Cross-ministerial Strategic Innovation Promotion Program (SIP)
Technologies for Smart Bioindustry and Agriculture
Research and Development Plan

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Cabinet Office

Bureau for the Promotion of Science, Technology and Innovation

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Overview of the Research and Development Plan

1. Significance and Goals

The “Technologies for Smart Bioindustry and Agriculture” (hereinafter referred to as “this SIP") will contribute to the expansion of Japan's bioeconomy [1] and the improvement of the productivity and competitiveness of the agriculture, forestry, fisheries, and food industries in order to realize the sustainability of food, and will additionally contribute to the realization of the four social visions proposed by “Bio-Strategies 2019 and 2020" ((i) a recycling-oriented society wherein all related industries are working together, (ii) a society wherein sustainable primary production is linked with diversifying needs, (iii) a society wherein raw materials and materials are bioprocessed through sustainable manufacturing methods, and (iv) a society wherein medical care and health care work in tandem to allow social participation over the long term).

Specifically, under the theme of food sustainability, we will build a model of a "smart food system" that will develop autonomously even after the end of SIP and that can contribute to the sustainability of global environmental resources as an example of a circular economy that has changed the conventional chain-like business model of "create," "produce," and "sell" to a recycling-oriented business model.

2. Research Projects

Research consortia that were judged through the stage-gate process by the Program Director (hereinafter referred to as the "PD") in FY 2020 to be unable to build a system for social implementation during the SIP implementation period or to be in a stage of demonstration oriented towards an exit, not in a stage of research, ended in FY 2020. In FY 2021, we will conduct research and development based on the following pillars.

(1) Development of practical technology for data collaboration platforms (smart food systems)

(i) Construction of a smart food chain platform

We will expand the functions of WAGRI, an agricultural data collaboration platform, to mutually provide, share, and utilize various information related to the production, distribution, and consumption of food in real time. The same consortia for the smart agricultural production described in (2) (ii) will implement this construction.

(ii) Construction of a data and information utilization platform that combines the collection of bio-related data generated by this SIP with domestic and international open data.

(iii) Construction of a comprehensive data utilization environment through system integration for (i) and (ii).

(2) Development of technologies to achieve individual task objectives for each of the stages of "development," "production," "sales and consumption," and "resource recycling," with the sustainability of food as a shared task.

(i) [Development] Improving breeding efficiency

Development of a data-driven breeding platform and precision genome editing technology to rapidly and accurately produce needed crops, including varieties that respond to market needs and climate change.

(ii) [Production] Smart agricultural production

Development of intelligent agricultural machinery that can be moved between fields unattended through the use of remote monitoring and that enables operation with a small number of people, as well as development of a data-driven smart production system that improves productivity and reduces food loss and food waste.

(iii) [Sales and Consumption] Promotion of a food-based healthcare industry

Construction and publication of a database that integrates the microbiome and health information of healthy persons, and development of indices and systems to evaluate minor ailments[2].

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[1] Refers to the group of markets and industries that use biotechnology and/or biomass. The Organisation for Economic Co-operation and Development (OECD) predicts that the bioeconomy of OECD countries will reach a GDP of $1.6 trillion by 2030, of which 39% will come from industry and 36% from agriculture (OECD report, "Bioeconomy to 2030”).

[2] A minor physical or mental ailment that is subjectively perceived by the individual, sometimes accompanied by a decrease in productivity. Symptoms caused by illness, regardless of severity, are not included in minor ailments. Examples of minor ailments include decreased energy, irritability, fatigue, anxiety, depression, and physical complaints. Minor ailments can often be remedied by lifestyle changes, including diet. (New standards established in SIP2)

(iv) [Resource Recycling] Utilization of unused agricultural resources

Development of technology to supply C6 sugar, a key substance for the chemical industry, at 30 yen/kg from the inedible parts of agricultural products and food residues, as well as the development of technology to produce highly functional bioplastics from C6 sugar.

3. Implementation System

PD Kobayashi Noriaki is responsible for the formulation and promotion of the research and development plan.

The PD will serve as the chair and the Cabinet Office as the bureau, and the Promotion Committee, consisting of relevant ministries, agencies, and experts, will be responsible for overall coordination.

Using grants provided to the Bio-Oriented Technology Research Advancement Institution (BRAIN) (hereinafter referred to as the "Management Corporation"), the Management Corporation shall engage in research and management in collaboration with the New Energy and Industrial Technology Development Organization (NEDO).

4. Intellectual Property Management

The Intellectual Property Committee established for the Management Corporation and the Intellectual Property Committee established for each consortium shall function effectively to examine intellectual property strategies for social implementation and strategically secure intellectual property based on these strategies, thereby conducting appropriate intellectual property management to promote social implementation and increase the benefits to the public.

In addition, in order to organize strategies for intellectual property management, necessary for the social implementation of genome editing technology, we will survey intellectual property rights relations for original varieties, target genes and genes after modification, genes contained in genome editing vectors, transformation methods, etc., in Japan and in regions targeted for sales and exports such as Taiwan, Hong Kong, Vietnam, and Singapore, targeting tomatoes (high GABA accumulation, parthenocarpy, high sugar content), melons (improved shelf life, high GABA accumulation), and flowering plants (morning glories that flower for two days, double-flowered cyclamens).

5. Evaluations

Prior to an evaluation by the Governing Board at the end of each fiscal year, peer review by external experts and self-examination by research participants and the PD will be conducted to create a system that allows for autonomous improvement. The peer review committee members shall be selected not only for their expertise but also for their ability to evaluate from the perspective of social implementation by evaluating from the user's viewpoint, thus creating a system to obtain evaluations from a broader perspective.

6. Exit Strategy

(1) Strengthening the system for social implementation

In order to support the activities of the PD and the person responsible for social implementation, a social implementation support team will be established directly under the PD with PwC Consulting as the supporting organization. In addition to strengthening support from the strategic coordinator, we will provide concrete support for the activities of the research representatives and the person in charge of social implementation, including clarification for the form of social implementation for each research task, identification of tasks and preparation of a project schedule through to implementation, preparation of a commercialization plan, and implementation of promotion for this plan, in cooperation with the relevant government ministries and agencies.

(2) Practical application of data collaboration platform (smart food system)

・ IT vendors and other businesses will utilize the data and information collaboration platforms of the "smart food chain platform" to be built on WAGRI-DEV to build and provide a variety of food-related services, which will be utilized by farmers and food-related businesses, the end users, to develop value-added agricultural products and processed products, provide advanced quality assurance, improve logistics efficiency, and reduce food loss and food waste from agricultural products through precision shipment forecasting.

・ The research and development data generated by this SIP, which constitutes a smart food system, will run on its own as a public service through WAGRI's collaboration with databases provided by DBCLS and NBDC, including for domestic and international open data collaboration.

(3) Practical use of the results of efforts to address individual tasks

As for the products and services to be introduced to the market as the research results of each of the constituent themes, they will be put to practical use by the companies participating in each consortium or by cooperating companies. For platform-type research results that are widely used by the public and private sectors, such as systems that support the food value chain, we will put them to practical use by inviting a wide range of new business ideas, including from companies participating in each consortium.

(i) Improving breeding efficiency

・By using a data-driven breeding platform, breeders can reduce the tremendous effort involved in acquiring, accumulating, and analyzing trait data, thereby reducing the time and cost required for breeding. Additionally, through the use of this platform we will provide consulting services, such as for the selection of breeding parents, in order to encourage new entries into the breeding business.

・Breeding companies will utilize precision genome editing technology and aim for the domestic production of breeding technology that can respond rapidly to climate change and future food issues.

(ii) Smart agricultural production

・Agricultural machinery manufacturers will commercialize intelligent agricultural machinery equipped with the developed technology.

・Data-driven production technologies will be introduced by farmers themselves and used to improve productivity and profits. In addition, this service will be used by IT vendors to provide farmers with growth and harvest forecast information.

(iii) Promotion of a food-based healthcare industry

・Food manufacturers and companies interested in the health business will use the integrated database of food, microbiome, and health information and the minor ailments evaluation system to provide new functional foods, health management support, and personal health control services.

・ Medical institutions and drug manufacturers will develop new drugs, diagnostics, and therapies by utilizing the integrated database of food, microbiome, and health information.

(iv) Utilization of unused agricultural resources

・We will establish and commercialize joint ventures in Japan and abroad that will be responsible for everything from the collection of unused agricultural resources to their conversion into C6 sugar and other new materials and the provision of these products.

・These processes will be introduced by environmentally conscious chemical companies to produce and provide biodegradable, highly functional materials of biological origin.

7. Other

(1) Cooperation with other related tasks

Research and development related to the “smart food system” will be conducted in collaboration with the "Smart Logistics Service” SIP, the "Big-Data and AI-Enabled Cyberspace Technologies” SIP, and PRISM related tasks.

(2) Public relations activities

In order to promote social implementation, public relations activities will be carried out for related companies, stakeholders in biotechnology and agriculture, and the general public. In addition, we will hold international symposiums on our SIP task and actively publicize our SIP task efforts and the research results from each consortium to the media.

Research and Development Plan

1. Significance and Goals

(1) Background and domestic and international situation

In recent years, technological innovations such as the Internet of Things (IoT), AI, robotics, and genome editing technologies have been advancing, and it is becoming possible to create new markets in the bioindustry and improve productivity in the agriculture, forestry, fisheries, and food industries by utilizing diverse sets and vast amounts of big data.

For bio-related fields, the Organization for Economic Cooperation and Development (OECD) predicts that the bioeconomy will grow to $1.6 trillion in OECD countries by 2030, of which 39% will come from industry and 36% from agriculture. The European Commission has set targets such as the replacement of 30% of petroleum-based products with bio-based products by 2030, and the United States has also presented a vision of replacing 36% of petroleum-based fuels and creating production, jobs, and markets for bio-based products by 2030. In Japan as well, the Council for Integrated Innovation Strategy formulated the “Bio-Strategy 2019" with the overall goal of "realizing the world's most advanced bioeconomy society by 2030" and aims to achieve (1) bio-first thinking, (2) bio-community formation, and (3) bio-data driven processes.

In the agricultural sector, Japan is facing issues such as a decline in the number of workers, as well as their ageing, and the impact of labor shortages on the expansion of scale and stable production. In addition, while progress is being made in the diversification of the needs of actual users and the expansion of the concept of what is required of food products, such as in on-time availability, constant supply, and stable quality, there is a mismatch between supply and demand due to a lack of coordination from the production to distribution stages, and this is causing food loss and food waste. As the global food market expands, it has become necessary to respond to the needs of the market, especially in Asia, but we are still in the middle of developing production, distribution, and export systems to be able to meet these needs. On the other hand, developed countries, mainly European countries and the United States, are developing precision agriculture[2] that meets the objectives and farming patterns of each country by utilizing cutting-edge technologies such as IoT and sensor technologies. In addition to accelerating the development of cutting-edge technologies in precision agriculture, they are beginning to create systems to automatically collect a variety of sensing data from production through to consumption and convert them into big data to form an "information value chain."

In light of the above, it is necessary to build a foundation for innovation in the fields of biotechnology and agriculture by creating tremendous synergy effects through the accelerated promotion of integrated project research conducted collaboratively between industry, academia, government, ministries, and agencies in order to expand Japan's bioeconomy and improve the productivity and enhance the competitiveness of the agriculture, forestry, fisheries, and food industries for the realization of food sustainability.

(2) Significance and policy importance

These “Technologies for Smart Bioindustry and Agriculture” (hereinafter referred to as “this SIP") will contribute to the expansion of Japan's bioeconomy and the improvement of the productivity and competitiveness of the agriculture, forestry, fisheries, and food industries in order to realize the sustainability of food, in addition to contributing to the realization of the four social visions proposed by “Bio-Strategies 2019 and 2020" ((i) a recycling-oriented society wherein all related industries are working together, (ii) a society wherein sustainable primary production is linked with diversifying needs, (iii) a society wherein raw materials and materials are bioprocessed through sustainable manufacturing methods, and (iv) a society wherein medical care and health care work in tandem to allow social participation over the long term).

In addition, in the government's "First Summary of the Data Strategy Task Force,"[3] agriculture is listed as one of the areas under "building platforms in priority areas."

Specifically, under the theme of food sustainability, we will build a model of a "smart food system" that will

[2] A method of agricultural management that aims to improve yield and quality and reduce environmental impact in a comprehensive manner by closely observing and minutely controlling the complex and varied conditions of farmland and crops.

[4] https://www.kantei.go.jp/jp/singi/it2/dgov/dai10/siryou_a.pdf

develop autonomously even after the end of SIP and that can contribute to the sustainability of global environmental resources as an example of a circular economy that has changed the conventional chain-like business model of "create," "produce," and "sell" to a recycling-oriented business model.

The goal is to build a model smart food system that incorporates "dialogue between the production site and the market" into the conventional model, which mainly focuses on the “provider” and which links production, processing, and distribution, and build a system that incorporates post-consumer processing and recycling, by deploying the “Agricultural Data Collaboration Platform (WAGRI)," which is the outcome of the first phase of the SIP, throughout the entire food value chain. Specifically, with a focus on agriculture, the project will construct a smart food chain platform for the mutual utilization of data from production to processing, distribution, sales, consumption, and exports; develop innovative smart agricultural technologies and systems driven by a variety of data; and develop technologies to promote data-driven breeding, with the aim of realizing a health-enhancing society through food and promoting and creating innovative bio-material and product industries. In addition, through these efforts, we aim to realize a sustainably growing society and to revolutionize the productivity and strengthen the competitiveness of the agriculture, forestry, fisheries, and food industries.

In Japan, where the birthrate has fallen particularly low even compared to other countries around the world and the population is aging, it is an urgent issue to improve the quality of life (QOL) of the people and to control the increasing cost of medical care, including nursing care. This research aims to contribute to the reduction of the risk for lifestyle-related diseases, the extension of healthy life expectancy, and the control of increasing medical costs through the promotion and creation of a "food health-care industry" that proposes and provides dietary habits and meals (food products) according to the health status and lifestyle of individuals.

At the same time, by accumulating scientific evidence on the effects of health maintenance and promotion, we aim to increase the added value of Japanese food and domestic agricultural, forest, marine, and food products, and to contribute to increasing the income of producers and expanding exports.

With international agreement on Sustainable Development Goals (SDGs) and global warming countermeasures (the Paris Agreement), the transition from dependence on oil to a sustainable economy and society has become an urgent issue to be addressed on a global scale. This research aims to contribute to global issues by realizing high added value that produces packaging and other related materials at high yields from unused agricultural, forest, and marine resources, such as the inedible parts of agricultural products and residues generated in the food value chain, as well as the development of highly functional materials that use material design calculations and biological functions and are composed of aromatic compounds that do not use petroleum as a raw material.

In addition, the project aims to contribute to the creation of new industries and employment in rural areas through the production of highly functional products using local biological resources.

As the global food market expands, Japan's agriculture, forestry, fisheries, and food industries, which can produce a wide variety of high-quality agricultural, forest, and marine products, are among the industries that are expected to grow the most in the future. This research aims to dramatically increase the productivity of the agriculture, forestry, and fisheries industries in the midst of a shrinking labor force, and to strengthen the competitiveness of the agriculture, forestry, fisheries, and food industries through agile production and distribution and the enhancement of brand strength for domestic agricultural, forest, marine, and food products by sharing and utilizing data from the production stage to the processing, distribution, sales, consumption, and export stages, and by making each operation highly labor-efficient and unmanned through data-driven smart agriculture.

In addition to developing crop varieties that contribute to the expansion of exports and the reduction of food loss, we aim to contribute to the stable supply of food in Japan and around the world by reducing food loss throughout the entire food value chain through agile production and distribution that meet market needs.

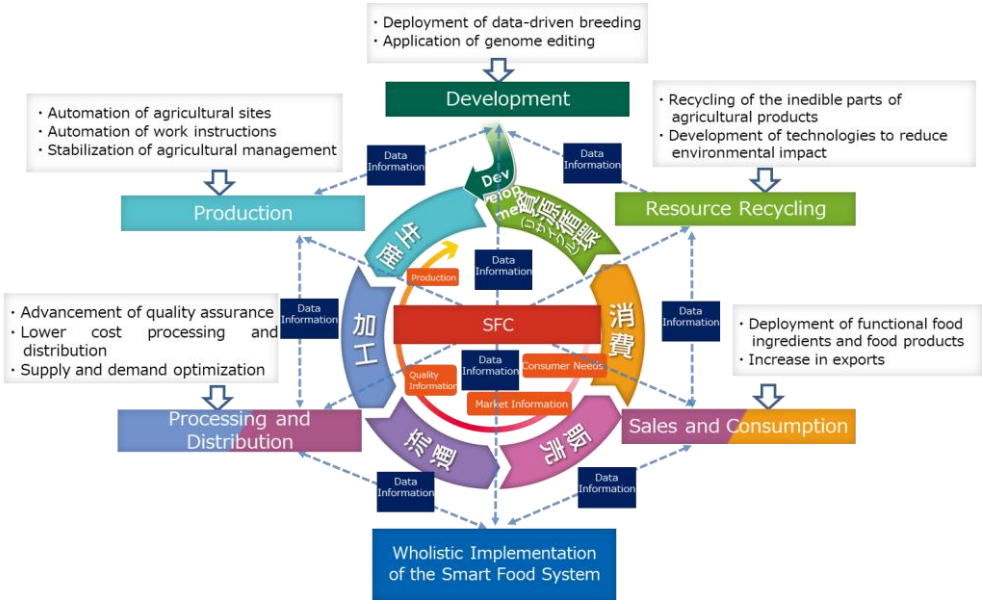


Figure 1-1: Overall concept for the "Technologies for Smart Bioindustry and Agriculture" SIP

(3) Goals and targets

(i) Toward the realization of Society 5.0

- Through the cross-sectional and comprehensive utilization of a large volume of "dynamic" data generated on a daily basis in production, processing, distribution, sales, and consumption, and "static" data, such as research and development data generated in this SIP and existing open data from Japan and abroad, we will solve food-related problems, such as in improving productivity, reducing food loss and food waste, and promoting exports, by sharing and utilizing data and information beyond the boundaries of industry.
- We will construct an architecture that contributes to cross-disciplinary data collaboration that can be widely applied beyond this SIP.
- We will construct a mechanism that allows for the development of varieties responsive to market needs and climate change in a short period of time through data-driven breeding and genome editing technology.
- We will realize technologies that contribute to a resource-recycling society through a combination of extracting useful substances from the inedible parts of agricultural products and functional design, production, and evaluation technologies for innovative biomaterials and highly functional materials using digital technology.
- We will improve productivity through an evaluation system for "minor ailments" (feelings of being unwell that do not reach the level of illness, including presenteeism) that makes use of digital technology and through the improvements in productivity deriving therefrom.
- We will create a market worth more than 240 billion yen by expanding the bioeconomy (including food-related areas), strengthening the technological base, and improving the productivity and competitiveness of the agriculture, forestry, fisheries, and food industries, including by expanding the functional food market.

(ii) Social goals

i. Overall implementation of the smart food system

As the spread of COVID-19 has thrown society into disorder, it will be necessary to continue to take into account the need to coexist with infectious diseases, and strengthening Japan's agricultural infrastructure will be important to maintain the domestic food environment in the event that the flow of people and goods is disrupted.

In addition to seeking to stabilize businesses and strengthen the management base for agriculture by achieving market-driven agricultural management, improving per farmer productivity, developing technologies to deal

with individual tasks, and developing an environment for the utilization of data and information related to the supply chain of primary commodities, this SIP aims to maintain and improve the primary commodity production base through an increase in the number of farmers by building a base that allows for the participation and provisioning of a variety of existing and new services that support farmers in production technology and management areas as well as those who wish to become farmers.

It also aims to contribute to the achievement of SDGs (stable global food supply, a sustainable economy and society, extension of healthy life expectancy (control of increasing medical costs), etc.) by increasing the added value of agricultural products, developing environmentally sustainable agricultural technologies, and presenting a circular economy model by recycling food residues and the inedible parts of agricultural products.

ii. Implementation of individual smart food system component themes

- We will contribute to the reduction of food loss through a need-based food supply using the smart food chain platform.
- We will reduce and effectively utilize untouched food waste by optimizing food products and ingredients within a specific region through the use of data.
- We will contribute to the realization of a carbon-recycling society through the production of high value-added products using the inedible parts of agricultural products.
- We will build a new health system that can suggest foods and dietary habits according to the health status and lifestyle of the individual, and through the utilization of this system, we will contribute to the improvement of productivity by eliminating presenteeism and improving “minor ailments,” or feelings of being unwell that do not reach the level of illness.

(iii) Industrial goals

- By creating new businesses that make use of food-related development data and information, and by developing data-driven technologies and implementing them in society, we will contribute to the expansion of the bioeconomy market*, on a scale comparable with or greater than the expansion of the world’s bioeconomy market (the OECD predicts that the GDP of the bioeconomy of OECD countries will expand to approximately $1.06 trillion by 2030).
  (*Based on the current ratio of Japan's GDP to the GDP of all OECD countries, Japan's bioeconomy GDP will expand to more than 20 trillion yen in 2030.)
- We will contribute to the formation of international hubs that attract human resources and investment from around the world, which is a goal of “Bio-Strategies 2019 and 2020,” by developing data and information platforms.
- We will contribute to the development of an environment in which almost all farmers can practice data-driven agriculture by 2025.
- We will contribute to the acquisition of a 100-billion-yen market by 2025 through the deployment of smart agriculture technologies and systems in Japan and abroad.
- We will contribute to the achievement of the government's export goals for agricultural, forest, marine, and food products (aiming to achieve 2 trillion yen by 2025 and 5 trillion yen by 2030).
- By FY 2025, we will contribute to the promotion and creation of a group of industries that contribute to the maintenance and promotion of the health of the people through food by utilizing the integrated database of health information on agricultural, forest, marine, and food products.
- By 2030, we will contribute to the establishment of a biomaterials market through the development of innovative biomaterials and highly functional chemicals by utilizing the inedible parts of agricultural products.

(iv) Technical goals

(Items without a specified time frame will be achieved by FY 2022)

[Development of Practical Technology for Data Collaboration Platforms (Smart Food Systems)]

I.) Construction of a smart food system

i. We will develop an information sharing system that links the production, processing, distribution, sales,

and consumption stages for agricultural, forest, and marine products

ii. We will expand the functions of the Agricultural Data Collaboration Platform (WAGRI-DEV), accumulate information, and build big data that enables distribution optimization

iii. We will establish a platform (a smart food system) by linking the data infrastructure of bio-databases from DBCLS (Database Center for Life Science)/NBDC (National Bioscience Database Center) and WAGRI-DEV, which supports the smart food chain.

II.) Construction of a bio-related value chain data platform for "smart food systems" to generate value

i. Development of bio-database collaboration and an integrated use system (an integrated database suite) to connect with analysis by AI.

ii. Promotion of the private sector's use of big data from biological information (construct a system to provide the bio-related big data held by national research institutes in a form that is easy for private companies to use).

iii. Promote the use of data obtained from each SIP task and improve the industrial use environment for biodata by developing open and closed systems.

[Development of Technologies to Achieve Individual Task Goals for Each Stage of "Development," "Production," "Sales and Consumption," and "Resource Recycling," with the Sustainability of Food as a Shared Task]

I.) Developing technologies that contribute to sustainability in agriculture: [Development], [Production]

i. Development of breeding technology to rapidly and accurately produce needed crops, including varieties that respond to market needs and climate change.
- Development of a breeding API and other technologies to promote "data-driven breeding" by industry, academia, and the government.
- Development of eight or more varieties and breeding materials that provide new value to consumers and users and promote distribution reform and export expansion.

ii. Development of a data-driven smart production system to provide primary commodities while increasing production efficiency through small-scale operations in response to the needs of the demand side.
- Development of sensing and automatic collection technology for cultivation management information, as well as the development of technology to convert this information into big data on platforms.
- Development of technology to analyze big data and reflect it in production management operations by FY 2021.

II.) Developing technologies that contribute to the sustainability of food ingredients and products: [Distribution and Processing], [Utilization of Information], [Sales and Consumption]

i. Development of information distribution platform technology that enables data linkage from the production stage to the distribution and consumption stages to reduce food loss and food waste and to support market-oriented agriculture.
- Conversion of a variety of related data from production to consumption and export stages into big data and construction of an ICT platform to utilize this data.
- The constructed smart food chain platform will be tested with the participation of farmers and related companies, including those involved in production, distribution, and consumption, to demonstrate the platform's effectiveness, and we will make a projection for social implementation based on the platforms effectiveness (e.g., a 10% reduction in food loss, a 30% reduction in working hours at production sites, etc.).

ii. Development of food ingredients and products that have evidence of their effects on health and that meet market needs, leading to increased value.
- Indexing of minor changes in physical condition, development of a simple, low-cost system that allows for daily measurements, and verification of the effectiveness of the indices and the system.
- Acquisition of scientific evidence on the health maintenance and promotion effects of agricultural, forest, marine, and food products.
- Development of intestinal microbiome data and verification of the effectiveness of food materials for

improving the intestinal environment

- Development of an integrated database of food, microbiome, and health information containing scientific evidence and data on food and health.
- We will use these systems to implement a model service that designs and proposes optimal dietary lifestyles according to the health status of the individual, and we will make a projection for social implementation.

III.) Developing technologies that contribute to sustainability for food-related resources and the environment: [Resource Recycling]

i. Development of next-generation core technologies for the chemical industry using unused resources from the agriculture, forestry, and fisheries industries

- Development of next-generation core technologies for the chemical industry using unused resources from the agriculture, forestry, and fisheries industries (establishment of technologies for extracting and manufacturing, through a series of processes, multiple useful components and materials from unused resources from local agriculture, forestry, and fisheries industries)
- We aim to improve the efficiency of the microbial production of raw material monomers, and we will apply the production of bio-polybenzimidazole (PBI) and polyhydric phenols, which are expected to be super heat-resistant polymers, to secondary cell electrolytes, and conduct demonstration tests.
- We will develop five or more innovative biomaterials and functional products through these technological developments, and make a projection for implementation.

(v) System goals

- Standardization of data for the mutual utilization of agricultural information by different systems and devices.
- Promotion of public understanding of cutting-edge biotechnology, including genome editing
- Evaluation system for the health maintenance and promotion effects of agricultural, forest, marine, and food products, and reflection of scientific evidence in the health function food system (evaluation of functionality according to the characteristics of fresh foods, and consideration of expansion of the health claims allowed on labels)
- Establishment of an integrated health and nutrition food certification system to improve minor ailments
- Formulation of policies for the standardization and international standardization of labeling and ingredient analysis methods in the field of food functionality, and standardization of methods for measuring the intestinal microbiome
- Visualization of the usefulness and environmental performance of products using biological functions and biological resources (establishment of labeling system, etc.)
- International standardization of standards and evaluation methods for biomass plastics, including for biodegradability evaluations (reflecting technologies developed in Japan)

(vi) Global benchmarks

- Conducting global benchmarking surveys for each consortium. Update research regularly based on results.
- The agricultural data collaboration platforms available overseas are mainly configured for large global companies to sell their products. Japan's strength is that a large number of companies participate, and public institutions lead the way. Leveraging this strength, we will be the first in the world to build an open data platform that extends from production to processing, distribution, sales, consumption, and exports, and we will contribute to the enhancement of the brand strength of domestically produced agricultural, forest, marine, and food products, and expand our smart agriculture technologies and systems overseas.
- By taking advantage of our strengths in breeding and cultivation technologies that produce high-quality, high-value-added rice, vegetables, and fruit; exploiting a world-class accumulation of genetic resources from plants; and building a system for promoting "data-driven breeding" through industry, government, and academia that integrates digital technologies, we will develop superior varieties that do not exist in foreign countries in a shorter period of time than before, and contribute to improving the income of

domestic producers.

- Taking advantage of Japan's world-class health and longevity, we will improve the added value of Japanese food and domestic agricultural, forest, marine, and food products by obtaining scientific evidence of their health-promoting effects, thereby contributing to higher incomes for domestic producers and expanding exports.
- We will develop innovative materials and highly functional products through smart cells and capture the market by leveraging our strengths in manufacturing using microbial functions, such as fermentation, and our technology for using biomass, for which Japanese companies have the largest number of patent applications.

(vii) Cooperation with municipalities

- In the development of stable production technology that meets the needs of actual users and consumers in the development and demonstration of an efficient food distribution system using artificial intelligence, we will collaborate with Japan Agricultural Cooperative groups and municipalities that are engaged in data-driven cultivation and quality control.
- In human intervention studies to obtain scientific evidence on the health maintenance and promotion effects of agricultural, forest, marine, and food products, we will collaborate with municipalities and medical institutions that are working to improve the health of local residents.
- In the development of next-generation core technologies for the chemical industry using unused resources from the agriculture, forestry, and fisheries industries, we will construct a collaborative framework for commercialization that incorporates participation from regional municipalities from the start of research and development.

2. Research and Development Projects

In order to expand Japan's bioeconomy and achieve Japan's SDGs, the following research and development will be carried out with the aim of realizing a health-promoting society through food; achieving innovation in the agriculture, forestry, fisheries, and food industries; and realizing a sustainably growing society.

I. [Development of Practical Technology for Data Collaboration Platforms (Smart Food Systems)]

(1) Construction of a smart food chain platform

We will expand the functions of WAGRI, an agricultural data collaboration platform, to mutually provide, share, and utilize various information related to the production, distribution, and consumption of food in real time.

(2) Construction of a bio-related value chain data platform

Construction of a data and information utilization platform that combines the collection of bio-related data generated by this SIP with domestic and international open data.

(3) Construction of a comprehensive data utilization environment through system integration for (1) and (2).

II. [Development of Technologies to Achieve Individual Task Goals for Each Stage of "Development," "Production," "Sales and Consumption," and "Resource Recycling," with the Sustainability of Food as a Shared Task]

(1) [Development] Improving breeding efficiency

Development of a data-driven breeding platform and precision genome editing technology to rapidly and accurately produce needed crops, including varieties that respond to market needs and climate change.

(2) [Production] Smart agricultural production

Development of intelligent agricultural machinery that can be moved between fields unattended through the use of remote monitoring and that enables operation with a small number of people, as well as development of a data-driven smart production system that improves productivity and reduces food loss and food waste

(3) [Sales and Consumption] Promotion of a food-based healthcare industry

Construction and publication of a database that integrates the intestinal microbiome and health information of healthy persons, and development of indices and systems to evaluate minor ailments[2].

(4) [Resource Recycling] Utilization of unused agricultural resources

Development of technology to supply C6 sugar, a key substance for the chemical industry, at 30 yen/kg from the inedible parts of agricultural products and food residues, as well as the development of technology to produce highly functional bioplastics from C6 sugar.

I. [Development of Practical Technology for Data Collaboration Platforms (Smart Food Systems)]

I-(1) Construction of a smart food chain platform

[Summary]

This is the data collaboration platform that supports the entire SIP task. The platform is to be built through cooperation between WAGRI-DEV (II-(2)-1), which supports the smart food chain, and the bio-database data infrastructure from DBCLS/NBDC (I-(2)).

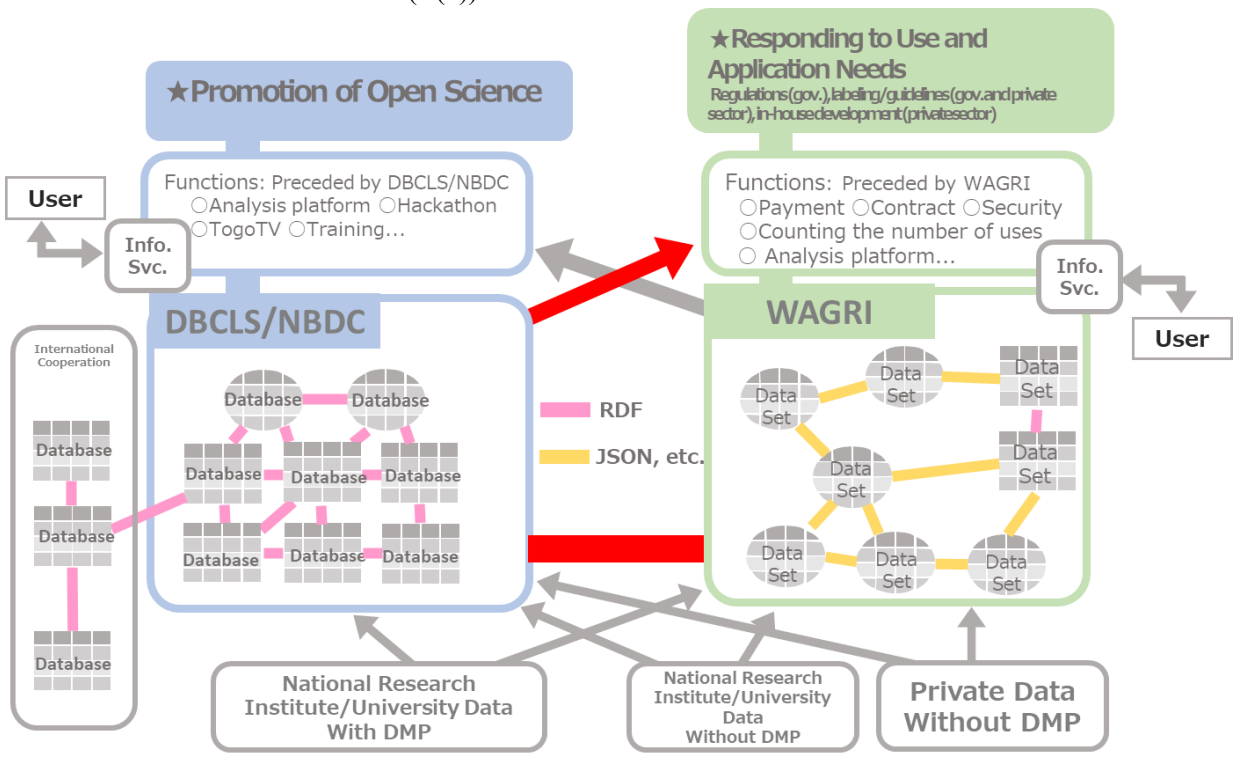


Figure 2-1: Overview of biodata collaboration and expected issues to be addressed

I-(2) Construction of a bio-related value chain data platform

Construction of a bio-related value chain data platform for the “smart food system” to generate value: [Construction of a Value Chain Data Platform]

Construction of an integrated bio-digital data distribution platform that consolidates and links database and data

[Summary]

In addition to developing technologies to provide “information” as a basis for the creation of innovation through the integration of biotechnology and digital technologies, we will conduct research studies and provide information to promote the use of biotechnology. These platforms will also be used in research and development for other tasks in relevant projects.

In order to promote the private sector use of bio-related data held by national research institutes, we will develop and construct APIs for bio-data collaboration based on surveys of the needs of industry.

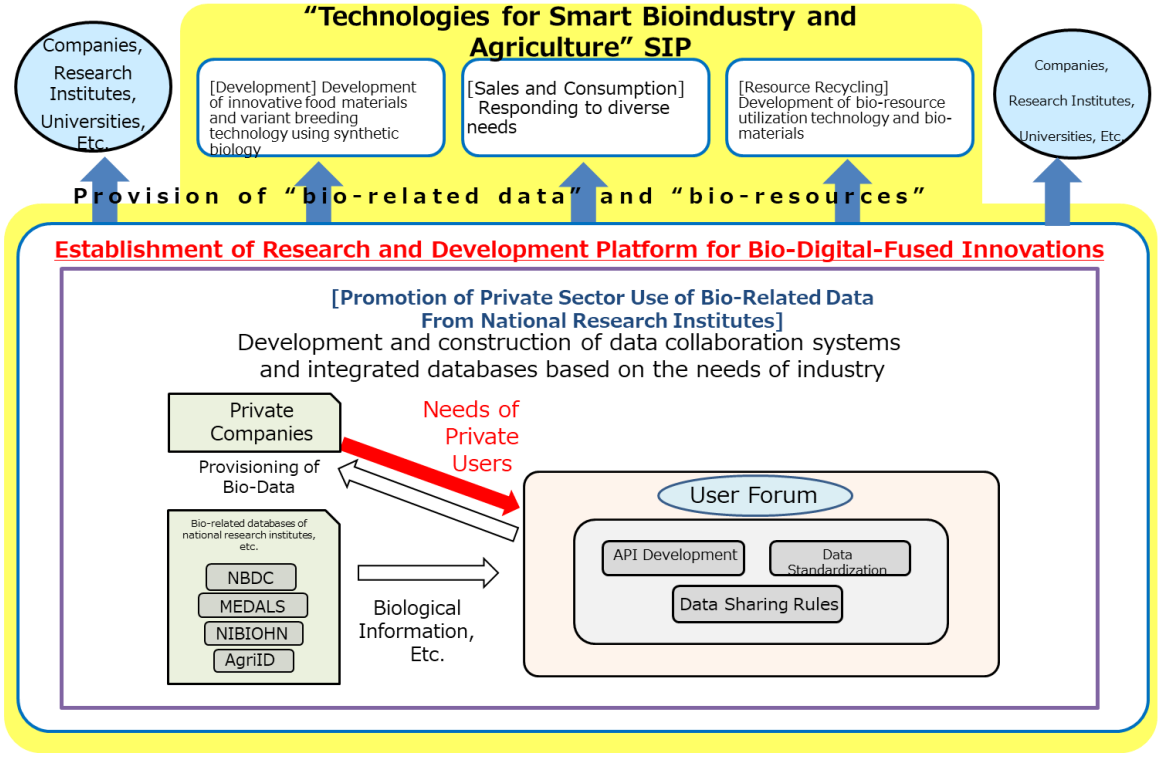


Figure 2-2: Visualization of the construction of a research and development infrastructure to create innovation that integrates biotechnology and digital technology

[Necessary Expenses]

FY 2018	¥185M
FY 2019	¥142M
FY 2020	¥121M
FY 2021	¥86M

[Research and Development Details]

We will conduct surveys on the needs of industry regarding the use of biological information, and promote the development of APIs for data collaboration for bio-related databases and bio-related DB to be constructed in this SIP task. We will develop applications for integrated analysis using AI, and build a bio-database collaboration and integrated use system (an integrated database suite) equipped with AI analysis functions. The establishment of security infrastructure, such as blockchain technology, and the creation of a mechanism for data provisioning will encourage the sharing of data from biotechnology companies for cooperative areas and will further accelerate innovation.

In order to develop fields in which Japan is strong, we will develop an infrastructure environment that facilitates the effective acquisition of data from the integrated database suite and facilitates the use of the data in AI analyses. We will introduce open and closed systems and stratify data into those that are open to the public and those that are open to user forums. And in addition to accelerating efforts to integrate bio-databases, we will promote efforts to develop and construct bio-digital collaboration hubs through the promotion of bio-database use.

[Participating Organizations]

Principal Researcher: Ohara Yuji (Research Organization of Information and Systems)

Research Organization of Information and Systems; National Agriculture and Food Research Organization; National Institutes of Biomedical Innovation, Health and Nutrition; National Institute of Technology and Evaluation; Institute of Physical and Chemical Research (RIKEN); Kazusa DNA Research Institute; Hitachi Ltd.

[Goals for FY 2021]

- Continue the conversion of data into RDFs by joint institutions, and evaluate and improve APIs for

searching across multiple databases. Complete the prototype of the bio-database collaboration and integrated use system (the integrated database suite) equipped with AI analysis functions developed in the third year. Test run the prototype and identify areas for improvement. Continue biodata standardization and storage in open and closed systems. Continue trials of the security infrastructure by companies, obtain the provision of possible cooperative areas, and start and verify the provisional operation of the security infrastructure. Reflect the compiled opinions on the data for cooperative areas in the security infrastructure.

- For microbial risk information during food production, start to develop a database for *Bacillus cereus*, one of the bacteria that cause food poisoning, to support contamination prevention and rapid responses, by accumulating case data and consolidating existing information. In addition, identify needs related to microorganisms that affect quality in the craft beer production process, and from among the information on microorganisms accumulated by major breweries, begin to develop information that is useful for craft beer production.

[Final Goals]

- Formally release the integrated database suite that has been developed, and continuously receive feedback to improve the system. Continue biodata standardization and storage in open and closed systems. Identify improvements for the security infrastructure and begin operating it in conjunction with the open and closed systems. Continue efforts to acquire providable data for cooperative areas. Integrate the databases that already exist in Japan so that they can be utilized by society and industry; establish a bio-digital distribution hub; and investigate mechanisms to continue system operation autonomously.
- For microbial risk information during food production, start to release a database for *Bacillus cereus*, one of the bacteria that cause food poisoning, by accumulating case data and consolidating existing information to support contamination prevention and rapid responses. In addition, identify needs related to microorganisms that affect quality in craft beer production, and from among the information on microorganisms accumulated by major breweries, collect and organize information that is useful for craft beer production.

[Social Implementation Goals]

- Through the creation of open and closed systems for biodata, the enhancement of international hubs for open data, and the creation of examples of analysis that combine closed and open data from companies, we will seek to contribute to the formation of international hubs that attract human resources and investment from around the world, which is a goal of "Bio-Strategies 2019 and 2020," by developing data and information platforms.
- We will provide information on harmful microorganisms and their contamination risks, and aim to reduce food loss and food waste and expand the market in Japan and abroad by improving quality control efficiency, ensuring stable product manufacturing, and preventing microbial accidents.

II. [Development of Technologies to Achieve Individual Task Goals for Each Stage of “Development," “Production," “Sales and Consumption," and “Resource Recycling," with the Sustainability of Food as a Shared Task]

II-(1) Developing technologies that contribute to sustainability in agriculture: [Development], [Production]

II-(1)-1 Improving breeding efficiency

[Development] Development of innovative food materials and breeding technologies

“Establishment of platform technology for the promotion of ‘data-driven breeding’ and crop development utilizing this technology”

[Summary]

In order to strengthen Japan's seed development system, we will develop technologies to promote "data-driven breeding," which is the development of varieties using big data for breeding and new breeding technologies, and we will also develop crop varieties that create new value for consumption and distribution and major crop varieties that contribute to the achievement of the country’s Sustainable Development Goals (SDGs). Furthermore, in addition to developing and demonstrating new genome editing technologies, we will conduct sociological research on the public's understanding of biotechnology and provide this information to stakeholders, with the aim of improving social receptivity.

[Necessary Expenses]

FY 2018	¥355M
FY 2019	¥272M
FY 2020	¥235M
FY 2021	¥286M

i. Development of breeding technology to rapidly and accurately produce needed crops, including varieties that respond to market needs and climate change.

ii. Development and demonstration of novel genome editing technologies

iii. Survey of public understanding of biotechnology, provision of information, and improvement of social receptivity

[Research and Development Details]

We will promote "data-driven breeding" through cross-disciplinary industry-academia-government collaboration for variety development that allows for the rapid and accurate production of varieties with high market demand by utilizing big data for breeding, data obtained from the "smart food chain platform," and new breeding technologies (genomic selection, genome editing, etc.). To this end, we will develop technologies such as a breeding API and through trials and verifications for "data-driven breeding," we will develop, in a shorter period of time and at lower cost than in conventional breeding, crop varieties that create new value that had been difficult to create previously. The target traits are those controlled by a number of genes, such as high value-added (transportability, shelf life, color retention, etc.) and high quality (high sugar content, large fruit, seedlessness, ease of peeling, suitability for processing, etc.) traits that provide new value to the diet, and we will further develop varieties by combining multiple traits. In conventional breeding, for example in the case of fruit trees, it takes several years to several decades to grow the tree from seed and produce fruit, and after harvesting a sufficient amount of fruit, these traits are evaluated by cutting the fruit open and tasting it, but in data-driven breeding, specimens that do not meet breeding goals can be discarded at the young seedling stage, before fruit is produced.

We will develop genome-edited crops by simultaneously modifying multiple traits, which has yet to be achieved anywhere in the world, and we will develop and demonstrate genome-editing technology that enables the precise rewriting of DNA. While listening to the opinions of actual users, such as seed and nursery companies, we will use internationally acclaimed varieties (melons with improved shelf life, tomatoes with a high accumulation of GABA, etc.) as model cases and establish a path from development to marketing, while also expanding to other products to which this technology can be applied.

In order to promote the use of biotechnology, we will conduct sociological research studies on the public's understanding, in addition to conducting surveys on technology, intellectual property, and regulations related to

cutting-edge biotechnology and providing this information to stakeholders. We will continue exhibiting genome edited morning glories, promoting their use in education, and exchanging opinions with actual users. In addition to the efforts up to the present, we will enhance the dissemination of information from the perspective of the mass media in order to strengthen collaboration with the mass media, and we will plan and hold workshops for the mass media. Furthermore, in order to strengthen cooperation with the ministries, such as cooperation with the outreach activities of the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Health, Labour and Welfare, the SIP will act cooperatively to provide materials, and the comments obtained will be fed back into the SIP's information dissemination. The SIP will also make proposals for cooperation to foster understanding of the results among the projects of the ministries.

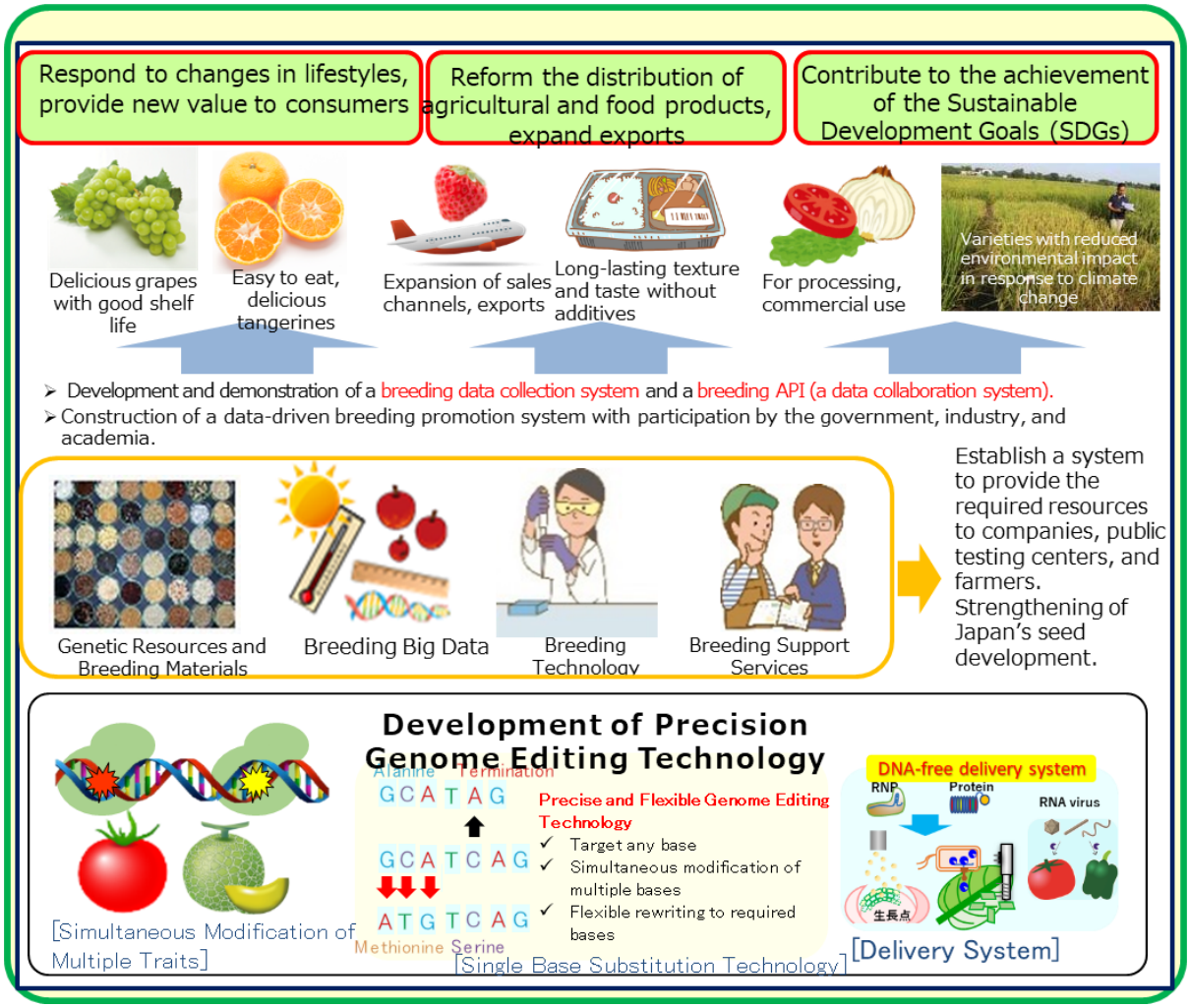


Figure 2-3: Visualization of technological development to promote "data-driven breeding".

[Participating Organizations]

Principal Researcher: Ishimoto Masao (National Agriculture and Food Research Organization)

National Agriculture and Food Research Organization; Nisshin Flour Milling Inc.; Nihon Shokuhin Kako Co. Ltd.; Kaneko Seeds Co. Ltd.; Watanabe Seed Co. Ltd.; ListenField Co., Ltd..; Fukui Agricultural Experiment Station; Fukuoka Agriculture and Forestry Research Center; Tochigi Agricultural Experiment Station; Chiba Prefectural Agriculture and Forestry Research Center; Kumamoto Prefectural Agricultural Research Center; Wakayama Fruit Tree Experiment Station; Aomori Prefectural Industrial Technology Research Center; Tottori Horticultural Experiment Station; Kazusa DNA Research Institute; Kyoto Prefectural University; University of Tokyo; Meiji University

National Agriculture and Food Research Organization; University of Tokyo, University of Tsukuba; Nissin Flour Milling Inc.; Nippon Norin Seed Co.; Kaneka Corporation; Sanatech Seed Co., Ltd.; Sumitomo Chemical Co., Ltd.; Sumika Agro Tech Co., Ltd.

National Agriculture and Food Research Organization; University of Tsukuba; Nagoya University; International

Christian University; Hokkaido University; Centcrest IP Attorneys; Japan Association for Techno-innovation in Agriculture, Forestry and Fisheries; Life & Bio Plaza 21; Leave a Nest Co., Ltd.

[Goals for FY 2021]

(i) Development of platform technology for the promotion of "data-driven breeding" and the development of valuable new crop varieties utilizing this technology

- Development of platform technology for the promotion "data-driven breeding"
  We will develop an improved versions of the breeding API and data analysis methods based on feedback from cooperating private companies and public institutions. We will connect the databases of public research institutes and independent organizations with breeding APIs, and implement and improve the breeding support system. We will implement genotyping support for analysis targets, such as for the mating mothers and segregating populations of the seventh crop.

- Development of valuable new crops using platform technology for the promotion of "data-driven breeding"
  For each crop, we will acquire genomic data using next-generation sequencers and evaluate and collect phenotypic data, and we will construct a prediction model. We will conduct selection based on the predictive model and evaluate the effectiveness of the selection. We will narrow down the candidate genes and try to establish more useful trait prediction methods. Additionally, we will evaluate the effectiveness of the preceding promising lines as breeding material.

(ii) Development of precision genome editing platform technologies to contribute to the bioindustry and agriculture

- Development of precision genome editing technology and genome editing enzyme delivery technology
  We will establish genome editing technology that can accurately modify genomes at the single nucleotide level, and we will build a system to supply large quantities of donor DNA for the construction of efficient targeted recombination systems. We will also precisely regulate gene expression by editing the genome of cis-regulatory elements in five new target genes, develop technology to deliver genome-editing enzymes using bacteria, and optimize viral vectors for base substitution in eggplant crops. Furthermore, we will develop technology to deliver genome-editing enzymes by physical methods and obtain genome-edited wheat through the use of TALEN proteins.

- Development of novel genome editing enzymes
  We will establish a CRISPR-Cas system with extended target sequences and produce BlCas9 mutants with different protospacer adjacent motif (PAM) specificities, based on the information obtained from crystal structures.

- Development of genome-edited crops with multiple improved traits
  As part of the development and practical application of innovative molecular breeding techniques for biotech potted flowers using genome editing, we will complete two dwarf varieties of genome edited morning glories. We will obtain two regenerated plant lines by introducing genome editing vectors into two varieties of cyclamen. We will run trial displays of the genome edited morning glories. In addition, we will also produce tomatoes endowed with multiple useful traits and melons that accumulate high amounts of GABA.

(iii) Promotion of public understanding of biotechnology and research studies for technology trends

- We will analyze and organize information on the bioeconomy collected by members, create content for dissemination, and continue to disseminate information. In particular, we will establish a new English version of the website and enhance the content for children while also enhancing information dissemination from the perspective of the mass media. In addition, we will continue to measure the effectiveness of information dissemination and provide feedback on the methods of dissemination and the content disseminated.

- Based on the results of AI analysis, we will begin to provide feedback to improve our information dissemination methods and content.

- A total of at least 10 model classes will be held using the developed teaching materials, including teaching materials on the theme of bio-derived chemical products and functional foods, and the teaching materials will be improved based on the opinions and impressions of teachers and students. We will produce, distribute, and publish article content for teachers and students on the theme of bio-derived chemical products.

- We will release and distribute the improved versions of the teaching materials sequentially on the website. We will plan and produce videos on genome editing. We will compile and publish an interim report for activities through to year three. Based on these results, we will strengthen cooperation with related ministries.

[Final Goals]

(i) Development of platform technology for the promotion of "data-driven breeding" and the development of valuable new crop varieties utilizing this technology

- Development of platform technology for the promotion "data-driven breeding"
  We will realize the adoption of and a full-scale operations start for data-driven breeding methods in actual breeding sites. Through the optimization of breeding strategies and decision support for the breeding process, we will promote an integrated "data-driven breeding" platform that significantly reduces the breeding period and breeding costs compared to conventional breeding for varieties that meet market needs, and we will establish a system for promoting data-driven breeding. After the project is completed, the use of the data-driven breeding platform to be developed will be offered as a fee-based service to a wide range of individuals besides the cooperating companies and public institutions.

- Development of valuable new crops using platform technology for the promotion of "data-driven breeding"
  We will develop a total of eight or more varieties and breeding materials for fruit trees and vegetables that will promote distribution reform and export expansion through the implementation of data-driven breeding.

(ii) Development of precision genome editing platform technologies to contribute to the bioindustry and agriculture

- Development of precision genome editing technology and technology for introducing genome editing enzymes
  We will deliver Cas9-base editors into plant cells as Cas9/gRNA complexes to establish an efficient base substitution delivery system that is free of foreign DNA. We will demonstrate that we can rewrite the base sequence as planned for practical crops. In the control of gene expression through genome editing, we will demonstrate that we can modify phenotypes as planned. We will demonstrate that a novel genome-editing enzyme can be used to create genome-edited populations with continuous phenotypes by setting multiple target sites in conserved sequences. In developing the technology for delivering genome-editing enzymes, we will successfully perform genome editing for the endogenous genes of practical crops using bacteria. We will also obtain tomato plants for which base substitution has been delivered through a viral vector. In addition, we will complete the technology for directly delivering genome-editing enzymes based on a new methodology.

- Development of novel genome editing enzymes
  We will broadly examine the effectiveness of the BlCas9-base editor and expand the target sequences.

- Development of genome-edited crops with multiple improved traits
  We will propagate two or more genome-edited varieties of morning glories. We will evaluate two varieties of genome edited cyclamen. For the production of tomatoes and melons imparted with multiple useful traits, we will begin cultivation of commercial tomato F1 hybrids in special netted houses (i.e., netted houses designed for genetically modified plants). For the melons, we will produce an F1 parental line.

(iii) Promotion of public understanding of biotechnology and research studies for technology trends

- We will establish a website to disseminate information on genome editing to the media, the education sector, industry, and the government; practice effective information dissemination and communication using this website; and establish a continuous management system for the website.

- We will develop educational programs (teaching materials, etc.) for the utilization of the bioeconomy, focusing on genome edited foods, bio-derived chemical products, and functional foods, and we will publish and disseminate these programs while putting them into practice in educational settings.

[Social Implementation Goals]

(i) Development of platform technology for the promotion of "data-driven breeding" and the development of valuable new crop varieties utilizing this technology

- By using a data-driven breeding platform, breeders will reduce the tremendous amount of labor involved

in acquiring, accumulating, and analyzing trait data. In addition, IT vendors will use this platform to provide consulting services, such as for the selection of breeding parents, to breeders, including new breeders.

(ii) Development of precision genome editing platform technologies to contribute to the bioindustry and agriculture

- The goal is for breeders to utilize precision genome editing technology to produce high value-added varieties in a short period of time.

iv. Development of a data-driven smart production system to provide primary commodities while increasing production efficiency through small-scale operations in response to the needs of the demand side.

II-(1)-2 Smart agricultural production

[Production] Development of a smart production system

To be implemented in an integrated manner in conjunction with II-(2)-1 below.

[Summary]

We will construct a "data platform for the smart food chain" through the development of a data system that shares information on everything from production to processing, distribution, sales, consumption, and exporting across industries, and through the development of technologies that enable production and supply that accurately respond to needs.

In particular, the part related to production will be performed in II-(1)-2 [Production] Development of a smart production system.

II-(2) Developing technologies that contribute to the sustainability of food ingredients and products: [Distribution and Processing], [Utilization of Information], [Sales and Consumption]

i. Development of information distribution platform technology that enables data linkage from the production stage to the distribution and consumption stages to reduce food loss and food waste and support market-oriented agriculture.

II-(2)-(1) [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system.

"Construction of a smart food chain that enables optimization by linking data from the production stage to the distribution and consumption stages."

[Summary]

We will construct a "data platform for the smart food chain" through the development of a data system that shares information on everything from production to processing, distribution, sales, consumption, and exports across industries, and through the development of technologies that enable production and supply that accurately respond to needs.

The part related to production will be performed in (1)-2 [Production] Development of a smart production system. The parts related to processing, distribution, sales, consumption, and exports will be divided into (2)-1 [Distribution and Processing] Development of technologies for cost reduction and optimization and (2)-2 [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system. This will be done within the overall task of "constructing a smart food chain that enables optimization through data linkage from the production stage to the distribution and consumption stages."

Specifically, we will construct an information transmission system that links information bidirectionally from the production stage to the consumption stage in the distribution process, in addition to developing technology for matching production and demand in Japan and abroad, and production technology that enables shipments in response to demand. We will also develop technologies and systems to realize data-driven smart production, such as feed-forward cultivation management technology based on crop growth information, soil data, and environmental forecasts.

This task deals with advanced ICT/AI technology, a variety of big data such as agricultural and biological information, and biotechnology in an integrated and complex manner, and requires collaboration among industrial, agricultural, and biological research institutes and universities, as well as private companies, through collaboration with ministries and agencies.

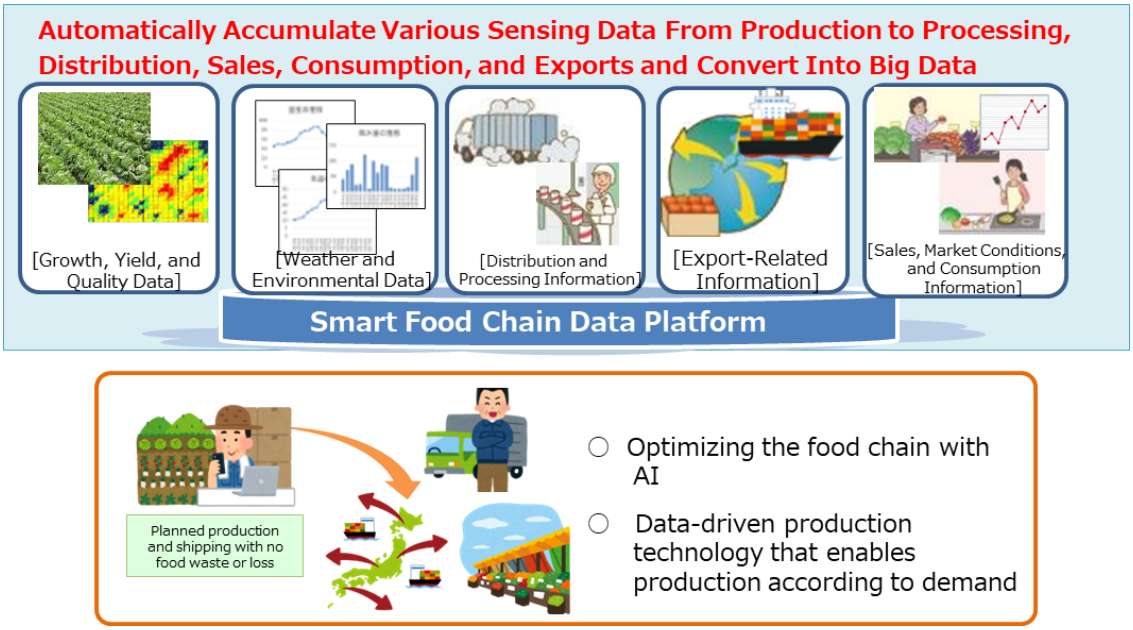


Figure 2-4: Visualization of the construction of a data platform to contribute to the smart food chain

[Necessary Expenses]

FY 2018	¥1,164M
FY 2018, Corrected	¥200M
FY 2019	¥1,086M
FY 2020	¥759M
FY 2021	¥837M

[Research and Development Details]

A new smart food chain, which includes everything from production to processing, distribution, sales, consumption, and exports, will be constructed to share information on domestic and international needs and to enable a production system that meets these needs. This smart food chain will create new value by ensuring reliability through integrated traceability and tampering prevention. It will also reduce food loss by enabling appropriate stock and shipment management in the production stage, stable supply through optimal networking among production areas, optimization of distribution based on production information, and stabilization of the supply-demand balance. In addition, the smart food chain will enable the promotion of exports by providing foreign consumer preference feedback to production. In order to realize these goals, the following technologies will be developed.

[Production]

In order to realize small-scale operations at production sites, we will develop big data that includes information on the agricultural environment and on crops, and develop technology to move between fields under remote monitoring and for unmanned and safe automatic driving, and an intelligent system that can predict and discern crop growth and quality. In particular, with an eye toward deployment in the mountainous regions of Japan and East Asia, we will work to make unmanned driving technology for farm roads more robust even in environments where GNSS signal reception is unstable, and to make it possible to apply this technology to a wide variety of products and terrains. In addition, we will demonstrate the effects of introducing the developed technology and clarify the effects of improving the profitability of agricultural management based on these results.

[Distribution and Processing], [Utilization of Information]

(i) By developing an information sharing system that links the production, processing, distribution, sales, and consumption stages for agricultural, forest, and marine products, expanding the functions of the Agricultural Data Collaboration Platform, and accumulating information, we will develop big data that will enable distribution optimization. In addition, we will develop AI-based technology for matching production and demand both in Japan and abroad. In particular, we will construct the architecture for a smart food chain and implement a project for the demonstration of joint logistics to expand exports of agricultural products. We will construct the architecture from export demonstrations from various crops and from other logistics data.

(ii) In addition to the elemental technologies mentioned above, we will develop an ICT platform that covers the entire process from production to consumption, capable of supplying primary commodities with guaranteed reliability at a price, quantity, quality, and timing that meets demand. We will reduce food loss and stabilize supply and demand for use cases through trial operations. The export demonstration project in (1) will be used as a use case.

(iii) We will clarify the advanced nature of WAGRI-DEV in the following points, and concretize the model for commercialization. First, we will achieve unified data linkage not only at the production stage but also throughout the entire food chain, including in breeding, distribution, and exports, and we will go beyond simply providing centralized information by implementing quality certification through JAS. In addition, by making the precision shipment forecasting system able to link shipment prediction data with the systems of distributors and retailers through WAGRI-DEV, we will aim to construct data linkages that reach from production to consumption. In addition, by assuming a B2B2C type business scheme (Figure 2-5), which is the relationship between the platform, service providers, and end users, we will construct a commercialization model and conduct more specific studies regarding costs and the conditions for establishing the platform. To increase the number of users, we will show that this leads to increased productivity and added value through JAS certification.

In addition, we will collaborate with the "Smart Logistics Service" SIP in realizing the technologies necessary to improve the efficiency of the distribution process for primary commodities (such as for shortening the lead

time to supply).

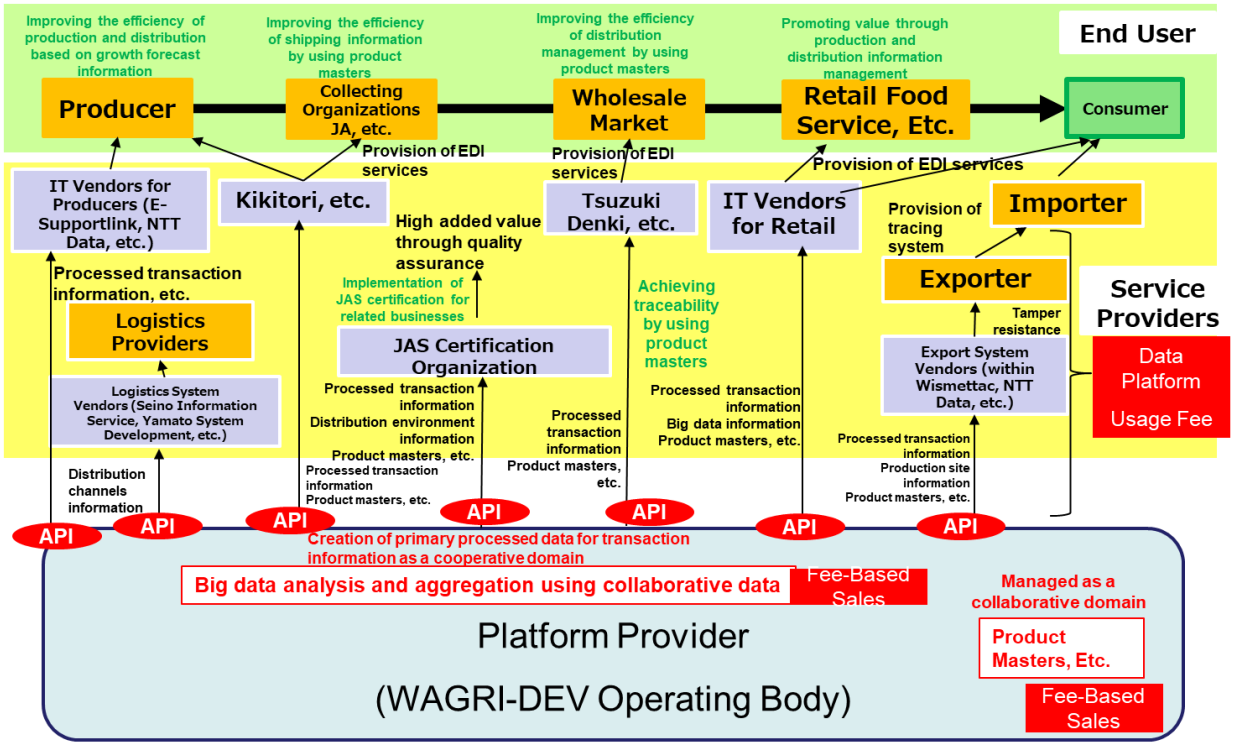


Figure 2-5: WAGRI-DEV's B2B2C business scheme

[Participating Organizations]

Principal Researcher: Harata Hisatomi (National Agriculture and Food Research Organization)

National Agriculture and Food Research Organization; Keio Research Institute at SFC; Akita Prefectural University; Gifu University; Kindai University; Chiba University; Mie University; Yamagata University; Kyoto University; University of Tokyo; Ritsumeikan University; Hokkaido University; Kitami Institute of Technology; Azabu University; Kagoshima University; Kyushu University; Tokyo University of Agriculture and Technology; University of Miyazaki; Nagoya University; Tohoku University; University of Tsukuba; NEC Corporation; NEC Solution Innovators Ltd.; Fujitsu Limited; Fujitsu Research Institute; Agri Open Innovation Practical and Applied Research Center; Kewpie Corporation; VisionTech Inc.; Academic Express Inc.; Hitachi Zosen Corporation; Space-Agri Corporation; E-Support Link, Ltd.; Agri Communications Co. Ltd.; Zukosha Co., Ltd.; Calbee Potato Inc.; Suzuki Motor Corporation; Shibuya Seiki Co. Ltd.; Toyo Noki K.K.; Iseki & Co. Ltd.; Yanmar Agri Co. Ltd.; Kubota Corporation; Mitsubishi Mahindra Agricultural Machinery Co. Ltd.; NTT Data Corporation; Panasonic Corporation; Takii & Co. Ltd.; Mitsubishi Chemical Corporation; Kikkoman Corporation; Horiba., Ltd.; Yamato Holdings Co. Ltd.; ZENRIN-Datacom Co. Ltd.; NEXTY Electronics Corporation; Maruyama Mfg. Co. Inc.; Nishi-Nippon Railroad Co. Ltd.; Oishi Sangyo Co. Ltd.; Kyushu Agricultural Products Trading Co. Ltd.; JA Memuro; JA Shikaoi; Tokachi Federation of Agricultural; Keyware Solutions Inc.; Okinawa Cellular Agri & Marche Corporation; Kanagawa Agricultural Technology Center; Kumamoto Prefectural Agricultural Research Center; Hokkaido Research Organization; National Institute of Advanced Industrial Science and Technology; Institute of Physical and Chemical Research (RIKEN); Distribution Economics Institute of Japan (DEI); Fukuoka Agriculture and Forestry Research Center; Kagoshima Prefectural Osumi Food Technology Development Center; JA Chikuzen Asakura; JA Yatsushiro Area; JA Ibusuki

[Goals for FY 2021]

- We will provide the test system to all members of the consortium, and conduct verification of the entire smart food chain from the production site to distribution and sales, in addition to examining issues related to the dissemination of this system based on usage needs in turn premised on social implementation and examining a sustainable operations system. We will expand and implement the functions of the required data entry and reference systems, such as those for receiving and shipping applications, viewers, and masters. Furthermore, we will examine the possibility of utilizing the smart food chain platform (SFP) for the application of the JAS Law. We will utilize a quality control data collaboration platform to contribute

to the promotion of infection prevention measures. We will integrate SFP and biodata collaboration platforms.

- We will demonstrate, evaluate, and improve functions oriented toward the social implementation of production information linkages (from production to shipping); demonstrate and verify databases and systems from production to shipping, distribution, and consumption (from shipping to consumption); establish development and demonstration fields; construct a domestic joint logistics system; promote standardization, including international standards for optimizing the distribution of agricultural products; accelerate social implementation and data linkages with the retail industry by expanding demonstrations of the smart food chain platform; and promote the development of an export system for the cooperation of production areas over a broad area.
- We will implement a comprehensive demonstration of the realization of logistics using a smart food chain platform that enables traceability and quality certification for the distribution of agricultural products by exchanging data based on a unified data format using EDI. We will demonstrate and implement functions to improve the handling of branded agricultural seeds and prevent counterfeiting using a smart food chain.
- We will identify issues in the trial operations of the ICT platform and improve the platform for practical use. We will start operations for a distribution information system to connect Japanese producers with overseas consumers, verify the effectiveness of freshness preservation technology, and collect and verify information on overseas consumers' preferences.
- With regard to movement between fields by remote monitoring, we will conduct on-site tests (in Toyama and other areas) to identify problems that can be expected during actual operation. In addition, we will load specifications for the intelligent agricultural machines under development, which are capable of unmanned and automated operations under remote monitoring, into a 3D simulator created based on point cloud data for the demonstration area using UAV surveying to verify the operability and safety of the machines, and we will create digital maps using the relevant data. For the low uplands, we will verify the operation of the environment recognition system, including communications, at the demonstration test site (Furano). We will proceed with the verification of the workability of a harvesting and transportation system prototype (for crop recognition - hand loading - container storage - transfer) for heavy vegetables (targeting pumpkins) using a robotic tractor. For the system for the automatic harvesting and transporting of fruit trees, we will construct a data set for apples and pears by linking quality with the image information obtained for each tree and fruiting position.
- We will improve the growth model and develop harvest prediction technology for open field vegetables that outputs the yield based on a simulation using precise growth information as input conditions. This will be turned into an API and implemented on WAGRI. As for the accuracy of the growth model, we will develop technology that can reproduce the yields for cabbage and lettuce within ±10% accuracy using the growth values of four weeks ago and two weeks ago, respectively, by tuning the variety parameters. For the lettuce demonstration, the trial operations for the system will be conducted at a cooperating organization, and through a comparison with past production results we will demonstrate that the introduction of the system results in a harvest yield improvement of 5% or more.
- We will implement a soil temperature estimation-based work support method for reducing bruising in potatoes in the Tokachi Federation of Agricultural Cooperatives' information system (TAF) together with the part in cooperation with WAGRI, and a trial operation will be started. To achieve the goal of a 5% increase in product yield by reducing bruising, we will verify the effect of introducing the developed technology by using the developed harvesting operation monitoring equipment. We will verify the labor-saving effects of technological elements for soil clod removal and reduction in potato harvests, unmanned transportation, and labor-saving technology in facility preparation. We will confirm the degree to which the target of a 30% reduction in labor has been achieved for potato cultivation.
- We will hold international symposiums, disseminate our activities widely overseas, and promote the advanced development of the smart food chain, including for exports.

[Final Goals]

- A trial version of the system will be provided to organizations that do not participate in the consortium, and after conducting risk management with a view to actual operation, a sustainable operations system

will be established with a view to after the research project is completed, and the official service will be launched in FY 2023. We will develop a sustainable operations system for the various database solutions implemented on the SFP. We will conduct studies to establish a system for the operation of the SFP and brand development after the completion of this project, including the establishment of a registering and certification body for the newly enacted JAS. We will expand operations as a platform for linking quality management data throughout the supply chain. For research and design for the overseas deployment of the SFP, we will conduct a model business project and identify issues for social implementation.

- We will demonstrate, evaluate, and improve functions oriented toward the social implementation of production information linkages (from production to shipping); demonstrate and verify databases and systems from production to shipping, distribution, and consumption (from shipping to consumption); establish development and demonstration fields; construct a domestic joint logistics system; promote standardization, including international standards for optimizing the distribution of agricultural products; accelerate social implementation and data linkages with the retail industry by expanding the demonstration of the smart food chain platform; and carry out verification or demonstration for use cases of an export system for the cooperation of production areas over a broad area.
- We will identify areas for improvement from the demonstration results, organize functional and operational requirements for actual use, and conduct interoperability tests. We will expand the scope of service provision beyond the consortium and those involved in the implementation trial, and we will concretize a form of service provision that will be used sustainably.
- We will verify a 10% reduction in food loss and a 30% reduction in working hours. We will perform trial operations and confirm effectiveness for the export ICT platform. We will conduct demonstration and verification of the distribution information system in the target country and verify a 10% reduction in food loss for target foodstuffs. In addition, in order to promote the social implementation of ICT platforms, we will create a roadmap for the creation of 5 trillion yen in value in 2030.
- With regard to movement between fields by remote monitoring, we will clearly demonstrate the establishment of the technology, the verification of safety, and the effect of introducing the relevant technology through on-site demonstration tests. In addition, we will use a simulator constructed using 3D coordinate data from UAV surveying to confirm the operability of the intelligent agricultural machinery to be applied, to verify the machinery's safety, and to demonstrate the simulator's effectiveness as a tool for infrastructure design and repair. At the same time, we will develop methods to convert the relevant data into maps and utilize the data in maps for intelligent agricultural machinery. For the harvesting and transporting system for heavy vegetables (targeting pumpkins), we will verify through on-site demonstration tests the systematization of the sequential work of recognizing, harvesting, and transporting crops with robotic hands. We will verify the validity of the automatic harvesting and transporting system for fruit trees, and using the associated fruit images and quality information, we will carry out organization for the system as a system that can be reflected in cultivation management, such as in fruit picking in the next fiscal year.

- We will link the system with the growth prediction APIs for other outdoor vegetable commodities implemented in WAGRI, and we will generalize the precision shipping forecasting system. Through on-site demonstration tests, we will identify issues and make improvements, and we will transition the system to a paid service. We will demonstrate the system's operation and show that it is possible to reduce the rate of harvest losses or unplanned goods for sale in the event of a harvest surplus by 30% or more when compared to production and shipping results from before the system was introduced. In the case of cabbage, we will expand the scope of the demonstration to include the entire Tokachi region, and we will demonstrate the effects of adjusting shipments through intermediate storage based on the shipment forecasts of cooperating nationwide production areas. Additionally, in the case of lettuce, we will demonstrate the effects of coordinating shipments among cooperating production areas and coordinating demand at stores.
- We will make the information support system for reducing the bruising of potatoes fully operational, and we will demonstrate that the main effect of reducing bruising, in combination with the cultivation support

technology developed, will be to increase the product rate by 5% or more through increased yield and stable production. We will also construct a system to support the dissemination of the developed technology to other regions. With regard to the series of operations for potatoes from harvesting of to their preparation in facilities, we will (1) develop a prototype of a harvester-mounted soil clod removal device, (2) publish a manual on cultivation methods for reducing the amount of soil clods, (3) evaluate the merits of unmanned transportation, and (4) present use methods to maximize the effect of introducing preparation devices in facilities, and we will thereby demonstrate a 30% reduction in labor for potato cultivation.

[Social Implementation Goals]

- IT vendors and other businesses will utilize the data and information collaboration platforms of the "smart food chain platform" to develop and provide a variety of food-related services.
- The goal is to have farmers and food-related businesses take advantage of the services provided above, such as advanced quality assurance, logistics efficiency, and precision shipment forecasting.
- Aiming for the commercialization of intelligent agricultural machinery through agricultural machinery manufacturers.
- For data-driven production, the goal is to have farmers introduce the technology themselves and utilize it for improved productivity and revenues. In addition, this system will be used by IT vendors to provide farmers with growth and harvest forecast information.

ii. Development of food ingredients and products with evidence of their effects on health and that meet market needs, leading to increased value

(iii)-(2)-2 Creation of a food-based health-care industry

[Sales and Consumption] Responding to diverse needs

"Contributing to the extension of healthy life expectancy by establishing a health system through food."

[Summary]

In Japan, lifestyle-related diseases, dementia, and cancer are increasing due to the super-aging of the population and changes in lifestyles, and reducing the risk of diseases such as lifestyle-related diseases, extending healthy life expectancy, and curbing rising national medical expenses have become social issues.

In order to solve these social issues and contribute to the expansion of demand for agricultural products, a new health system will be established to extend healthy life expectancy through food, which is the source of health. Specifically, we will develop and construct a system to evaluate the health maintenance and promotion effects of agricultural, forest, marine, and food products, which, unlike pharmaceuticals and supplements, contain a wide variety of ingredients and have mild effects on the body. In addition, we will collect and maintain the data on the microbiomes of Japanese people, and we will evaluate the functionality of foods that regulate the intestinal microbiome environment. Through these efforts, we will promote and create a group of health care industries that contribute to improving the health of the people through food based on scientific evidence. Furthermore, these efforts will form the basis of a self-medication system through food, which will enable the proposal and provision of dietary habits and meals according to the health status and lifestyle habits of individuals.

This task deals in an integrated manner with the development of a system to determine minor changes in physical condition; research on the effects of agricultural, forest, marine, and food products on health; and the construction of a health-related database. The task requires collaboration among industrial, agricultural, and biological research institutes and universities, as well as private companies, through collaboration with ministries and agencies.

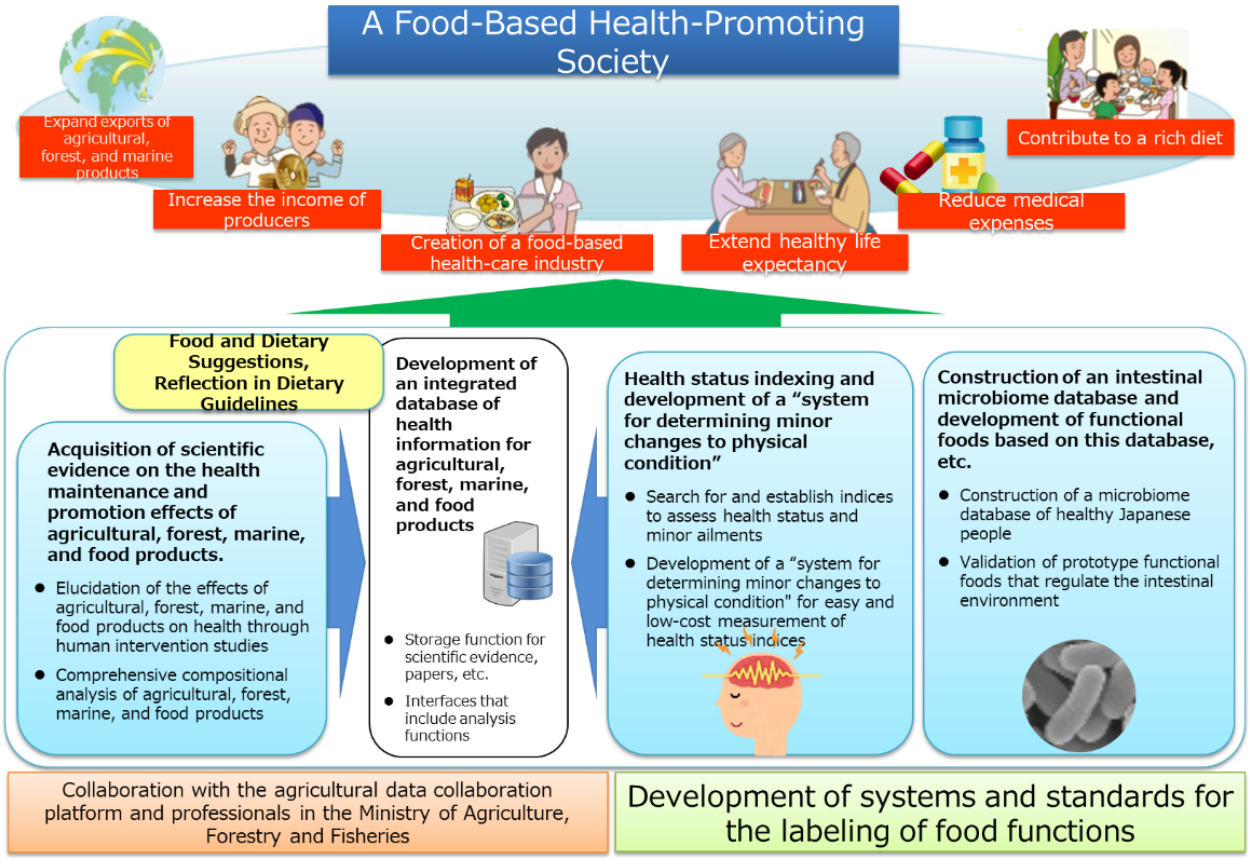


Figure 2-6: Visualization of response to diverse needs

[Necessary Expenses]

FY 2018	¥445M
FY 2019	¥341M
FY 2020	¥340M
FY 2021	¥350M

[Research and Development Details]

We will index health statuses and minor changes to physical condition; develop a "system for determining minor changes to physical condition"; obtain scientific evidence on the health maintenance and promotion effects of agricultural, forest, and marine products; develop intestinal microbiome data; and use this evidence and data to develop an integrated database of food, microbiome, and health information to analyze the health maintenance and promotion effects of agricultural, forest, marine, and food products. Specifically, we will implement the following.

(i) Development of health status indexes and a "system for determining minor changes to physical condition" (hereinafter referred to as the "minor ailment evaluation system")

We will search for and establish indices to evaluate health status and minor changes to physical condition, and develop a "minor ailment evaluation system" to measure these indices on a daily basis in a simple and low-cost manner.

(ii) Acquisition of scientific evidence on the health maintenance and promotion effects of agricultural, forest, marine, and food products.

We will scientifically identify agricultural, forest, marine, and food products that can improve minor changes to physical condition through human intervention tests using the "minor ailment evaluation system." In addition, we will clarify the components of agricultural, forest, marine, and food products through comprehensive analysis.

(iii) Development of intestinal microbiome data and verification and use of functional food prototypes.

We will collect and maintain standard Japanese intestinal microbiome data, including metagenomic and metabolomic information that is in high demand from industry, develop sampling and data analysis protocols

associated with food, and verify the usefulness of the data using prototypes of functional foods.

As for the utilization of the intestinal microbiome, we will utilize the integrated database of food, intestinal microbiome, and health information in the selection of food materials and subjects for food development. In exams, diagnoses, and health care, we will utilize the database for health and disease risk evaluations. In the development of drugs, we will analyze differences in intestinal microbiota between diseased and healthy persons and examine specific methods for use of the system in treatment through the correction of pathological intestinal microbiota.

[Participating Organizations]

Principal Researcher: Yamamoto (Maeda) Mari (National Agriculture and Food Research Organization)

National Agriculture and Food Research Organization; Hokkaido Information University; Kyoto University; University of Miyazaki; University of Nagasaki; Sapporo Medical University; Kyushu University; National Institutes of Biomedical Innovation, Health and Nutrition; Institute of Physical and Chemical Research (RIKEN); National Institute of Advanced Industrial Science and Technology; National Institute of Genetics (Research Organization of Information and Systems (ROIS)); Nagasaki Agricultural & Forestry Technical Development Center; Japan Microbiome Consortium (JMBC); PGV Inc.; Japan Food Research Laboratories; Asahi Quality & Innovations, Ltd.; Ezaki Glico Co., Ltd; Otsuka Pharmaceutical Co., Ltd.; Kagome Co., Ltd.; Kirin Holdings Company, Ltd.; Gekkeikan Sake Company, Ltd.; POKKA SAPPORO Food & Beverage Ltd.; Suntory Holdings Ltd.; Shimadzu Corporation; Taisho Pharmaceutical Co., Ltd.; Chitose Laboratory Corp.; Toto Ltd.; Nisshin Seifun Group Inc.; Biofermin Pharmaceutical Co., Ltd.; Mitsubishi Chemical Corporation; Meiji Co., Ltd.; Link & Communication Inc.; LAWSON, Inc.

[Goals for FY 2021]

- We will conduct a demonstration study in a form similar to those for products (services). We will implement the following activities in order to achieve the final goal of a foundation for a scientific evidence-based “self food planning system” that 1) promotes and creates industrial groups that contribute to the improvement of the health of the people through food, and proposes and provides dietary habits and meals that meet the health status and lifestyle habits of individuals; and that 2) enables individuals to understand their own health status and make appropriate food choices.
- We will formulate parameters for detecting mental and physical disorders by integrating autonomic nervous system activity, sleep quality, stress levels based on subjective scores, lack of sleep, and intestinal microbiome information. We will develop a “minor ailment evaluation system" using devices that can measure sleep quality and disorder in the autonomic nervous system on a daily basis.
- We will conduct intervention tests to verify the effectiveness of five or more types of "agricultural, forest, marine, and food products" in improving minor ailments, and we will clarify their effectiveness in maintaining and promoting health.
- We will analyze the gut microbiome data of 1,000 healthy Japanese individuals and will determine the profile of the intestinal microbiome for Japanese individuals. In addition, we will develop technology to analyze the relationship between food and health information and the microbiome with high accuracy using a standards database constructed from healthy Japanese intestinal microbiome data. We will conduct intervention tests to verify the effectiveness of one or more types of food products and food product ingredients in improving the intestinal microbiome, and we will clarify their effectiveness in maintaining and promoting health.
- In Ebetsu City, Hokkaido, and Kameyama City, Mie Prefecture, we will conduct trials of a health care application that identifies minor ailments and guides people to good health, and we will also conduct consumption tests of ingredients and *bento* that improve minor ailments and verify the possibility of social implementation.
- We will establish a Committee on Integrative Health and Nutritional Foods (tentative name) to determine the definition of “minor ailments,” evaluation methods, and certification criteria for integrative health and nutritional foods that alleviate minor ailments. The committee will consist of three physicians, three private sector operators, two national laboratories, with the Ministry of Agriculture, Forestry and Fisheries; the Ministry of Economy, Trade and Industry; and the Consumer Affairs Agency as observers.

[Final Goals]

- We will further promote 2021 activities, and we will conduct a demonstration study in a form similar to those for products (services). In order to complete the output of this project, we will implement the following activities, and we will formulate a practical application plan based on the following results, centered around the companies participating in the consortium, in order to promptly promote social implementation after the completion of this experimental research plan.
- We will introduce a food and health management application that utilizes the “minor ailment evaluation system" in cooperation with about 900 convenience stores and supermarkets in the model area, and we will verify the effects on food on health maintenance and promotion.
- We will conduct intervention tests to verify the effectiveness of five or more types of "agricultural, forest, marine, and food products" in improving minor ailments, and we will clarify their effectiveness in maintaining and promoting health.
- Using the standards database developed in the previous fiscal year, we will analyze the samples of the above-mentioned intervention tests for new food products and food product ingredients, and confirm and demonstrate the effectiveness of the system as a scientific evaluation system for the evaluation of how well food products and food product ingredients improve intestinal flora. We will conduct intervention tests to verify the effectiveness of two or more types of food products and food product ingredients in improving the intestinal microbiome, and ultimately we will clarify the effectiveness in maintaining and promoting health of five or more functional foods.
- We envision outcomes for social implementation as including the release of an integrated database of food, microbiome, and health information; the development of high value-added functional foods that improve minor ailments; the sale of personalized health-care lunches and restaurant meals; the provision of health management services based on indicators of minor changes to physical condition; and the provision of simple new devices for assessing minor ailments. Based on these outcomes, we will work to practically implement these items, mainly with participating companies.
- We will establish a private certification system through the Committee on Integrative Health and Nutritional Foods (tentative name) for social implementation of the results. The newly established general incorporated association will be the scheme owner and will utilize the private certification system promoted by the Ministry of Agriculture, Forestry and Fisheries.

[Social Implementation Goals]

- Food manufacturers and companies interested in the health business will aim to use the integrated database of food, microbiome, and health information and the minor ailments evaluation system to provide new functional foods, health management support, and services such as health tourism.
- Medical institutions and drug manufacturers will aim to develop new drugs, diagnostics, and therapies by utilizing the integrated database of food, microbiome, and health information.

II-(3) Utilization of unused agricultural resources

Developing technologies that contribute to sustainability in food-related resources and the environment: [Resource Recycling]

[Summary]

In order to reduce dependence on petroleum resources and realize a sustainably growing society, we will develop technologies to produce new biomaterials and highly functional products based on biofunctional design, and we will develop technologies to eliminate bottlenecks in the supply chain of biomaterials.

This task deals with the creation of new biotechnology-related industries that transcend the boundaries of existing industrial fields, and requires collaboration among industrial, agricultural, medical, and biological research institutes and universities, as well as private companies, through collaboration with ministries and agencies.

We will develop common platform technologies that enable large-scale cultivation and screening of highly functional microorganisms, and we will construct a high-throughput microbial cultivation and screening platform.

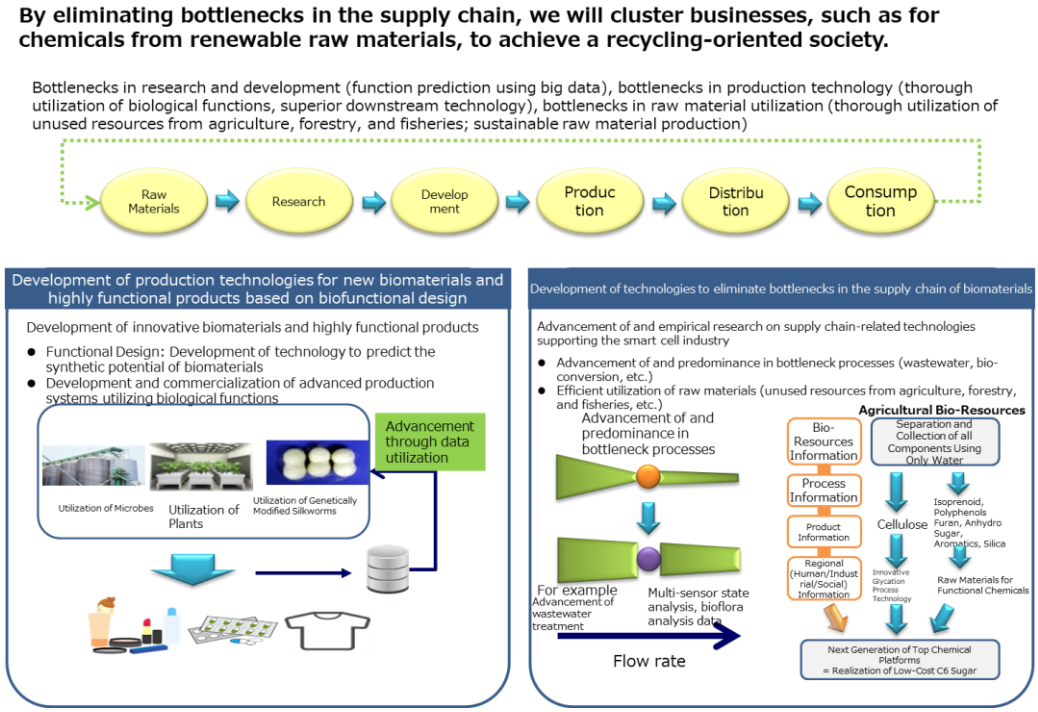


Figure 2-7: Visualization of the realization of a sustainably growing society through "manufacturing with biological functions"

[Necessary Expenses]

FY 2018	¥761M
FY 2019	¥584M
FY 2020	¥496M
FY 2021	¥351M

i. **Advancement of and empirical research on supply chain-related technologies supporting the recycling of the inedible parts of agricultural products**

ii. **Development of next-generation core technologies for the chemical industry using unused resources from the agriculture, forestry, and fisheries industries**

iii. **Development of production technologies for new biomaterials and highly functional products based on biofunctional design**

iv. **Promotion of the development of small-scale equipment and the utilization of databases for the cultivation and sorting of microorganisms for sugar production with new biomaterials**

II-(3)-1 Development of chemical and bioproduction technologies for bioresource recycling

[Research and Development Details]

We will develop an agribio-smart chemical production system through the recycling of inedible parts of agricultural products, technology to produce new biomaterials and highly functional products based on biofunctional design, and new highly functional products using living organisms.

In addition, we will develop high-speed and compact separation, cultivation, and screening technologies for microorganisms, construct a platform that enables the large-scale cultivation and screening of microorganisms, store the platform in an integrated database suite that will be promoted in parallel, and promote use of the database.

1) Development of an agri-bio and smart chemical production system

The bottleneck in the creation of a chemical industry using unused resources from the agriculture, forestry, and fisheries industries is that system technology for the stable supply of key compounds at low cost has not yet been established. In order to solve this bottleneck, we will develop an integrated process for separating and collecting at high yield the components of unused agricultural, forest, and marine resources as multiple useful components and high-quality biomaterials with added value (e.g., C6 sugars), or converting them into functional chemicals, and this process will provide key compounds at low cost in a stable manner. We will also develop an "agri-bio smart chemical production system (ABCs)" for implementing this process regionally and we will construct a business model for multiple regions. Additionally, we will develop technologies to utilize organic residues for the production of raw materials for next-generation chemical industries.

(2) Development of functional design technologies and production technologies for innovative biomaterials and highly functional products

We will aim to secure food sustainability and contribute to resource recycling by converting agricultural residues into monomers that can be used as raw materials for high value-added polymers in order to achieve a low carbon society, and we will develop and put into practical use new biopolymers.

We will develop platform technology for "biopolymer design" (BPD) for the efficient design and production of high-performance polymers made from monomers produced with biotechnology. We will also aim to develop and verify elemental technologies using data-driven methods to realize the efficient production of monomers through microorganisms, and to establish a production system that enables bioproduction without relying on plant-derived sugar sources.

In addition, using highly functional bio-polybenzimidazole (PBI) and polyphenol-based materials (PPM) as a base, we will utilize microbial functions to produce these core aromatic biomass materials and develop highly functional and high value-added products using these materials.

[Participating Organizations]

Principal Researcher: Hayashi Junichiro (Kyushu University)

Kyushu University; Kyoto University; Tohoku University; Nagaoka University of Technology; Kagoshima University; Akita Prefectural University; National Agriculture and Food Research Organization; National Institute of Advanced Industrial Science and Technology; Akita Research Institute of Food and Brewing; Mizuho Information & Research Institute, Inc.; DKS Co. Ltd.; Kao Corporation; Toray Industries, Inc.; Shinko Sugar Co., Ltd.; Fuji Oil Holdings, Inc.; Akita Prefectural Livestock Experiment Station; Japan Association for Techno-innovation in Agriculture, Forestry and Fisheries

Institute of Physical and Chemical Research (RIKEN); National Institute of Advanced Industrial Science and Technology; Research Institute of Innovative Technology for the Earth; University of Tokyo; National Institutes of Biomedical Innovation, Health and Nutrition; National Institute of Health and Nutrition; Tohoku University; University of Tsukuba; Japan Advanced Institute of Science and Technology; Niigata University

Nagaoka University of Technology; University of Tokyo; University of Yamanashi, National Institute of Technology and Evaluation (NITE); Niigata University of Pharmacy and Applied Life Sciences; National Institute of Technology, Tsuruoka College; Waseda University; National Institute of Advanced Industrial Science and Technology; Kyushu University; On-Chip Biotechnologies Co., Ltd.; Nikon Solutions Co., Ltd.

[Goals for FY 2021]

(i) Development of an agri-bio and smart chemical production system

- We will achieve performance demonstrations through larger-scale bench-scale tests in research and development on technologies for converting agri-bio resources into low-cost raw materials, in research

and development on supply and value chain evaluation and optimization systems, in research and development on interim product manufacturing, in research and development on agri-pulp-derived product manufacturing, and research and development on agri-pulp or C6 sugar-derived product manufacturing.

(ii) Development of functional design technologies and production technologies for innovative biomaterials and highly functional products

- We will determine the optimal conditions for the production of PBI-related candidate compounds and produce them at 10 g/L, and we will determine the conditions for refinement from fermentation solutions (target yield: 90%, purity: 96% or higher). For PBI-derived battery materials (e.g., active anode materials for Li-ion secondary cells), we will further improve the batteries based on interface and deterioration behavior. In addition, we will achieve high performance through the use of PBI copolymers and through the calcination of PBI after compositing with porous materials. For coating materials resistant to high heat, we will establish the coating processing conditions for PBI/PA films on copper wire. We will also develop a method to control membrane elongation.
- We will determine the optimal conditions for production, and establish methods for preparing bio-PPM with a purity and properties comparable to those of petroleum-derived compounds by producing target PPM compounds and refining them from fermentation solutions (target: 90% yield, purity: 96% or higher). We will clarify the suitability of caffeic acid binder systems for rapid charging and discharging (target: achieve charging conditions within 15 minutes).
- We will carry out investigations using quantum chemical simulation technology for biopolymer design technology. For the ionic conduction mechanism of PBI-Li ion batteries, we will elucidate the mechanism of fast lithium-ion conduction in boronated PBI-Li ion batteries and establish design guidelines. We will elucidate the reason why nitrogen doping of a graphite surface improves battery performance as an active anode material, and we will propose design guidelines for higher performance PBI anode materials. We will implement large-scale simulations for polybenzimidazole polymers to propose candidate wire coating materials. In addition, we will perform rapid evaluations of and molecular design for marine degradable plastics.
- For biomonomer production research, we will develop enzymes to expand the biosynthetic pathway for PBI raw materials. We will target an enzyme (AurF) that oxidizes amino groups in aromatic rings to nitro groups and an enzyme (RufO analog: RufO2) that introduces nitro groups directly onto aromatic rings. We will achieve a five-fold or greater conversion rate by modifying the substrate specificity and improving the activity of each enzyme.

(iii) Development of a microbe search platform

- We will collaborate with companies to create prototypes and improve these prototypes for detecting microbial droplets with fluorescent probes. In order to further accelerate the demonstration of large-scale cultivation and screening using the high-speed microbial separation and cultivation platform developed so far, we will further promote microbial screening, such as for the acquisition of microbial groups that coexist with plants. In addition, we will push the acquisition of useful enzymes by utilizing the high-throughput screening platform that makes use of WODL. In order to promote the widespread use of the screening platform, we will push for the clarification and organization of experimental protocols and processes. We will advance metagenomic analysis of the microbial resources obtained through the above research promotion, and provide the acquired data to an integrated database. We will determine the information items to be registered as data to construct a data storage system, and we will supply data on cultivation to the integrated database.

[Final Goals]

(i) Development of an agri-bio and smart chemical production system

- We will complete the technology to supply agri-bio resources at 20 yen/kg dry matter, demonstrate technology for the stable supply of C6 sugar at 30 yen/kg through the gross value added of these chemicals, and determine the process and system specifications for the implementation scale. We will also achieve 200-300 yen/kg of nanocellulose. We will perform partial implementation of the proposed system through technical assessment, user tests, and process design in the Yokote region of Akita Prefecture, and we will

show that the proposed system can be implemented in other regions of Japan.

(ii) Development of functional design technologies and production technologies for innovative biomaterials and highly functional products

- We will conduct pilot-scale microbial production (on the scale of several tens of grams) for PBI raw materials. We will evaluate test data and obtain standard data for prototypes of lithium-ion conductors as solid electrolytes, electrical wire coating prototypes, and prototypes insulation materials resistant to high heat. We will develop technology to produce lithium-ion conductors and wire coatings as "functionally designed, innovative, bio-enhanced products" and establish a firm foothold for practical application. We will produce insulation materials resistant to high heat, with a volume resistivity exceeding 10^{10} Ωcm at 400℃. As for lithium-ion secondary cell active anode material, we aim to optimize the binder type and electrode fabrication conditions for PBI-based active material and PBI-based composite active material, and to maintain a capacity retention rate of 80% or higher over 1,500 cycles.
- We will perform microbial production at a scale (target: on the order of grams) sufficient to evaluate the performance of one type of bio-PPM raw materials. We will obtain PPM with a purity and properties that do not interfere with the materialization process for electrical and battery components, and we will make prototype bio-PPM. We will clarify that these materials can be used as highly functional biomaterials and anticipate their practical application. We will produce battery cells by combining PBI-based active material with a caffeic acid binder. We will optimize the material composition of battery cells and identify the best performing system.
- Based on the design guidelines for PBI anode materials obtained in the previous fiscal year using quantum chemical simulation technology for biopolymer design technology, we will propose higher performance PBI anode materials and examine the feasibility of demonstration after the completion of the SIP. In addition, we will perfect technology for the rapid evaluation and molecular design of marine degradable polymers, and verify the effectiveness of this technology by demonstrating it for the target problem we have set.
- For AurF (an amino acid oxidase) and RufO2 (an enzyme that introduces nitro groups), we will improve the conversion rate of the target substrate of either enzyme by more than 10-fold through enzyme discovery and functional modification, and we will examine the possibility of demonstration after completion of the SIP. We will construct nitrobenzoic acid compound producing strains by introducing modified enzymes into PBI monomer raw material producing strains. We will investigate the productivity of the producer strains constructed by examining the culture conditions, and we will achieve a production concentration of 1 g/L or higher for nitrobenzoic acid compound productivity.

(iii) Development of a microbe search platform

- We will complete a user-friendly and versatile technology platform for biological resources that meets the needs of companies, develop biological and biogenetic resources, strengthen efforts to put the developed platform into practical use, and further utilize biodata and biological resources in the private sector. For this purpose, we will complete technologies for the high-speed separation, cultivation, and screening of microorganisms based on WODL, and we will establish a system to utilize these technologies. Among the elemental technologies, we aim to put to practical use as soon as possible after the completion of the project those technologies that can be put to practical use, such as microdevices suitable for WODL observations and reagent kits for technology for the detection of microbial growth droplets using fluorescent probes. While collaborating with other consortia as appropriate, we will further advance the acquisition of intestinal bacteria groups and microbial groups symbiotic with plants, acquire metagenomic data, and provide this information to the integrated database. We aim to focus not just on genomic information but on the acquisition of real data, such as data obtained from cultivation, by using our strengths in obtaining microorganisms themselves. We also aim to contribute to the improvement of the international competitiveness of Japan's bioresource data. Through social implementation, we aim to spread the new technological base for efficient and effective utilization of Japan's microbial resources to the private sector and society at large. The goal is to establish a solid foundation for the expansion of Japan's bioeconomy and the international competitiveness of the bioindustry in this way.

[Social Implementation Goals]

(i) Development of an agri-bio and smart chemical production system

- The joint ventures in Japan and abroad that will be responsible for everything from the collection of unused agricultural resources to their conversion into C6 sugar and other new materials and provision as products will implement this development and they will aim for commercialization

(ii) Development of functional design technologies and production technologies for innovative biomaterials and highly functional products

- This will be introduced by environmentally conscious chemical companies with the aim of producing and providing highly functional materials of biological origin.

II-(3)-2 Development of bioprocess optimization technology to realize a smart bio-society

[Research and Development Details]

We will develop technologies to eliminate bottlenecks in the supply chain of biomaterials and functional products.

In order to eliminate bottlenecks for the optimization of the food value chain, which is important for the practical application of biomaterials production, we will improve operations for membrane separation technology, which is expected to improve the efficiency of wastewater treatment and the quality of treated water, by using various sensors. We will also achieve low costs by producing a database for analyzing the biological flora and observing the condition of activated sludge and by developing rational methods for operations. Additionally, we will create a regional bioeconomy simulation tool.

[Participating Organizations]

Principal Researcher: Tamura Tomohiro (National Institute of Advanced Industrial Science and Technology)

National Institute of Advanced Industrial Science and Technology; Institute of Physical and Chemical Research (RIKEN); Saga University; Saga City; Mitsubishi Chemical Corporation; Ajinomoto Co., Inc.; Chitose Laboratory Corp.; Nagaoka City; Nagaoka University of Technology

[Goals for FY 2021 (Final Goals)]

- At the Nagaoka City Environmental Sanitation Center, we will install a pilot-scale model membrane separation reactor, a sensing system, and a bacterial flora management device and conduct treatment experiments for methane fermentation digestive fluid from food waste. In addition to operating the system under different load and aeration conditions to produce membrane blockage, we will collect water quality data, operational data, and biodata, such as for bacterial flora, and identify candidate control indicators involved in reducing membrane blockage and aeration through data science analysis. By using these control indices to control operations, we aim, for example, to increase the amount of wastewater treated by 10-20%, or increase the efficiency of the treatment speed by 10-20%, or reduce power consumption by 10-20%.
- Participating organizations and cooperating organizations whose old tasks were completed in FY 2020 will continue to participate in the consortium and cooperate by providing information and data that will contribute to the demonstration tests in Nagaoka City, and will also analyze and compile data for the social implementation of the results of this SIP project.

[Social Implementation Goals]

- We aim to implement a new data-driven wastewater treatment prediction system. Sensor companies and infrastructure companies will commercialize and operate the system by collecting usage fees, and vendor companies will act as contact points to collect usage fees for confidential data and prediction algorithms. Consortia members and private companies that possess wastewater treatment processes are assumed to be the users.
- We aim to implement advanced membrane separation and activated sludge processes (a membrane blockage control system) through electrical potential control and sensing. We will install the system in existing and new wastewater treatment facilities, and we will also collect maintenance and management fees. We will introduce a pilot machine into the existing processes in Nagaoka City and will start trial operations. We aim to hand over the technology to sensor and infrastructure companies for them to start services.

3. Implementation System

(1) Utilization of the National Agriculture and Food Research Organization's Bio-Oriented Technology Research Advancement Institution

This project will be carried out through a grant to the Bio-Oriented Technology Research Advancement Institution, National Agriculture and Food Research Organization (hereinafter referred to as the "Management Corporation"), with the structure shown in Figure 3-1.

In addition to soliciting research participants, holding selection and evaluation committees, and concluding contracts in accordance with the decisions of the PD and the Promotion Committee, the Management Corporation manages funds, manages the progress of research (including intellectual property management), operates planning review meetings and peer review meetings, and publicizes tasks and research results. In addition, necessary support will be provided for administrative work related to self-examination by research participants and third-party evaluations necessary for self-examination by the PD, based on instructions from the PD and the Cabinet Office Secretariat.

(2) Selection of principal researchers

The Management Corporation will make an open call for research participants according to this plan, and select research participants based on the results of reviews by the selection and evaluation committee, which consists of the PD, the Sub-PD, and external specialists. The Management Corporation will perform the administrative work for the examination.

The examination criteria and committee members for the selection and evaluation committee shall be determined in consultation with the PD and the Cabinet Office.

Any committee members having interests in the research participants making proposals to be examined shall be excluded from examinations of the relevant proposals.

(3) Optimization of the research system

(1) Establishment of a promotion committee

To make the adjustments required to implement this task, we will establish a Promotion Committee. In this Promotion Committee, the PD shall serve as the chairperson and the Cabinet Office shall serve as the secretariat. In addition, the Acting PD, Sub-PD, Strategy Coordinators, related ministries, the Management Corporation, and specialists shall participate in the Promotion Committee.

(2) Collaboration with the New Energy and Industrial Technology Development Organization

For the advancement of the work described above in (1), the Management Corporation shall collaborate with the New Energy and Industrial Technology Development Organization (hereinafter referred to as "NEDO") and make efforts to generate a synergetic effect.

(3) Research system

(i) Promotion of consortium-based research

This task is based on forming for each recruitment a consortium consisting of universities, national research and development institutions, and companies that will be responsible for the practical application of the research results so that research and development are carried out in an integrated manner, from basic research to practical application. Furthermore, the task is based on the implementation of research.

The Principal Researcher for each consortium will closely collaborate with other members under guidance and advice from the PD and the Sub-PD and advance research capable to generating synergetic effects.

(ii) Cooperation between consortia

The PD or the Sub-PD shall understand the progress status of research in the respective research consortia, and will provide guidance and advice to the respective principal researchers for the matters that require collaboration between the consortia. Simultaneously, the PD or the Sub-PD shall convene relevant parties as necessary and examine effective collaboration measures.

(4) Cooperation with ministries and agencies

We will create innovations to expand the bioeconomy in Japan, improve productivity in the agricultural, forestry, fisheries, and food industries, and strengthen the industries' competitiveness. For this purpose, we need to gather and fuse the advanced technologies as well as the basic and platform technologies in various fields, such as biotechnology, IoT, robotics, data science, and AI, which the respective ministries are involved in. Simultaneously, we need to systematically implement the projects of the respective research and development tasks in a multi-layered manner.

In addition, we need to develop an environment to facilitate the use of research and development results in the private sector, such as by constructing a data collaboration system and an integrated database that cross over the boundaries between ministries and agencies, and we need to collaborate with the ministries and agencies responsible for related regulations and systems.

To this end, the PD will take the lead and the related ministries and agencies will closely collaborate with each other to conduct this research and development, develop the required environment, and reform regulations and systems.

(5) Contributions from industry

The companies that participate in the respective consortiums shall contribute to research and development by providing resources, such as human resources, technologies, knowledge, and funds. The (expected) investment ratio from the participating companies and business partners for overall research and development expenses shall be based on the Strategic Innovation Guidelines.

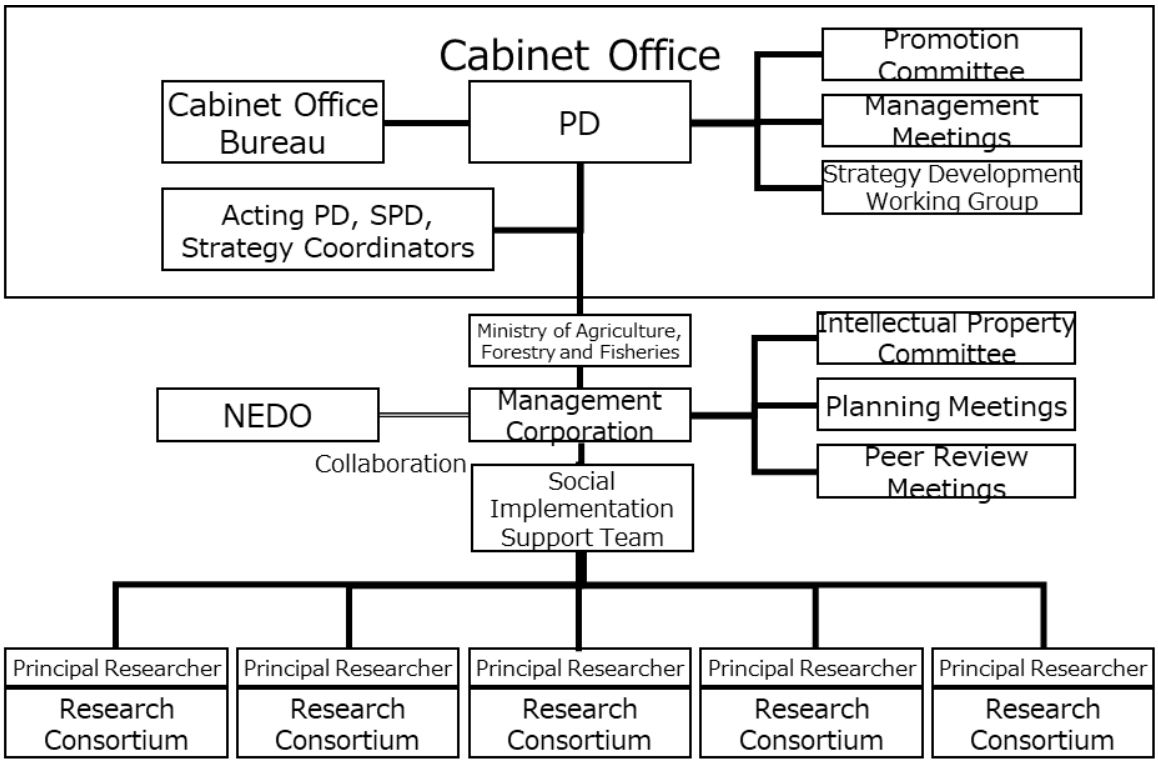


Figure 3-1: Implementation system

Organization	Members
Promotion Committee	PD (chairperson); Acting PD; Sub-PD; Strategy Coordinator National Strategy Office of Information and Communication Technology, Cabinet Secretariat; Space Strategy Promotion Secretariat, Cabinet Office; National Tax Agency; Ministry of Education, Culture, Sports, Science and Technology; Ministry of Agriculture, Forestry and Fisheries; Ministry of Economy, Trade and Industry; Ministry of Land, Infrastructure, Transport and Tourism; Ministry of the Environment; Cabinet Office (Secretariat); Management Company; etc.
Management	PD (chairperson); Acting PD; Sub-PD; Strategy Coordinator; etc.

Meetings	
Strategy Development Working Group	PD (chairperson); Acting PD; Strategy Coordinator; etc.
Peer Review Meetings	Peer Review Evaluation Committee (including the chairperson); PD; Acting PD; Sub-PD; Strategy Coordinator; research representatives; etc.
Planning Meetings	PD (chairperson); Acting PD; Sub-PD; Strategy Coordinator; external specialists; etc.

Title	Full Name	Affiliate Organization
PD	Kobayashi Noriaki	Kirin Holdings Company, Ltd.
Acting PD	Noguchi Noboru	Graduate School of Agriculture, Hokkaido University
Sub-Program Directors (Sub-PDs)	Kamagata Yoichi	National Institute of Advanced Industrial Science and Technology
	Komari Toshihiko	Kaneka Corporation
	Mizunashi Wataru	New Energy and Industrial Technology Development Organization (NEDO)
Strategy Coordinators	Kadowaki Koichi	National Agriculture and Food Research Organization
	Kawakami Takayoshi	Industrial Growth Platform Inc. (IGPI)
	Shoji Masahiko	Musashi University
	Hagiwara Asahiro	Object of Null Inc.
	Miwa Yasafumi	Japan Research Institute, Ltd
	Kondo Keiji	Former Kirin Holdings Company, Ltd.

4. Matters Related to Intellectual Property

(1) Intellectual Property Committee

- We have established an Intellectual Property Committee under the Management Corporation. Based on the policy of this committee, a committee of intellectual properties can be established at the affiliate institutions (contractors) of the principal researchers.
- The Intellectual Property Committee shall be in charge of policy decisions for the filing of applications for and the maintenance of patents and for the publishing of papers related to the research and development results of institutes where a committee of intellectual properties has been established (hereinafter referred to as IP rights) and will make adjustments regarding licenses for IP rights as necessary.
- As a general rule, the Intellectual Property Committee shall be composed of a PD or an Acting PD, major concerned parties, and experts.
- Details of the operating method of the Intellectual Property Committee shall be defined by the institutes that establish the Intellectual Property Committee.
- We will dispatch an advisor who is familiar with intellectual property, international standardization, data protection, and data distribution.

(2) Agreements on IP rights

- The Management Corporation shall determine details by advance agreement with contractors regarding how to handle confidentialities, background IP rights, and foreground IP rights. Here, background IP rights refers to IP rights acquired by the principal researcher and/or that individual's affiliate institute before participation in the program and IP rights acquired without SIP management expenses after participating in the program. Foreground IP rights refers to IP rights generated through the SIP project expenses during the program.

(3) Licensing background IP rights

- Licensing of the background IP rights to participants in other programs shall be based on the conditions set forth by the holder of the IP rights (or "based on an agreement between the program participants") and such IP rights holders can grant use of the license.
- If there is a concern that the IP rights holder's response under the relevant conditions will negatively affect the promotion of the SIP (including practical use and commercialization of the results as well as research and development), such an issue shall be coordinated by the Intellectual Property Committee to obtain a reasonable solution.

(4) Management of foreground IP rights

- As a general rule, Article 17 of the Industrial Technology Enhancement Act shall be applied to foreground IP rights, and the IP rights shall belong to the affiliated institution (the contractor) of the principal researcher who is the inventor.
- Patent rights generated through joint research between contractor members or between the contractor and cooperating agencies can be shared between the involved parties based on the joint application contract between the parties of the joint research. The share of each party shall be determined via consultation between the involved parties according to the level of contribution for the creation of the patent right.
- If the IP rights holder has little intention of commercialization, the Intellectual Property Committee shall recommend the IP rights be held by a person who actively aims for commercialization or that a license be granted to a person who actively aims for commercialization.
- For individuals who leave during the participation period, the Management Corporation can require at the time of withdrawal a voluntary conveyance or may grant a license for all or part of the results that the individual obtained through the SIP project fund during the relevant participation period, provided that, if the person participated for multiple years, the results herein refer to any results since the individual joined the project.
- As a general rule, the expenses to file an application and maintain IP rights shall be borne by the IP rights

holder. If an application is filed jointly, the share ratio and expense allocation shall be determined via consultation between the parties.

(5) Licensing foreground IP rights

- Licensing of the foreground IP rights to participants in other programs shall be based on the conditions set forth by the holder of the IP rights (or "based on an agreement between the program participants") and such IP rights holders can grant use of the license.
- Licensing of foreground IP rights to a third party may be allowed by the IP rights holder according to the conditions set by the IP rights holder to the extent that that such a third party shall not have more advantageous conditions than those of the program participants.
- If there is a concern that the IP rights holder's response under the relevant conditions will negatively affect the promotion of the SIP (including practical use and commercialization of the results as well as research and development), such an issue shall be coordinated by the Intellectual Property Committee to obtain a reasonable solution.

(6) Approval of the transfer of foreground IP rights and establishment/transfer of exclusive licenses

- Based on Article 17, paragraph 1, item 4 of the Industrial Technology Enhancement Act, transfer of foreground IP rights and the establishment and/or transfer of exclusive licenses requires approval from the Management Corporation, except in the case of transfers due to company mergers or splits, or in the case of transfer of IP rights to a subsidiary or parent company, or in the case of establishment and transfer of exclusive licenses (hereinafter, referred to as "cases of IP rights transfers accompanied by a company merger, etc.").
- In cases of IP rights transfers accompanied by a company merger, etc., based on the contract with the Management Corporation, the IP rights holder shall need approval from the Management Corporation.
- Even after an IP rights transfer accompanied by a company merger, etc., the Management Corporation can hold a license with a re-licensing right for the relevant IP rights. If the IP rights holder cannot accept the conditions, such a transfer shall not be approved.

(7) Management of IP rights at the time of completion

- Upon completion of research and development, the Intellectual Property Committee shall discuss what to do with the IP rights that nobody desires to hold (abandonment or inheritance by the Management Corporation).

(8) Participations of foreign institutes (companies, universities, and researchers of foreign countries)

- When participation of foreign institutes is necessary for the promotion of the task, such participation shall be allowed.
- As a general rule, from the perspective of proper execution management, they must have a liaison office or an agent in Japan that can perform administrative work related to the contracting of research and development.
- In the case of IP rights based on inventions by foreign institutes, the IP rights shall be shared between the Management Corporation and the foreign institutes.

5. Evaluations

(1) Evaluating body

Referencing a report of self-examination results undertaken by the PD and the Management Corporation, the Governing Board shall invite external experts and conduct the evaluation. At this time, the Governing Board can organize the evaluation by field or by task.

(2) Timing of evaluations

- Evaluations shall include an advance evaluation, a year-end annual evaluation, and a final evaluation.
- After completion, once a certain period of time (3 years in general) has passed, follow-up evaluations may be conducted as necessary.
- In addition to the above, evaluations can be conducted as necessary, such as in the middle of the fiscal year.

(3) Evaluation items and standards

Based on the "General Guidelines for Evaluating National Research and Development (Decision by the Prime Minister on December 21, 2016)," evaluation items and standards are set as follows from the perspective of evaluating necessity, efficiency, and effectiveness. Evaluations shall not be conducted focusing only on the degree to which goals are accomplished, but rather, they should be conducted to analyze the causes/reasons for progress or lack thereof and to propose measures for improvements.

(i) Consistency with the significance and objects of the SIP system.
(ii) Rationality of goals, particularly outcome goals, and degree of achievement in the project timeline for achieving the goals.
(iii) Appropriateness of management, especially in view of how the effects of ministerial and agency collaboration are exhibited.
(iv) Strategic approaches for and degree of achievement toward practical use and commercialization.
(v) Expected or ripple effects at the time of final evaluation. Follow-up method after completion that is properly and clearly set.
(vi) The items listed below.
1) Consistency with Society 5.0
2) Degree of emphasis on areas requiring a productivity revolution
3) Contribution to social change
4) Contribution to the resolution of social issues and to the competitiveness of the Japanese economy and industry
5) Clarity of exit strategy for commercialization, practical application, and social implementation (are the details of commercialization in five years clear?)
6) Existence of systemic exit strategies such as in intellectual property strategy, international standardization, and regulatory reform
7) Degree of cross-sectoral efforts for which ministry and agency collaboration is essential
8) Strategic nature of research and development, from basic research to commercialization and practical application
9) Existence of a distinction between the establishment of "cooperative domains" and "competitive domains" (having an open/closed strategy)
10) The degree of built-in mechanisms and matching funds for the establishment of an industry-academia-government collaboration system and for linking the results of research and development to practical application and commercialization by participating companies
(vii) Achievement status of TRL (Technology Readiness Levels) for each research theme for each task

(4) How to reflect the evaluation results

- Advance evaluations shall be conducted for plans for subsequent years and the evaluation results shall be reflected in the plans for the subsequent years.
- In the year-end evaluation for each year, we will narrow down or add tasks and research themes as necessary.

Year-end evaluations shall be conducted for performance up to the relevant year and for plans for subsequent years, and the evaluation results shall be reflected in the plans for subsequent years.

- Final evaluations shall be conducted for results up to the final year and the evaluation results shall be reflected in follow-ups after completion of the task.
- Follow-up evaluations shall be conducted to assess progress in practical use and commercialization of the results for each task and shall include the proposal of measures for improvement.

(5) Publication of the evaluation results

- As a general rule, the evaluation results shall be published.
- The Governing Board that conducts the evaluations also handles research and development information that is not open to public. Therefore, its evaluation results shall not be released.

(6) Self-examination

(i) Self-examination by principal researchers

A PD shall select principal researchers to conduct self-examinations (as a general rule, the primary researchers/research institutes of the respective research items shall be selected for this position). The selected principal researchers shall follow the Evaluation Items and Standards in 5.(3) and shall conduct examinations for both performance after the previous evaluation and future plans. The principal researchers shall compile analysis of the causes/reasons for their performance and measures for improvement, in addition to judging the level of achievement of their goals.

(ii) Technical evaluations from an expert's point of view (peer review)

Self-examinations shall be conducted by the Management Corporation using technical evaluations from an expert's point of view (peer review). The results of this self-examination shall be reported to the Governing Board. The peer review committee members should be selected not only for their expertise but also for their ability to evaluate from the perspective of social implementation by evaluating from the user's viewpoint, thus creating a system to obtain evaluations from a broader perspective.

(iii) Self-examination by the PD

Using the self-examination results from the principal researcher and the peer review results from the external experts as a reference, and following the evaluation items and standards in 5.(3) listed above, the PD shall evaluate him/herself, the Management Corporation, and the respective principal researchers in terms of their performance and future plans. The PD shall also compile analysis of the causes/reasons for the given performance and measures for improvement, in addition to judging the level of achievement of their goals. The results will be used to decide whether or not to continue the research for each research task, and to provide necessary advice to the principal researchers. This will make the system capable of autonomous improvement.

Based on these results, the PD will prepare materials for the Governing Board with the support of the Management Corporation.

(iv) Self-examination by the Management Corporation

A self-examination by the Management Corporation shall be conducted to evaluate whether the administrative procedures have been properly implemented for budget implementation.

6. Exit Strategy

(1) Promotion of exit-oriented research

Overall, the following points should be noted.

- Promote a further increase in private investment, which has been increasing since the previous fiscal year
- Going forward, conduct global benchmarking surveys for each consortium. Update research regularly based on these results.

(i) Contributions of manpower, materials, and funds from participating companies

The companies that participate in the respective consortiums shall contribute to research and development by providing resources, such as human resources, technologies, knowledge, and funds. The (expected) investment ratio from the participating companies and business partners for overall research and development expenses shall be based on the Strategic Innovation Guidelines.

(ii) Collaboration with other related tasks

In the area of "revolutionizing productivity and increasing profitability in the agriculture, forestry, fisheries, and food industries through a 'smart food system' that utilizes diverse data," we will collaborate with the “Smart Logistics Service” SIP, the "Big Data and AI-Enabled Cyberspace Technologies” SIP, and PRISM related tasks to achieve synergies.

(iii) Transfer destination (recipient) for the research results

For results that will be used to introduce products and services to the market as an outlet for the research results, they will be put to practical use by companies participating in each consortium or by companies that have received IP rights from national research and development corporations or universities that have IP rights.

For platform-type research results that are widely used by the public and private sectors, such as the smart food system, we will put them to practical use by inviting a wide range of new business ideas, including from the companies participating in each consortium. The operation and maintenance of the platform itself will be carried out mainly by the companies participating in the consortium.

(iv) Technology transfers to private companies

For results that are to be practically implemented or developed into actual products, the SIP shall create a prototype. Then, the recipient company will be in charge of practical use, including mass production.

For the research results to be widely used by the government and the private sector, the SIP shall validate the effectiveness of the results for use cases. Thereafter, the operation, maintenance, and management shall be primarily performed by the companies participating in the consortium.

(v) Human resources development

In order to create innovation through the fusion of biotechnology and digital technology, it is essential to develop human resources with interdisciplinary skills and knowledge, as well as human resources with a sense of management. In research and development for this task, we will rally young researchers and conduct on-the-job training, and we will also develop human resources in cooperation with measures to promote recurrent education related to AI and informatics human resource development.

(2) Measures for dissemination

Overall, the following points should be noted.

- We will expand information dissemination in Japan and abroad and international collaboration, such as by hosting international conferences, depending on the progress of the task.

[Overall Implementation for the Smart Food System]

(1) [Value Chain Data Platform Construction] Construction of integrated bio-digital data distribution platform that consolidates and links databases and data

For the development and operation of bio-related big data, we will promote planning from industry and advance the use of biological information by industry through the construction of a system for collaboration for the National Bioscience Database Center (NBDC) of the Japan Science and Technology Agency (JST) and

other database-related organizations, the establishment of a system that enables the integrated use of omics data linked to biological functions, such as metabolic capacity, as one big data set, and the organization of a system that allows for open and closed data and provides incentives for closed data.

[Smart Food System Individual Implementation]

(1) [Development] Development of innovative food materials and breeding technologies

We will strengthen Japan's seed development system by creating an environment in which Japan's major seed companies and local governments can implement and use "data-driven breeding" and enable the early breeding of varieties that meet the needs of domestic and overseas markets and users. In addition, by lowering the technical barriers, we will promote the entry of other industries into seed development.

By overcoming regulatory and public understanding hurdles and realizing examples of the production and commercial sales of genome-edited crops, we will promote further participation by agriculture, forestry, fisheries, and food companies in the production, utilization, and sale of genome-edited crops.

(2) [Production] Development of a smart production system, [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system.

The completed technology will be completely commercialized by the participating companies or by the companies that have been provided with the technology by the research institutions that have the IP rights. In addition, we will continue to work on expanding the number of participating organizations and improving the functions of the smart food system even after the completion of this task.

(3) [Sales and Consumption] Responding to diverse needs

In parallel with the promotion of research, we will expand the network of industry-academia-government collaboration and continue to build and develop a system for accumulating and using scientific evidence even after the completion of this task.

The integrated database of food, microbiome, and health information will be used to enhance research reviews and secondary analyses of data on the health-promoting effects of agricultural, forest, marine, and foods by research institutes, universities, and private companies, thereby encouraging agricultural corporations, food companies, and food service companies to file for and market functional agricultural, forest, marine, and food products labeled as functional. In addition, the provision and use of agricultural, forest, marine, and food products that are expected to have health-maintaining and health-promoting effects based on scientific evidence will be promoted by formulating new dietary guidelines for health maintenance and promotion.

A new service that understands the health status of individuals using the health check technology developed for judging minor changes in physical condition and proposes food and food design according to the health status of individuals will be introduced in selected model municipalities in advance to demonstrate the service’s effectiveness. The results will be disseminated in cooperation with the media to expand this service on a nationwide scale.

After the completion of this task, national research and development agencies will continue to play a central role in the development and operation of the integrated database of food, microbiome, and health information in collaboration with private companies and related research institutions and will construct a system for development and operations. As for intestinal microbiome data, private companies and related research institutes will collaborate to establish a system to develop and operate a database that can be used by industry.

4) [Resource Recycling] Development of bio-resource utilization technology and bio-materials

For the development and practical application of production systems for highly functional products and biomaterials that utilize biological functions, development and application will be conducted at the pilot scale level to demonstrate the usefulness of the systems. We will encourage the construction of full-scale plants through corporate investment to promote commercialization.

In the development of next-generation core technologies for the chemical industry using unused resources from the agriculture, forestry, and fisheries industries, we will construct a collaborative system for commercialization with the participation of related companies, organizations related to the agriculture, forestry,

and fisheries industries, and local governments from the beginning of the research and development stage. In addition, we will develop an environment for commercialization by examining the collection system and the business model for unused resources from the agriculture, forestry, and fisheries industries, taking into account cost and supply stability.

7. Other Important Matters

(1) How to proceed

In FY 2021, we will further promote the social implementation of the smart food system in research consortiums that have passed through the stage-gate process. In particular, we will advance the following points under the guidance of the PD.

- Clarification of the social implementation policy, establishment of the implementation system, and acceleration of implementation through these actions

(2) Flexible plan modifications

This plan will be reviewed flexibly to ensure the fastest and best results.

(3) Applicable laws and regulations

This project shall be conducted in accordance with the following.

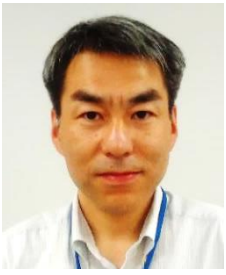
Act for Establishment of the Cabinet Office
(Act. No. 89, 1999) (Article 4, Paragraph 3, Item 7-3)
Basic Policy on Funds for the Creation and Promotion of Innovation in Science and Technology
(Council for Science, Technology, and Innovation, May 23, 2014)
Cross-Ministerial Strategic Innovation Promotion Program (SIP) 2nd Term (Amended Budget Measures for 2017) Implementation Policy
(Council for Science, Technology, and Innovation, March 29, 2018)
Cross-Ministerial Strategic Innovation Promotion Program (SIP) (Amended Budget Measures for 2018) Implementation Policy
(Council for Science, Technology, and Innovation, February 28, 2019)
2019 Cross-Ministerial Strategic Innovation Promotion Program (SIP) Implementation Policy
(Council for Science, Technology and Innovation Governing Board, June 27, 2019)
Cross-Ministerial Strategic Innovation Promotion Program Guidelines
(Council for Science, Technology and Innovation Governing Board, June 27, 2019)

(4) Program director and persons-in-charge

(i) Program Director

Kobayashi Noriaki
(April 2018-)

(ii) Directors (Officers, Counselors)



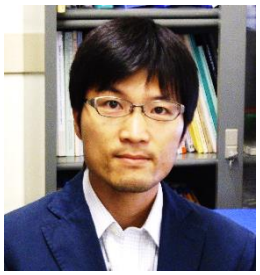
Nakajima Kiyoshi
(April 2018–December 2018)

Mori Sachiko
(January 2019–March 2021)

Ui Shinichi
(April 2021-)

(iii) Persons-in-Charge

Ishii Takeshi
(April 2018–April 2020)



Ogino Akifumi
(April 2018–April 2019)

Numa Hisataka
(April 2019–December 2019)

Fukushima Akira
(January 2020–March 2020)

Arata Yuto
(April 2020–)

Hibi Tadaharu
(April 2020–)

Appendix

Financial Plan and Estimates

FY 2018 Total ¥3,200M

(Breakdown)

1. Research expenses (including general management expenses and indirect expenses) ¥2,910M
   (Expenses by research and development item)
   (A) Establishment of new food-based health system to extend healthy life expectancy ¥445M
   (B) Revolutionizing productivity and strengthening competitiveness of the agriculture, forestry, fisheries, and food industries through the use of diverse data ¥1,489M
   (C) Realization of a sustainably growing society through "manufacturing using biological functions" ¥761M
   (D) Establishment of research and development infrastructure to create bio-digital fusion innovation ¥215M
2. Project promotion expenses (personnel expenses, evaluation expenses, conference expenses, etc.) ¥90M
3. Expenses necessary for efforts to enhance business projects
   (*These expenses were increased at the time of final allocation and are expected to be adjusted in the next fiscal year) ¥200M

Total ¥3,200M

FY 2018, Amended Budget Measures Total ¥200M

(Breakdown)

1. Research expenses (including general management expenses and indirect expenses) ¥194M
   (Expenses by research and development item)
   (2) [Production] Development of a smart production system, [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system. ¥194M
2. Project promotion expenses (personnel expenses, evaluation expenses, conference expenses, etc.) ¥6M

Total ¥200M

FY 2019 Total ¥2,500M (However, includes adjustment of breakdown item 3 for FY 2018)

(Breakdown)

1. Research expenses (including general management expenses and indirect expenses) ¥2,425M
   (Expenses by research and development item)
   (1) [Development] Development of innovative food materials and breeding technology using synthetic biology ¥272M
   (2) [Production] Development of a smart production system, [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system. ¥1,086M
   (3) [Value Chain Data Platform Construction] Validation of the database data distribution platform that aggregates and links database data. ¥142M
   (4) [Sales and Consumption] Responding to diverse needs ¥341M
   (5) [Resource Recycling] Development of bio-resource utilization technology and bio-materials ¥584M
2. Project promotion expenses (personnel expenses, evaluation expenses, conference expenses, etc.) ¥75M

Total ¥2,500M

FY 2020 Total ¥2,375M

(Breakdown)

1. Research expenses (including general management expenses and indirect expenses) ¥2,233M

(Expenses by research and development item)

(1) [Development] Development of innovative food materials and breeding technologies ¥235M

(2) [Production] Development of a smart production system, [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system.

¥759M

(3) [Sales and Consumption] Responding to diverse needs ¥340M

(4) [Resource Recycling] Development of bio-resource utilization technology and bio-materials ¥496M

(5) [Value Chain Data Platform Construction] Construction and validation of the database data distribution platform that aggregates and links database data

¥121M

2. Strategic accelerated research expenses (reserved at the beginning of the fiscal year) ¥281M

3. Project promotion expenses (personnel expenses, evaluation expenses, conference expenses, etc.) ¥143M

Total ¥2,375M

FY 2021 Total ¥2,256M

(Breakdown)

1. Research expenses (including general management expenses and indirect expenses) ¥1,910M

(Expenses by research and development item)

(1) [Development] Development of innovative food materials and breeding technologies ¥286M

(2) [Production] Development of a smart production system, [Distribution and Processing] Development of technologies for cost reduction and optimization, and [Utilization of Information] Construction of a prototype ICT platform for the construction of a smart food system.

¥837M

(3) [Sales and Consumption] Responding to diverse needs ¥350M

(4) [Resource Recycling] Development of bio-resource utilization technology and bio-materials ¥351M

(5) [Value Chain Data Platform Construction] Construction of an integrated bio-digital data distribution platform that consolidates and links databases and data ¥86M

2. Strategic accelerated research expenses (reserved at the beginning of the fiscal year) ¥211M

3. Project promotion expenses (personnel expenses, evaluation expenses, conference expenses, etc.) ¥135M

Total ¥2,256M

Project Timeline