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)
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
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<td>Energy</td>
<td>Innovative Combustion Technology</td>
<td>Improving fuel efficiency of automobile engines</td>
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<td>Next-Generation Power Electronics</td>
<td>Integrating new semiconductor materials into highly efficient power electronics system</td>
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<td>Structural Materials for Innovation (SM⁴I)</td>
<td>Developing ultra-strong and –light materials such as magnesium-, titanium-alloys and carbon fibers</td>
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<td>Energy Carriers</td>
<td>Promoting R&amp;D to contribute to the efficient and cost-effective technologies for utilizing hydrogen</td>
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<td>Next-Generation Technology for Ocean Resources Exploration</td>
<td>Establishing technologies for efficiently exploring submarine hydrothermal polymetallic ore</td>
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<td>Automated Driving System</td>
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<td>Infrastructure Maintenance, Renovation and Management</td>
<td>Developing low-cost operation &amp; maintenance system and long life materials for infrastructures</td>
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<td>Enhancement of Societal Resiliency against Natural Disasters</td>
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<td>Cyber-Security for Critical Infrastructures</td>
<td>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.</td>
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<td>Local resources</td>
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<td>Innovative Design/Manufacturing Technologies</td>
<td>Establishing new styles of innovations arising from regions using new technologies such as Additive Manufacturing</td>
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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)

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

Epoch-making varieties

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**

### 2-1) Development of functional health foods
- **Functional healthy foods**
- **Improvement of brain function**
- **Cultivation of DHA-rich algae**
- **Aquaculture feed**
- **DHA-rich seafood**

### 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**

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.

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

2. Locomotion improvement
   Muscle
   Bone

3. Food-sports synergism
   chrono-nutrition

4. Homeostasis maintenance

5. Seaweed

17 items for commercialization
- Lactoferrin (milk)
- Nobiletin (citrus fruits)
- γ-Oryzanol (brown rice)
- Procyanidin (apple)
- Quempherol (mulberry)
- Inulin (kikuimo)
- Rosmalinic acid (Herb)
- SAM \cdot 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)
“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 “Society 5.0” 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.

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

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

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

Farmer
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.
Nationwide weather prediction of 1 km-mesh

Crop status and disease/pest forecasting system

- 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
- Weather information
- Cloud computing

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

Base Station

Water supply valve

Drainage opening

1 km-mesh covered whole Japan
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

- Multi-robot combine harvester
- Precise positioning system using Quasi-Zenith Satellites System (QZSS)

**Standard-size field (30a)**
- Neighbored
- Separated

**Multi-robot system for Japan standard field**
- 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

**Large-size field (>1ha)**
- Human detection for safety

**Multi-robot system for large scale field**
- Reduction of 30% fertilizer application
Robot system by remote observation

Robot management system

Multi-GNSS

Real-time monitoring & Automated documentation

Task planner

GIS map

Start working

Tillage

Weeding

Spraying

Seeding

Harvesting
Multi-robot tractor

Multiple small farm lands

Large farm land

Benefit

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

Small size machine is good for both safety and soil compaction.
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.

![Diagram showing various types of data integration and analysis]

- **Soil data**
- **Yield data**
- **Sensor data**
- **Remote-sensing data**
- **Weather data**
  - Temperature, day length, etc.
- **Variety and cultivation data**
  - Varietal characteristics, etc.
- **Agricultural material data**
  - Amount and target crops of agricultural chemicals and fertilizers
- **Market data**
  - Market data of wholesale market

**Strategic management decision based on data**
Realizing ‘Society 5.0’ by smart agriculture

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

**Agricultural data platform**

- **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

**Farm equipment:***
- Multi-robot tractor
- Smart rice transplanter
- Smart top-dresser
- Yield-sensing combine harvester

**Sensors & Data:***
- Plowed soil depth
- Fertility
- Real-time top-dressing
- Growth
- Water temperature
- Water depth
- Underground water depth
- Soil moisture and temperature
- Inflow
- Outflow
- Reservoir storage

**Water management:***
- Reservoir bulb (pouring)
- Water management bulb (drainage)

**Other Information:***
- Soil fertility
- Growth
- Reservoir planning simulation system
- Optimum farming plan
- Various research results
- Farming field information, sales
- Water management

**Data Input & Operation:**
- Data input from sensors etc.
- Operation instructions to smart agricultural machines