APEC PPFS Webinar on “Sharing good practices on Sustainable Agricultural Development through the Principle of Sufficiency Economy Philosophy”

Digital and Innovative Farming is Key to Developing Sustainable Agriculture

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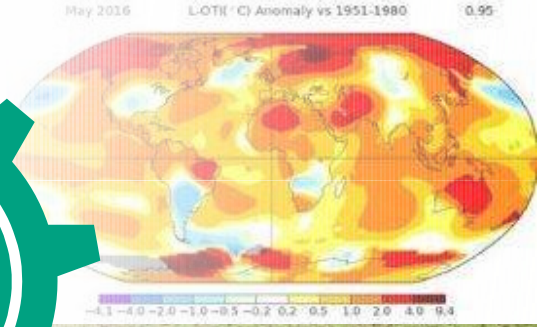
Outline

- Introduction
- How Smart Technology Is Driving Agricultural Innovation
- On-going Cases of Digital and Innovative Farming (DIF) Application in Taiwan
- Prospects
- Conclusions

Introduction

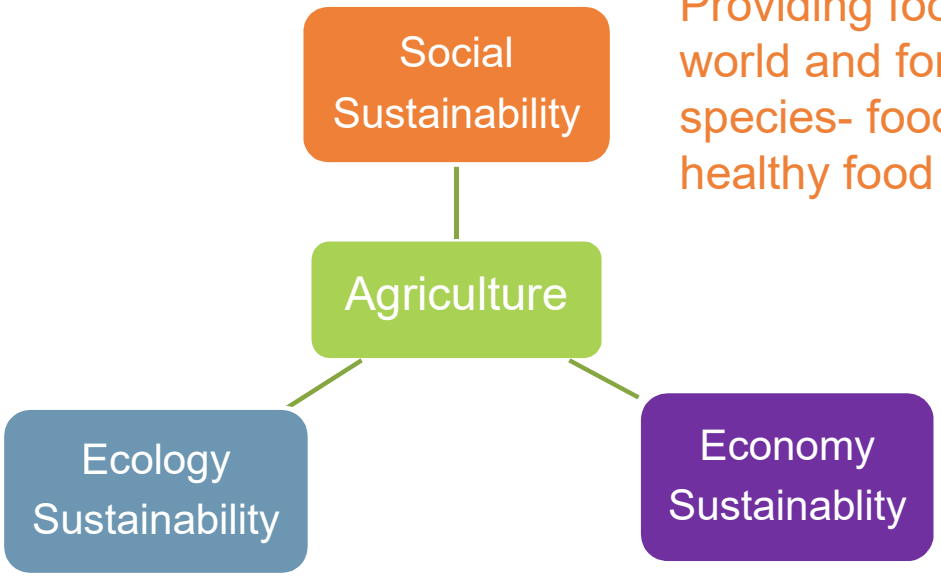
Global Agricultural Issues

- Global Warming & Climate Change
- Water Shortage (70% used by Agriculture)
- Arable Land Scarcity
- Increase in food demand
- Pest Outbreaks



Sustainability Driven by Agriculture

(Hrustek, 2020)



Providing food for all people in the world and for all animal and plant species- food safety and control of healthy food

Care for the environment and the protection of the biodiversity of nature and animals- reducing the use of pesticides, herbicides, and fertilizers, then reducing emissions and more

Current viability of the agricultural business, and the revenues and profits generated- low price of agricultural products and competition from world market

Sustainable Development Goals

- In adopting the 2030 Agenda for Sustainable Development, world leaders resolved to free humanity from poverty, secure a healthy planet for future generations, and build peaceful, inclusive societies as a foundation for ensuring lives of dignity for all.
- This collective journey has at its heart a promise to leave no one behind. The 2030 Agenda is deliberately ambitious and transformational, with a set of 17 integrated and indivisible Sustainable Development Goals and targets to guide us. Crucially, it is a universal agenda, applying to all countries; even the richest have yet to fully ensure women's rights, conquer inequality or safeguard the environment.

Source: https://unstats.un.org/sdgs/files/report/2017/TheSustainableDevelopmentGoalsReport2017.pdf

How Smart Technology Is Driving Agricultural Innovation

What Technologies can be Integrated with Agriculture?

Existing technologies

- Interactive voice response
- Web applications
- Internet & broadband
- Mobile
- Satellite
- Broadcasting

Technology in the agriculture ecosystem

- Farm management
- Land-ownership record
- Weather forecasts
- Smart horticulture
- Environment
- Mechanized cultivation & harvesting
- Agri-edutech (know-how upgrade)
- Fertilizers
- Water management
- Precision/smart farming
- Access to Finance

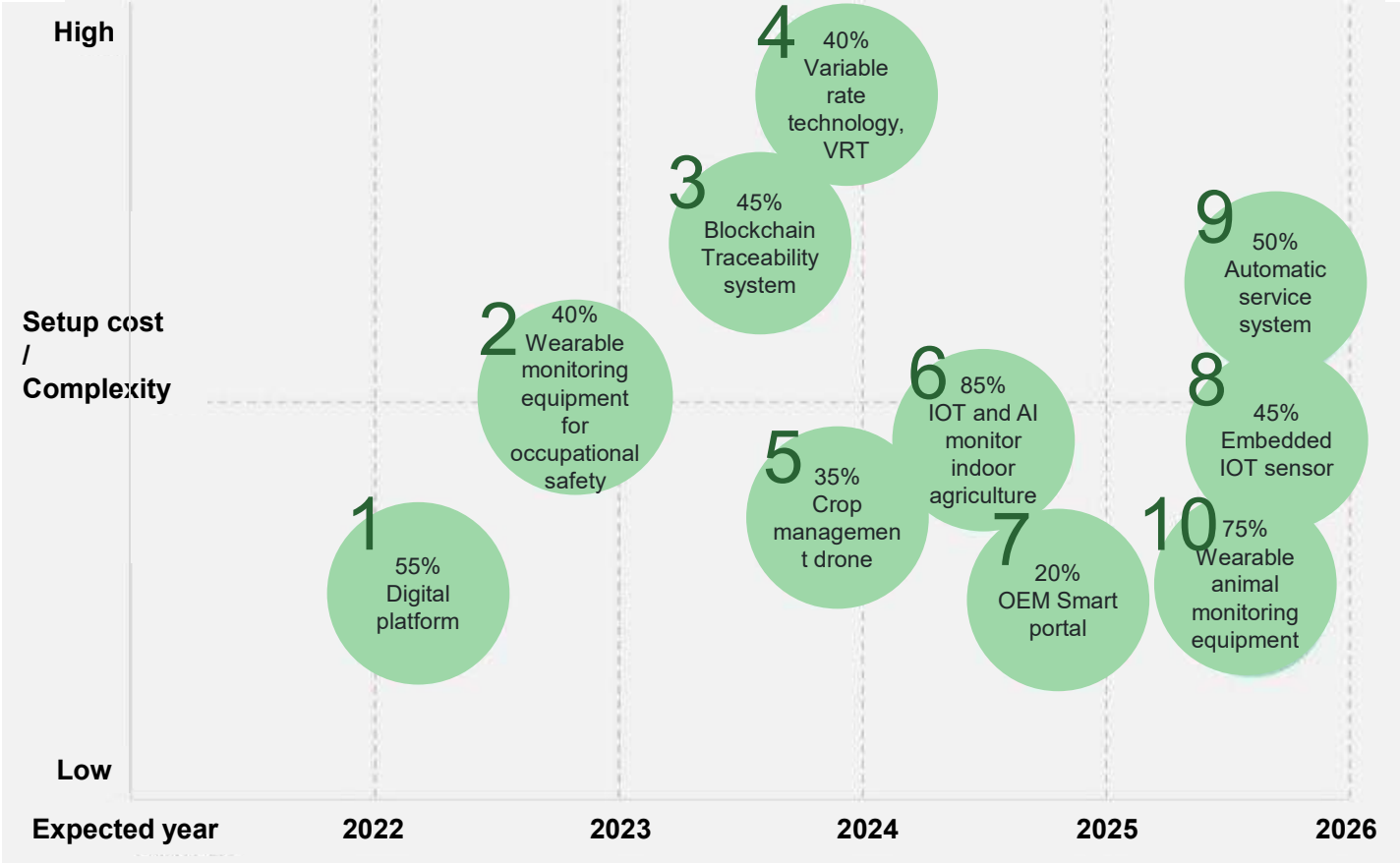
Emerging technologies

- Artificial intelligence
- Blockchain
- Big data
- Drones
- Internet of things
- Cloud
- Robotics

Source：https://www3.weforum.org/docs/WEF_Artificial_Intelligence_for_Agriculture_Innovation_2021.pdf

Development and Forecast of International Agricultural Technology Trends

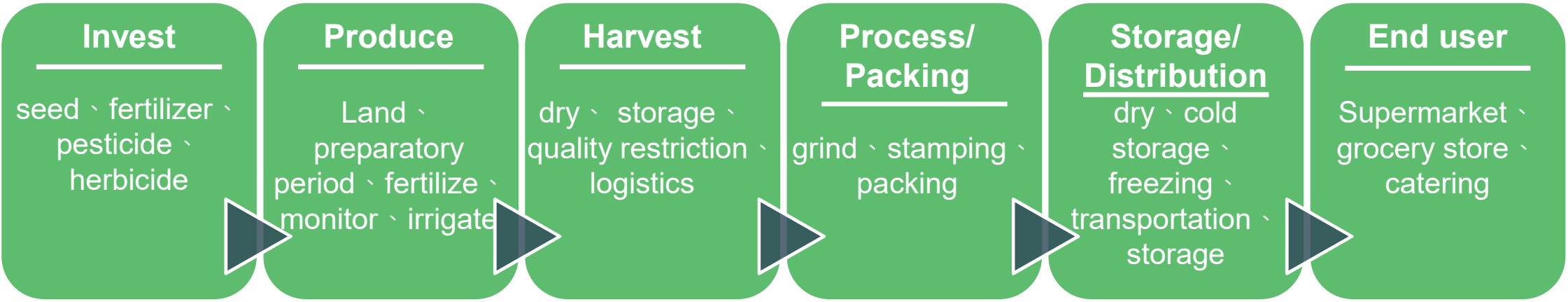
- COVID-19 has significantly impacted agriculture organizations' digital transformation plans, and over 50% of farms around the world are cutting their IT spending.
- The agriculture organizations use the digital transformation that will display more **resilience** and **agility** coming out of the pandemic .

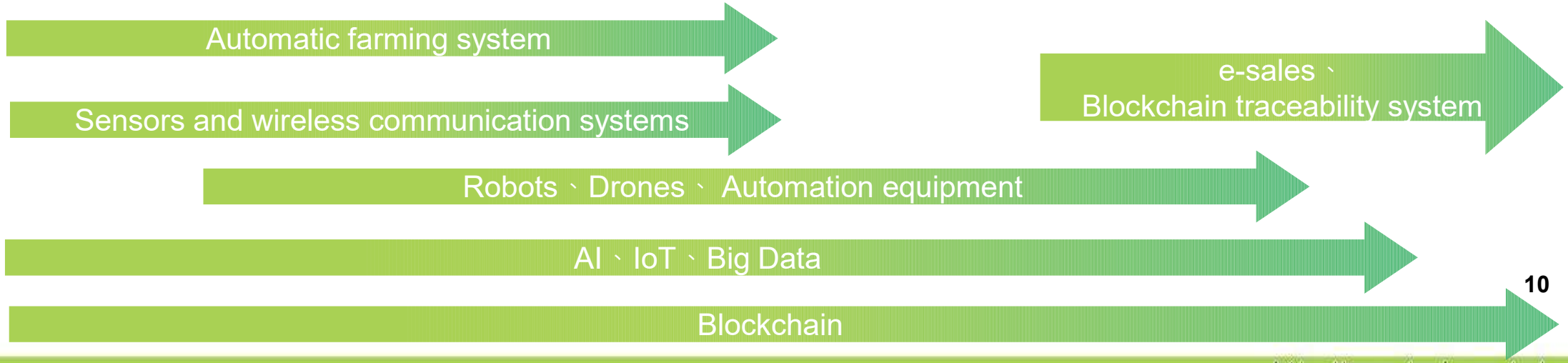


- Top 10 international agricultural technology trends in the next five years

Source：IDC、科技發展觀測平台

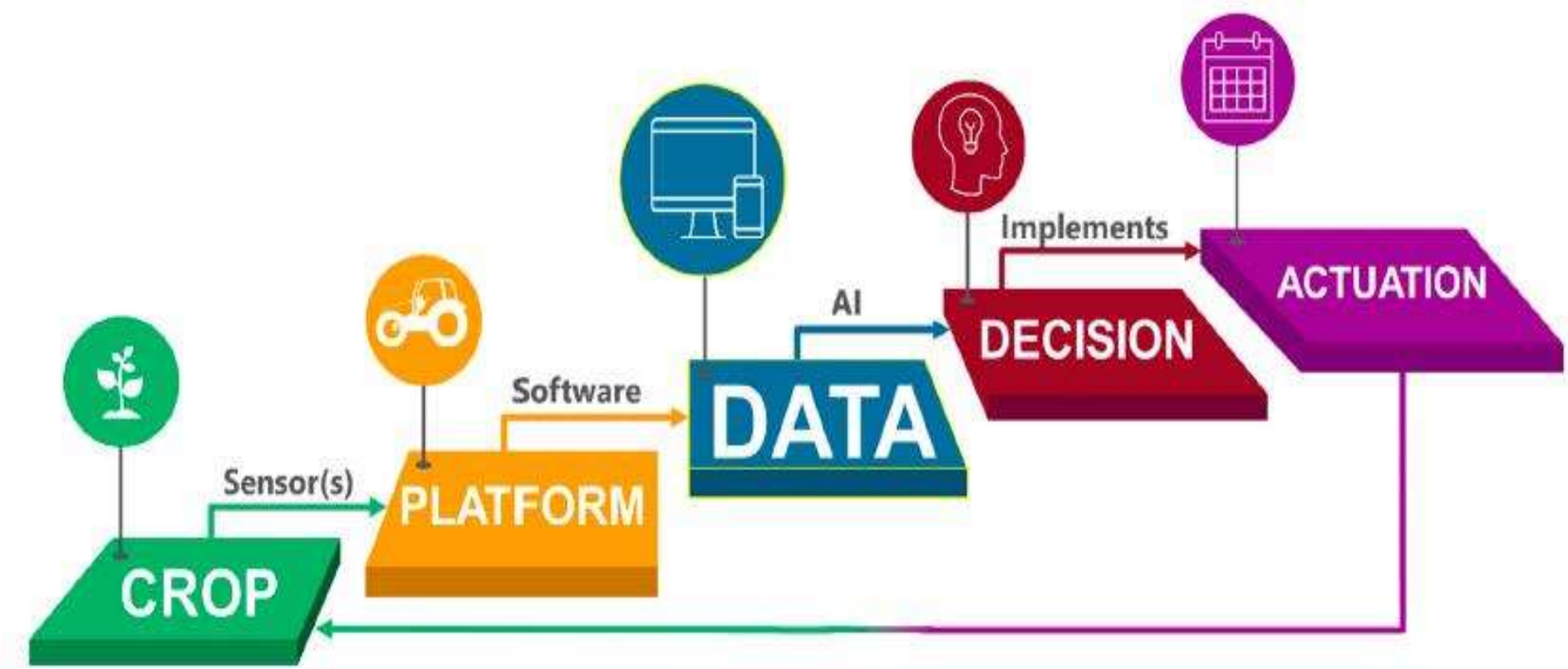
Application of Smart Technologies in the Agricultural Supply Chains



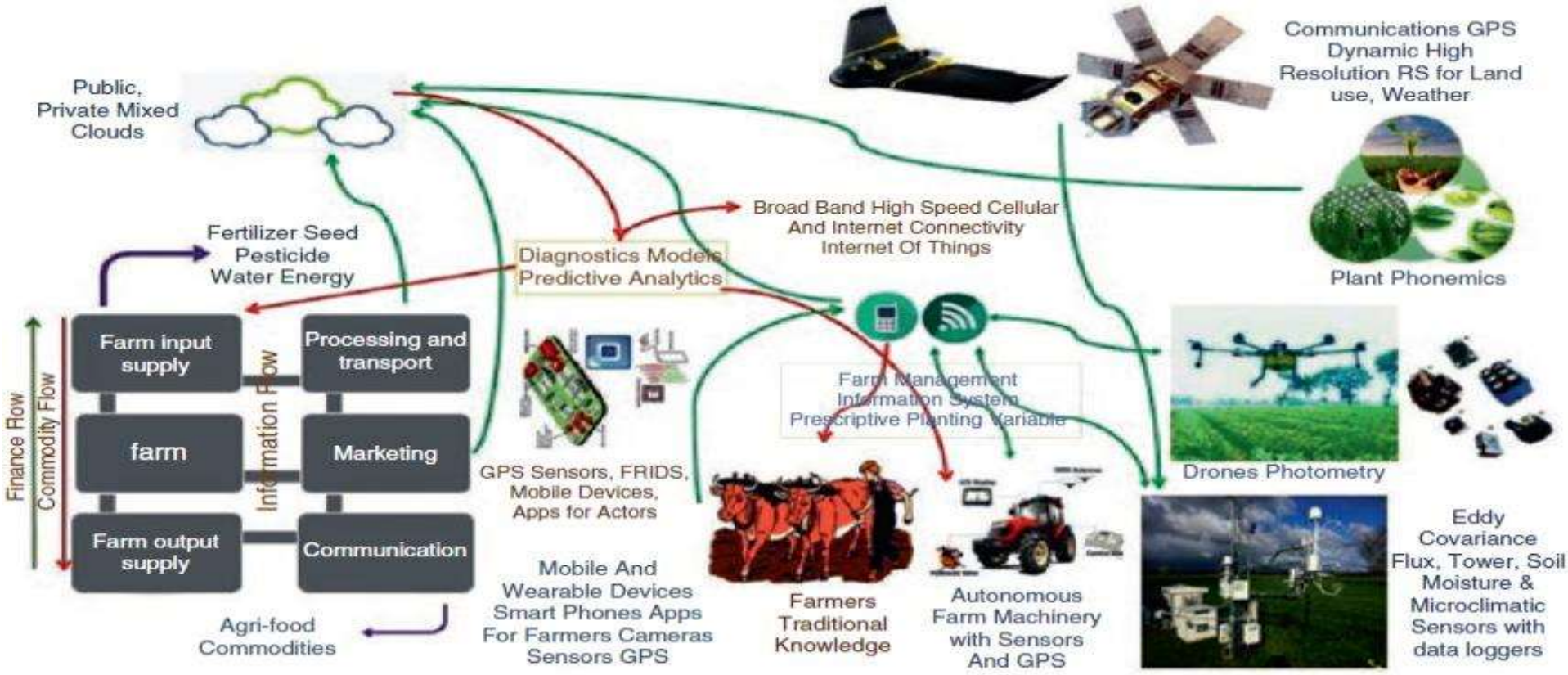


Source：Frost & Sullivan，科技發展觀測平台整理(中翻英)

Information-based Management Cycle for Advanced Agriculture (Saiz-Rubio and Rovira-Más, 2020)



Conceptual Information Tecnology based Agricultural Data Flow System (Cheema and Khan, 2019)



Smart Technology and Agriculture

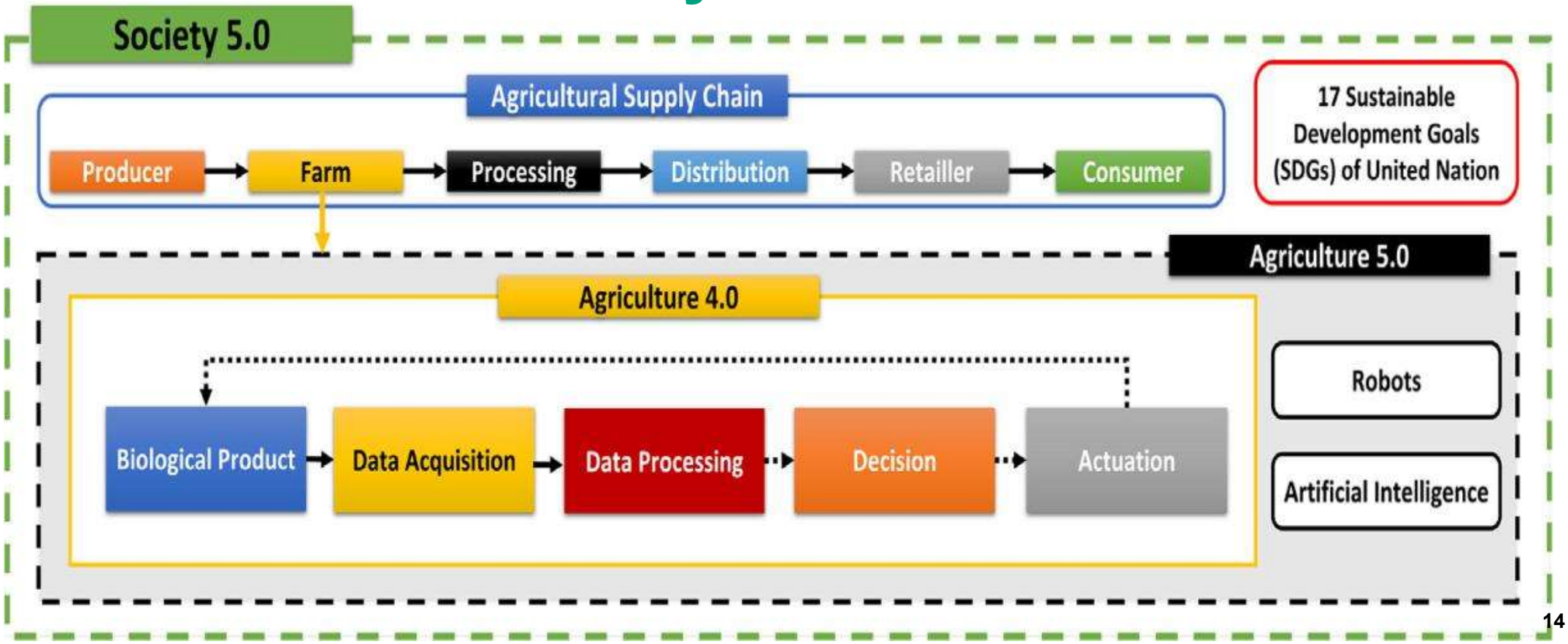
Agriculture X Technology

Smart Agriculture Expect

- **Agriculture and livestock can be better explored**
  Humans can understand animals and plants better.
- **Knowledge can be recorded**
  Cultivate knowledge can be recorded with accurate numbers.
- **Experience can be grasped**
  Data-based cultivation experience can be aggregated and analyzed.
- **Risks can be predictable**
  Infer possible future risks from historical data.

Source:陳駿季 (2020) 5G時代下的農業大未來

Integration of the Agriculture 5.0 in the context of the Society 5.0 (Debauche et al, 2021)



Project Framework of Smart Agriculture in Taiwan (SAiT)

Basis New Agricultural Innovation Promotion Program → **Smart Agriculture**

Vision **Establish farming environment of high quality**
Create new paradigms of agri. management.

Theme **Smart production** | **Digital service**

Strategy

① Improve the ability to stably supply of produce via Smart Farmers Alliance (SFA)

② Build an application model with value chains via ICTs

③ Create a new communication model via friendly interactive technologies

Action

Personnel	Object	Technology	Field
Smart Farmers Alliance (SFA) Group Cultivation	Smart Tools, Robots, Sensors, Smart Devices, UAVs	IOT, Big Data, AI, Common Information Platform, Smart Logistics, Traceability	Pilot Industries Demo Sites

Objective

Efficiency/Effectiveness

Safety/Risk control

High quality / Convenience

Promotion via Three Strategies

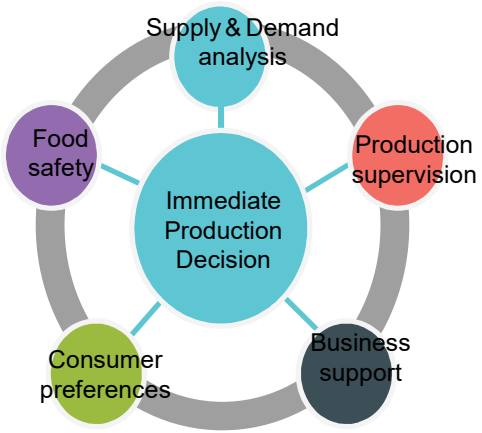
Strategy I

Improve the ability to stably supply produce by innovating the agricultural management model with **Smart Farmers Alliance (SFA)**

Smart Farmers Alliances
Work in group / Dispersion risk / Reduce losses

Strategy II

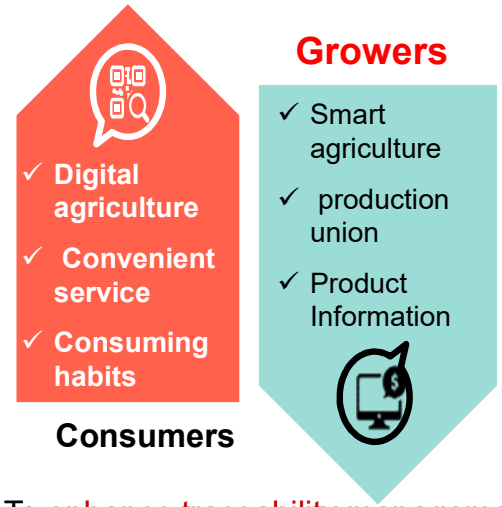
Build **application models** integrating convenient and diversified agricultural digital services with value chains via **ICTs**



Constructing digital service networks to combine agricultural production and marketing

Strategy III

Create new communication models between growers and consumers via **Friendly Interactive Technologies**



To enhance traceability management for mass production & quality of traceable products via e-commerce

On-going Cases of Digital and Innovative Farming (DIF) Application in Taiwan

Agricultural Wearable Aids for Harvesting and Handling Activities

Before Farming is a job with high physical load, so the young people aren't willingness to join and do in agriculture.

After

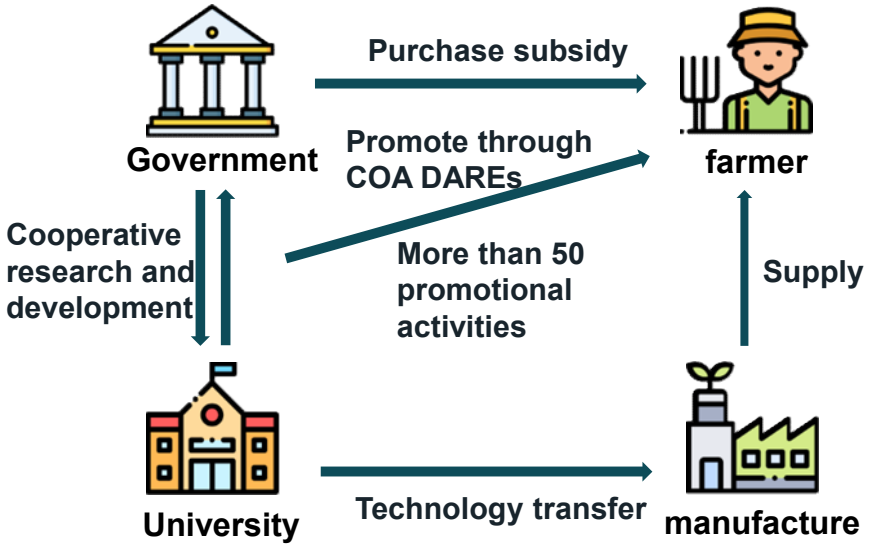
Decrease the load-bearing situation of labors.

Advantages of the agricultural wearable aids

- ✓ Unpowered
- ✓ Lightweight：Under 2kg
- ✓ Auxiliary force:3, 6, 9kg/one hand(adjustable)
- ✓ Fast adaption
- ✓ With flexibility and no discomforts
- ✓ Obvious auxiliary force when picking

▲Field application (Cherry tomato)

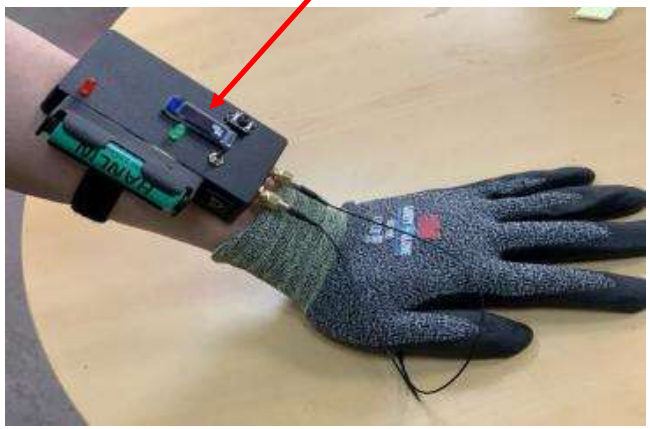
▲ Promotional activity (Grape)



▲ Technology Transfer Signing Ceremony

Smart Sensory Glove for Pineapple Quality

Detection area



Advantage

1. Improve the accuracy of quality classification and work efficiency
2. Inexperienced people can operate

Disadvantage

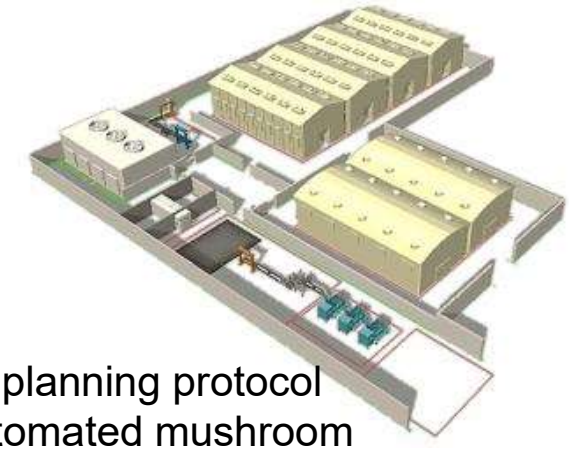
It takes manpower to press the fruits one by one

Fully-automatic packaging machine for mushroom growing medium

Traditional way needs 4-6 people

Fully-auto packaging machine

Bag products



Virtual planning protocol for automated mushroom factory

1. **High efficiency: 26-30 bags per minute.**
2. **Labor saving up to 90%.**
3. **With QR code Labeling system for production traceability.**

Smart Cultivation Management System for Facility Vegetable

Before For short-term leafy vegetables, the cultivation time is short, the water demand is large, and the soil should not be too wet. In cultivation management, manpower is needed to assist in stabilizing water supply to maintain quality and yield.

After

Smart Cultivation Management System

- The Model development using the IoTs and AI
- According to the growth period of crops, integrated management of field equipment → smart greenhouse management and remote production
- Significantly reduce farmers' costs and create high value

- ✓ At the demonstration site, 75 simple greenhouses (approximately 2.5 hectares) were retrofitted to introduce the system and model
- ✓ Automatic irrigation **saves 1,218 hours** of management man-hours every year, **reduces water** consumption by about **50%**
- ✓ Automated management can be achieved for ensuring crop yield and quality, and improving farm management efficiency
- ✓ **The system integrating R programs and environmental sensors was used to remotely monitor irrigation, thus smartly saving time and effort for precise management.**

▲The system is equipped with sensors to detect light intensity and air temperature and humidity

▲ The irrigation pipeline uses a controller and solenoid valve to automatically irrigate according to the light integral value

Plant Diseases and Pests Management Service Network

Expert System For Plant Diseases And Pests Management

One-stop service

Service Architecture

Pest information collection APP

Pest data collection

Pest consultation helper via Line

Real-Time Pest consultation

Expert System For Plant Diseases And Pests Management

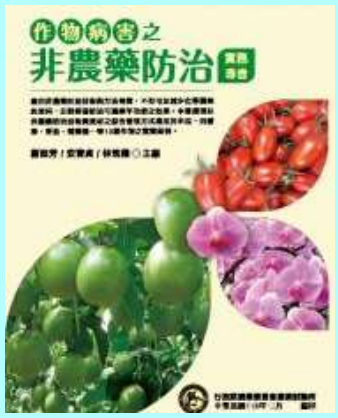
(https://azai.tari.gov.tw/)

Static-
Data Integration

Pests And Diseases

IPM Knowledge

Publications



Videos

Dynamic-
Interactive Application

Image Consultation

Chatbot

Pest information collection APP

- Convenient for experts to widely record crop and pest information
- Compile the original survey results, then share information

01 Experts go to various places for investigation and research

02 information were quickly recorded via APP

03 Data were sent to database

04 Immediate warning, combining prevention and treatment

05 Integrated applications

Pest consultation helper via Line

- ✓ mobile device (cell phone) application
- ✓ Launch：Since 2021/7/21
- ✓ Members： 5,532 people

Using Information Technology for Sustainable Agriculture

data

Collecting data by IoT, RS and others

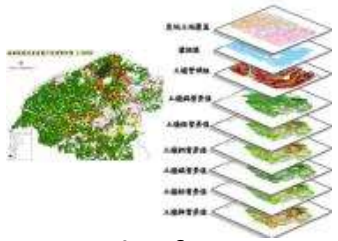
Field data
Meteorology data
Satellite data

WSN

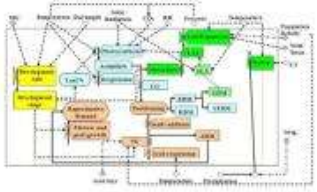
information

Integrating and organizing data

Temporal information
Spatial information



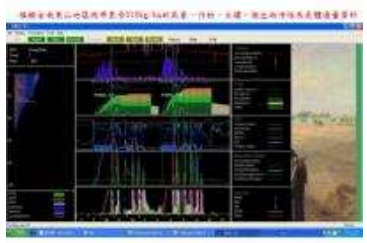
Spatial information



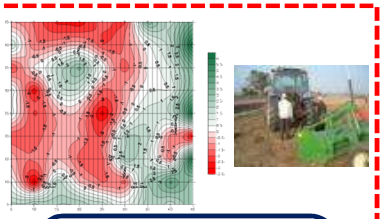
decision

Using knowledge and tools

Expert system
Field prediction
Decision management



modelling



action

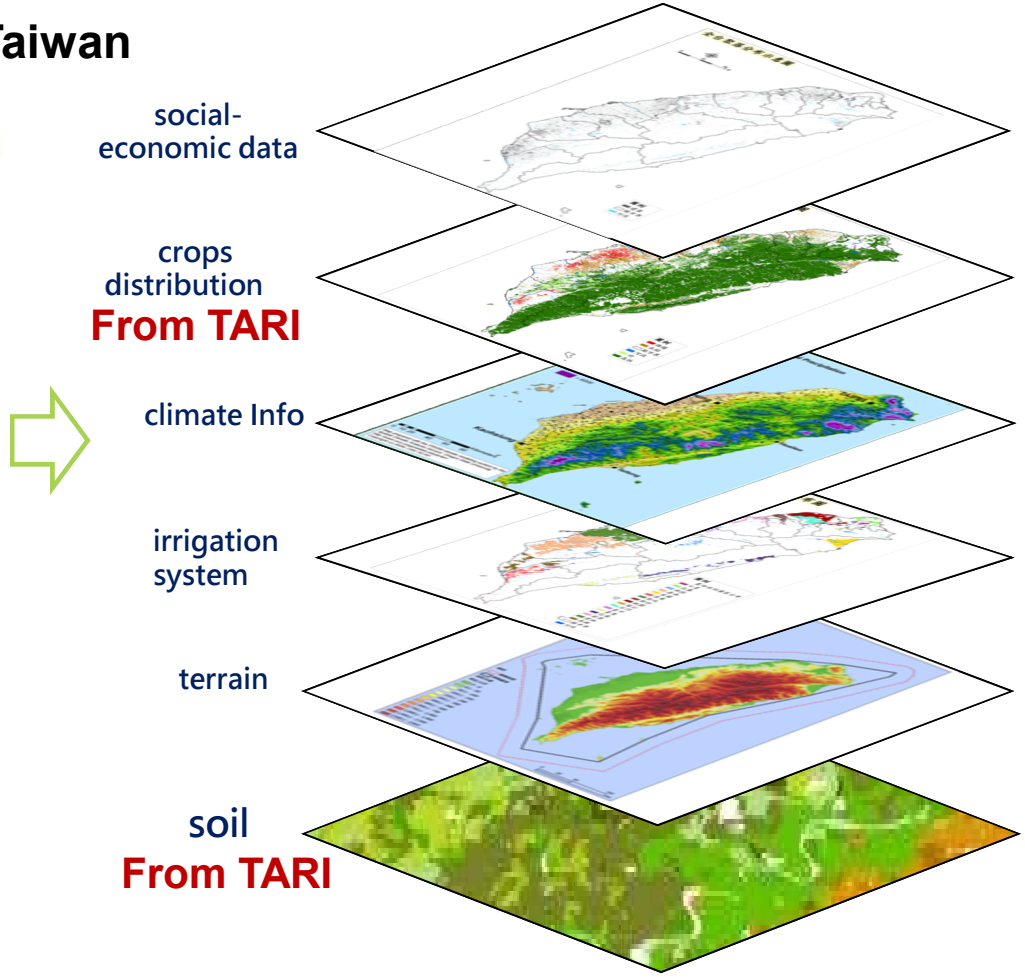
Precision and risk control

Visual farming
Wisdom production
Digital services

Laser leveler

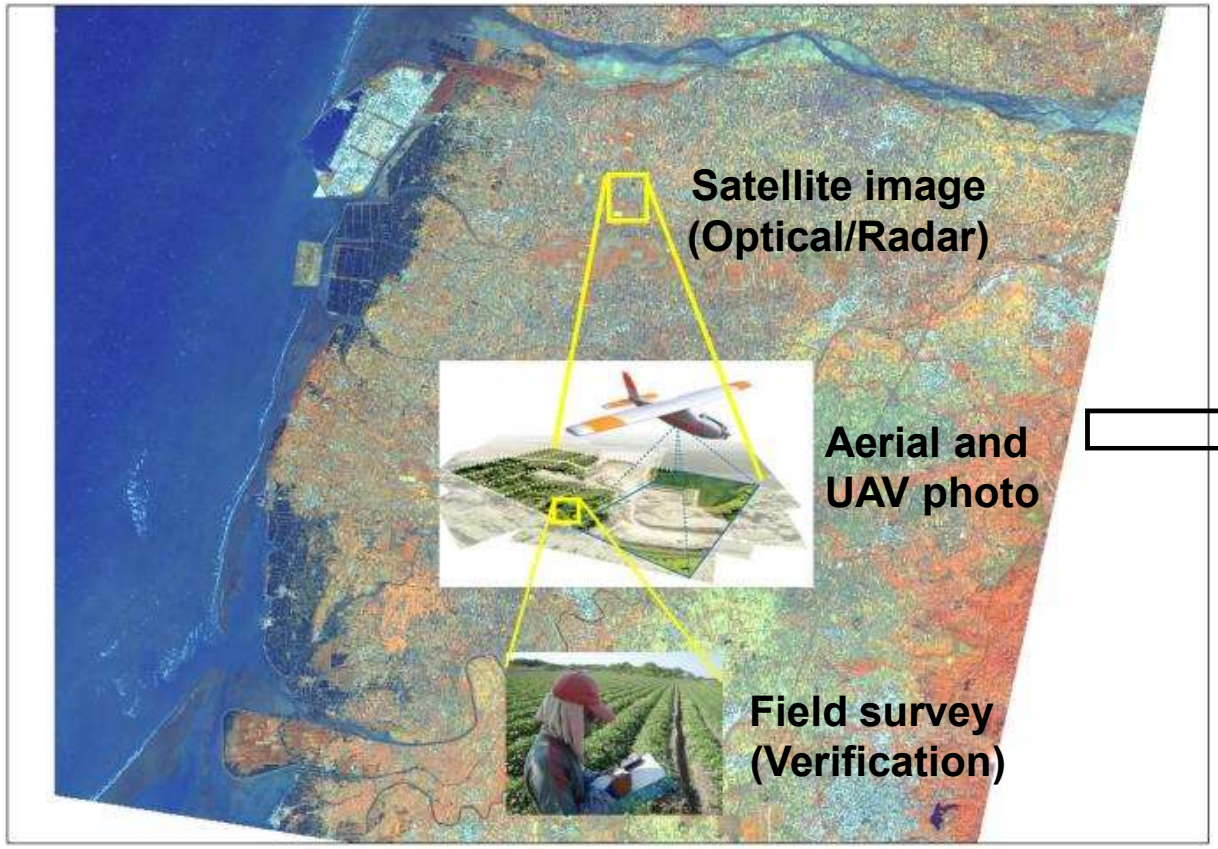
Using GIS to Integrate Agricultural Spatial Information

Land cover map of Taiwan

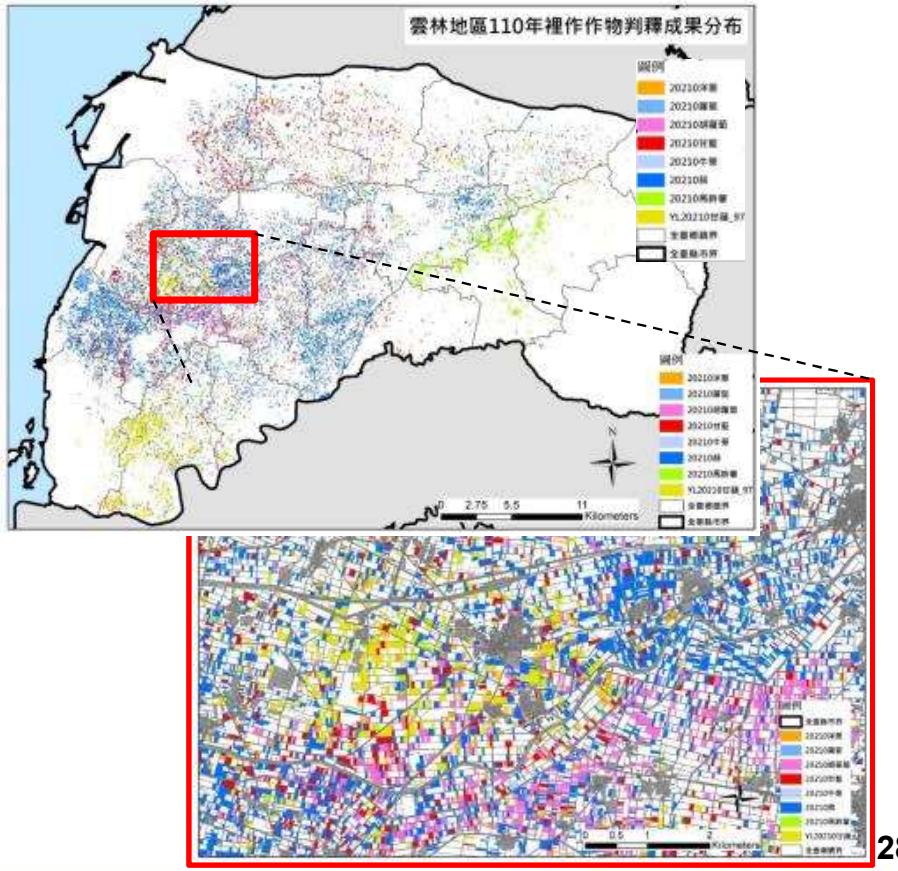


Integrated Agricultural Monitoring System

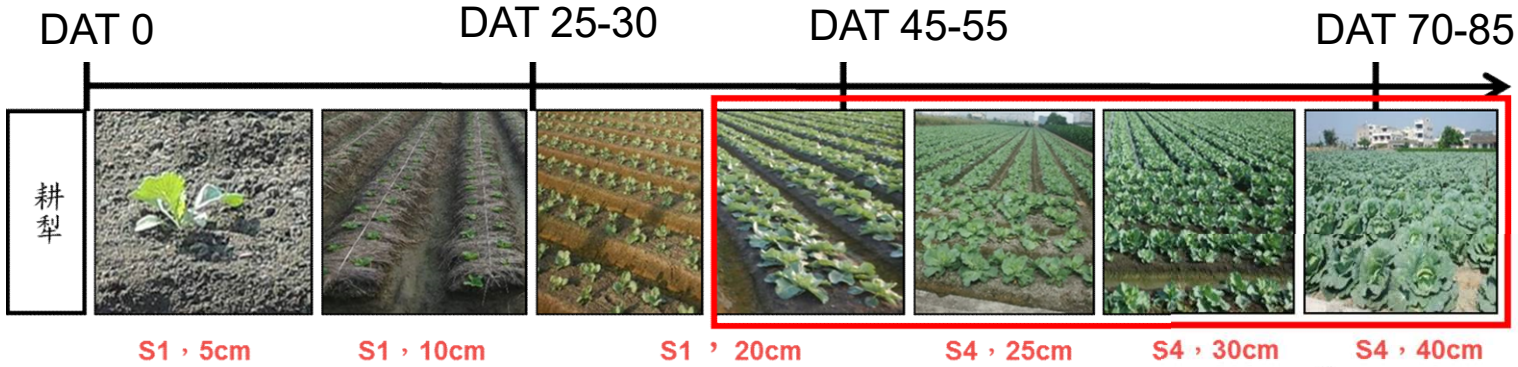
Remote sensing



Land cover map of Yunlin County in 2022



Crop Monitoring - Cabbage

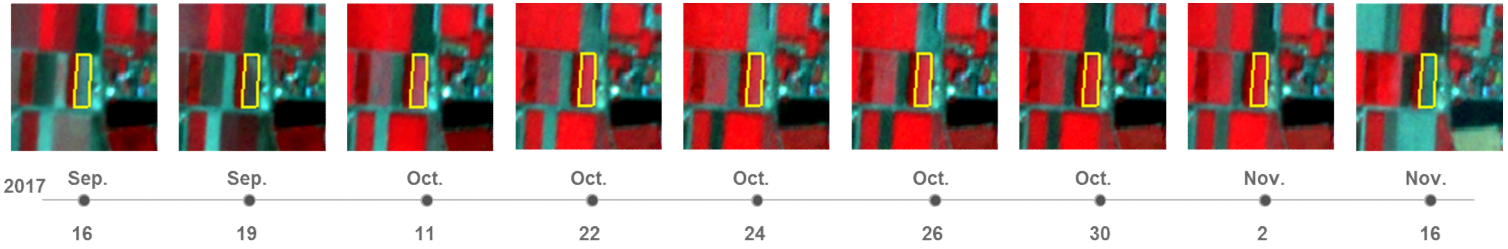


DAT: Day after transplantation

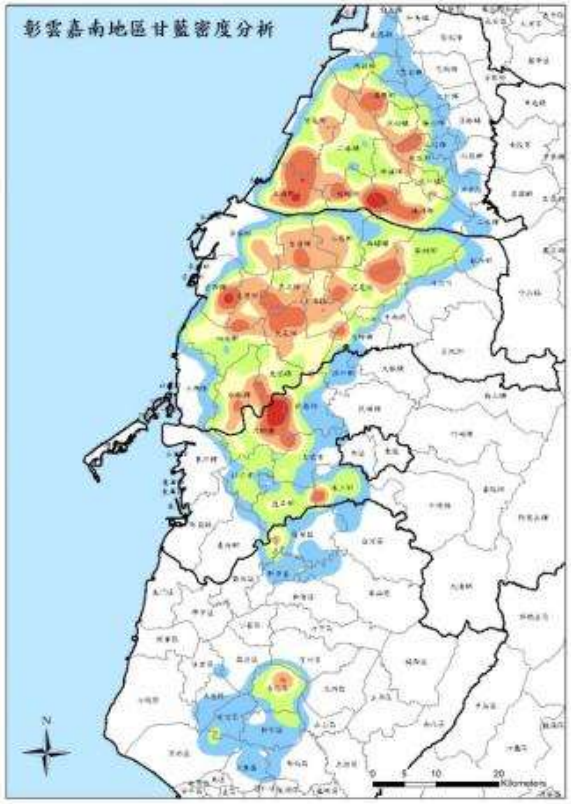
Crop phenology

Images analysis

Satellite images

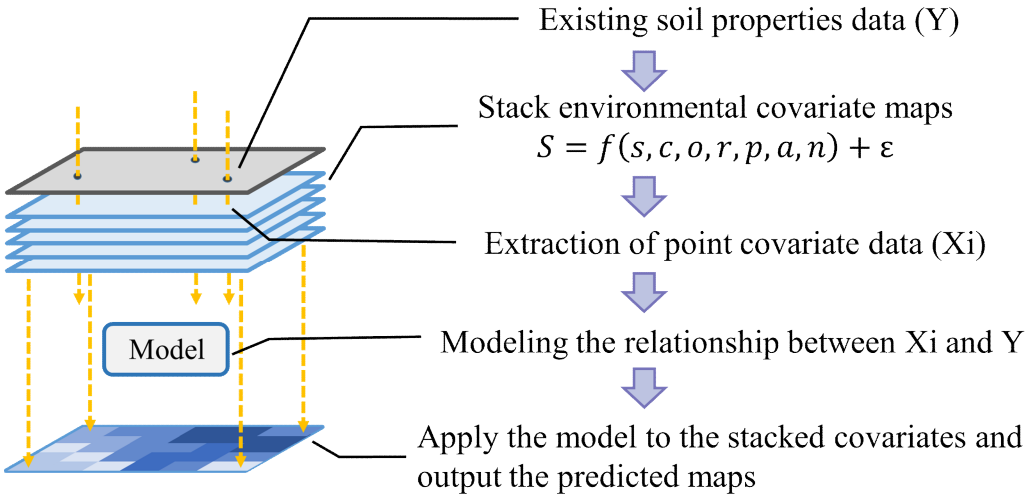


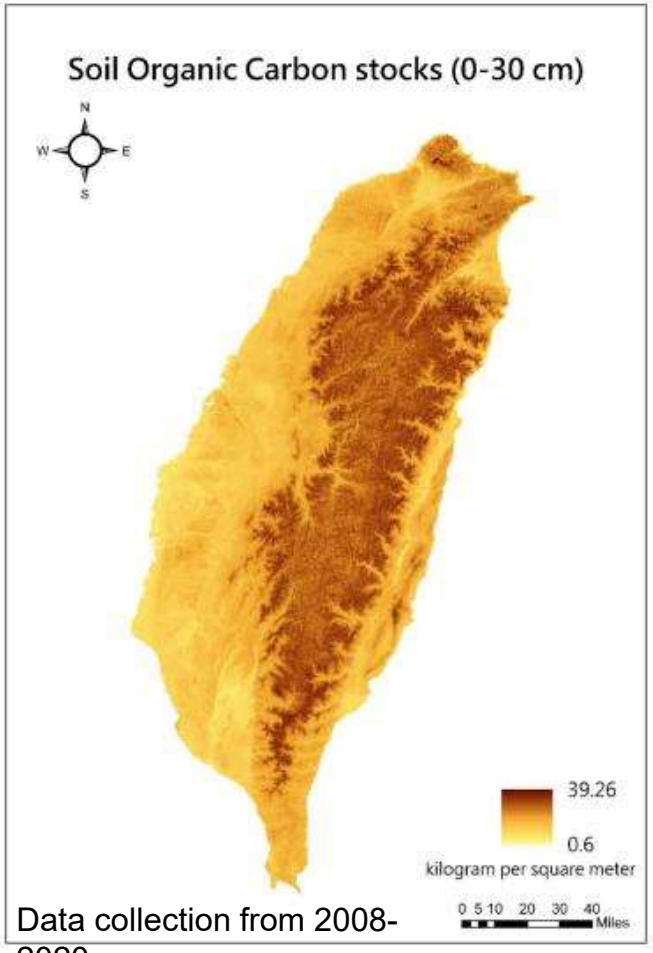
Distribution of cabbage planting density



Soil Organic Carbon Stocks Estimation

Digital Soil Mapping





Data collection from 2008-2020

Total SOC stocks in Taiwan (0-30 cm)

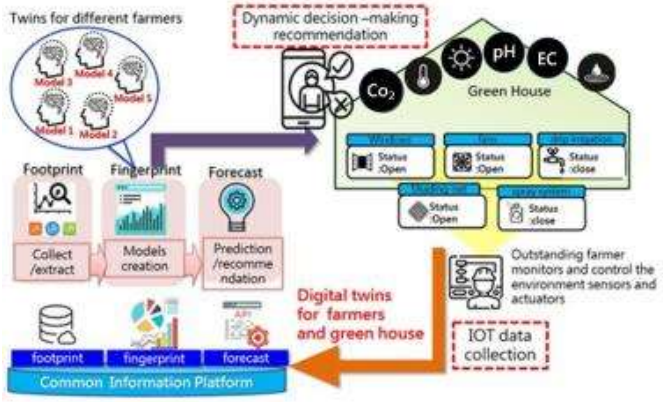
332.5 Tg C (Mt C)

Application of Digital Twin for Data-driven Greenhouse Farming

Before

Farmers have no idea about how to integrate agriculture with information and communication technologies to upgrade agricultural operation and solve urgently related issues, including the shortage of agricultural labor, inefficient management and quality improvement.

After



▲Digital twin operation model

- ✓ A greenhouse master digital twin model based on Common Information Platform (CIP) was developed by integrating internet of things(IoT) data and using human intelligence (HI) and artificial intelligence (AI) technology.
- ✓ This model provides two kinds of digital services. One is a digital service of **Greenhouse Doctor that can help diagnose greenhouse staffs' operating habits**. The other is a digital service of **Greenhouse Coach that can provide decision-making management suggestions to improve management policy.**
- ✓ The two digital services not only can let young farmers easily involved in agriculture industries, but also can reduce staff training hours and related costs of farm management.

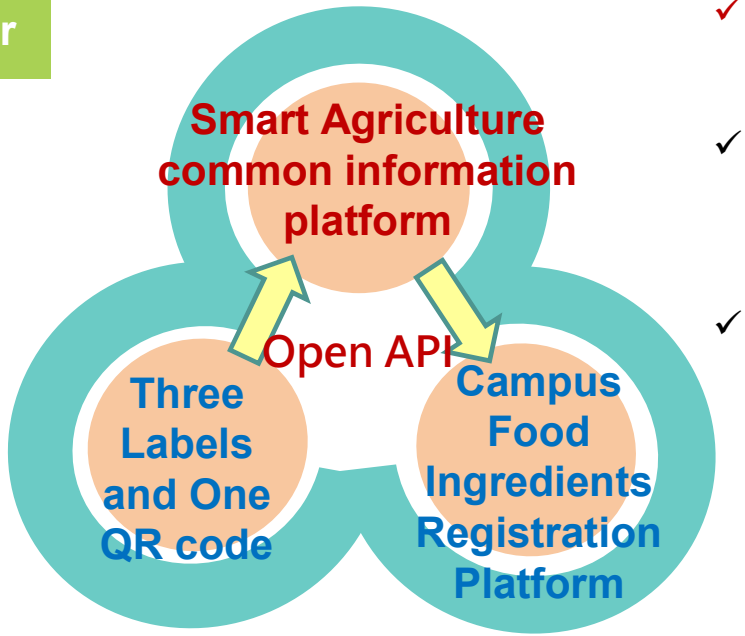
▲Greenhouse Coach - Situation room

▲Greenhouse Doctor - Behavioral pattern analysis

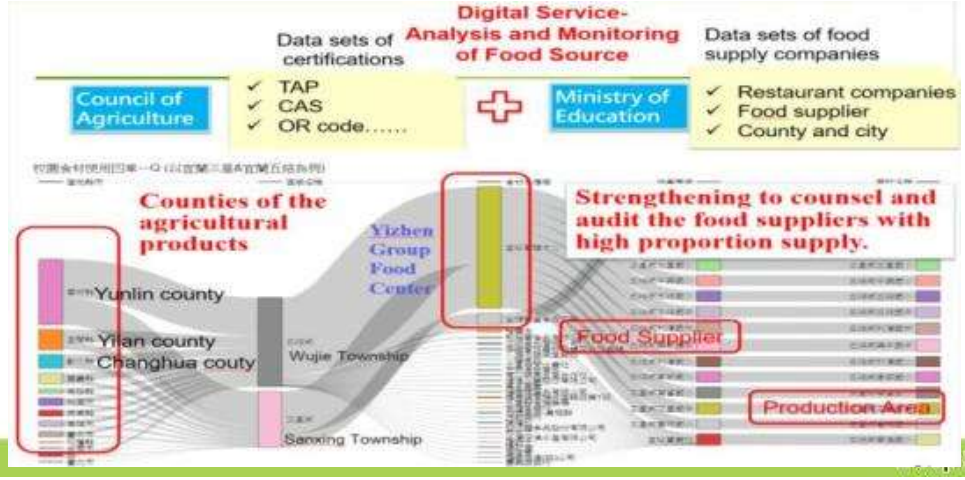
FOOD SAFETY SITUATION ROOM (FSSR) for Campus Food Safety Traceability Chain

Before The Ministry of Education needs to build its own food material database, which consumes resources. Cross-unit data cannot be efficiently aggregated.

After



- ✓ **FSSR**, an efficient and clear way to integrate and transform heterogeneous food safety information, can further monitor and reduce the risk and reaction time of food incident.
- ✓ By querying on line, **it provides immediate, transparent school food information to the community, teachers, students, and parents, thus increasing the peace of mind and trust of all stakeholders on campus lunch**.
- ✓ It can also supervise the quality of school food and beverage management jointly by combining the campus food safety management system.



▲ Food safety traceability analysis

Agribusiness (Alliance Operation) ⟷ Farmers (Field) ⟷ Smart Technology ⟷ Consumers (Table)

Full Disclosure and Self-management

Traceable

- Farmland Location → Shows the correct location and ensure the production environment
- Farmers Information → Provide producer information / photo
- Environment Safety → Regular soil/water quality inspection to ensure no pollution
- Environment Climate → Daily climate information to control quality
- Crops Traceability → Exposure of crop management process by photos
- Pesticide Inspection → Batch disclosure Health, safety and transparency

Transparent and Traceable

SUSTAINABLE DEVELOPMENT GOALS

※

Smart Traceability Technology Based on QR-Code, iPLANT

Supply and Management Platform for Biochar Materials

- To monitor the process and utilization of biochar materials, the platform developed by TFRI collects data about material spatial distribution, material management, current situation, and terminal use of biochar materials, as well as en conducts GIS-based analyses.
- 3 system:

Using GIS based analyses to estimate the material spatial distribution and the potential supply of biochar materials.

Provides relevant information.

Including processing records and tracking information, such as biochar industrial information, biochar associated equipment, actual amount of biochar materials, record and tracking management of biochar production and inspection data.

https://biochar.tfri.gov.tw/BiocharPortal

Construction of an AI-based Unmanned Disposal Site for Organic Waste (By Dr. Chiu-Chung Young, NCHU)

- The site applies a rapid treatment technology, that uses artificial intelligence for precisely transforming organic wastes into customized organic fertilizer within three hours, thereby effectively overcome the environmental problem caused by the massive organic waste and the labor shortage of the industry.

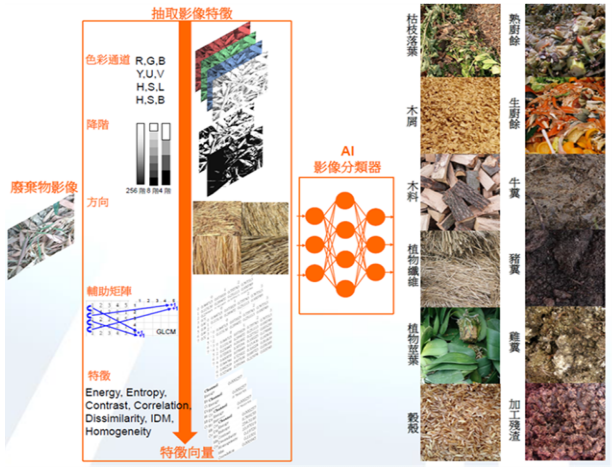
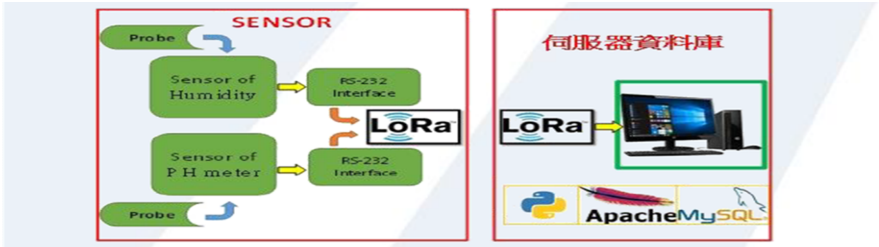
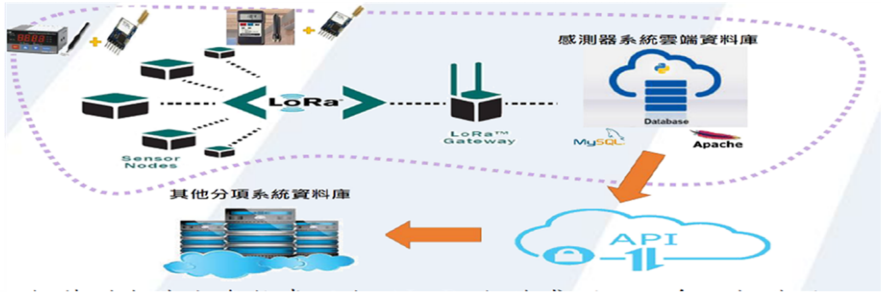


Image recognition for organic waste



Sensor function and communication test architecture figure

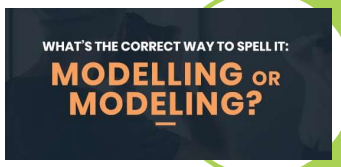


The LoRa wireless sensor network system architecture figure for the smart organic waste disposal site

Prospects

Prospects from the Perspective of DIF

The development of SA will enrich the information from field to table- an era of informatics. SA is the opportunity for farmers to connect with the different players in the food chain to exchange useful data and services. Agricultural data can be directly monetized in the future.



Between production and marketing, SA brings about new digital services, such as smart logistics, traceability and sales. By leveraging IoTs, big data and cloud computing, cross-border research and replication of successful application models will be an increasing and unchanging trend.

Cross-sectoral cooperation of SA industries and chains will need an ecosystem urgently

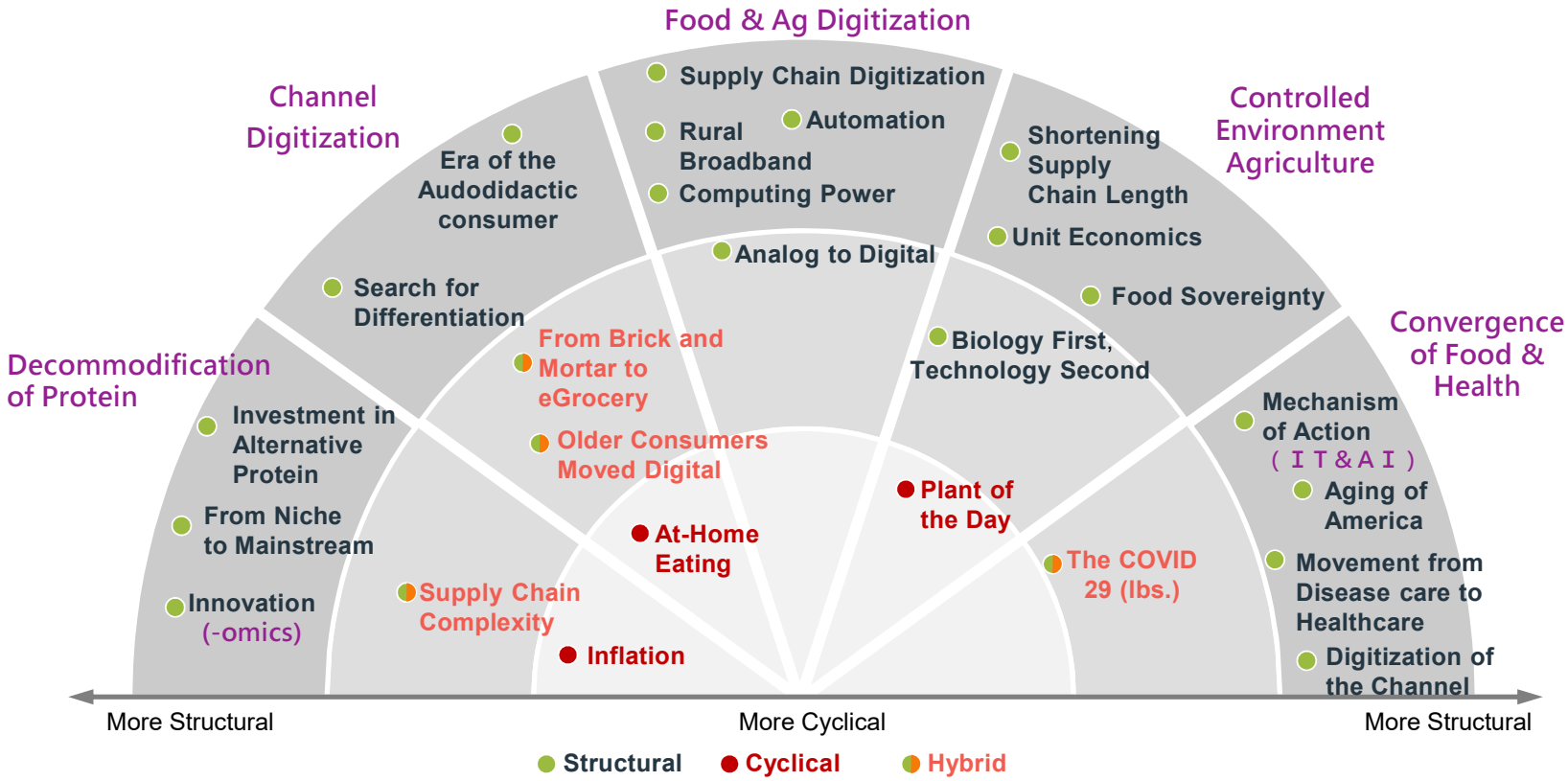
SA will emerge as a necessary paradigm in increasing the profitability and economic, environmental, and social sustainability of farming.

Future Efforts from the Perspective of DIF

Klerkx and Rose (2020) argued for reflection on how agriculture 4.0 technologies relate to diverse transition pathways towards sustainable agricultural and food systems driven by mission-oriented innovation systems.

Digitalization can contribute to lower environmental footprints, lower costs, higher profits of farming, greater animal welfare, and to better agricultural policy. Yet, technology alone is insufficient. The new technologies need to be considered in conjunction with the diversity of agricultural systems (e.g. crop and livestock systems) and the markets and policies in which agriculture is embedded. Only then sustainable (and 'smart') futures of farming in the digital era can be achieved. (Finger et al., 2020)

The Future of Food: Under the epidemic Food and Agriculture Has Undergone Significant Structural Changes that Could Alter the Course of the Industry (Krishnan, 2021)

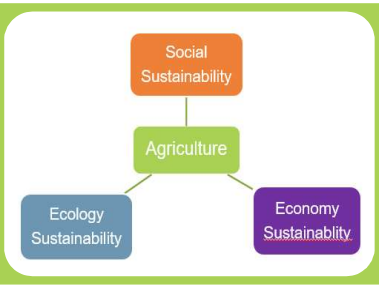


Structural Changes Throughout the Food System Will Create a More Resilient, Decentralized, Consumer Driven Future (a key to achieve sustainability)

From Sustainable Agriculture to Sustainability driven by Agriculture (Hrustek, 2020)

Sustainable agriculture: ensure the sustainability of the agricultural holding through the application of technological solutions that were limited to individual business processes.

- Data were collected and represented the main resource whose role was mainly of informative importance.
- Agriculture business dealt exclusively with communication with customers, and innovations were limited to product or production innovation.



Sustainability driven by agriculture: combine the economic, environmental, and social concept of sustainability.

- The strategic orientation of policies and plans is aimed at ensuring and harmonizing sustainability goals.

Conclusions

Innovations like developing new products, services, and introducing new financial schemes for digital and innovative farming which address challenges faced in agricultural sectors would be the key to achieve sustainability, thus realizing Sustainable Agriculture.

To take advantage of this potential, the current production-oriented focus of digital and innovative farming needs to be expanded. Other benefits including better environmental performance, better agricultural policies, and more transparency need to be explored. Ultimately, advancing from digital and innovative farming to further include sustainability driven considerations is key for a more sustainable agriculture in the future.

Thanks for your attention !