Smart Agriculture toward Society 5.0

SIP ”Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries”

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Outline

1. What is SIP?
(Cross-Ministerial Strategic Innovation Promotion Program)

2. SIP agriculture
(Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries)

3. Smart Agriculture toward Society 5.0
(Utilization of IoT, Bigdata, AI and Robot)

1. What is SIP?

(Cross-Ministerial Strategic Innovation Promotion Program)

SIP (Cross-Ministerial Strategic Innovation Promotion Program)

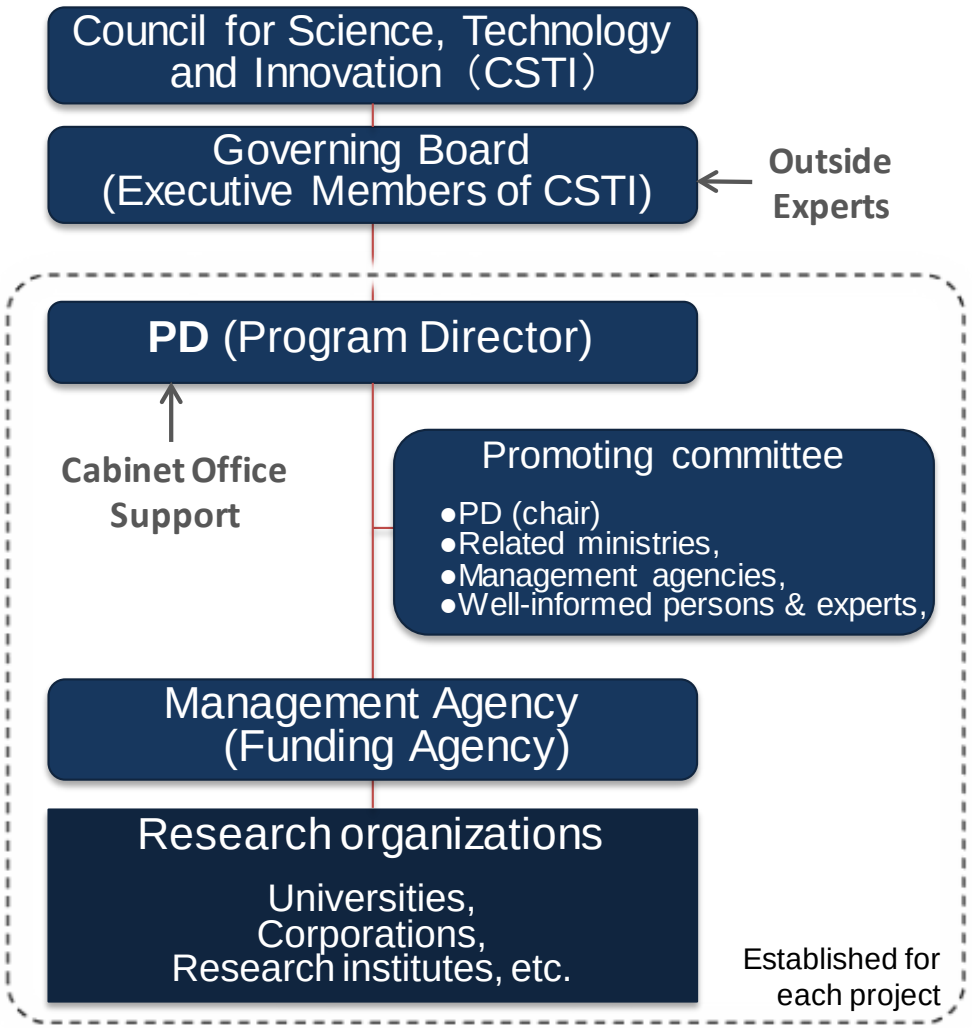
- Realizing Science, Technology and Innovation through promoting R&D overlooking from basic research to application and commercialization **by cross-ministerial cooperation**.

- **Council for Science, Technology and Innovation (CSTI)** defined the themes to solve societal issues and achieve economic growth

- CSTI appoints **Program Directors (PDs)** for each project and allocates the budget by a top-down approach.

Established in 2013
Total ¥50B* (budget for FY2017)
*Of this amount, 35 percent(¥17.5 billion) was allocated to medical fields

< Governance structure >



11 Themes of SIP

Priority policy issues	Themes	Objective
Energy	Innovative Combustion Technology	Improving fuel efficiency of automobile engines
	Next-Generation Power Electronics	Integrating new semiconductor materials into highly efficient power electronics system
	Structural Materials for Innovation（SM^{4}I）	Developing ultra-strong and –light materials such as magnesium-, titanium-alloys and carbon fibers
	Energy Carriers	Promoting R&D to contribute to the efficient and cost-effective technologies for utilizing hydrogen
	Next-Generation Technology for Ocean Resources Exploration	Establishing technologies for efficiently exploring submarine hydrothermal polymetallic ore
Next-generation infrastructures	Automated Driving System	Developing new transportation system including technologies for avoidance accidents and alleviating congestion
	Infrastructure Maintenance, Renovation and Management	Developing low-cost operation & maintenance system and long life materials for infrastructures
	Enhancement of Societal Resiliency against Natural Disasters	Developing technologies for observation, forecast and prediction of natural disasters
	Cyber-Security for Critical Infrastructures	Development of technologies that monitor, analyze, and defend control and communication system as well as confirm integrity and authenticity of system components to protect critical infrastructures against cyber threats.
Local resources	**Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries**	**Realizing evolutionary high-yield and high-profit models by utilization of advanced IT etc**
	Innovative Design/Manufacturing Technologies	Establishing new styles of innovations arising from regions using new technologies such as Additive Manufacturing

SIP

2. SIP Agriculture

(Technology for Creating Next-Generation Agriculture, Forestry and Fisheries)

1. Summary of the project plan

Current situation of agriculture, forestry and fisheries in Japan

- **Decrease of core persons mainly engaged in farming**
  (1.75 million, 15% decrease in 5 yrs)
- **Aging of core persons mainly engaged in farming**
  (65 yrs-old or older accounts for 65%)
- **Rapid increase of large-scale farm**
  (100ha or larger increased by 30% in 5 yrs)

Chance for agricultural structure reform

- **Rapid progress of technologies** related to smart agriculture and breeding
- **Expansion of food market** such as health function
- (Production value of agriculture- or food-related industries: about 100 trillion yen)

Science and technology innovation aimed by SIP (2 goals)

1. **To develop a highly productive and labor-saving smart agriculture model** by innovative technologies such as **robotics, IT, and NBT <Realize Society 5.0 in agriculture>**
2. To add high value to agricultural and forest products by differentiation focusing on **functionality** and developing **new materials from unutilized resources**

Future vision of agriculture, forestry and fisheries in Japan

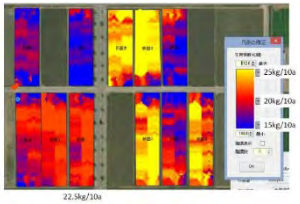
- **Strong agriculture competitive with foreign countries mainly by core farmers**
- **Market expansion of agri-food industry and regional development by enhancing the value of products**

Goal 1: Development of smart agriculture models

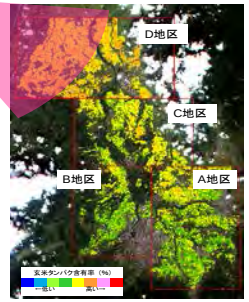
Develop ultra-laborsaving and highly productive smart agriculture model using innovative technologies such as robotics, ICT, and NBT

1-1) Paddy rice farming

Smart fertilization system



Labor-saving water management



Multi-robot tractors

Remote sensing

Reduce rice production cost **by 40%** by **improving cultivation techniques by automation and intelligentization**.

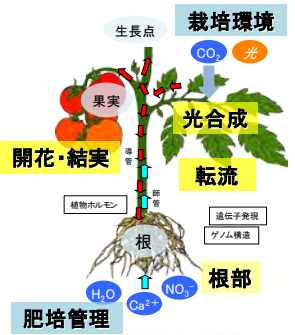
Japanese genome-editing techniques

Epoch-making varieties

Develop competitive **Japan-made genome-editing techniques** which produce **high-yield and high-quality** varieties.

1-2) Greenhouse horticulture

Technologies for disease and pest prevention



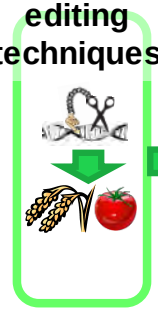
Utilization of omics data

Establish an **optimum cultivation condition of tomato that can balance high-yield and high-quality** using omics data.
Reduce disease and pest damage substantially using new pesticide-free technologies.

Goal 2: Enhancing the value of agricultural and forestry products

Promote enhancing values of agricultural and forest products for example development of high-quality or **functional healthy foods** and **new materials from unutilized resources**

Japanese genome-editing techniques

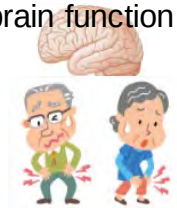


Epoch-making varieties

2-1) Development of functional health foods

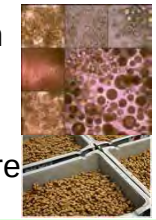
Functional healthy foods

Improvement of brain function



Cultivation of DHA-rich algae

Aquaculture feed

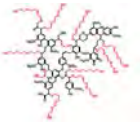


DHA-rich seafood

Obtain evidences about new functions of foods such as brain function and body locomotion and **commercialize more than 15 foods** by cooperating with food companies and agricultural cooperatives.

2-2) Creation of new local industries by developing new materials

Take out forest residues



Modified lignin production plant

Electronic substrate

IC tag (tags for merchandise management)

Heat-resistant gasket

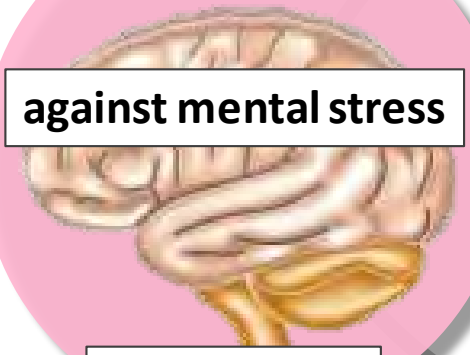
Slow-release fertilizer

Creating regional new industries by extracting modified lignin (biomaterial) from forest residues safely at lower cost, developing high-functioning products, and establishing a sales structure.

2-1) Development of functional health foods

1. Cognition activation

against mental stress



brain-gut coordination

4. Homeostasis maintenance

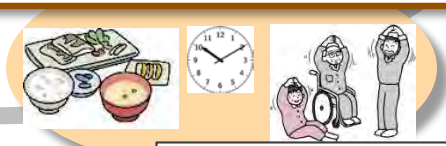
2. Locomotion improvement

Muscle

Bone

5. Seaweed

3. Food-sports synergism



chrono-nutrition

17 items for commercialization

- Lactoferrin (milk)
- Nobiletin (citrus fruits)
- γ-Oryzanol (brown rice)
- Procyanidin (apple)
- Quempherol (mulberry)
- Inulin (kikuimo)

- Rosmalinic acid (Herb)
- SAM・GPC (sake)
- High pressure-treated rice
- Oligosaccaride (mukago)
- Teaflavin (tea)
- DHA (eugrena)

- Fish muscle (fish)
- Muslinic acid (olive)
- Oleanolic acid
- Molin
- Tomatin (tomato)

3. Smart Agriculture toward Society 5.0

(Utilization of IoT, Bigdata, AI and Robot)

What is “Society 5.0”? (continued)

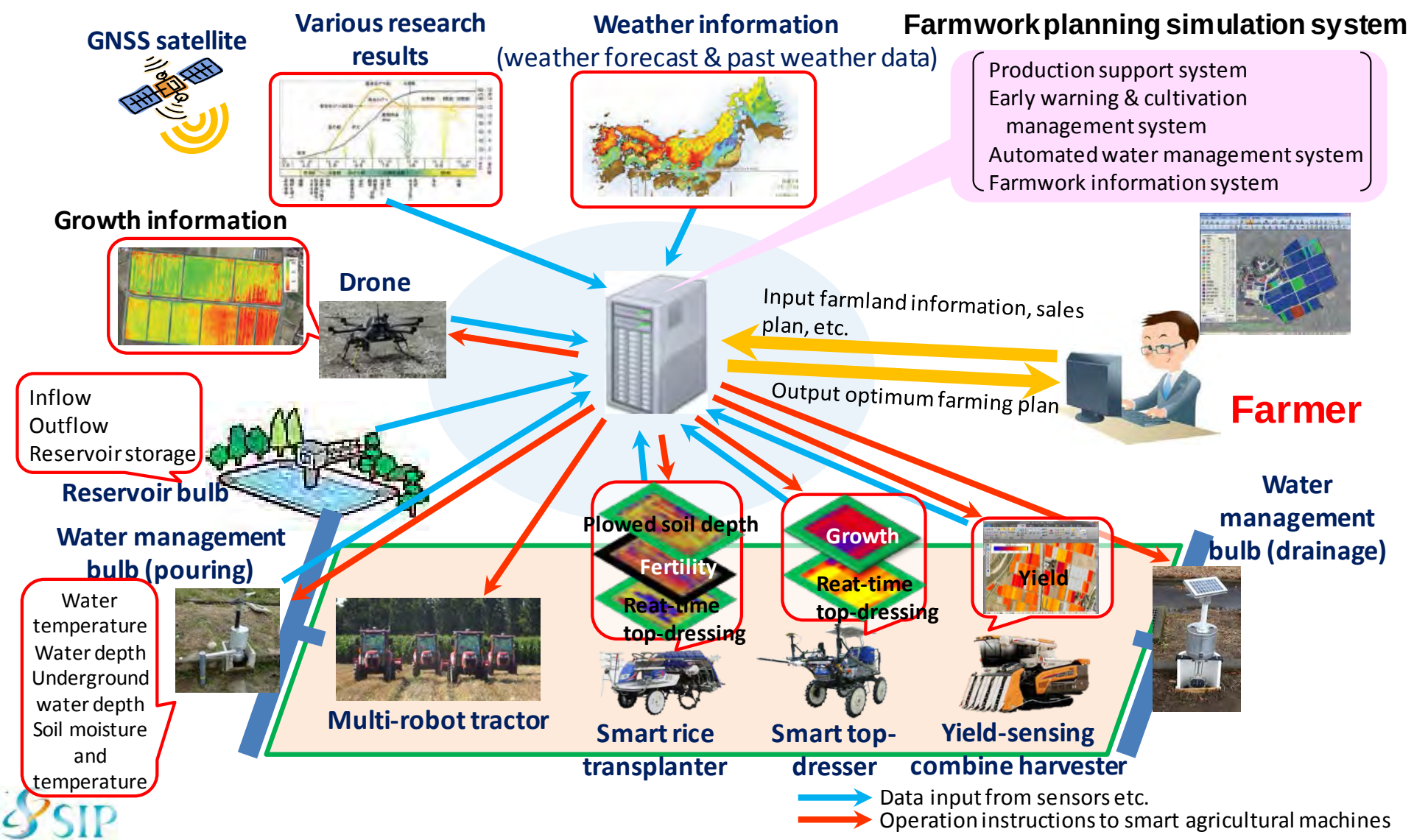
“Society 5.0” is a concept proposal of an advanced, future and human-centered society, in which the integration of cyber space and physical space(cyber-physical system: CPS) is to be realized through such state-of-the-art technologies as AI, IoT, robotics and big data.

By transforming the concept of “Society5.0” into reality, it is intended to achieve a super smart society in which necessary goods and services will be provided to anybody at any time and at any place regardless of region, age, gender, language or other limitations.

The goal of “Society 5.0” is to achieve economic growth/well-being and overcome societal challenges at the same time, contributing to the prosperity of global communities.

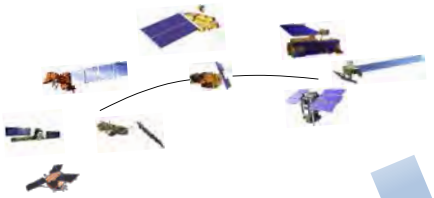
Realizing 'Society 5.0' by smart agriculture

- ✓ Create bigdata by collecting geospatial data and information by sensors and satellite, and analyze the bigdata using AI.
- ✓ Cooperate with SIP "Cyber security", national AI research centers, etc.

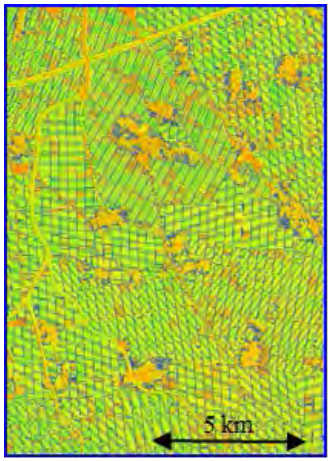


Creation of crop status information using satellite

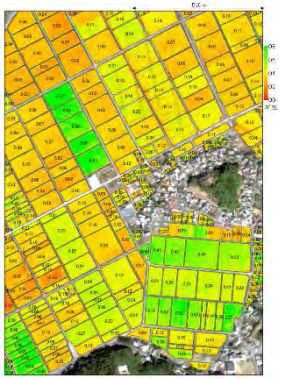
Using satellite imagery, prediction of protein content of grain before harvest become possible, and the appropriate timing for harvest can be provided. The technologies can contribute to improve the quality of rice in large production area. In addition, these available information can be acquired through a tablet PC or a smartphone using a WebGIS system.



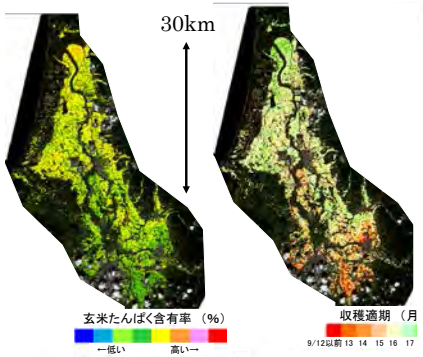
Satellite imagery



N content of rice panicle formation stage



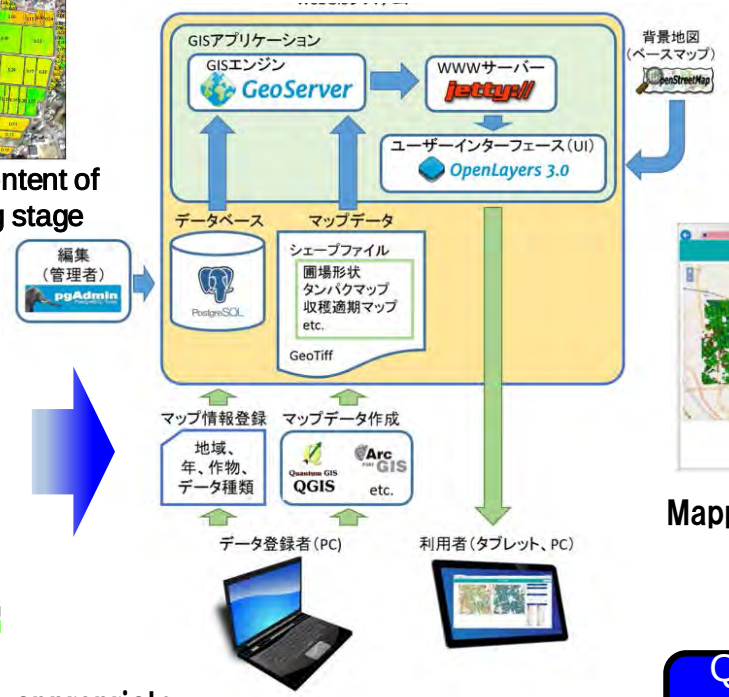
Chlorophyll content of wheat growing stage



Protein content map

Map for appropriate timing of harvest

WebGIS



Uniform management from in-field to large production area

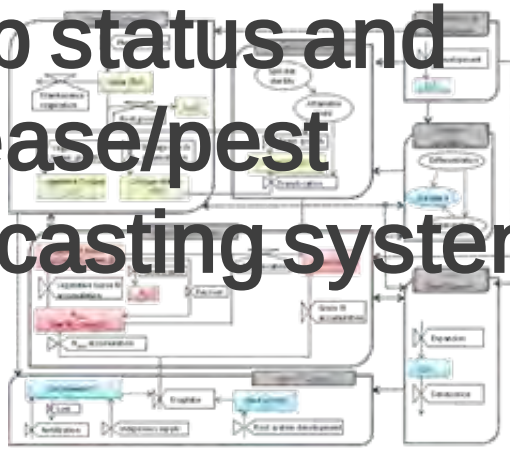
It easy to use in any time and any place

Mapping function

Quality and taste of rice improve in large scale area

Meteorology

Crop status and disease/pest forecasting system



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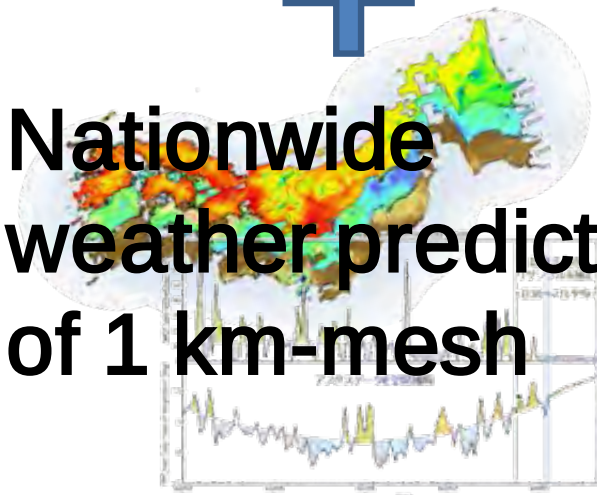
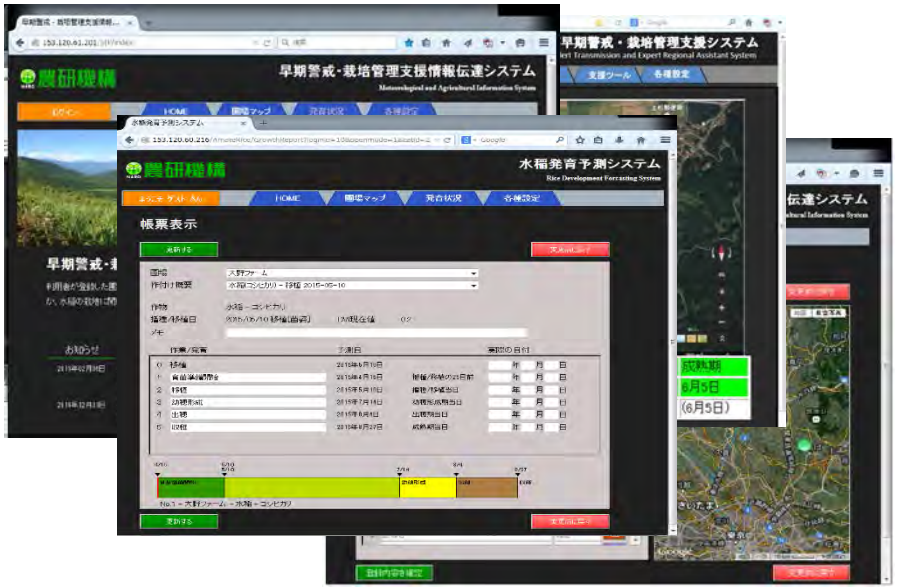
Nationwide weather prediction of 1 km-mesh



- Growers
- Extension center
- Private services



Decision support for farm management practice

- ✓ Hot/cold weather alert
- ✓ Foehn warming
- ✓ Crop disease warning
- ✓ Pest forecasting
- ✓ Advise for preventing from quality degradation of rice
- ✓ Prediction of start date for harvest
- ✓ Prediction of chemical application date
- ✓ Prediction of quality and yield

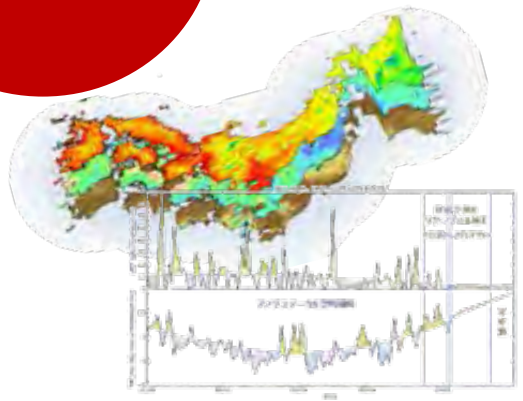
Smart water control system in paddy field

Crop growth prediction model

Cloud computing

Weather information

1 km-mesh covered whole Japan



Sensed data
- Water level
- Groundwater level
- Water temp.
- Moisture content

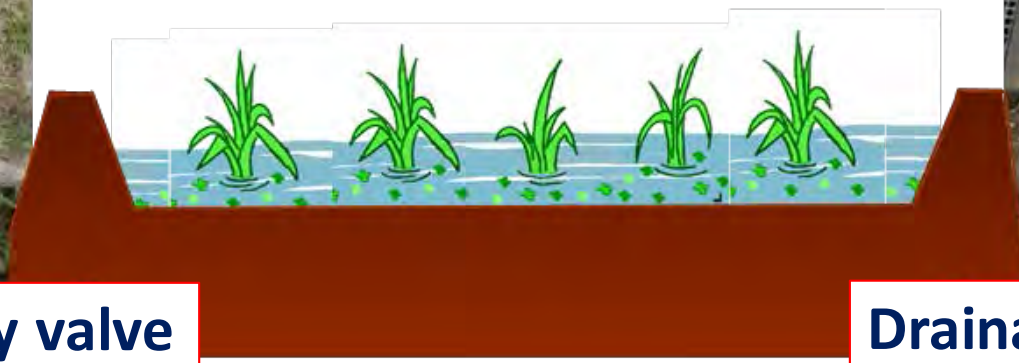
Sensed data

Control signal

Base Station

Control signal

Water supply valve



Drainage opening

New Rice Breeding System by Genome Editing Technique 【Super high-yielding rice】

The target yield is 12 t/ha as brown rice (by 2019).

If 12 ton/ ha has been achieved,
the production cost will be reduced by 60%, compared to current cultivars.
(154 yen/kg → 90 yen/kg)

Increase by genome editing technique

- the grain number
- the grain size

Current cultivar (*japonica*) (5 ton/ ha)

Selected line (crossed with *indica* line) (10 ton/ ha）

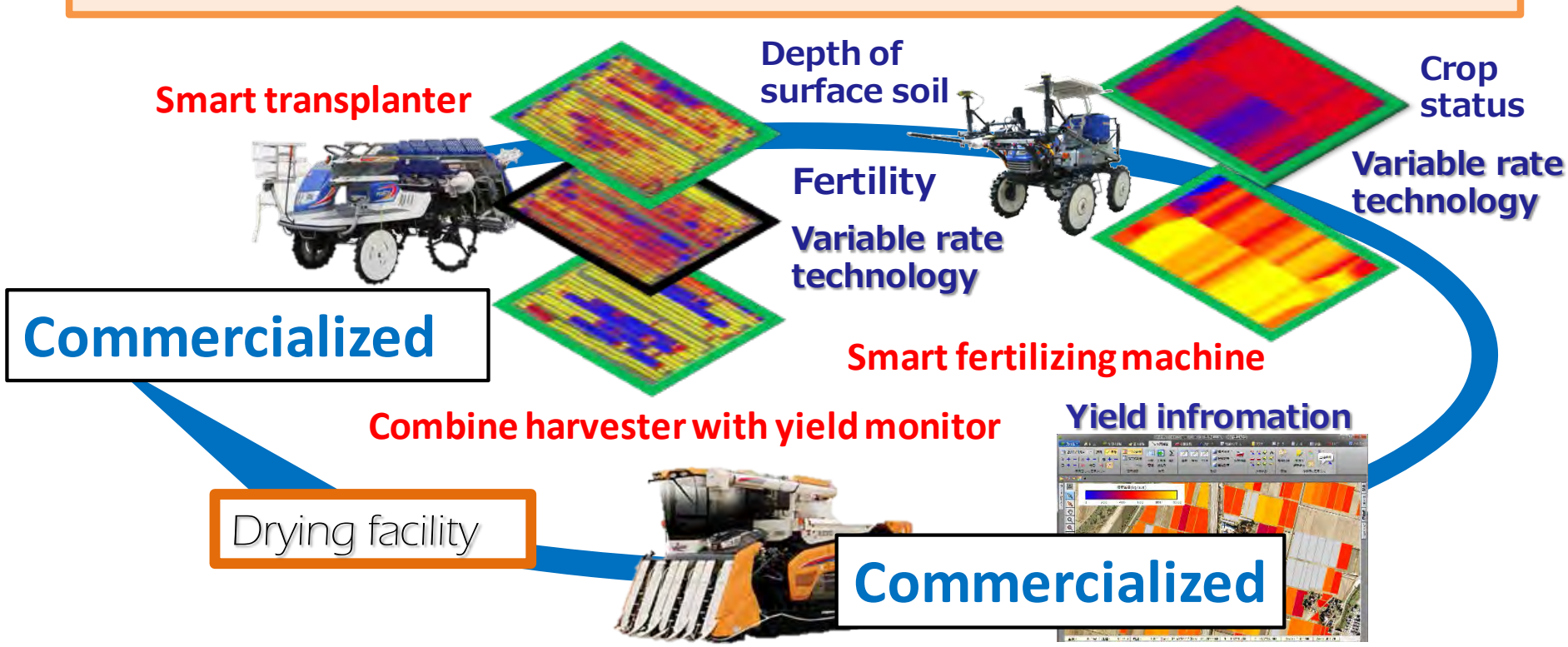
Genome editing

Genome-edited rice

Close Cooperation with Production system Group
→ Development of Growth Prediction Model for Precise Management and Low Cost Production

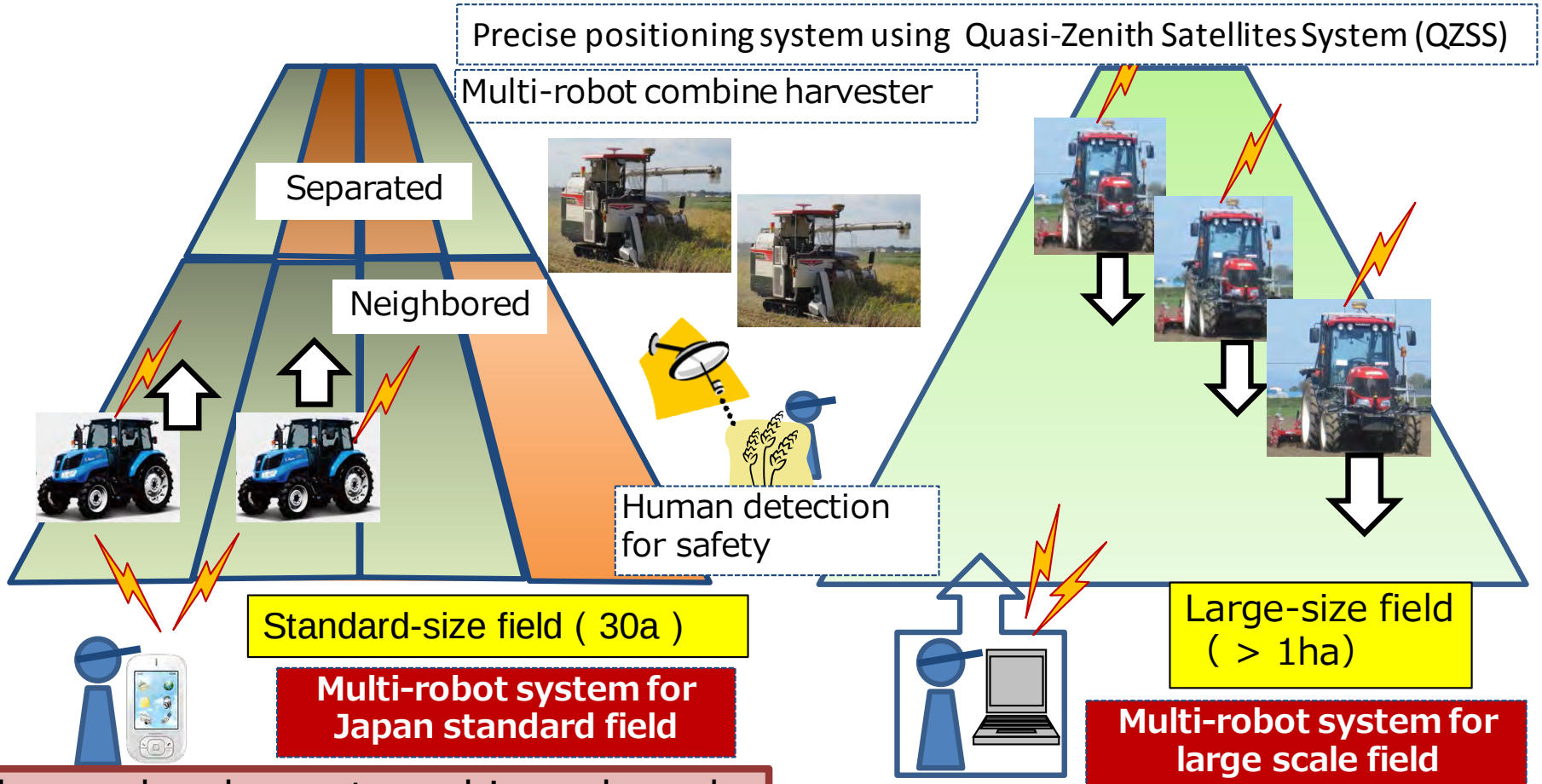
Optimal fertilizer application using smart machinery

Development of smart machineries including rice transplanter, fertilizing machine, top dressing machine and rice combine harvester. These machines can reduce production cost and quality of rice.



- 20% decrease of amount of fertilizer, and 15 % increase of ratio of perfect grains have been achieved. ⇒ **Reduction of production cost**
- Increased working efficiency by reducing lodging. ⇒ **Increase of quality**

Farm work by robot



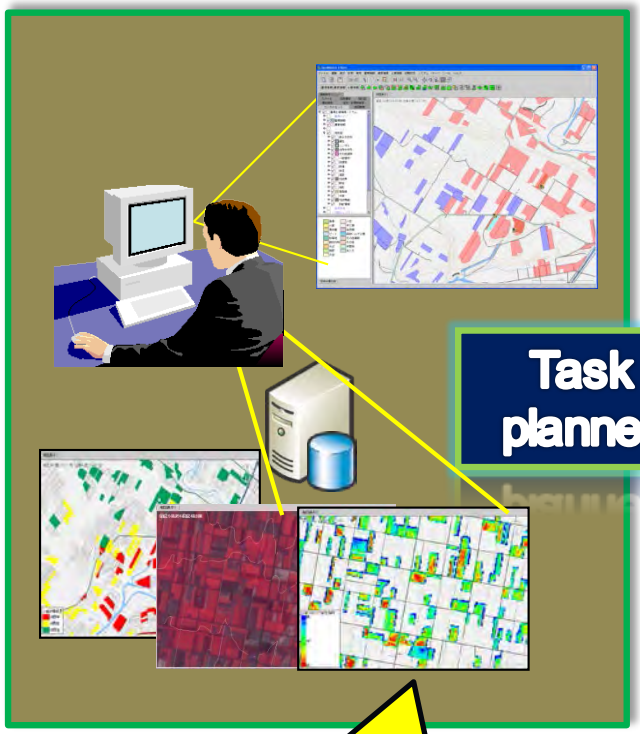
Advanced and smart machinery based on precise positioning

- High speed communication between a tractor and an implement.
- Map-base and sensor-base variable rate technology
- Link with farm management system

→ Reduction of 30% fertilizer application

Robot system by remote observation

Robot management system



Task planner

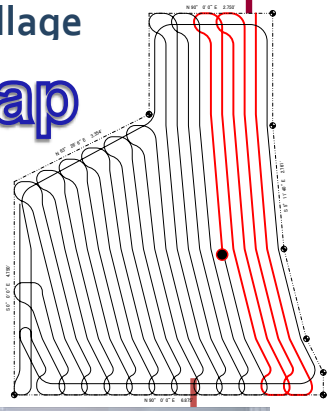
Real-time monitoring & Automated documentation

Multi-GNSS

Tillage

Weeding

GIS map



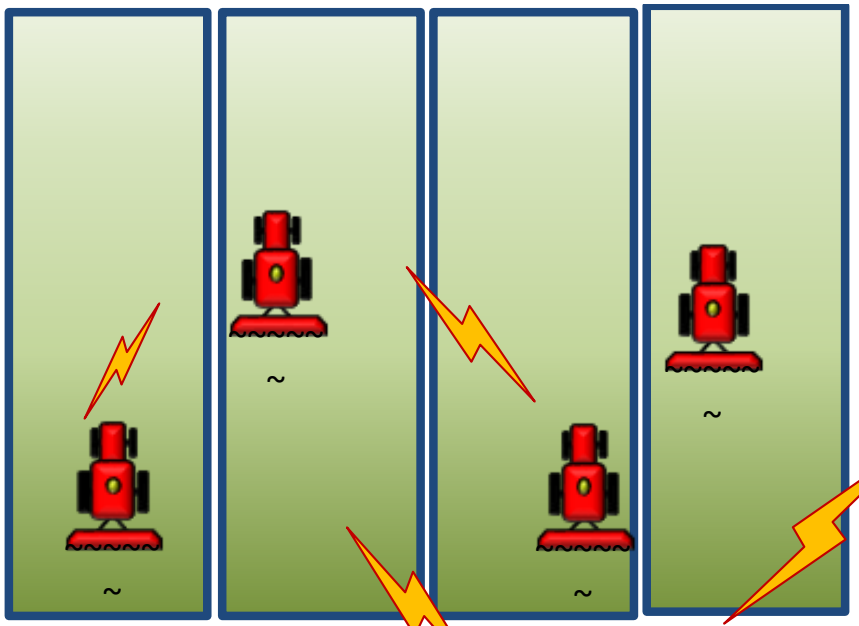
Spraying

Seeding

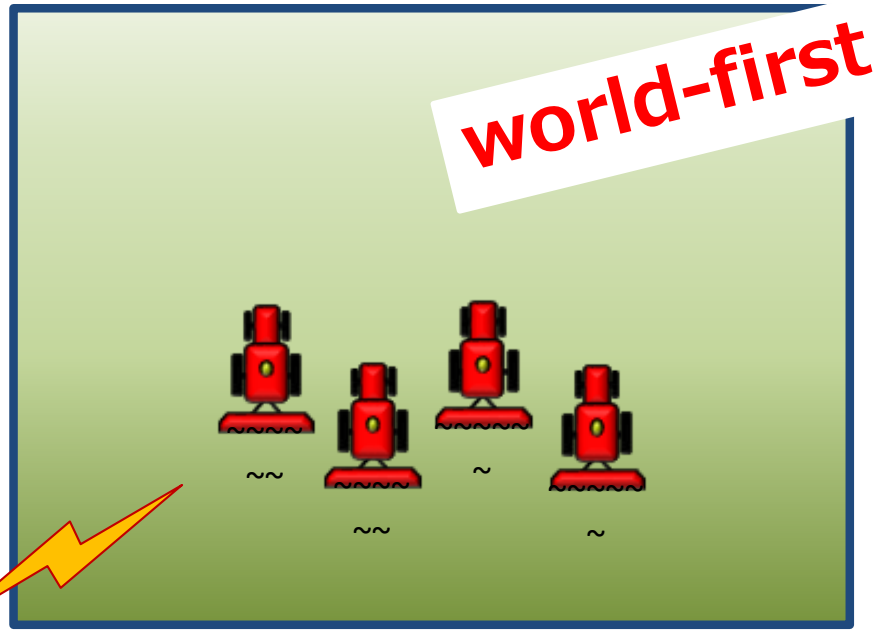
Harvesting

Multi-robot tractor

Multiple small farm lands



Large farm land



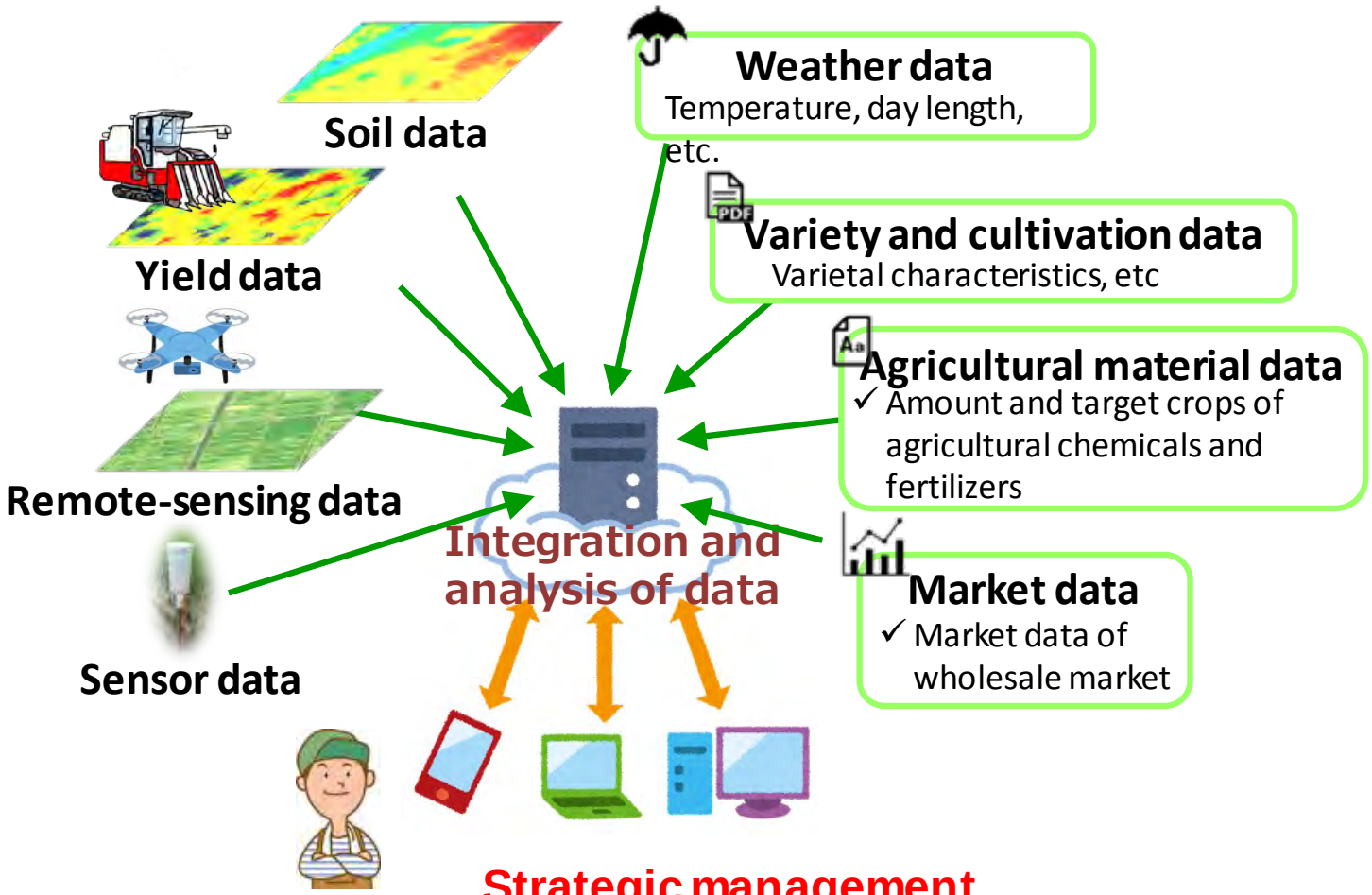
Small size machine is good for both safety and soil compaction

Benefit

Each farmer borrows a small robot tractor each other, and make a flexible and quite efficient work.

Agriculture data platform

- ✓ Although various agricultural ICT services are recently coming out, there is no interconnectivity among the systems of ICT service providers.
- ✓ The useful data of administrative or research organizations scattered in various places, and it is not convenient to use at all.

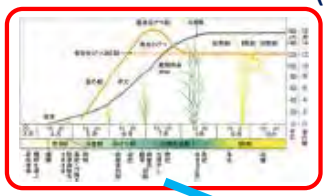


Realizing 'Society 5.0' by smart agriculture

- ✓ Create bigdata by collecting geospatial data and information by sensors and satellite, and analyze the bigdata using AI.
- ✓ Cooperate with SIP "Cyber security", national AI research centers, etc.

GNSS satellite

Various research results

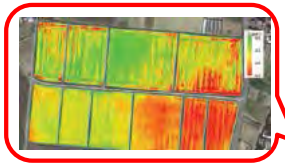


Weather information
(weather forecast & past weather data)

Farmwork planning simulation system

Production support system
Early warning & cultivation management system
Automated water management system
Farmwork information system

Growth information



Drone

rmland information, sales
c.

optimum farming plan

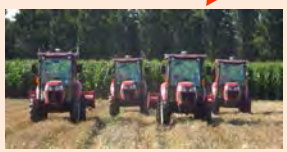
Agricultural data platform

Inflow
Outflow
Reservoir storage

Reservoir bulb

Water management bulb (pouring)

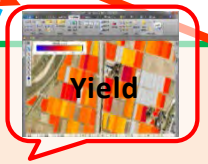
Water temperature
Water depth
Underground water depth
Soil moisture and temperature



Multi-robot tractor

Smart rice transplanter

Smart top-dresser



Yield-sensing combine harvester

Water management bulb (drainage)

Data input from sensors etc.
Operation instructions to smart agricultural machines