Billion in 2022, at a CAGR of 13.8%
- Business Intelligence
DRONES
Health assessment, irrigation, crop monitoring, crop spraying, planting, and soil and field analysis
Precision Farming
With IoT, all data from different sensors is accessible to the agriculturist on their mobile phones
Soil Management
Analyze soil status, temperature and humidity
Livestock Management
Monitor livestock productivity and health
Water Management with Automated Irrigation


(SEP) SOWING
(OCT)
(NOV)
(FEB)
Satellite
Imagery
Weather
Data
SmartFarm
SmartFarm
Geo tagging labels

• NDVI
• LAI
• SAVI
• EVI
• NDWI
• Precipitation
• Temperature
• Humidity
• Evaporation
Feature Engineering
CROP 1
CROP 2
CROP 3
Crop Signatures

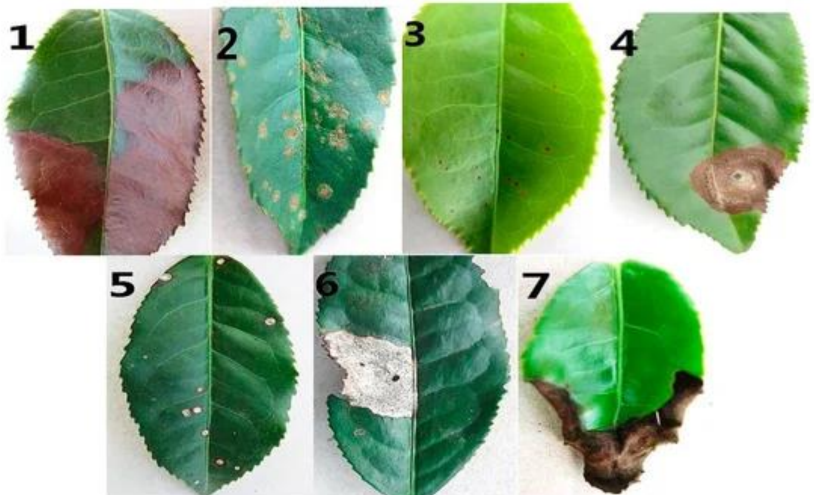
Crop Model 1
Crop Model 2
Yield Model 1
Yield Model 2
Stress Model 1
Stress Model 2
AI & ML Prediction
Cropin
Model Training

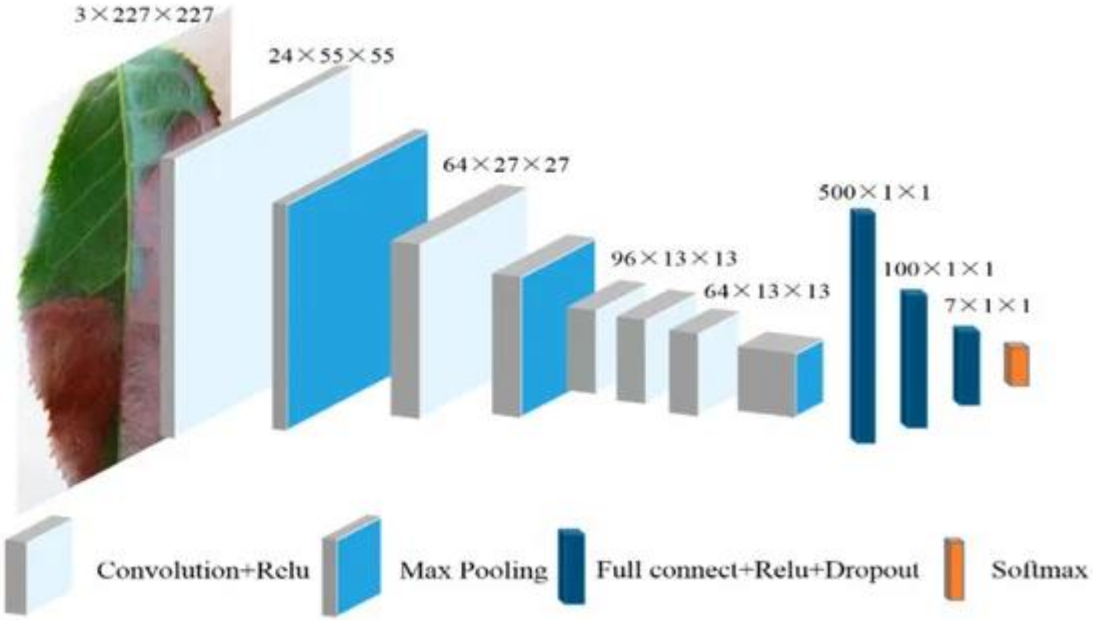


Growth
Heading
Maturity
Harvest
BUSINESS USE CASE
Agri Input Companies
BFSI
Farming Companies
PIXEL LEVEL OUTPUT
CROP YIELD
CROP HEALTH
WATER STRESS
CROP DETECTION
LAND USE

Case Studies

Leaf disease detection/ Identification of weeds - CNN

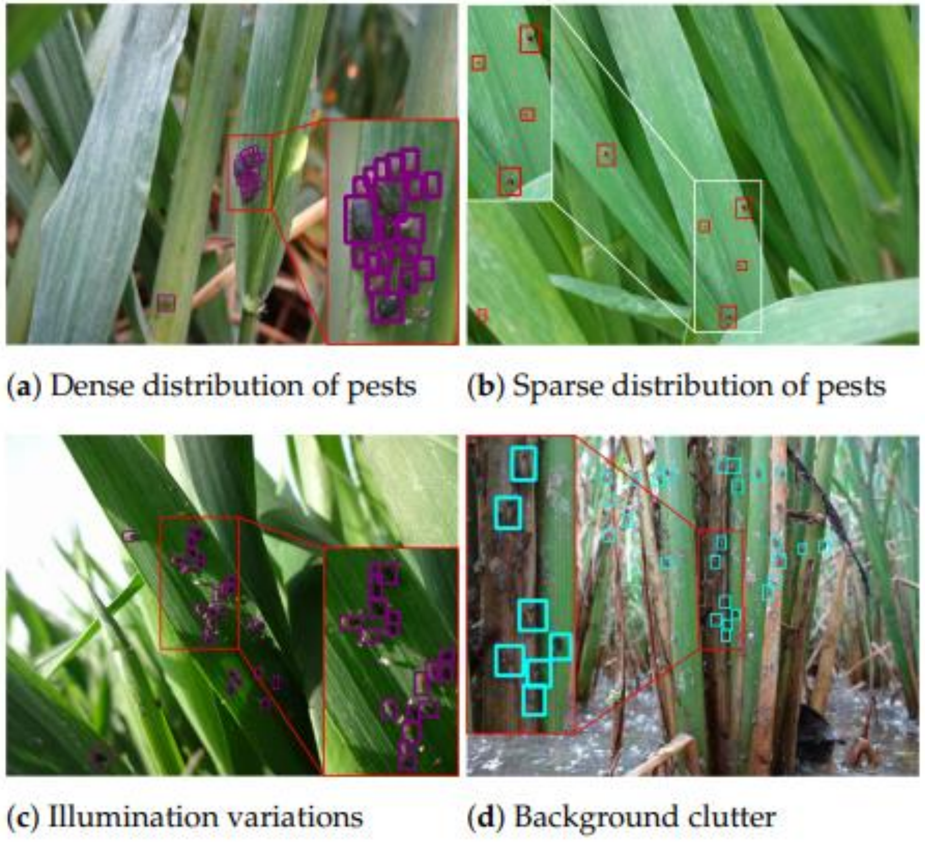


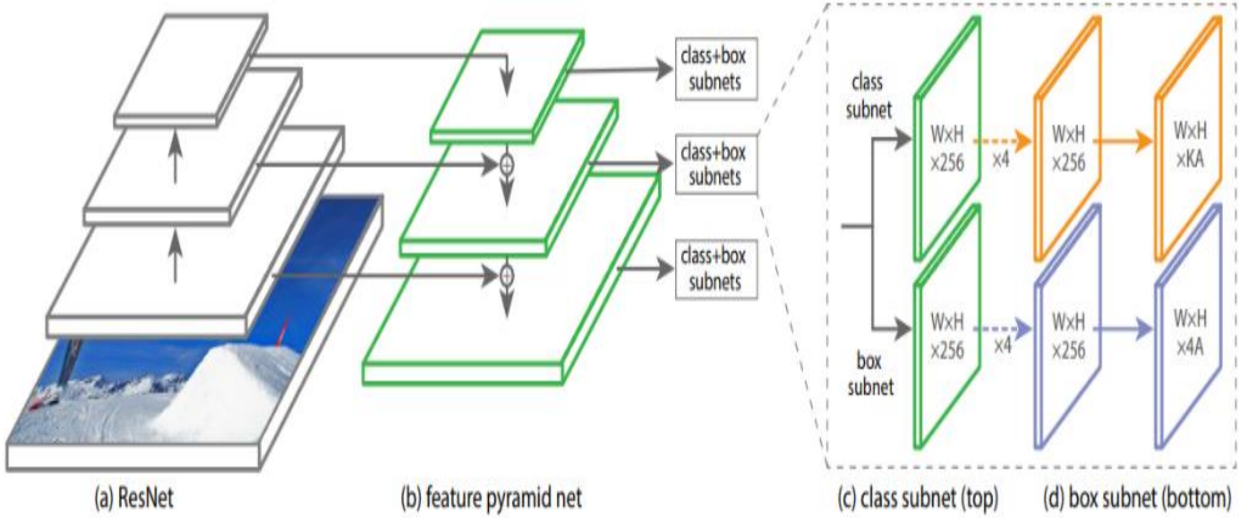


Chen, Jing, Qi Liu, and Lingwang Gao. 2019. "Visual Tea Leaf Disease Recognition Using a Convolutional Neural Network Model" *Symmetry* 11, no. 3: 343. https://doi.org/10.3390/sym11030343

Fenil D.et al. Analysis of robust weed detection techniques based on the Internet of Things (IoT), Procedia Computer Science,Volume 160,2019, https://doi.org/10.1016/j.procs.2019.11.025.

Pest Population Counting- RetinaNet

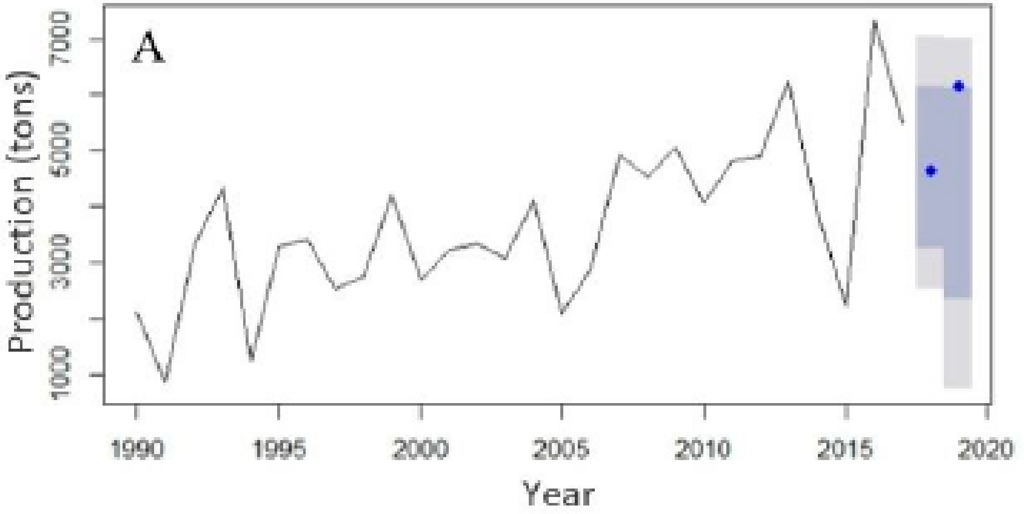




Wang, R.et al. AgriPest: A Large-Scale Domain-Specific Benchmark Dataset for Practical Agricultural Pest Detection in the Wild. *Sensors* **2021**, *21*, 1601. https://doi.org/10.3390/s21051601

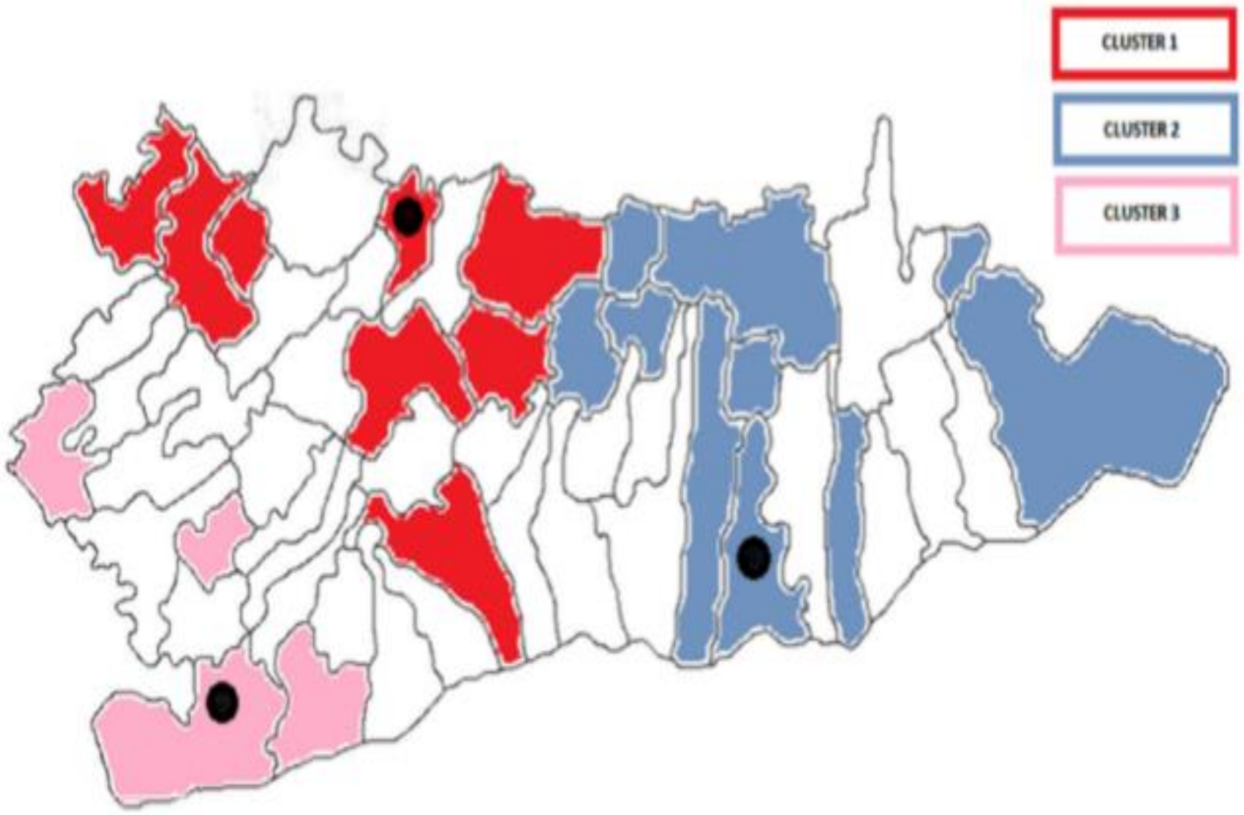
Crop Yield Prediction

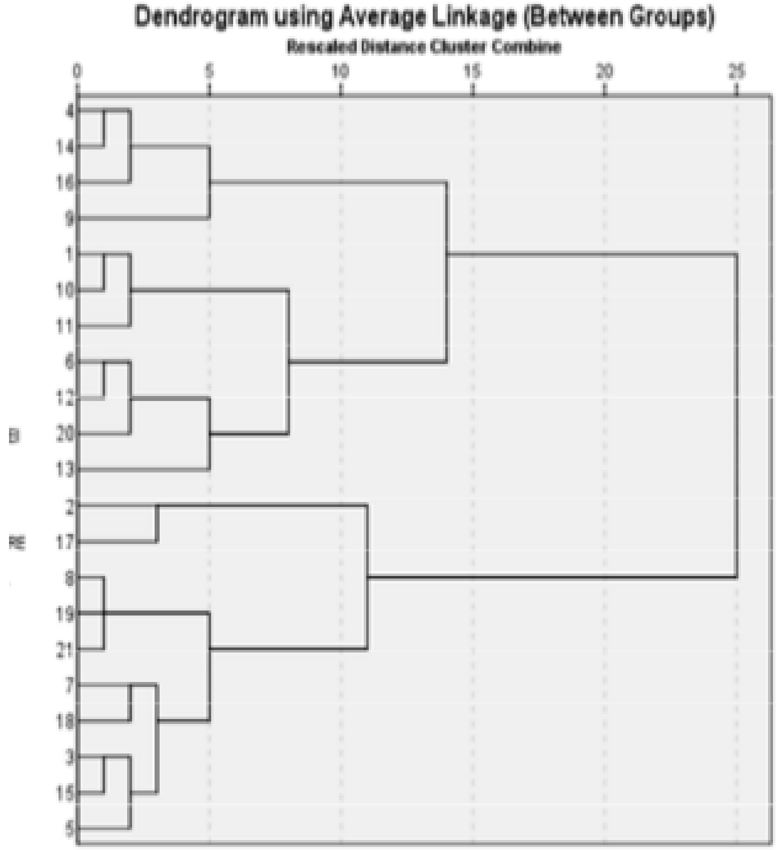
Data Names	Abbreviation	Sources
Normalized Difference Vegetation Index	NDVI	MODIS (MOD13Q1)
Potential Evapotranspiration	PET	Climate Research Unit
Precipitation	PRE	Climate Research Unit
Minimum Temperature	TMN	Climate Research Unit
Maximum Temperature	TMX	Climate Research Unit
Soil Moisture	SM	European Space Agency
Size of land cultivated for maize production	Land	Department of Agriculture, Forestry and Fisheries



Adisa, O. M. et al. (2019) ‘Application of Artificial Neural Network for Predicting Maize Production in South Africa’, Sustainability. Vol. 11, No. 4.

Organic Farming Patterns Analysis Based on Clustering Methods





A-V Bălan et. al. Organic Farming Patterns Analysis Based on Clustering Methods, Agriculture and Agricultural Science Procedia, Volume 6, 2015, Pages 639-646, ISSN 2210-7843, https://doi.org/10.1016/j.aaspro.2015.08.110.

Hands-on Session

Plant disease detection

Dataset:

- https://www.kaggle.com/emmarex/plantdisease

Code:

- https://www.kaggle.com/sarithdivakar/plant-disease-detection-using-keras