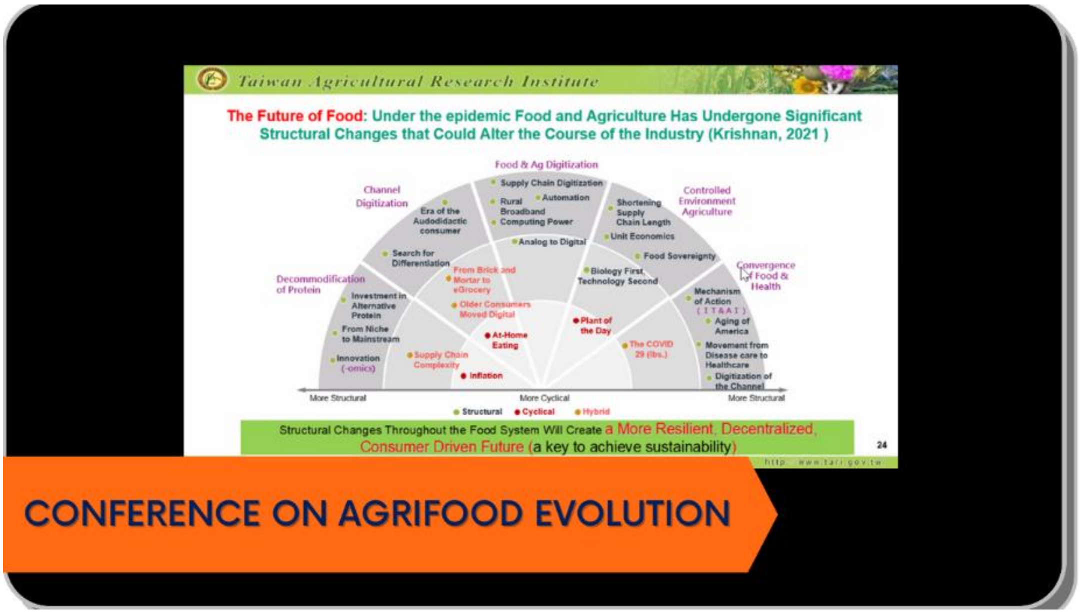
出國報告（出國類別：其他）(視訊報告)

參加「永續、韌性管理的農業食品演變會議(CONFERENCE ON AGRIFOOD EVOLUTION FOR SUSTAINABLE, RESILIENT MANAGEMENT)」(視訊報告)


Taiwan Agricultural Research Institute

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)

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CONFERENCE ON AGRIFOOD EVOLUTION

服務機關：行政院農業委員會農業試驗所

姓名職稱：蔡致榮研究員兼副所長

舉辦國家：日本(視訊)

出國期間：111年8月31日

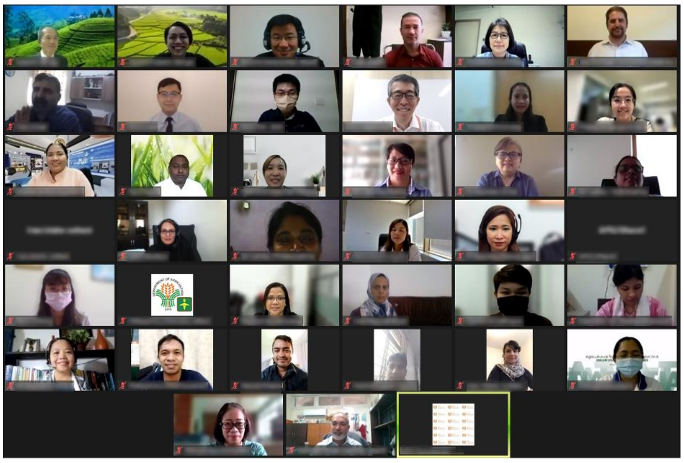
報告日期：111 年 10 月 24 日

摘要

農業食品部門的持續生產力增長和轉型一直是APO成員的共同目標。該部門面臨著許多隨著時間推移而不斷演變的挑戰，例如全球暖化，減少收成並降低作物品質；消費者偏愛更新鮮、更有吸引力的農產品，導致農藥使用量增加；浪費的包裝;和更大的糧食損失。而大流行造成的大規模供應鏈中斷是重大的新挑戰。快速增長的亞洲人口需要更多的食物，而在日本等一些發達國家，人口正減少和老齡化，更凸顯農業勞動力減少的問題以及加速採用智能農業技術的緊迫性。

亞洲生產力組織(Asia Productivity Organization, APO)秘書處於2022年8月31日規劃一次關於農業食品演變的虛擬會議。來自9個國家的35名參與者了解農產品行業面臨的最新和未來挑戰、鑑於不斷演變挑戰而進行永續農產品管理所需的準備工作，以及具有韌性農產品企業確保公民糧食安全的技術。

除了更廣泛的目標外，會議也強調未來發展農業食品業務、準備減輕農業未來風險以及將多樣性和全球化納入未來食品的政策。來自日本的兩位專家、中華民國(本文報告人)和泰國各一位的專家在會上發表演講。



目錄

本文

一、 目的

基於促進國際交流及提升我國與本所國際聲譽，報告人接獲亞洲生產力組織邀請擔任該國際組織2022年8月31日所主辦「農食演變(Agrifood Evolution)」數位多國線上會議講座並參與綜合座談，講題為「為未來農業風險做準備(Preparing for Future Risks in Agriculture)」。

二、 議程

22-CL-03-GE-CON-A
Conference on Agrifood Evolution

31 August 2022

Implementing Organizations: APO Secretariat

TENTATIVE PROGRAMME

Time (Japan Time)	Agenda	Speaker
	Wednesday, 31 August 2022	
13:30–14:00	Registration/Zoom Connection	APO Secretariat
14:00–14:20	**Opening Session:** Welcome Remarks Overview of the Conference	Head/Representative APO Secretariat
14:20–15:00	Topic 1: Policies to Evolve the Agrifood Business in the Future The session aims to share Japanese national strategy to promote both production capacity and sustainability by means of innovation. This strategy is called as MeaDRI for Sustainable Food Systems, and its objectives and contents will be explained.	Shingo Futami Deputy Director International Strategy Division Ministry of Agriculture, Forestry and Fisheries, Japan
15:00–15:40	Topic 2: Preparing for Future Risks in Agriculture The session aims to review challenges in evolving agriculture in the future and share smart agriculture in Taiwan as an example for preparing for future risks in agriculture. Some other research efforts of the like are also shortly mentioned.	Dr. Jyh-Rong Tsay, Deputy Director-General, Taiwan Agricultural Research Institute
15:40–15:50	Short Break	
15:50–16:30	Topic 3: Challenges of Food Manufacturing in the Future The session aims to update the information regarding the current food manufacturing technology, consumer trend, and surrounding situation. The challenges in the future that the manufacturer of food products should consider will be described.	Dr. Weerachet Jittanit, Associate Professor Department of Food Science and Technology, Faculty of Agro-Industry, Kesetsart University, Thailand
16:30–17:30	Topic 4: Localization and Globalization of Future Food in Japan	Dr. Tetsu Kobayashi, Professor of Marketing, Graduate School of Business, Osaka

Time (Japan Time)	Agenda	Speaker
	The session aims to describe the two strategic directions: globalization and localization of Japanese food services. Globalization and localization are not contradictory but co-exist, and the significance of these two strategies for food diversification will be explained.	Metropolitan University, Japan
17:30-18:10	**Panel Discussion** Questions/Opinions from viewers	TBD
18:10–18:20	**Closing Session:** Vote of Thanks Closing Remarks Administrative Announcements by APO Secretariat (Evaluation, Certificates if any)	APO
End of Activity		

三、 講述內容

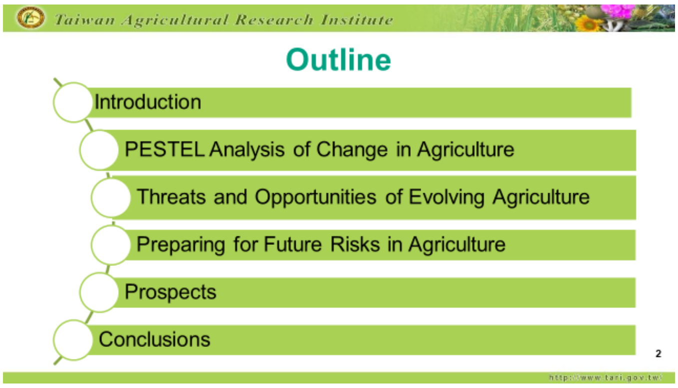
Taiwan Agricultural Research Institute

APO Conference on Agrifood Evolution

Preparing for Future Risks in Agriculture

Dr. Jyh-Rong Tsay
Deputy Director-General
Taiwan Agricultural Research Institute (TARI)
jrtsay@tari.gov.tw
31 August, 2022

http://www.tari.gov.tw



Taiwan Agricultural Research Institute

Outline

- Introduction
- PESTEL Analysis of Change in Agriculture
- Threats and Opportunities of Evolving Agriculture
- Preparing for Future Risks in Agriculture
- Prospects
- Conclusions

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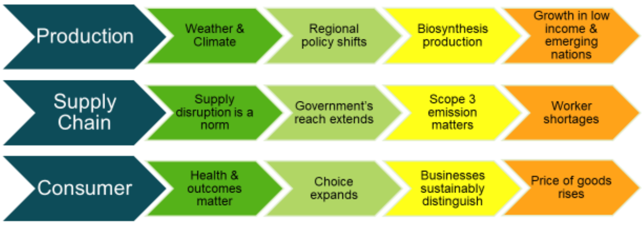
Introduction

Global Agricultural Issues


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

Agrifood Innovation Accelerates, Driven by Sustainability (Lux Research, 2022)



Production	Weather & Climate	Regional policy shifts	Biosynthesis production	Growth in low income & emerging nations
Supply Chain	Supply disruption is a norm	Government's reach extends	Scope 3 emission matters	Worker shortages
Consumer	Health & outcomes matter	Choice expands	Businesses sustainably distinguish	Price of goods rises

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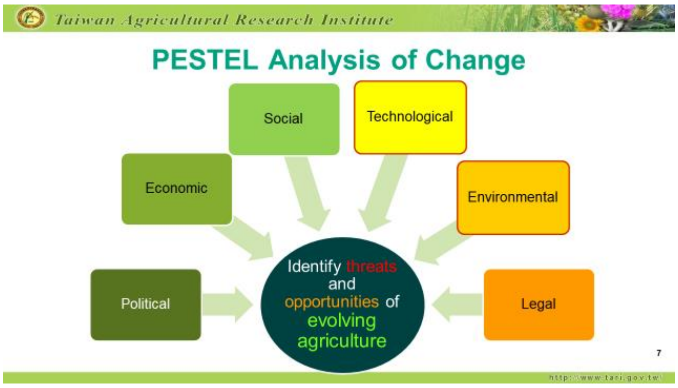
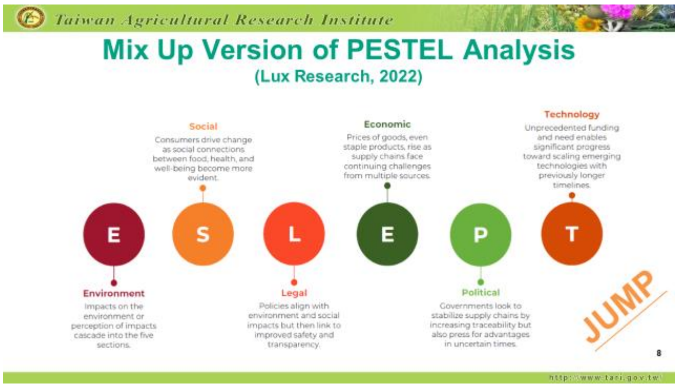
PESTEL Analysis of Change in Agriculture



PESTEL Analysis of Change



Mix Up Version of PESTEL Analysis

(Lux Research, 2022)

Environment
Impacts on the environment or perception of impacts cascade into the five sections.

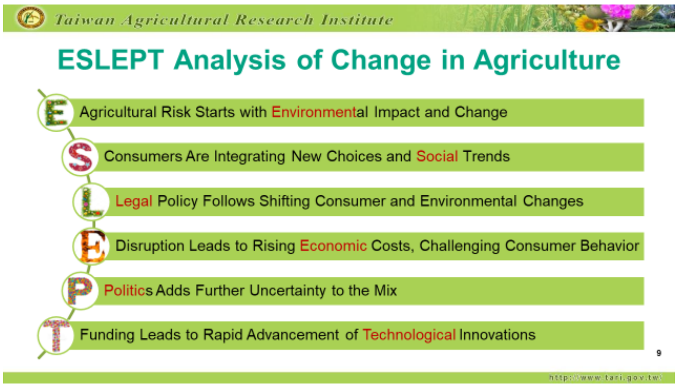
Social
Consumers drive change as social connections between food, health, and well-being become more evident.

Legal
Policies align with environment and social impacts but then link to improved safety and transparency.

Economic
Prices of goods, even staple products, rise as supply chains face continuing challenges from multiple sources.

Political
Governments look to stabilize supply chains by increasing traceability but also press for advantages in uncertain times.

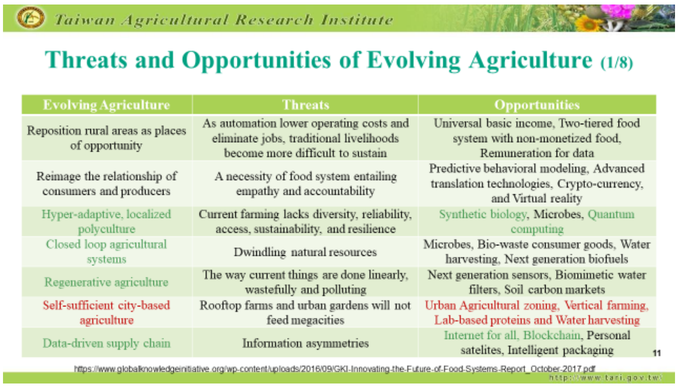
Technology
Unprecedented funding and need enables significant progress toward scaling emerging technologies with previously longer timelines.



ESLEPT Analysis of Change in Agriculture

- E Agricultural Risk Starts with Environmental Impact and Change
- S Consumers Are Integrating New Choices and Social Trends
- L Legal Policy Follows Shifting Consumer and Environmental Changes
- E Disruption Leads to Rising Economic Costs, Challenging Consumer Behavior
- P Politics Adds Further Uncertainty to the Mix
- T Funding Leads to Rapid Advancement of Technological Innovations

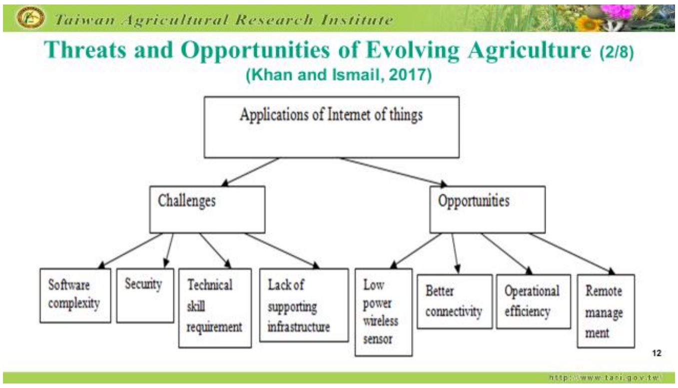
Threats and Opportunities (T&Os) of Evolving Agriculture



Threats and Opportunities of Evolving Agriculture (1/8)

Evolving Agriculture	Threats	Opportunities
Reposition rural areas as places of opportunity	As automation lower operating costs and eliminate jobs, traditional livelihoods become more difficult to sustain	Universal basic income, Two-tiered food system with non-monetized food, Remuneration for data
Reimage the relationship of consumers and producers	A necessity of food system entailing empathy and accountability	Predictive behavioral modeling, Advanced translation technologies, Crypto-currency, and Virtual reality
Hyper-adaptive, localized polyculture	Current farming lacks diversity, reliability, access, sustainability, and resilience	Synthetic biology, Microbes, Quantum computing
Closed loop agricultural systems	Dwindling natural resources	Microbes, Bio-waste consumer goods, Water harvesting, Next generation biofuels
Regenerative agriculture	The way current things are done linearly, wastefully and polluting	Next generation sensors, Biomimetic water filters, Soil carbon markets
Self-sufficient city-based agriculture	Rooftop farms and urban gardens will not feed megacities	Urban Agricultural zoning, Vertical farming, Lab-based proteins and Water harvesting
Data-driven supply chain	Information asymmetries	Internet for all, Blockchain, Personal satelites, Intelligent packaging

https://www.globalknowledgeinitiative.org/wp-content/uploads/2016/09/GKI-Innovating-the-Future-of-Food-Systems-Report_October-2017.pdf



Threats and Opportunities of Evolving Agriculture (2/8)

(Khan and Ismail, 2017)

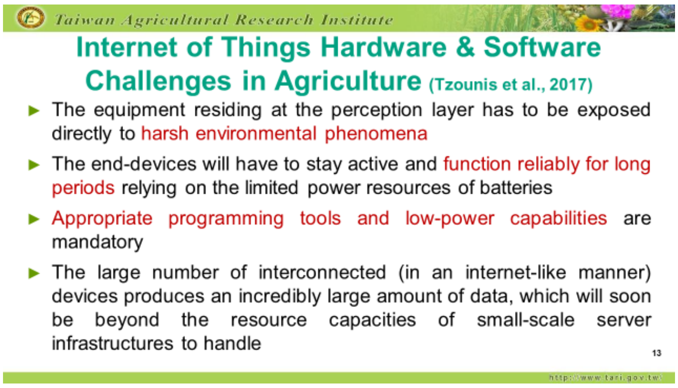
Applications of Internet of things

Challenges

- Software complexity
- Security
- Technical skill requirement
- Lack of supporting infrastructure

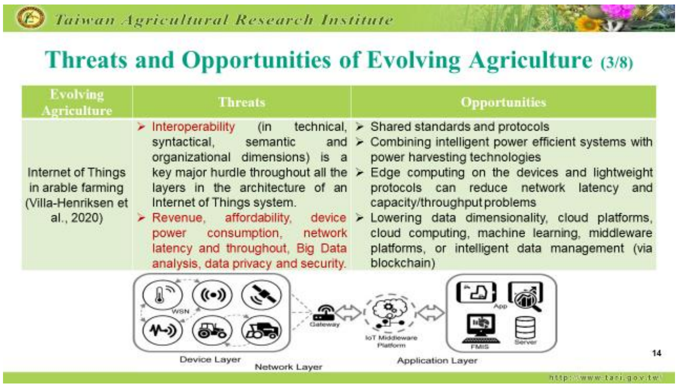
Opportunities

- Low power wireless sensor
- Better connectivity
- Operational efficiency
- Remote management



Internet of Things Hardware & Software Challenges in Agriculture (Tzounis et al., 2017)

- The equipment residing at the perception layer has to be exposed directly to harsh environmental phenomena
- The end-devices will have to stay active and function reliably for long periods relying on the limited power resources of batteries
- Appropriate programming tools and low-power capabilities are mandatory
- The large number of interconnected (in an internet-like manner) devices produces an incredibly large amount of data, which will soon be beyond the resource capacities of small-scale server infrastructures to handle



Threats and Opportunities of Evolving Agriculture (3/8)

Evolving Agriculture	Threats	Opportunities
Internet of Things in arable farming (Villa-Henriksen et al., 2020)	➢ Interoperability (in technical, syntactical, semantic and organizational dimensions) is a key major hurdle throughout all the layers in the architecture of an Internet of Things system. ➢ Revenue, affordability, device power consumption, network latency and throughout, Big Data analysis, data privacy and security.	➢ Shared standards and protocols ➢ Combining intelligent power efficient systems with power harvesting technologies ➢ Edge computing on the devices and lightweight protocols can reduce network latency and capacity/throughput problems ➢ Lowering data dimensionality, cloud platforms, cloud computing, machine learning, middleware platforms, or intelligent data management (via blockchain)

Threats and Opportunities of Evolving Agriculture (4/8)

Evolving Agriculture	Threats	Opportunities
Future food-production systems: vertical farming (VF) and controlled-environment agriculture (CEA) (Benke and Tomkins, 2017)	➢ Start-up costs can be high if land is purchased in central business districts. ➢ The number of crops grown is not as great as for rural farming. ➢ Production volumes are also not as large as broadacre farming and scaling-up may add cost and complexity. ➢ More specific challenges are the need to manage disruption to the rural sector, to raise investment capital, and to train a skilled workforce.	➢ More accurate quantification of the economics of VF and its derivatives ➢ Greater in-depth exploration of multiple-rack stacked designs that can be rotated according to optimum solar exposure ➢ Considering development of change-management strategies for future transition of affected parts of the field-horticulture industry ➢ Identify employment opportunities in technology, monitoring, maintenance, customer service, and research and development surrounding VF ➢ Increased funding for research in plant genetics

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Threats and Opportunities of Evolving Agriculture (5/8)

Evolving Agriculture	Threats	Opportunities
Nano-Enabled Products for Sustainable Agriculture (Rajput et al., 2021) or nano bio-farming (Manjunatha et al., 2016)	➢ Several NPs (like Ag-NPs) exhibit antimicrobial properties considered in food packaging processes. However, NPs have also been demonstrated to have negative impacts on plant growth and development. ➢ The major concern is the potential concentration of NPs used, because they could be transferred from root to leaf and leaf to root, thus entering into the food chain. Moreover, they exhibit large-scale bioretention and accumulation within living organisms, possibly beyond safe levels.	➢ Determining the underlying mechanisms of nano-enabled products' interplay with the food chain, and their epigenetic consequences. ➢ Improving the commercial readiness of these technologies to create clean, safe, and environmentally friendly alternatives to products being currently used in various industries. ➢ Nontoxic, biocompatible and biodegradable nanomaterials and robust, portable or remote in situ nanotechnology-based sensing and monitoring, backed up with analytical software.

Threats and Opportunities of Evolving Agriculture (6/8)

Evolving Agriculture	Threats	Opportunities
Digital Agriculture in New Zealand 1. Value-add attributes along the supply chain 2. New supply chain business models 3. Productivity 4. Cost of achieving and demonstrating compliance (Shepherd et al., 2018)	➢ Lacking evidences for achieving the desired attributes of technological applications and goals relating to environmental, health, safety, and animal welfare requirements ➢ Can information from consumers feed back? ➢ Can the tools deliver lower cost productivity without unforeseen consequences? ➢ Can the tools deliver improved decision-making at lower cost than current approaches?	➢ Sensors, analytics, decision support systems, and Traceability ➢ Barriers to uptake of technologies ✓ Data ownership, use and trust ✓ Competing business models-Two extremes are closed systems with the farmer integrated as part of the value chain *versus* open, highly collaborative systems that give all stakeholders in the value chain flexibility in the way they operate. ✓ Unclear benefits ✓ Changing farmer roles, practices, and identities

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Four possible scenarios for New Zealand agriculture depending on compliance costs and the target consumer (Shepherd et al., 2018)

Scenario: Business Growth Agenda
- High value niche systems
- Fragmented
- Sector competiveness
- Individual brand
- Aligned to business
- Lots of small customers

Scenario: Bio-Economy the "NZ Story "
- Tight/integrated value chains
- Consumer-led
- Diversified VCs/ products
- Resource trading & carbon economy
- Traceability to consumer needs
- Connected data: paddock-plate
- Use of Big Data
- Joined up sectors "NZ inc "
- Premium
- More SME focussed

Scenario: "Grasping Agriculture"
- Volume is king
- Expansion
- Intensification
- Price takers
- Increased volatility
- "more from less "
- Mostly on Farm focus
- Not diversification

Scenario: Regulation Rules
- Increased Global pop
- Volume but safe
- Domestic food security
- NZ Urban licence to operate
- Undifferentiated product
- Local policy regulation(environment)
- Requirement for transition path to new environmental states
- Increased costs of compliance
- Management of price volatility

Threats and Opportunities of Evolving Agriculture (7/8)

Evolving Agriculture	Threats	Opportunities
Robotics and Automation in Agriculture (Mahmud et al., 2020)	➢ Operations such as planting, inspection, spraying and harvesting are conducted efficiently with minimum operational costs and human labor, however more efficient autonomous systems with minimum errors need to be developed to meet specific characteristics and specifications based on the specific environment and plant species.	➢ Focus in planting process changes from seed uniformity & detection to path correction ➢ For inspection process, plant diseases and quality defect must be detected inside a real dynamic environment ➢ Focus for spraying task changes from efficient spraying to selective spraying, even fully autonomous systems ➢ Autonomous harvesting system able to plan a specific strategy to harvest a maximum amount of product with shortest time ➢ Multifunctional agricultural robot with affordable cost ➢ Modular robotic design with great robustness

Threats and Opportunities of Evolving Agriculture (8/8)

Evolving Agriculture	Threats	Opportunities
Planning Scenarios for Japanese Farming Systems and Operations in 2040 to mitigate climate change and increase resource-energy efficiency (Sekine, 2021)	➢ Modern farming operation is labor-saving and relies on a high input of resource-energy, thus increasing labor productivity and environmental burdens ➢ Labor-intensive organic business farming relying on off-farm resources needs to purchase labor and manure from markets	➢ Drastically reform existing agri-food policies to promote agroecology and mitigate climate change ➢ Strengthen measures supporting small-scale family farms that are considered guardians of the agri-food system ➢ Create new measures to build more decentralized, localized, democratic and smaller agri-food systems

Planning Scenarios for Japanese Farming Systems and Operations in 2040 (Sekine, 2021)

Preparing for Future Risks in Agriculture

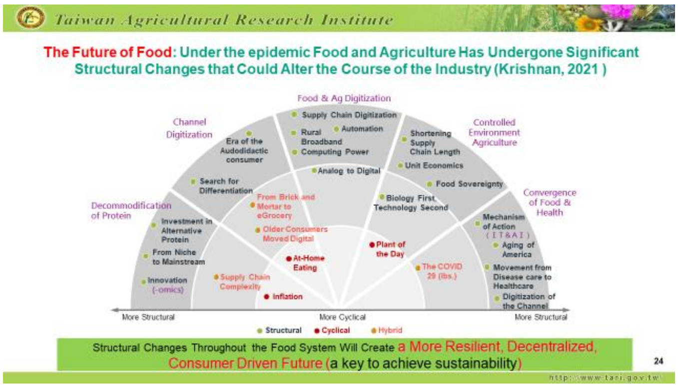
You Can Not Solve Complex Challenges in A Simple Manner

An integrated approach is needed to tackle the challenges

- Knowledge, technology and expertise
- Cross-sectoral cooperation
- Public-private partnerships

Taiwan's endeavors

- Smart Agriculture
- Resilient Agriculture System to cope with climate change
- Decision-making Systems via precision technology for Agricultural Water Resources
- Core Technology Optimization of Cold Chain for Agricultural Products
- Net Zero Carbon Emissions in Agriculture



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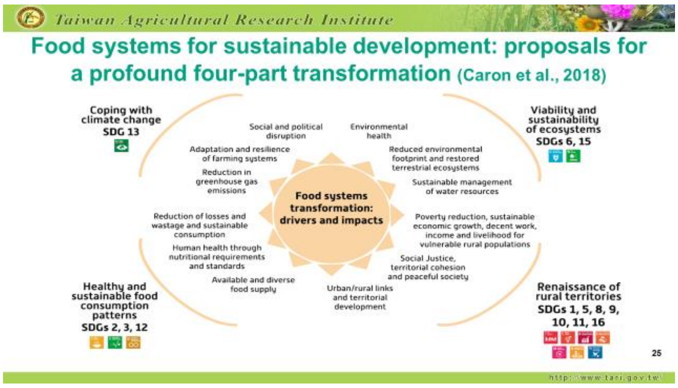
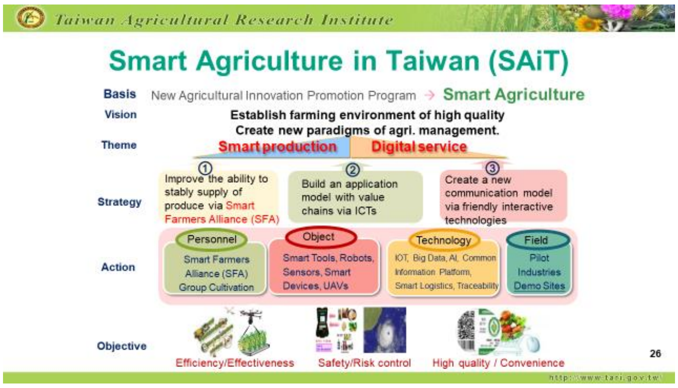
Structural Changes Throughout the Food System Will Create a More Resilient, Decentralized, Consumer Driven Future (a key to achieve sustainability)



Food systems for sustainable development: proposals for a profound four-part transformation (Caron et al., 2018)



Smart Agriculture in Taiwan (SAiT)

Basis New Agricultural Innovation Promotion Program → Smart Agriculture

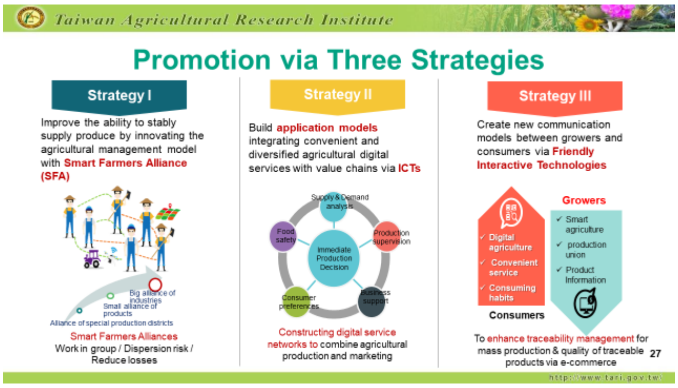
Vision Establish farming environment of high quality
Create new paradigms of agri. management.

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

Objective
Efficiency/Effectiveness
Safety/Risk control
High quality / Convenience



Taiwan Agricultural Research Institute

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

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Taiwan Agricultural Research Institute

Smart Farmers Alliance for Vegetable Soybean

- Mechanized seed production
- Mechanized seed harvesting
- Seeds automated drying and sorting

Integration of production and consumption information systems

Soybean smart production management and marketing system

Counseling large professional farmers and 1,500 small farmers for mechanization and intelligent upgrading.

Smart GPS tractor screen

Info. of GPS position & image were received instantly via mobile phone

✓ Export value of Taiwan vegetable soybean exceeded NT$2.5 billion in 2020.
✓ Vegetable Soybean SFA – help maintaining leading status of Taiwan's export to Japan.

Taiwan Agricultural Research Institute **On-going Cases**

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

Taiwan Agricultural Research Institute **On-going Cases**

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

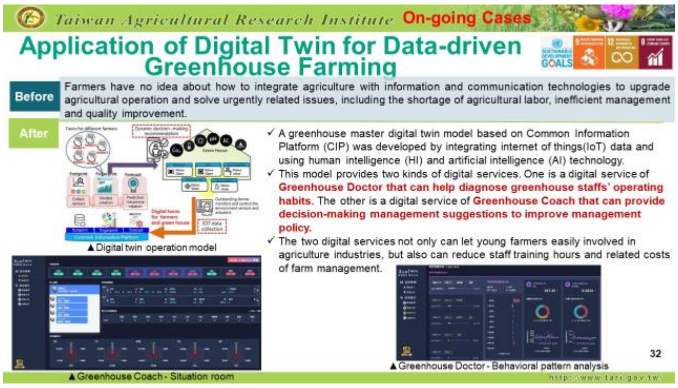
Smart Cultivation Management System

- 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



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

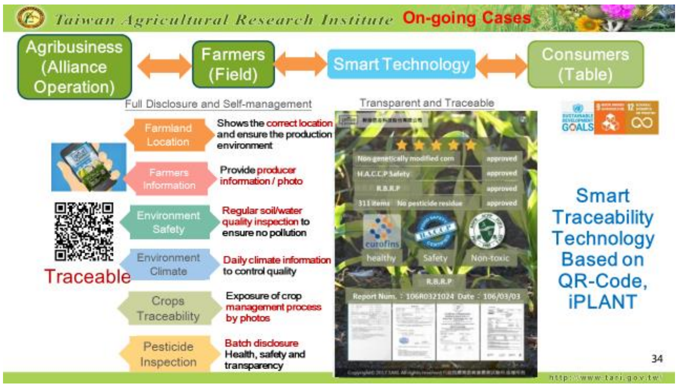
FOOD SAFETY SITUATION ROOM (FSSR) for Campus Food Safety Traceability Chain

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



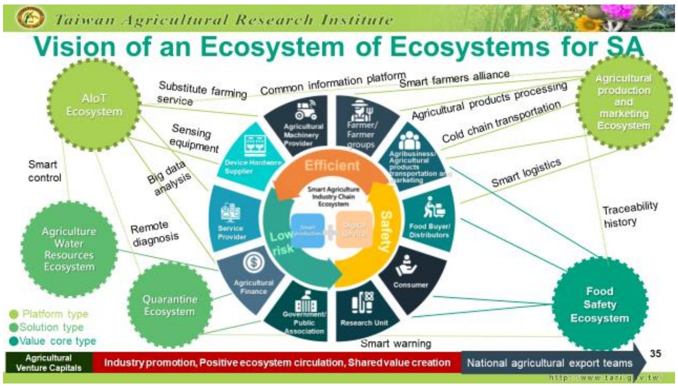
Full Disclosure and Self-management

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

Traceable

Transparent and Traceable

Smart Traceability Technology Based on QR-Code, iPLANT



Vision of an Ecosystem of Ecosystems for SA

AIoT Ecosystem

Agriculture Water Resources Ecosystem

Quarantine Ecosystem

Agricultural production and marketing Ecosystem

Food Safety Ecosystem

Substitute farming service

Common information platform

Smart farmers alliance

Agricultural products processing

Cold chain transportation

Smart logistics

Traceability history

Sensing equipment

Big data analysis

Smart control

Remote diagnosis

Smart warning

Agricultural Machinery Provider

Farmer/ Farmer groups

Agribusiness/ Agricultural products transportation and marketing

Food Buyer/ Distributors

Consumer

Research Unit

Government/ Public Association

Agricultural Finance

Service Provider

Device Hardware Supplier

Efficient

Safety

Low risk

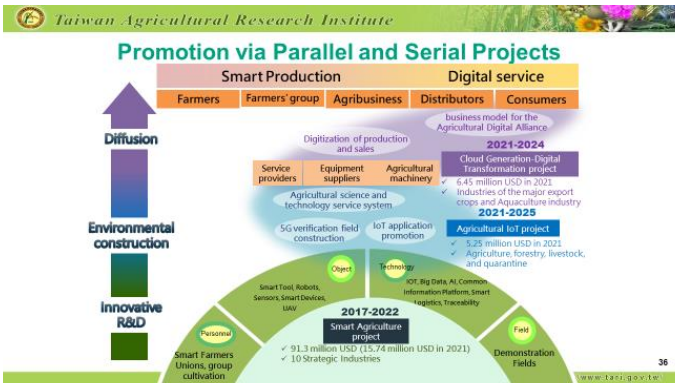
Smart Agriculture Industry Chain Ecosystem

Smart production

Digital service

- ● Platform type
- ● Solution type
- ● Value core type

Agricultural Venture Capitals | Industry promotion, Positive ecosystem circulation, Shared value creation | National agricultural export teams



Promotion via Parallel and Serial Projects

Smart Production			Digital service	
Farmers	Farmers' group	Agribusiness	Distributors	Consumers

Diffusion

Environmental construction

Innovative R&D

business model for the Agricultural Digital Alliance

Digitization of production and sales

Service providers | Equipment suppliers | Agricultural machinery

Agricultural science and technology service system

5G verification field construction

IoT application promotion

2021-2024

Cloud Generation-Digital Transformation project

- ✓ 6.45 million USD in 2021
- ✓ Industries of the major export crops and Aquaculture industry

2021-2025

Agricultural IoT project

- ✓ 5.25 million USD in 2021
- ✓ Agriculture, forestry, livestock, and quarantine

Object: Smart Tool, Robots, Sensors, Smart Devices, UAV

Technology: IOT, Big Data, AI, Common Information Platform, Smart Logistics, Traceability

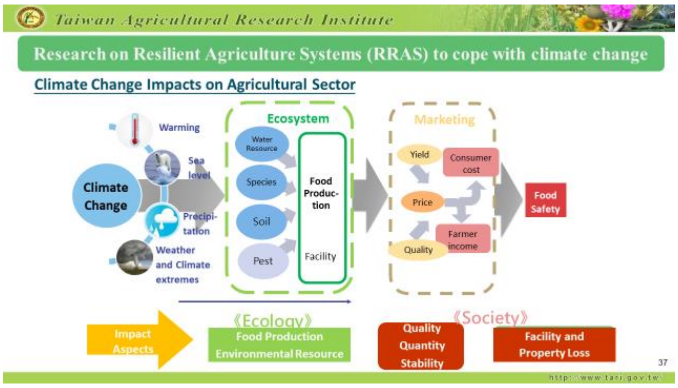
Personnel: Smart Farmers Unions, group cultivation

Field: Demonstration Fields

2017-2022

Smart Agriculture project

- ✓ 91.3 million USD (15.74 million USD in 2021)
- ✓ 10 Strategic Industries



Research on Resilient Agriculture Systems (RRAS) to cope with climate change

Climate Change Impacts on Agricultural Sector

Climate Change

Warming

Sea level

Precipitation

Weather and Climate extremes

Ecosystem

Water Resource

Species

Soil

Pest

Food Production

Facility

Marketing

Yield

Price

Quality

Consumer cost

Farmer income

Food Safety

Impact Aspects

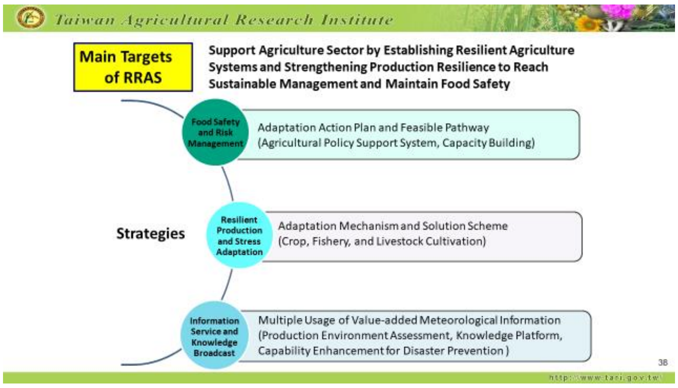
《Ecology》

Food Production
Environmental Resource

《Society》

Quality
Quantity
Stability

Facility and Property Loss



Main Targets of RRAS

Support Agriculture Sector by Establishing Resilient Agriculture Systems and Strengthening Production Resilience to Reach Sustainable Management and Maintain Food Safety

Strategies

Food Safety and Risk Management

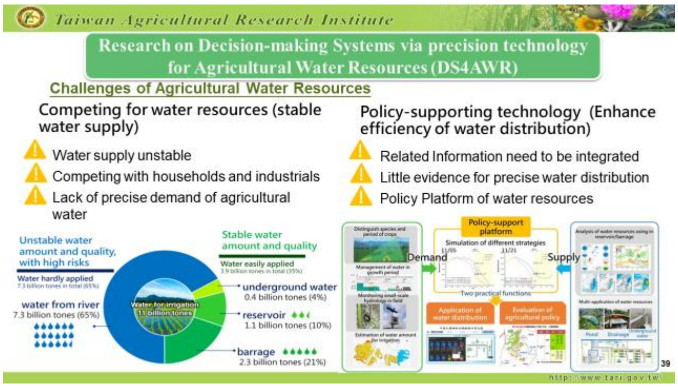
Adaptation Action Plan and Feasible Pathway
(Agricultural Policy Support System, Capacity Building)

Resilient Production and Stress Adaptation

Adaptation Mechanism and Solution Scheme
(Crop, Fishery, and Livestock Cultivation)

Information Service and Knowledge Broadcast

Multiple Usage of Value-added Meteorological Information
(Production Environment Assessment, Knowledge Platform, Capability Enhancement for Disaster Prevention)



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Research on Decision-making Systems via precision technology for Agricultural Water Resources (DS4AWR)

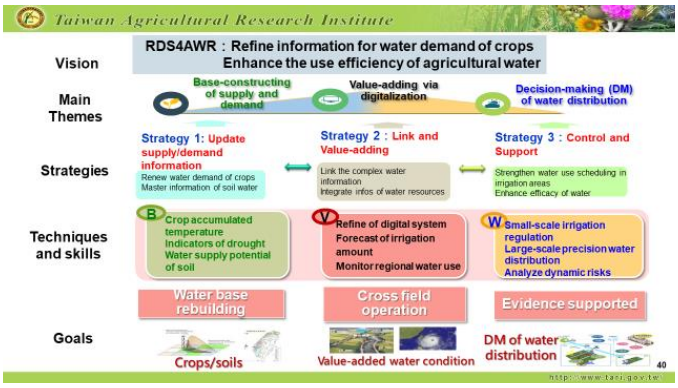
Challenges of Agricultural Water Resources

Competing for water resources (stable water supply)

- ⚠ Water supply unstable
- ⚠ Competing with households and industrials
- ⚠ Lack of precise demand of agricultural water

Policy-supporting technology (Enhance efficiency of water distribution)

- ⚠ Related Information need to be integrated
- ⚠ Little evidence for precise water distribution
- ⚠ Policy Platform of water resources



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Vision	RDS4AWR：Refine information for water demand of crops Enhance the use efficiency of agricultural water		
Main Themes	Base-constructing of supply and demand	Value-adding via digitalization	Decision-making (DM) of water distribution
Strategies	Strategy 1: Update supply/demand information Renew water demand of crops Master information of soil water	Strategy 2：Link and Value-adding Link the complex water information Integrate infos of water resources	Strategy 3：Control and Support Strengthen water use scheduling in irrigation areas Enhance efficacy of water
Techniques and skills	B Crop accumulated temperature Indicators of drought Water supply potential of soil	V Refine of digital system Forecast of irrigation amount Monitor regional water use	W Small-scale irrigation regulation Large-scale precision water distribution Analyze dynamic risks
	Water base rebuilding	Cross field operation	Evidence supported
Goals	Crops/soils	Value-added water condition	DM of water distribution

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Research on Core Technology Optimization of Cold Chain (RCTOCC) for Agricultural Products

Value chain

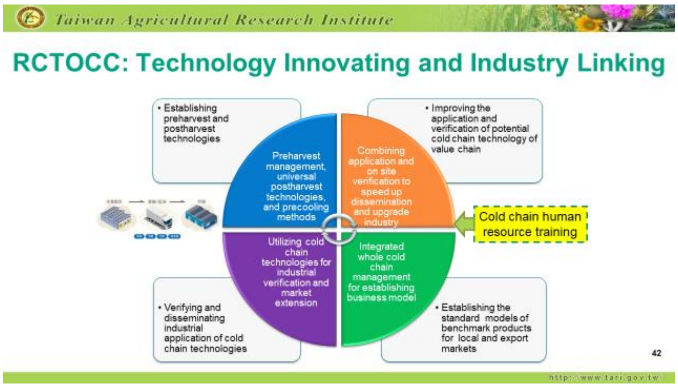
- ➢ Pre-harvest management and post-harvest processing technologies in the upstream
- ➢ Development and optimization of core technologies in the middle and downstream
- ➢ Filling channel demands and technology gaps

Local Market

- ➢ Promote the Prioritized domestic products with industrial scale and competitiveness
- ➢ Improve the key points of post-harvest loss
- ➢ Reduce losses during storage, transportation and sales

Export

- ➢ Develop storage and transportation technologies for long-distance
- ➢ Expand into emerging markets
- ➢ Assist exporters to maintain quality



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RCTOCC: Technology Innovating and Industry Linking

- Establishing preharvest and postharvest technologies

Preharvest management, universal postharvest technologies, and precooling methods

- Improving the application and verification of potential cold chain technology of value chain

Combining application and on site verification to speed up dissemination and upgrade industry

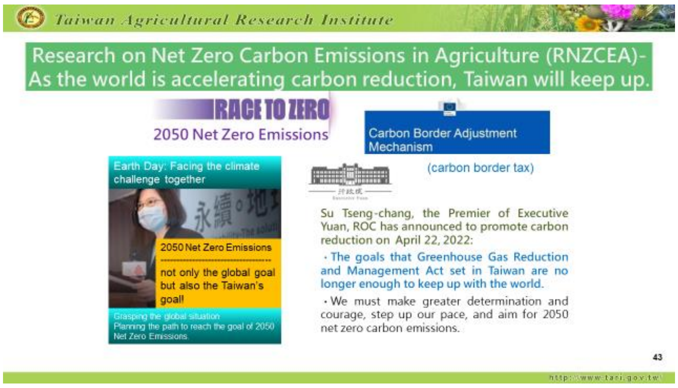
Cold chain human resource training

Utilizing cold chain technologies for industrial verification and market extension

- Verifying and disseminating industrial application of cold chain technologies

Integrated whole cold chain management for establishing business model

- Establishing the standard models of benchmark products for local and export markets



Research on Net Zero Carbon Emissions in Agriculture (RNZCEA)- As the world is accelerating carbon reduction, Taiwan will keep up.

RACE TO ZERO

2050 Net Zero Emissions

Carbon Border Adjustment Mechanism

(carbon border tax)

Earth Day: Facing the climate challenge together

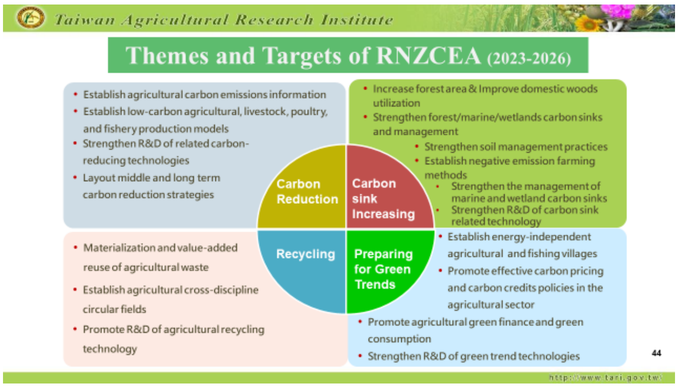
2050 Net Zero Emissions

not only the global goal but also the Taiwan's goal!

Grasping the global situation
Planning the path to reach the goal of 2050 Net Zero Emissions

Su Tseng-chang, the Premier of Executive Yuan, ROC has announced to promote carbon reduction on April 22, 2022:

- The goals that Greenhouse Gas Reduction and Management Act set in Taiwan are no longer enough to keep up with the world.
- We must make greater determination and courage, step up our pace, and aim for 2050 net zero carbon emissions.



Themes and Targets of RNZCEA (2023-2026)

Carbon Reduction

- Establish agricultural carbon emissions information
- Establish low-carbon agricultural, livestock, poultry, and fishery production models
- Strengthen R&D of related carbon-reducing technologies
- Layout middle and long term carbon reduction strategies

Carbon sink Increasing

- Increase forest area & Improve domestic woods utilization
- Strengthen forest/marine/wetlands carbon sinks and management
- Strengthen soil management practices
- Establish negative emission farming methods
- Strengthen the management of marine and wetland carbon sinks
- Strengthen R&D of carbon sink related technology

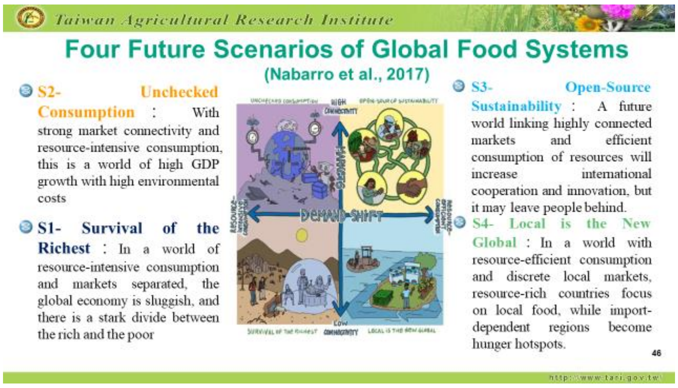
Recycling

- Materialization and value-added reuse of agricultural waste
- Establish agricultural cross-discipline circular fields
- Promote R&D of agricultural recycling technology

Preparing for Green Trends

- Establish energy-independent agricultural and fishing villages
- Promote effective carbon pricing and carbon credits policies in the agricultural sector
- Promote agricultural green finance and green consumption
- Strengthen R&D of green trend technologies

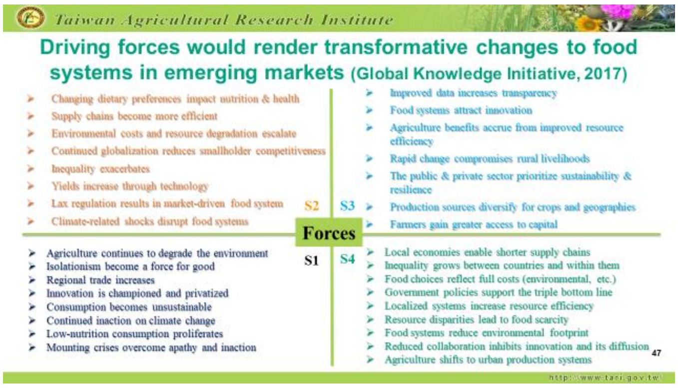
Prospects



Four Future Scenarios of Global Food Systems

(Nabarro et al., 2017)

- **S2- Unchecked Consumption** : With strong market connectivity and resource-intensive consumption, this is a world of high GDP growth with high environmental costs
- **S1- Survival of the Richest** : In a world of resource-intensive consumption and markets separated, the global economy is sluggish, and there is a stark divide between the rich and the poor
- **S3- Open-Source Sustainability** : A future world linking highly connected markets and efficient consumption of resources will increase international cooperation and innovation, but it may leave people behind.
- **S4- Local is the New Global** : In a world with resource-efficient consumption and discrete local markets, resource-rich countries focus on local food, while import-dependent regions become hunger hotspots.



Driving forces would render transformative changes to food systems in emerging markets (Global Knowledge Initiative, 2017)

Forces

S2
- Changing dietary preferences impact nutrition & health
- Supply chains become more efficient
- Environmental costs and resource degradation escalate
- Continued globalization reduces smallholder competitiveness
- Inequality exacerbates
- Yields increase through technology
- Lax regulation results in market-driven food system
- Climate-related shocks disrupt food systems

S3
- Improved data increases transparency
- Food systems attract innovation
- Agriculture benefits accrue from improved resource efficiency
- Rapid change compromises rural livelihoods
- The public & private sector prioritize sustainability & resilience
- Production sources diversify for crops and geographies
- Farmers gain greater access to capital

S1
- Agriculture continues to degrade the environment
- Isolationism become a force for good
- Regional trade increases
- Innovation is championed and privatized
- Consumption becomes unsustainable
- Continued inaction on climate change
- Low-nutrition consumption proliferates
- Mounting crises overcome apathy and inaction

S4
- Local economies enable shorter supply chains
- Inequality grows between countries and within them
- Food choices reflect full costs (environmental, etc.)
- Government policies support the triple bottom line
- Localized systems increase resource efficiency
- Resource disparities lead to food scarcity
- Food systems reduce environmental footprint
- Reduced collaboration inhibits innovation and its diffusion
- Agriculture shifts to urban production systems

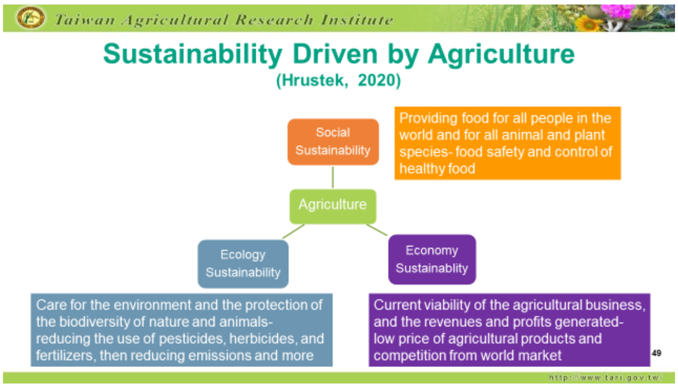
Prospects from the Perspective of SAiT

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.



Sustainability Driven by Agriculture

(Hrustek, 2020)

Social Sustainability

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

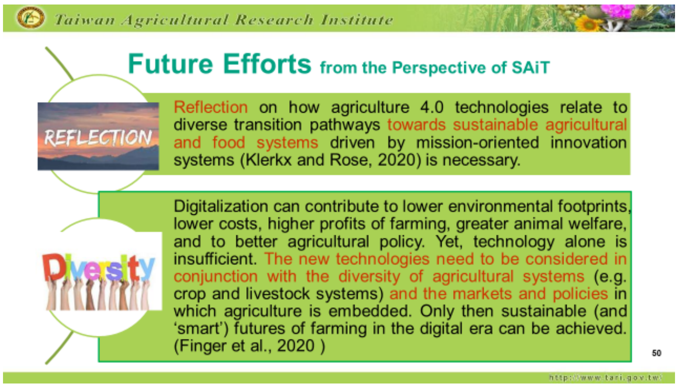
Agriculture

Ecology Sustainability

Economy Sustainablity

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

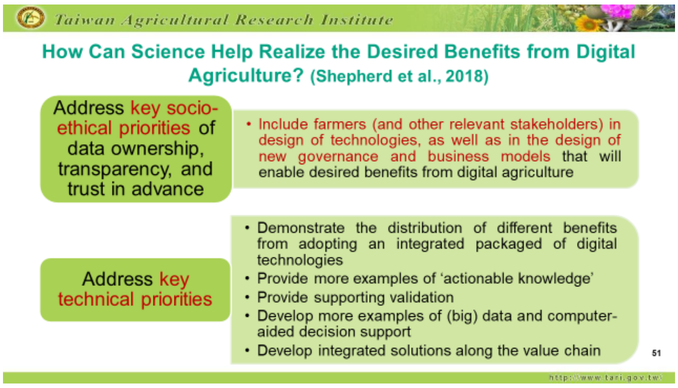
Current viability of the agricultural business, and the revenues and profits generated- low price of agricultural products and competition from world market



Future Efforts from the Perspective of SAiT

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

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)



How Can Science Help Realize the Desired Benefits from Digital Agriculture? (Shepherd et al., 2018)

Address key socio-ethical priorities of data ownership, transparency, and trust in advance

- Include farmers (and other relevant stakeholders) in design of technologies, as well as in the design of new governance and business models that will enable desired benefits from digital agriculture

Address key technical priorities

- Demonstrate the distribution of different benefits from adopting an integrated packaged of digital technologies
- Provide more examples of 'actionable knowledge'
- Provide supporting validation
- Develop more examples of (big) data and computer-aided decision support
- Develop integrated solutions along the value chain

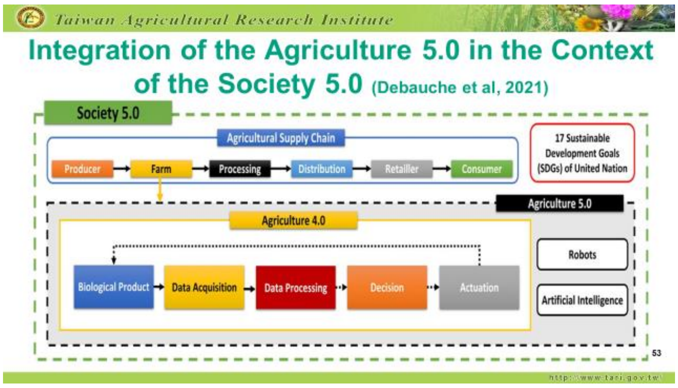
From Sustainable Agriculture to Sustainability Driven by Agriculture (Hrustek, 2020)

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.



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

Society 5.0

Agricultural Supply Chain

Producer → Farm → Processing → Distribution → Retailler → Consumer

17 Sustainable Development Goals (SDGs) of United Nation

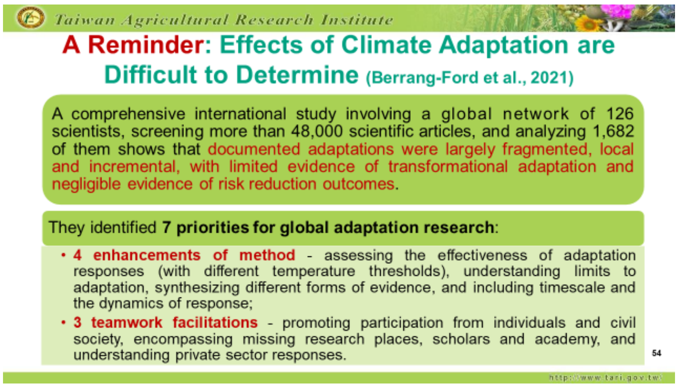
Agriculture 5.0

Agriculture 4.0

Biological Product → Data Acquisition → Data Processing → Decision → Actuation

Robots

Artificial Intelligence

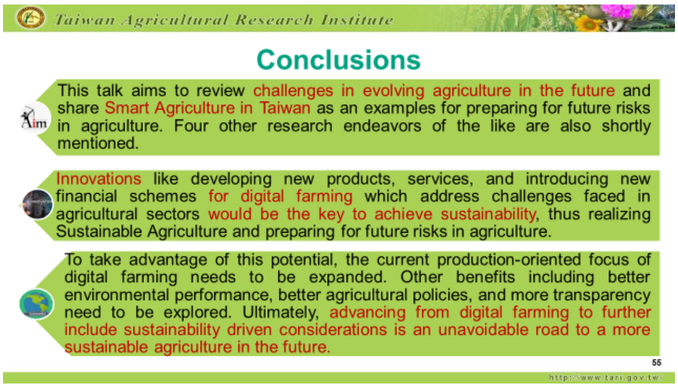


A Reminder: Effects of Climate Adaptation are Difficult to Determine (Berrang-Ford et al., 2021)

A comprehensive international study involving a global network of 126 scientists, screening more than 48,000 scientific articles, and analyzing 1,682 of them shows that documented adaptations were largely fragmented, local and incremental, with limited evidence of transformational adaptation and negligible evidence of risk reduction outcomes.

They identified **7 priorities for global adaptation research**:

- **4 enhancements of method** - assessing the effectiveness of adaptation responses (with different temperature thresholds), understanding limits to adaptation, synthesizing different forms of evidence, and including timescale and the dynamics of response;
- **3 teamwork facilitations** - promoting participation from individuals and civil society, encompassing missing research places, scholars and academy, and understanding private sector responses.



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Conclusions

This talk aims to review challenges in evolving agriculture in the future and share Smart Agriculture in Taiwan as an examples for preparing for future risks in agriculture. Four other research endeavors of the like are also shortly mentioned.

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

To take advantage of this potential, the current production-oriented focus of digital 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 farming to further include sustainability driven considerations is an unavoidable road to a more sustainable agriculture in the future.

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Thanks
for your attention !

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四、　心得與建議

除了本文報告人外，本次會議另有日本的兩位專家及泰國一位專家發表演講，其內容摘述如下：

主題 1：未來農業食品業務發展的政策—永續糧食系統：“MedDRI”策略，由日本農林水產省國際策略司副司長 Shingo Futami先生主講。他分享日本透過創新促進產能和永續發展的國家策略。該策略被稱為永續糧食系統的MeaDRI，並解釋其目標和內容。Futami先生結論道：(1)沒有“一體適用”的解決方案導致永續糧食系統，每個國家都有自己的優先事項。(2)在日本的情況下，重點是創新，但每個國家都應考慮到地理、氣候、農業/其他條件，找到自己的優先事項和解決方案。(3)日本開發的技術（例如數位工具和害蟲防治）可以幫助面臨類似挑戰的國家。例如，亞洲的稻米生產國可能會發現它們很有用，它們在氣候上有相似之處。(4)目標是實現人類可以在永續環境下生活的世界。日本已準備好與國際社會合作應對這些挑戰。

主題 2：為未來的農業風險做準備，由本文報告人中華民國行政院農業委員會農業試驗所副所長蔡致榮博士主講。本文報告人回顧未來農業發展面臨的挑戰，並分享台灣智慧農業作為為未來農業風險做準備的例子。還簡短地提到其他四項類似的研究工作。本文報告人總結說：(1)開發新產品、服務和導入新的數位農業金融計劃等創新以解決農業部門面臨的挑戰將是實現永續發展的關鍵，從而實現永續農業並為農業未來的風險做準備。（2）為了利用此一潛力，目前數位農業以生產為導向的重點需要擴大。需要探索其他好處，包括更好的環境績效、更好

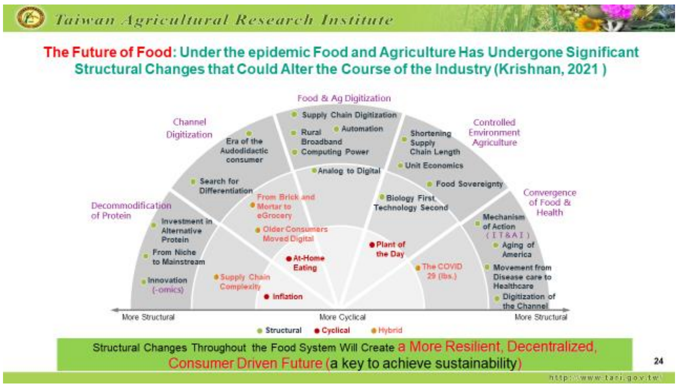
的農業政策和更高的透明度。歸根究柢，從數位農業發展到進一步考慮永續性驅動因素是未來實現更永續農業的必經之路。

主題 3：未來食品製造的挑戰，由泰國Kesetsart大學農工業學院食品科學與技術系副教授Weerachet Jittanit博士主講。Jittanit博士談到更新有關當前食品製造技術、消費趨勢和周邊情況的信息。描述食品製造商應考慮的未來挑戰。 Jittanit博士總結說：(1)未來食品製造面臨全球暖化、人口結構變化、消費者行為以及未來可能出現的危機等各種挑戰。(2)食品科學技術是應對這些挑戰的關鍵知識。（3）食品科技的角色與時俱進，以應對不斷變化的環境和挑戰。(4)未來還需要加強跨學科合作以克服食品製造的挑戰。

主題 4：日本未來食品的本地化和全球化，由日本大阪城市大學商學院行銷學教授Tetsu Kobayashi博士主講。Kobayashi博士描述兩個策略方向：日本食品服務的全球化和本地化。全球化與本土化並不矛盾，而是並存，並解釋這兩種策略對食品多樣化的意義。 Kobayashi博士總結說(1)從短期餐飲服務的角度來看：日本的餐飲服務在數量和品質都受到COVID-19的顯著影響。然而，非接觸式服務的增加，是一個定性的影響，植根於透過降低勞動力成本以提高服務生產力的長期觀點。(2)從長期餐飲服務的角度：對日本餐飲服務的長期影響包括以下三點：(i)透過降低勞動力成本提高服務生產力(ii)應對入境旅遊(iii)關注當地食物作為區域資產。（3）餐飲服務的活力和多樣性：日本的一些地方菜是純本地起源的，但許多是起源於其他地區的產品，並被引入該地區（全球化），然後適應當地的飲食文化（本土化）。因此，食品服務的全球化促進多樣化，而不是同質化。餐飲服務的多樣化也促進人們間尋找起源的互動。

總結而言，日本兩位講者有關永續糧食系統(“MedDRI”)與食品服務的全球化和本地化策略思維，以及泰國講者的未來食品製造挑戰，都值得借鏡，建議提供參考。

整體而言，就如本報告人於與會簡報的第24頁所揭示食品的未來(**Krishnan, 2021**)：實際上，在疫情之下，食品和農業經歷可能改變行業進程的重大結構變化。其中，五個不斷發展領域(包括蛋白質去商品化、渠道數位化、食品和農業數位化、受控環境農業和食品與健康的融合)中的許多趨勢，都與數位化密切相關，而且其中若干項目國內雖已有相對著力，但需要以系統系思維進行進一步運籌實做。顯然，整個食品系統的結構變化將創造一個更具韌性、去中心化、消費者驅動的未來，這也是實現永續性的關鍵，建議提供參考。



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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)

Food & Ag Digitization
● Supply Chain Digitization
● Rural Broadband
● Automation
● Computing Power
● Analog to Digital

Channel Digitization
● Era of the Audodidactic consumer
● Search for Differentiation
● From Brick and Mortar to eGrocery
● Older Consumers Moved Digital

Controlled Environment Agriculture
● Shortening Supply Chain Length
● Unit Economics
● Food Sovereignty
● Biology First, Technology Second

Decommodification of Protein
● Investment in Alternative Protein
● From Niche to Mainstream
● Innovation (-omics)
● Supply Chain Complexity
● Inflation
● At-Home Eating

Convergence of Food & Health
● Mechanism of Action (IT&AI)
● Aging of America
● Movement from Disease care to Healthcare
● Digitization of the Channel
● Plant of the Day
● The COVID 29 (lbs.)

More Structural　More Cyclical　More Structural

● Structural　● Cyclical　● Hybrid

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

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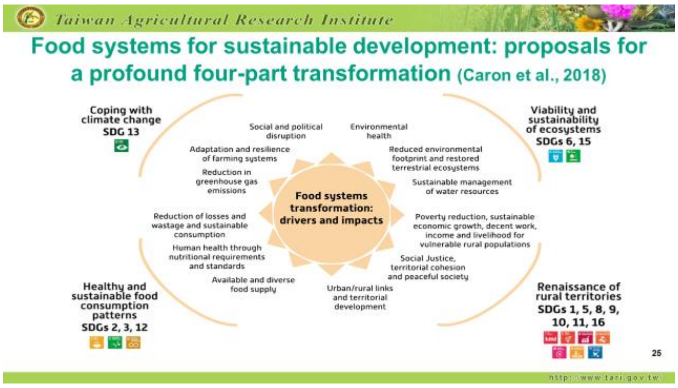
再如本報告人於與會簡報的第25頁所揭示促進永續發展的糧食系統：深刻的四部分轉型提議，係指透過評估糧食系統轉型經由農業-糧食和營養安全-環境健康-氣候-社會正義關係實現2030年議程的能力，**Caron et al. (2018)**透過突顯四個部分(應對氣候變遷、生態系統的可行性和永續性、健康和永續的食物消費模式、農村地區的復興)提出糧食系統轉型的總體框架，每個部分都可用特定的變量表徵且不可或缺，這些可用於設計相關指標以評估系統轉型的影響，實值得借鏡，建議提供參考。



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Food systems for sustainable development: proposals for a profound four-part transformation (Caron et al., 2018)

Coping with climate change
SDG 13

Viability and sustainability of ecosystems
SDGs 6, 15

Healthy and sustainable food consumption patterns
SDGs 2, 3, 12

Renaissance of rural territories
SDGs 1, 5, 8, 9, 10, 11, 16

Food systems transformation: drivers and impacts

Social and political disruption
Environmental health
Adaptation and resilience of farming systems
Reduction in greenhouse gas emissions
Reduced environmental footprint and restored terrestrial ecosystems
Sustainable management of water resources
Reduction of losses and wastage and sustainable consumption
Human health through nutritional requirements and standards
Available and diverse food supply
Urban/rural links and territorial development
Poverty reduction, sustainable economic growth, decent work, income and livelihood for vulnerable rural populations
Social Justice, territorial cohesion and peaceful society

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附錄

除了本文報告人外，本次會議另有日本的兩位專家及泰國一位專家發表演講，其內容簡報如下：

1. Topic 1: Policies to Evolve the Agrifood Business in the Future- sustainable food systems: strategy “MedDRI” presented by Mr. Shingo Futami, Deputy Director, International Strategy Division, Ministry of Agriculture, Forestry and Fisheries, Japan.
2. Topic 3: Challenges of Food Manufacturing in the Future presented by Dr. Weerachet Jittanit, Associate Professor, Department of Food Science and Technology, Faculty of Agro-Industry, Kesetsart University, Thailand.
3. Topic 4: Localization and Globalization of Future Food in Japan presented by Dr. Tetsu Kobayashi, Professor of Marketing, Graduate School of Business, Osaka Metropolitan University, Japan.