2016 - 2017

English

JIRCAS

Japan International Research Center for Agricultural Sciences

Introduction

In the 21st century, the Earth we live in is confronted by a host of pressing global problems, among them, the poverty of more than a billion people, a tightening global food market, climate change, and environmental degradation. These problems have been deeply affecting sustainable production in agriculture, forestry and fisheries. In particular, they present threats to the maintenance of basic human needs and human security in economically and socially vulnerable developing countries. I believe the solutions for these global issues cannot be achieved without global cooperation.

The Japan International Research Center for Agricultural Sciences (JIRCAS), a National Research and Development Agency under the Ministry of Agriculture, Forestry and Fisheries, plays a core role in international collaborations in the field of agriculture, forestry and fisheries research in Japan. In April 2016, JIRCAS began implementation of its Fourth Medium to Long-Term Plan. Under this new five-year plan, we will avoid conducting research for research's sake, but instead, we will make innovative organizational changes aimed at creating "research results and technology development that meet global challenges" more efficiently, more effectively, and with a high cost performance.

President Masa Iwanaga

Meeting global challenges through JIRCAS

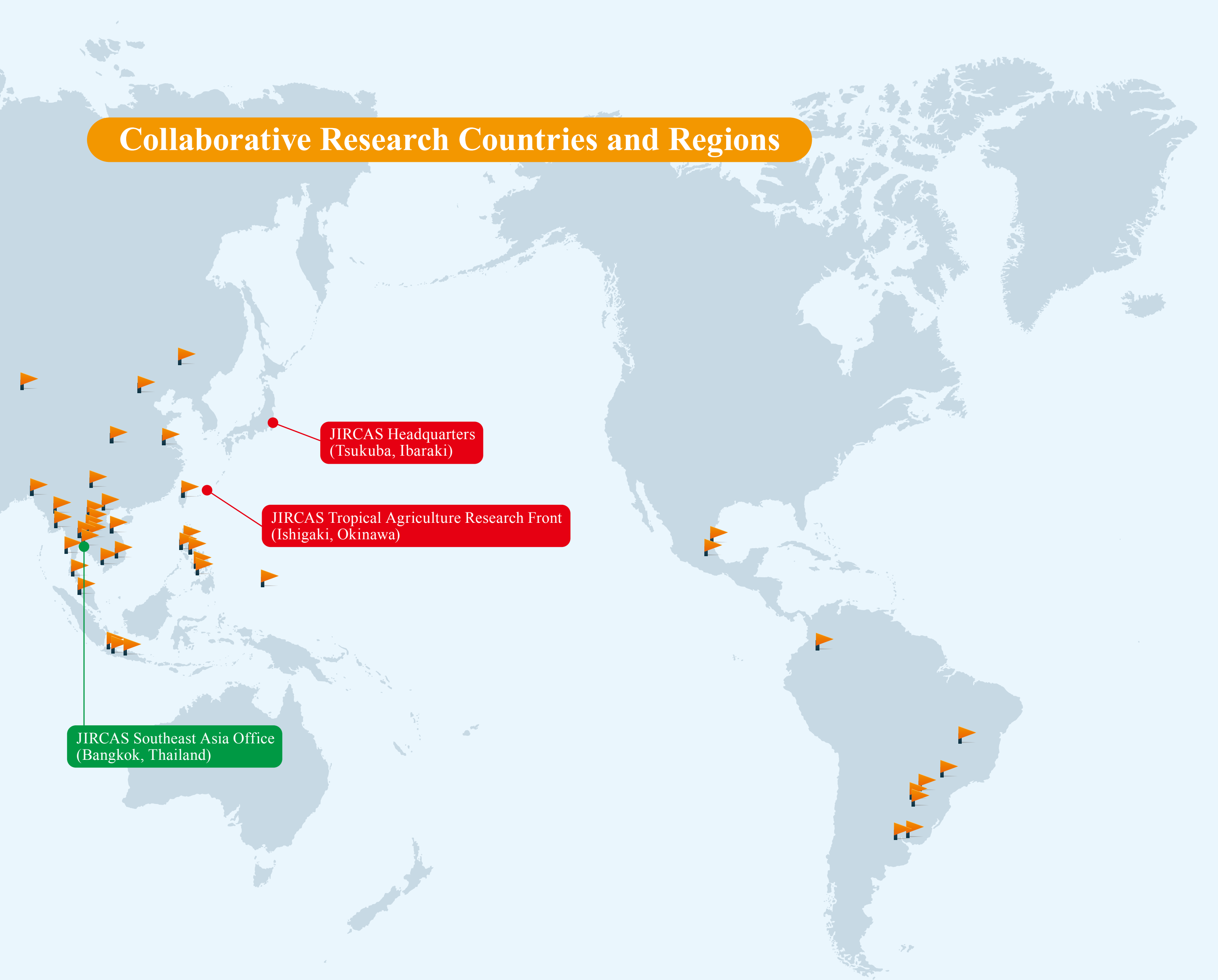
Roles

1. Plays a core role in international collaborations in the field of agriculture, forestry and fisheries research in Japan
2. Undertakes comprehensive experimental research for technological advancement of agriculture, forestry, fisheries and related industries in tropical and subtropical zones of developing regions
3. Provides solutions to global environmental problems, food insecurity, and extreme poverty for the future of agriculture, forestry and fisheries in the developing world

Activities

1. International Collaborative Research
2. Dispatch and Invitation of Researchers
3. Research Planning and Evaluation
4. Cooperation with Developing Regions

Collaborative Research Countries and Regions



research and technology development

History

1970 Establishment of the Tropical Agriculture Research Center by the Ministry of Agriculture and Forestry

1977 Transfer of TARC Main Office from Kita-ku, Tokyo, to Tsukuba City

1993 Reorganized as the Japan International Research Center for Agricultural Sciences under the umbrella of the Ministry of Agriculture, Forestry and Fisheries

2001 Restructured as an Incorporated Administrative Agency (IAA)

2015 Restructured as a National Research and Development Agency

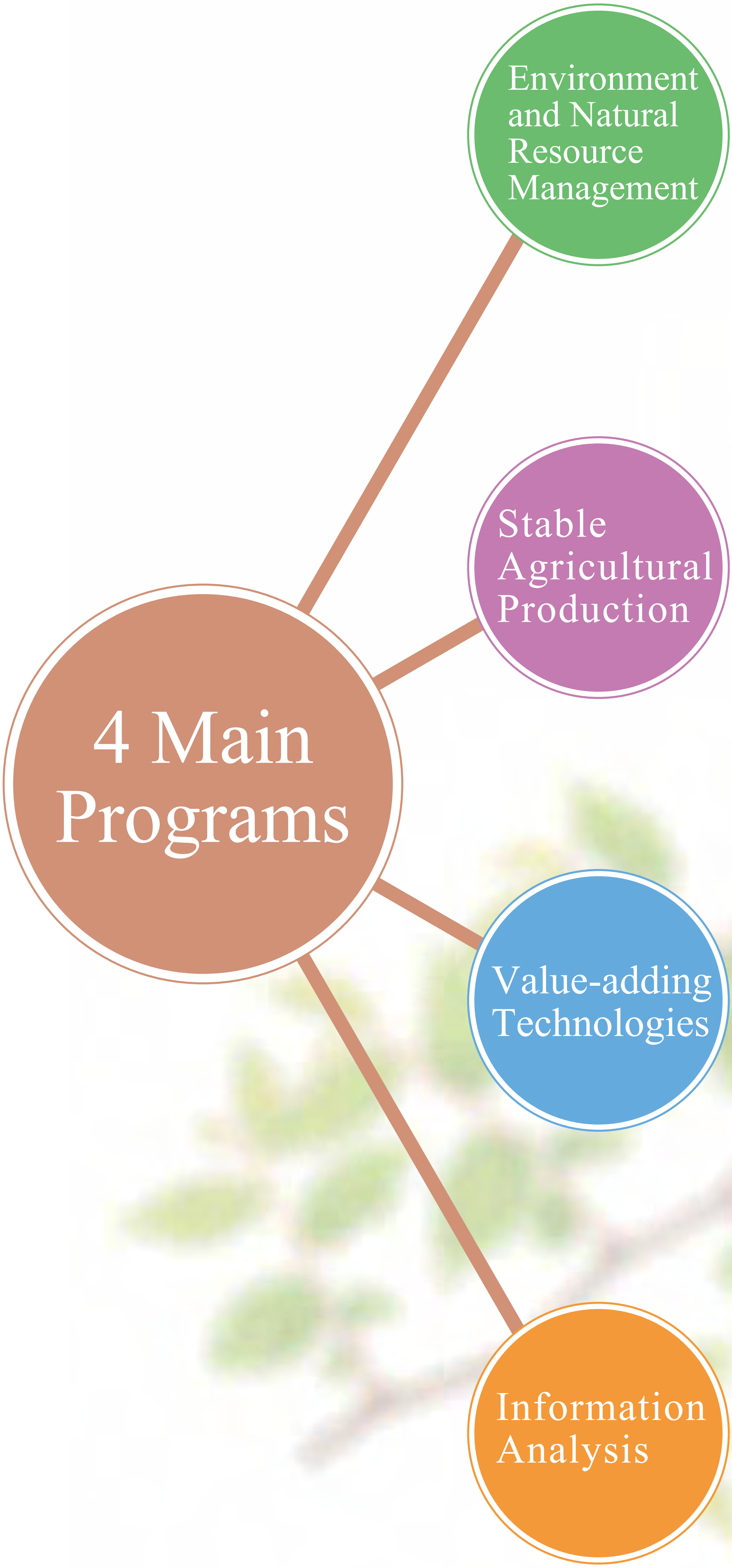
2016 Beginning of Fourth Medium to Long-Term Plan

Mission

1. To cope with climate change and environmental degradation, agricultural technologies for sustainable management of the environment and natural resources in developing regions will be developed.
2. To promote food production and to improve nutrition in the world including Africa, technologies for stable production of agricultural products in the tropics and other adverse environments will be developed.
3. To establish sustainable agriculture, forestry and fishery in harmony with the environment, and value chain contributing to processors and consumers as well as farmers, high value-adding technologies with various local resources in developing regions will be developed.
4. To solve global food and environmental problems, information for grasping trends in international agriculture, forestry and fisheries will be collected, analyzed and disseminated.

JIRCAS Medium to Long-Term Plan

FY 2016 → 2020



Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions

P06 ▶▶ P09

Development of agricultural technologies for reducing greenhouse gas emissions and climate-related risks in developing countries

- Development of intensive watershed management models for soil erosion-prone areas in Sub-Saharan Africa
- Development of sustainable resource management systems in the water-vulnerable areas of Asia and the Pacific Islands
- Development of ecologically sustainable agricultural systems through practical use of the biological nitrification inhibition (BNI) function

Technology development for stable production of agricultural products in the tropics and other adverse environments

P10 ▶▶ P13

Development of sustainable technologies to increase agricultural productivity and improve food security in Africa

- Development of breeding materials and basic breeding technologies for highly productive crops adaptable to adverse environments
- Development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments
- Development of technologies for the control of migratory plant pests and transboundary diseases

Development of high value-adding technologies and utilization of local resources in developing regions

P14 ▶▶ P17

Formation of food value chain through value addition of food resources to support sustainable rural development

- Development of saccharification and utilization technology for lignocellulosic biomass resources in Southeast Asia
- Multiple use and value addition of regional resources for improvement of sustainable productivity in semi-mountainous villages in Indochina
- Development of silvicultural and forest management techniques for indigenous tree species in Southeast Asia to achieve higher value production
- Development of technologies for sustainable aquatic production in harmony with tropical ecosystems

Collection, analysis and dissemination of information for grasping trends of international agriculture, forestry and fisheries

P18 ▶▶ P19

- Evaluation of global food supply-demand and nutritional balance
- Dissemination of research trends and local information

Program A

Environment and Natural Resource Management

Global environmental problems such as climate change, desertification, and soil degradation are getting more serious, and this can be partly attributed to agricultural activities especially in developing regions. Fertile soils are eroded, salt is accumulated by rising groundwater levels, fertilizers are leached through soil to pollute aquifers and the marine environment, and powerful greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) are produced and trapped in the atmosphere, leaving developing countries especially vulnerable to its negative impacts. JIRCAS Program A, titled "Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions" (short title: Environment and Natural Resource Management), is composed of four projects, formulated with the aim of developing agricultural technologies and adaptation measures to mitigate such environmental problems and cope with abrupt environmental fluctuations through adequate management of natural resources such as soil, water, and fertilizer (Fig. 1).

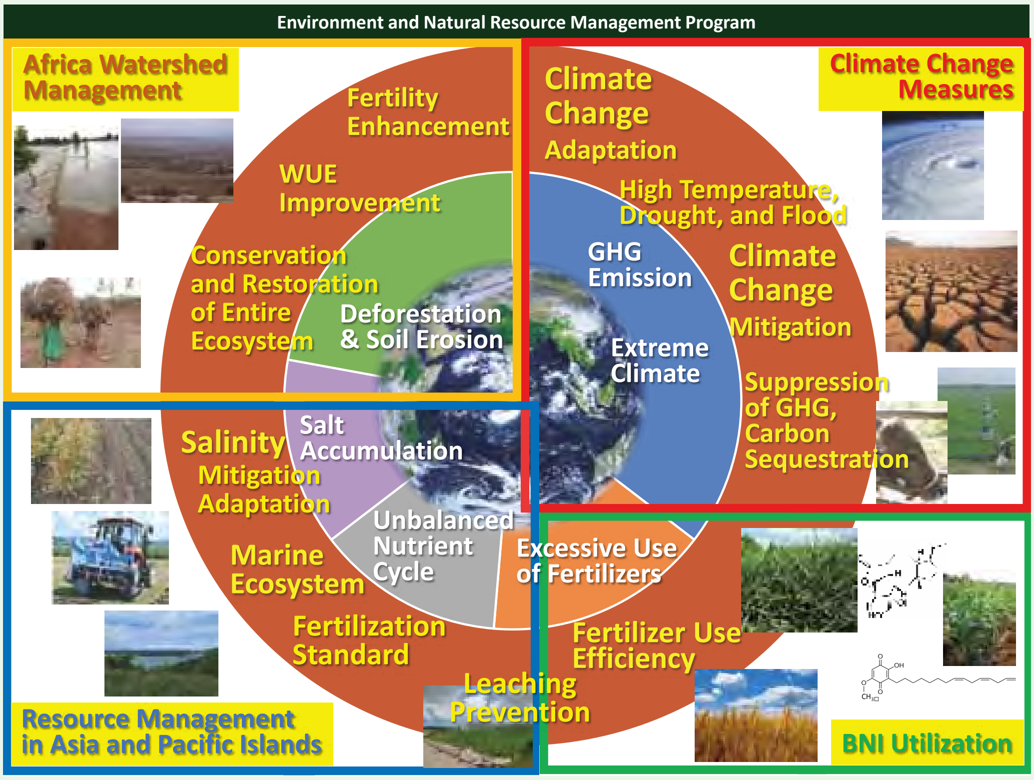


Fig. 1. Global problems (in inner circle around the earth) and our activities (outer circle) encompassing four projects to cope with these problems

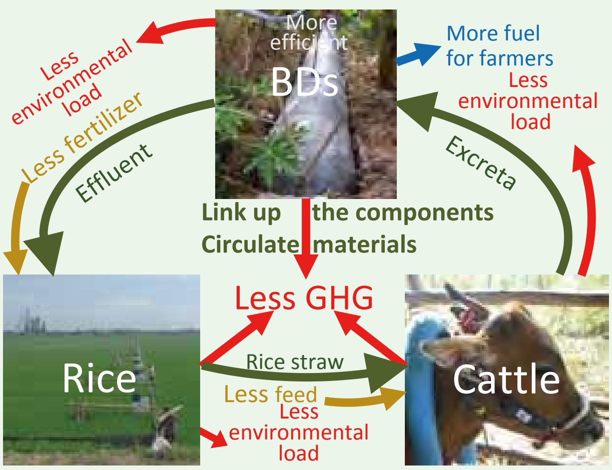


Fig. 2. Linkage of GHG-reducing technologies for efficient resource use and less environmental load

1 Development of agricultural technologies for reducing greenhouse gas emissions and climate-related risks in developing countries

GHG emissions caused by agricultural activities account for about 14% of all GHGs from human activities, with methane (CH_4) and nitrous oxide (N_2O) comprising half of human-related emissions from the agricultural sector. Therefore, it is critical to develop agricultural technologies for reducing GHG emissions and for minimizing potential negative economic impacts to farmers.

As for mitigation methodology, we will conduct researches in three areas. First, we will improve the alternate wetting and drying (AWD) technique in view of the increased number of farmer-practitioners in the Mekong Delta. The AWD method enables farmers to save irrigation water in paddy fields and reduce methane emission at the same time. More precisely, we will integrate various techniques, for example, by making better use of underutilized local materials and incorporating it into the AWD technique. Second, we will improve the biogas digester (BD) by identifying non-kitchen uses for the excess methane gas and by improving the design of the kitchen burner. Third, we will invent techniques to reduce GHG emissions from the livestock sector using presently underutilized local materials like rice straw in Thailand and Vietnam (Fig. 2).

As for agriculture risk management for climate change adaptation, we will try three techniques as well. First is the development and economic evaluation of adaptation measures to extreme weather events in the Bay of Bengal Region. To build high and long embankments for food prevention is not feasible in developing countries; therefore, the adoption of a weather index insurance scheme for agricultural products is being considered as a promising and practical measure to protect farmers in disaster-prone areas (Fig. 3). Second is the development of the Weather-Rice-Nutrient Integrated Decision Support System (WeRise). The unpredictable nature of rice production is a major challenge for farmers in rainfed environments. WeRise will support rainfed farmers to stabilize paddy yield. Third is the improvement of irrigation methodology in the Central Dry Zone of Myanmar. JIRCAS will develop methodologies to improve irrigation efficiency and promote adaptive farming practices to reduce drought risk.

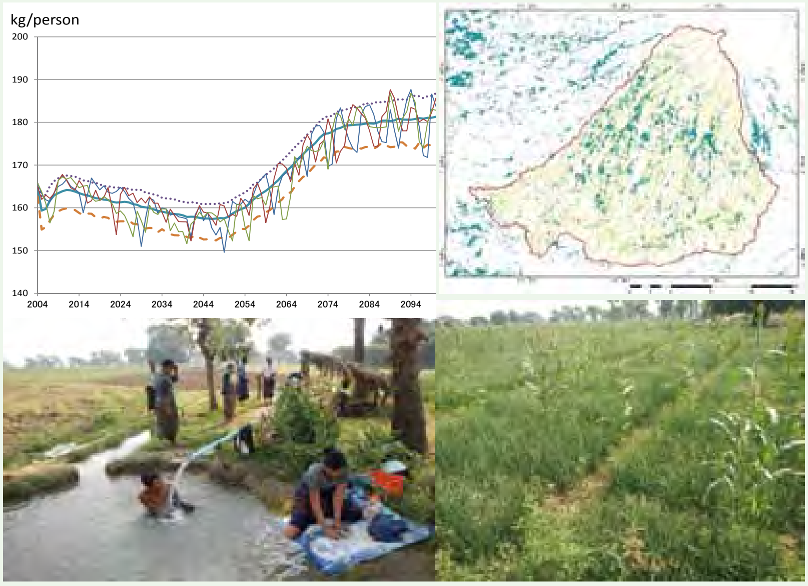


Fig. 3. *Clockwise from top left*: Sample output of the rice consumption model, suitability map of rainfed rice in Indonesia, drought-tolerant farming in Myanmar, and multiple use of irrigation water in Myanmar

2 Development of intensive watershed management models for soil erosion-prone areas in Sub-Saharan Africa

Land degradation such as soil erosion has been continuing in many regions of Sub-Saharan Africa (SSA) due to ongoing deforestation activities to expand farmlands and obtain firewood (Fig. 4). We will conduct the following researches at the Central Plateau of Burkina Faso in the Sudan Savanna Zone as well as the Ethiopian Highlands, both of which are at a high/very high risk of land degradation in SSA.

At the Central Plateau of Burkina Faso, soil erosion is a serious problem because rainfall intensities are high and fragile soils vulnerable to water erosion are distributed (Fig. 5). Also, low-input agriculture has been causing lower soil fertility and stagnation of agricultural productivity. To make effective use of the region's soil and water resources at a watershed scale, we will propose and evaluate soil and water conservation techniques, and maximize the use of resources by classifying arable lands into vegetation zones, conservation agriculture areas, and rainfed rice fields depending on specific land conditions of the watershed. Moreover, we will develop and propose improved sorghum cultivation and animal feeding management techniques to promote intensive agriculture and land use. Then, we will evaluate the effects of introducing the above-mentioned techniques on resource use efficiency using the Soil and Water Assessment Tool (SWAT) and the Universal Soil Loss Equation (USLE). We will also examine the effect of technology implementation on the income of agricultural households using prediction models based on a survey of farmers' existing conditions.

Longstanding deforestation and slope-land reclamation are considered as the major causes of soil erosion on the slopes of the Ethiopian Highlands in Eastern Africa, making a significant impact on the farming and living environment of the rural area in recent years (Fig. 6). This project is aimed at conducting empirical

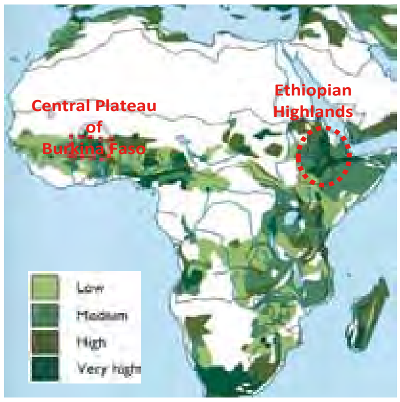


Fig. 4. Water erosion risk map of Africa

Fig. 5. Sediment-laden runoff water flows into the lowlands (Burkina Faso)

Fig. 6. Sloping landscape of farmland and mixed-forest in the watershed (Ethiopia)

research to develop sustainable natural resource conservation methods for appropriate watershed management by 1) introducing symbiotic fungus and soil improvement materials to rehabilitate native Acacia scrub forests that are vulnerable to artifacts, 2) introducing conservation-oriented agriculture to maintain productivity and conserve soils on small-scale hillsides or slope farms, and, with due consideration to the specific land system in Ethiopia, 3) predicting the future of the land-use system in the rural area by clarifying the impacts of improved land-use and forest- and farm-conservation activities on rural livelihood. We intend to formulate an appropriate watershed management method for forest and farm conservation that would contribute to a positive interaction between people in rural areas and natural resource sustainability.

3 Development of sustainable resource management systems in the water-vulnerable areas of Asia and the Pacific islands

Agriculture is by far the largest consumer of the Earth's available freshwater (about 3.9 x 10^9 tons per year). Seventy percent of freshwater withdrawals from surface water and groundwater sources are for agricultural usage. This volume is three times more compared to 50 years ago, in which 70% is consumed by Asian countries. With the increase in world population and the subsequent increase in cereal consumption, freshwater resources and global public goods should be conserved and sustainably maintained through development of effective utilization technologies and well-crafted regulations, especially in areas where resource availability is highly fluctuating.

In the Asia-Pacific region where water consumption is high, water resource areas can be characterized as dry or humid depending on rainfall. We then selected the Philippines and Palau from the humid island areas, and Uzbekistan, North India, and Bangladesh from the dry and salinized areas.

In the humid island areas, a) we will assess the current status of water and material balance and evaluate ecosystem functions through monitoring of water, soil, and nutrients within the watershed of Babeldaob Island, Palau (Fig. 7). The results will be utilized by simulating future scenarios of climate and land use changes in the region. A recycling system will be established to facilitate the reuse of deposited soil in the sedimentation basin of the purification plant, which will be built and enable the estimation of water and nutrient balances. As a next step, b) we will develop a cropping system that reduces soil and nutrient loss into the river. A land management system will be also developed through utilization of local resources such as crops, fruit trees, and marine and forest products. Furthermore, c) we will develop a sustainable crop cultivation system that can reduce nutrient leaching to underground and holds promise for a sustainable crop production through application of a simulation model that analyzes solute dynamics between soil and crop in the Philippines.

Fig. 7. Contamination due to sedimentation and mineral salt buildup is a concern in a water reservoir in Babeldaob Island, Palau.

Fig. 8. An irrigation and drainage experiment on a salt-affected land in Uzbekistan

In the dry salinized areas, d) we will apply a low-cost, subsurface drainage technology (which was developed in the multi-purpose paddy fields of Japan) to Uzbekistan, India, and Bangladesh. Soil and water management methods will be developed for salt-affected fields where salt and soil moisture often fluctuate under dry conditions. Research knowledge on supplemental subsurface drainage will be applied for the development of a low-cost technology. In addition, an adaptable irrigation technology will be applied on the improved field drainage (Fig. 8). Regarding the development of salt-tolerant crops for salt-affected lands in South Asia (Fig. 9), e) we will cross *Ncl*, a salt tolerance gene developed by JIRCAS, into local soybean strains, and backcross them for several generations. Locally adopted salt-tolerant soybean strains will be developed through screening in the local fields of India and Bangladesh.

Fig. 9. Salt-accumulated land in India where only few species of salt-tolerant plants can survive

4 Development of ecologically sustainable agricultural systems through practical use of the biological nitrification inhibition (BNI) function

BNI is an active plant-mediated natural function where nitrification inhibitors released from plant root systems suppress soil-nitrifying activity. Nitrification, the process in which limited group of nitrifying microbes (nitrifier) oxidize ammonia to nitrate, is crucial to how nitrogen cycles through global environment systems and affects crop production.

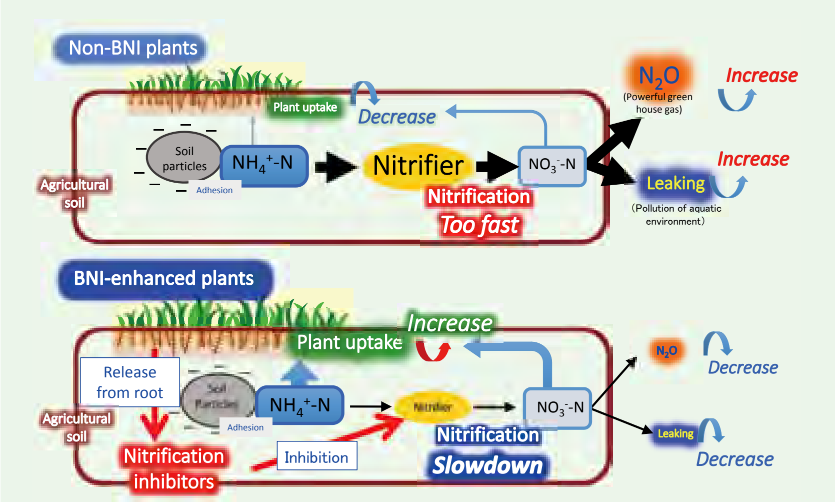


Fig. 10. Improvement of fertilizer use efficiency and reduction of environmental pollution through the utilization of BNI

Modern crop production systems depend heavily on fertilizer-nitrogen inputs to drive agricultural productivity, resulting in very high nitrification rates. This causes the constant decline of nitrogen-use efficiency (NUE) and various big problems to the earth's environment. Nitrification converts the immobile form of fertilizer-N, i.e., NH_4^+, in the soil to highly mobile nitrate (NO_3^-), resulting in the pollution of the aquatic environment. In addition, some are released into the atmosphere as nitrous oxide (N_2O), a powerful greenhouse gas, by denitrification and also in the course of nitrification. Suppressing nitrifier-activity to control nitrification in agricultural soils by the BNI technology is thus central to improve NUE and reduce N-leakage to the environment. This leads to the reduction of fertilizer inputs as a result (Fig. 10).

JIRCAS develops genetic tools, genetic stocks and agronomic strategies for exploiting BNI function using three model systems - wheat, sorghum and Brachiaria grasses (Fig. 9). For cultivated wheat, introducing high-BNI capacity largely depends on transferring BNI trait (i.e., high-BNI capacity), located in one of its wild relatives (*Leymus racemosus*) using chromosome-engineering tools. The International Maize and Wheat Improvement Center (CIMMYT) participates as the strategic research partner in this activity. For sorghum, genetic improvement of BNI capacity is through acceleration of sorgoleone release from root systems. With the participation of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), JIRCAS is developing genetic markers for sorgoleone trait to facilitate marker-assisted selection to improve BNI capacity in sorghum. JIRCAS is also closely working with the International Center for Tropical Agriculture (CIAT) to exploit the high-BNI capacity of Brachiaria pastures for the benefit of non-BNI crops such as maize, soybean, and upland rice using agro-pastoral systems, which is undergoing operational testing at present. In addition, JIRCAS clarifies the factors involved in the development of crop cultivation techniques with effective use of BNI function. Through this multi-partnered consortium effort, JIRCAS is developing several BNI-research components to build low-nitrifying production systems as a long-term goal for agricultural sustainability.

Stable Agricultural Production

Agricultural potential in developing regions, including Africa, has not been fully realized because of adverse conditions such as low fertility and droughts. Therefore, ensuring food and nutrition security is a challenge. This program aims to enhance agricultural productivity and improve nutrition in developing countries through development of technologies for stable production of agricultural products in the tropics and other adverse environments (Fig. 1). In other words, we will develop breeding materials with high productivity and agricultural technologies for adverse environments, conduct verification trials, and make manuals and commentary articles. This will be carried out through joint research with national and international agencies, and we will rapidly disseminate the developed technologies to breeders, government officials, and farmers. By promoting the research and the dissemination of the developed technologies to maximize the research results, we hope to contribute to enhancing agricultural productivity, improving the nutrition situation in developing regions, eradicating poverty, and building more peaceful societies across the world. At the same time, we also contribute to food security in Japan through our efforts to stabilize global agricultural production.

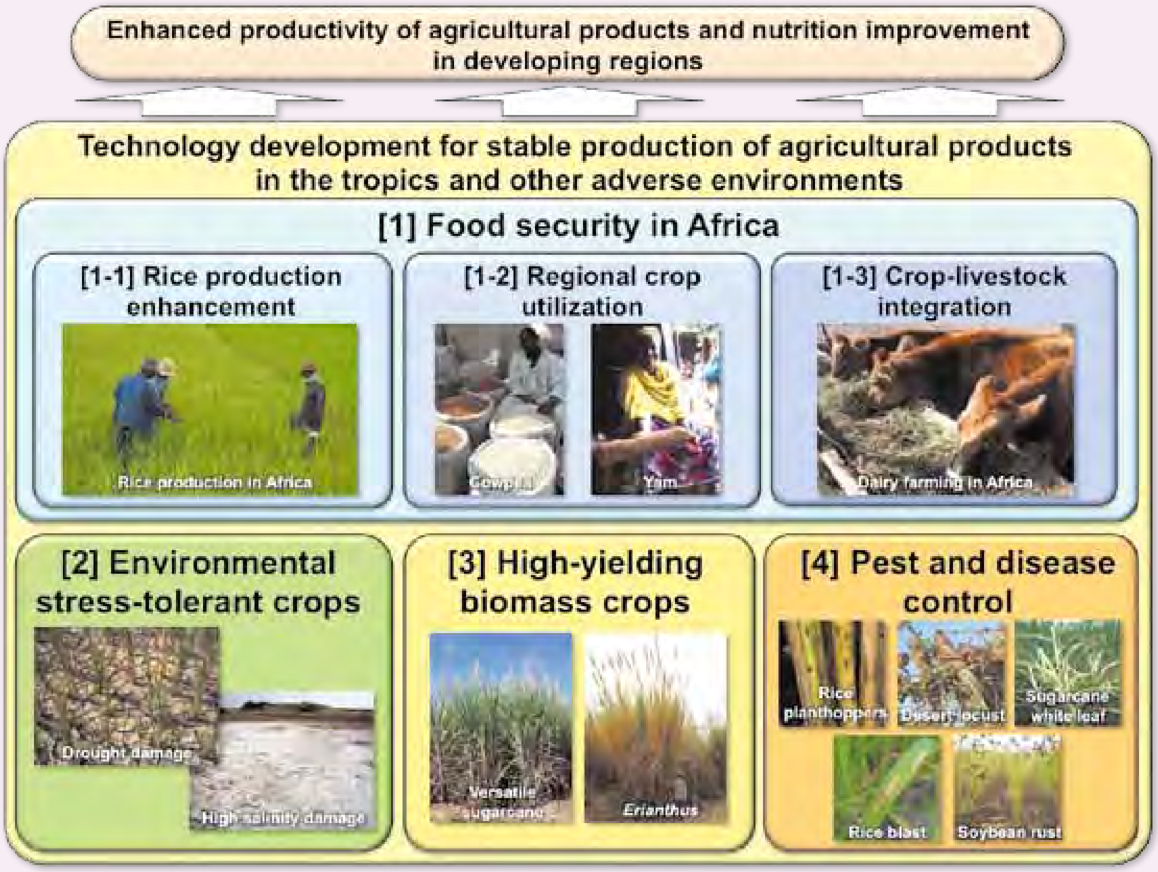


Fig. 1. Outline of the Stable Agricultural Production Program

1 Development of sustainable technologies to increase agricultural productivity and improve food security in Africa

The second of the 17 Sustainable Development Goals (SDGs) adopted by the UN General Assembly calls on all nations to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture." For JIRCAS, finding ways to overcome food shortage in Sub-Saharan Africa (SSA), where 215 million people are currently undernourished, would be its contribution toward meeting this challenging goal.

During the third medium-term plan period, JIRCAS conducted research studies on rice, yam, and cowpea for Africa. Desirable traits in rice were investigated to increase yield and meet the recent rapid increment in consumption in SSA. Two regional crops, yam and cowpea, were also examined because of their importance in the regional food and nutritional supply chain.

This project, titled "Development of sustainable technologies to increase agricultural productivity and improve food security in Africa," is Program B's flagship project under JIRCAS's fourth medium to long-term plan. The project is aimed at maximizing the previous medium-term plan's outputs, which were obtained in collaboration with either national or international research institutions, and thus contribute to enhancing food security in SSA. In this project, our research activities were planned based on the premise of "improving sustainability with efficient utilization of resources," "utilizing unused germplasm efficiently," and "capturing the preferences of consumers and needs of farmers." The project will be focusing on the three sub-themes enumerated below:

1-1 Rice production enhancement: Essential components of efficient rice production (e.g., breeding materials with improved nutrient uptake, simple diagnosis of nutrient condition, and smart fertilizer management depending on specific soil and environmental conditions) will be developed and their intergradation will be examined. Other challenges under this sub-theme include the development of technologies to improve water use efficiency by channeling excess water for rice irrigation, and the impact assessment and factor analysis of farmers' acceptance of these new technologies (Fig. 2).

1-2 Regional crop utilization: Cowpea and yam, two important regional crops in West Africa, still hold tremendous potential for productivity and quality improvements, and various demands deeply linked with regional culture and tradition will be met through utilization of unused genetic resources. Towards the active utilization of the rich genetic diversities of both crops in international and national breeding programs, we will generate fundamental information about their genetic diversities by exploring useful parental materials, and by developing tools to enable breeders to select and evaluate their materials effectively (Fig. 3).

Fig. 2. More rice is required (Ghana)

Fig. 3. Left: Cowpea being weighed and sold at the market (Nigeria); Right: Piles of yam awaiting long distance transportation (Ghana)

Fig. 4. Dairy farming can make a contribution to peoples' diets (Mozambique)

1-3 Crop-livestock integration: We will develop an effective and efficient crop-livestock integration model applicable throughout the year to increase dairy production in tropical savanna areas, which have distinct rainy and dry seasons. We will develop technologies to produce animal feeds utilizing the byproducts generated from crop production and food processing. We will also utilize wastes from livestock farming as a soil fertility management method to improve food crop production and sustain forage crop production by farmers. These are the main components of the model and we will evaluate their applicability and effectiveness in the target areas (Fig. 4).

The outputs of our research for development activities are expected to be utilized by governments, researchers, extension workers, farmers, consumers, and even international organizations, and further contribute in achieving stable food production and supply and in diversifying people's diets in SSA.

Fig. 5. Rice near-isogenic line with early-morning flowering trait that mitigates high temperature-induced sterility

Fig. 6. Soybean near-isogenic line with salt tolerance gene *Ncl* (right) and susceptible cultivar (left)

Fig. 7. New variety of multi-purpose sugarcane (left) and conventional cultivar for sugar production (right)

2 Development of breeding materials and basic breeding technologies for highly productive crops adaptable to adverse environments

There are concerns that global strains on food supply could occur in the medium to long term due to global population rise, chronic malnutrition in developing countries, projected economic growth in emerging countries, and increased frequency of abnormal weather events. Thus, it is necessary that sustainable agricultural production activities are carried out especially in developing countries where the production potential of the agricultural sector has not been fully harnessed.

In order to establish stable and sustainable production of agricultural crops in developing countries that are vulnerable to climate change impacts such as droughts, high salinity, and poor soil, we will work on developing breeding materials and basic breeding technologies to produce crops that are highly productive yet adaptable to such adverse environments.

For rice, breeding materials that have high temperature resistance, drought tolerance, phosphate deficiency resistance, and high nitrogen use efficiency will be developed (Fig. 5). For soybean, development of breeding materials that are tolerant to drought and high salinity will be undertaken (Fig. 6). In addition, we will develop a double haploid breeding technology, a non-GM crop production technology, and a growth evaluation method in a greenhouse to mimic the stress conditions of farm fields.

3 Development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments

With the increase in world population, problems such as inadequate food and tight energy supply have also arisen. Hence, fields of low agricultural productivity must be improved and food and energy production must increase. Sugarcane was chosen for further investigation among important candidate crops because it can produce food and energy from its sugar and fiber. Sugar is a food and can be a source of bio-ethanol, whereas bagasse, the fibrous byproduct from sugarcane, can be used to generate electricity. JIRCAS has developed new multi-purpose sugarcane varieties with good yield of both sugar and fiber in Northeast Thailand, where productivity of sugarcane is low because of severe drought and infertile soils. They have been registered as new varieties of sugarcane by the Department of Agriculture, Thailand (Fig. 7).

In this project, we will develop sustainable cultivation methods and utilization technologies for high-yielding biomass crops such as multi-purpose sugarcane and *Erianthus*, which is a wild relative of sugarcane tolerant to unstable environmental conditions (Fig. 8). We will also develop new breeding materials that produce high biomass yield in several unstable environments through intergeneric hybridization between sugarcane and *Erianthus*. For this purpose, we will establish techniques for evaluating important characteristics related to biomass production of *Erianthus* in stress conditions and for selecting intergeneric hybrids using DNA markers.

Fig. 8. *Erianthus* showing vigorous growth in Northeast Thailand

4 Development of technologies for the control of migratory plant pests and transboundary diseases

Some insect pests and diseases spread transboundary, damaging crop production. It is difficult for any country alone to combat the pests and diseases; therefore, cooperation with surrounding countries is necessary.

We will focus our research on migratory rice planthoppers (Fig. 9), which are abundant in Southeast Asia and Japan; desert locusts, which form large swarms; and leafhoppers, which transmit sugarcane white leaf disease, the most important disease in sugarcane production in Southeast Asia. Against rice planthoppers, we will obtain information about their occurrence, insecticide resistance and natural enemies, as well as the resistance of rice varieties in order to develop control techniques. Against desert locusts, we will elucidate the factors that provoke phase polyphenism (from solitary to gregarious form) by conducting field observations. Against leafhoppers and sugarcane white leaf disease, we will develop an integrated pest management method for healthy seed cane production based on the ecology of the vectors.

Fig. 9. Brown planthoppers infesting rice

Fungicide application has been found effective in controlling the wide dissemination of airborne diseases such as rice blast or soybean rust. However, fungicides need to be applied regularly, thereby increasing application costs and the risk of developing fungicide-resistant strains. JIRCAS, through international research networks that it has constructed, will develop rice breeding lines resistant to blast for Asia by incorporating field resistance genes as well as soybean cultivars resistant to rust for South America by pyramiding resistant genes (Fig. 10).

Fig. 10. Developing soybean line resistant to rust (left) and susceptible cultivar (right)

Value-adding Technologies

This program addresses the utilization of various regional resources in Asia and the development of high value-adding technologies to increase farmers' income in developing regions as well as contribute to the "Global Food Value Chain Strategy" launched by the Japanese government. The program also supports rural development in the region by practicing sustainable agriculture, forestry and fisheries in harmony with the environment.

To ensure high quality products and stable food value chains, the following activities are required, namely, the identification of regional food resource characteristics, the development of effective food processing technologies, and the elucidation of customer needs. Regarding our strategy for rural development, technologies are equally important to promote environmentally-sound energy cycles through utilization of unused biomass, and to realize highly sustainable agriculture, forestry and fisheries by conservation and utilization of resources. JIRCAS conducts the following five research projects to achieve these targets and accelerate technology transfer and dissemination (Fig. 1).

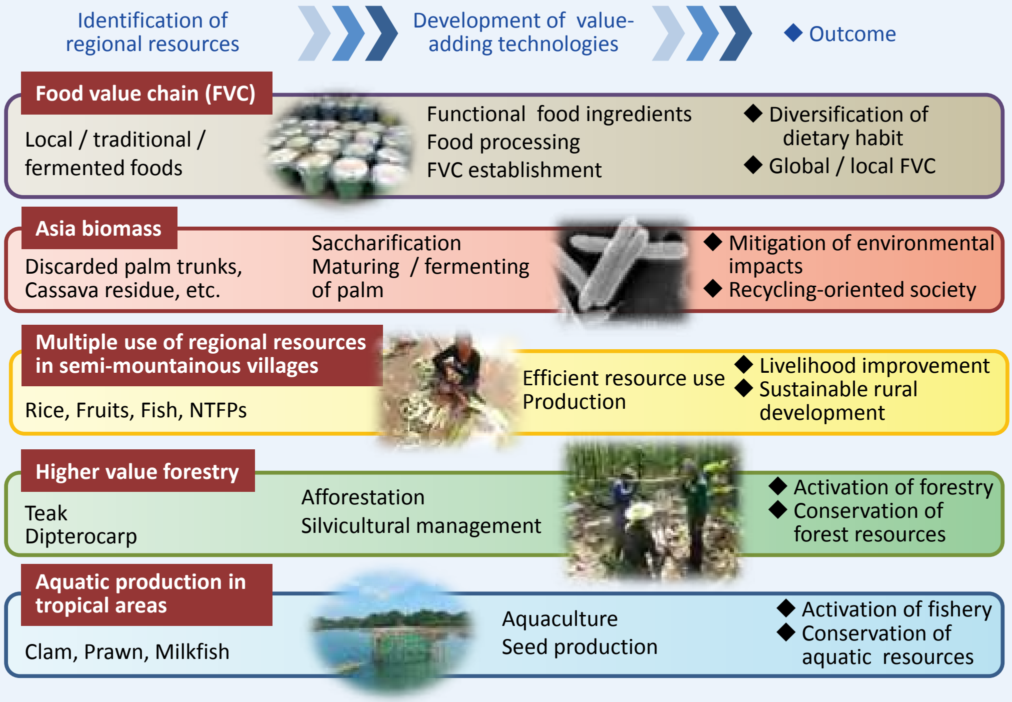


Fig. 1. Structure of the Value-adding Technologies Program

Fig. 2. Traditional salty-fermented freshwater fish paste "*pa-daek*" sold at a market in Lao PDR

1 Formation of food value chain through value addition of food resources to support sustainable rural development

Our daily food is transferred from harvested materials to marketable products through a process that ensures reliability for human consumption. In order to formulate this scheme, the producer side should be able to supply high quality food that satisfies consumers' needs and preferences. Additionally, the scheme should be profitable for the producer side and to people engaged in processing and distribution so they can maintain their activities. If the scheme is coordinated and functions effectively, it could be called a "Food Value Chain (FVC)." Value addition is a key word in the formation of an FVC; however, the criteria for determining value addition, which could be generated anywhere within the chain-link or steps (from production to consumption) are not clearly defined. In this project, we will investigate not only individual technological developments relating to food processing and distribution but also the effectiveness of FVC formation for specific food products, with due consideration to the interrelation between consecutive steps.

The project's major collaborative institutes are located in Thailand, Lao PDR, and China. These countries have a wide variety of local and traditional food resources as well as a great deal of tacit knowledge about food processing (Figs. 2-4). However, although many among these food resources contain potentially high functionality or high added value, they have not yet been scientifically evaluated. Also, problems still remain regarding technologies for producing high quality food and for establishing a distribution system in these areas. Therefore, it would be meaningful to discover and analyze the present state of food resource utilization and to provide solutions for effective utilization as the bases of formation of an FVC.

The project activity consists of the following four major subjects: The first is to develop a method to evaluate food quality through scientific analysis of materials in local food resources such as underutilized food components, cereal, and fermented foods whose quality and functionality have not yet been identified. The second is to develop a technology to produce food that is high quality and has high functionality based on tacit knowledge of traditional cereal or fermented food processing technologies. The third is to develop effective strategies to formulate an FVC through analysis of distribution and consumption characteristics, focusing on rice and fermented foods and applicable to areas under various economic levels. The fourth is to develop methods to evaluate the effectivity of an FVC formed for a specific food product and also, to examine the applicability of ICT (Information and Communication Technology) to enhance the added value of the products.

Fig. 3. Various brands of rice displayed at a rice shop in China

Fig. 4. Another type of fermented soybean "*tua-nao*," left to dry in the sun in Thailand

2 Development of a saccharification and utilization technology for lignocellulosic biomass resources in Southeast Asia

A biomass is an organic material of biological origin that is devoid of any fossil material and is continuously renewed as long as there is life and solar energy. Biomass is considered "carbon neutral" which means it does not allow the increase of CO_2 in the atmosphere. Substituting fossil fuel-based energy and manufactured products with biomass-derived ones will therefore contribute greatly to the reduction of greenhouse gases, the main cause of global warming.

Southeast Asian countries are expected to experience sustained economic growth which, due to their large population, will have a great impact on the world's energy situation and the environment. On the other hand, most of them possess abundant renewable biomass resources. Japan has been accumulating many technologies in this field and therefore can contribute to the development of sustainable biomass utilization in Southeast Asian countries through collaborative research.

The Asia Biomass project deals with the following two primary themes: the development of an efficient and cost-effective saccharification technology for tropical crop residues such as oil palm, cassava, or sugarcane residues, and the development of a conversion technology to transform renewable energy and materials (Figs. 5-6). The achievements will contribute to identifying the socio-economic effects of increased biomass use in Southeast Asia on agriculture and industries. The outcomes of the project will also provide inputs for the construction of sustainable social systems in Southeast Asia, encourage cascade utilization of biomass, and help address global environmental issues.

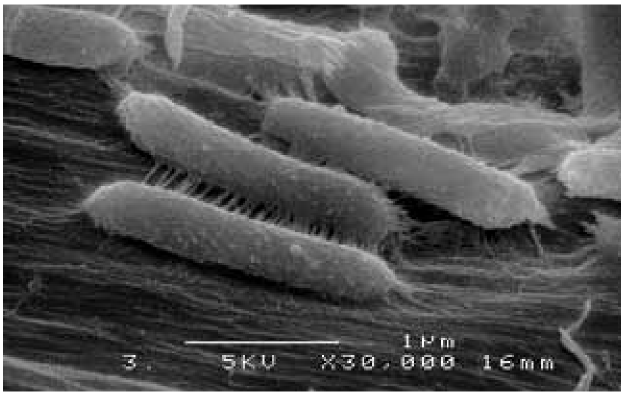


Fig. 5. Direct saccharification technology for lignocellulosic biomass conversion using anaerobic thermophilic bacteria

Fig. 6. Spray tests using iodine solution to determine sugar-accumulating old oil palm trunks (OPT). Left: non-accumulating OPT; Right: sugar-accumulating OPT

Fig. 7. Upland rice farming in Laos

Fig. 8. Fermented fish "*pa-daek*," a nutritionally important value-added food material in Laos

Fig. 9. Furniture made of teak wood, Thailand

3 Multiple use and value addition of regional resources for improvement of sustainable productivity in semi-mountainous villages of Indochina

Small-scale agriculture is the principal industry in most of the inland parts of the Indochinese Peninsula, with semi-mountainous areas being the main farming fields (Fig. 7). However, the livelihoods of farmers in these areas are being threatened because of decreased agricultural productivity due to recent population growth, insufficient water supply, and soil fertility deterioration caused by inappropriate land use. This is widespread particularly in Laos, where high poverty rates and insufficient nutrient supply in semi-mountainous rural areas are considered national problems. Efforts to improve food production/supply through sustainable agriculture in such areas are also recognized as an important political subject. However, agricultural systems in semi-mountainous areas are composed of complex components, and due consideration must be given to farmers' preferences and product marketability as well as water/soil management methods to increase productivity and promote product diversification.

As for forest areas, they are also very important because of their role in maintaining farmland productivities and as major collection sites of food materials and other commodities, thus investigations on conservation and sustainable use of forest areas are indispensable. In addition, value-added products that were nutritionally enhanced or made preservable by appropriate processing techniques are to be introduced to improve the nutritional situation of farmers (Fig. 8).

Taking the above aspects into account, this project will be undertaken in the semi-mountainous areas of Laos with a focus on improving the productivity of major crops (mainly paddy field and upland rice). Conservation/sustainable use of forest areas, product diversification (e.g., by introducing fruit cultivation and fish culture techniques to create value-added products) and development of food processing techniques (to produce nutritionally enhanced value-added products) will also be tackled. The results of these research activities are expected to contribute toward improving the livelihoods of farmers in these areas.

4 Development of silvicultural and forest management techniques for indigenous tree species in Southeast Asia to achieve higher value production

A tropical forest sustains a huge biomass and rich biodiversity, controls the local and global environments, and supplies various products such as timber, fuel, food, and medicine, thus supporting local livelihoods and benefiting the lives of those outside the forest (Fig. 9). However, deforestation and degradation of tropical forests have been advancing rapidly, and valuable tree species have been depleted from forests in many tropical countries.

The demand for these depleted tree species/resources is being supplemented by products harvested from plantations (Fig. 10). Such plantations contribute to restoring forest cover, mitigating the logging pressure on the remaining natural forests, and, if owned by local people, improving their livelihoods. For the local people, however, trees are not often viewed as attractive alternative crops for long-term investment. To attract more local people to plant trees, it is necessary to demonstrate the competitiveness of tree plantations.

This project, therefore, intends to develop and disseminate techniques and knowledge to grow higher-value plantation products in a more efficient and stable manner. To achieve its goals, a suite of techniques such as adding value to the standing trees, improving the soil, monitoring the plantations efficiently, and breeding trees of higher-value traits, will be developed for indigenous tree species in Southeast Asia.

Fig. 10. A 15-year-old teak (*Tectona grandis*) plantation, Thailand

5 Development of technologies for sustainable aquatic production in harmony with tropical ecosystems

Southeast Asian countries have achieved rapid economic development in recent years. Fisheries, especially aquaculture, have also developed markedly in these countries; for example, 40 to 50% of the world's cultured shrimp production is occupied by products coming from Southeast Asian countries. On the other hand, the construction of aquaculture farms has caused environmental destruction, made worse by diseases often spreading to many other shrimp farms. Around urbanized areas, industrial and domestic wastewater flows into the sea, polluting the coastal waters. To solve these problems, the development of environment-friendly and sustainable aquaculture technologies is needed.

In this project, efficient aquaculture techniques like combining multiple organisms, e.g., fish with sea cucumber and seaweed (Fig. 11), and environmentally friendly non-feeding aquaculture techniques for bivalves (Fig. 12), are being developed for sustainable aquatic resources production in harmony with tropical ecosystems. Low fishmeal feed using alternative resources is also being developed to reduce aquaculture feed costs. Also, a new aquaculture system for indigenous freshwater shrimp is being developed in inland areas to improve the food supply. The results of these research activities will make aquaculture technologies more sustainable and enhance the livelihood of fishermen in developing regions. Furthermore, the issue of securing a stable supply of high-quality aquaculture products for Japan will be addressed.

Fig. 11. A facility for demonstrating integrated aquaculture in the Philippines

Fig. 12. Blood cockle, a very popular foodstuff in Southeast Asia and one of the target species in this project

Program D

Information Analysis

The global situation and problems surrounding agricultural production and the food market as well as food and nutrient supply are extremely complex and widely diverse. Moreover, they are constantly affected by global phenomena such as climate change, along with deteriorating natural environments and international socio-economic trends. To address the stable and sustainable development concerns of agriculture, forestry and fisheries, it is essential to analyze the current status, identify the problems, assess the impact of past development efforts, and integrate foresight studies. We also recognize that incorporating recurrent feedback and the results of analyses into institutional strategies would make our research for development (R4D) activities more adequately focused, efficient, and cost-effective.

Program D, in coordination with JIRCAS's other three programs, plays a role in analyzing global research trends and needs in agricultural sciences through the following activities:

- "Food and Nutritional Balance Project" to evaluate current status and to develop a foresight model of global supply-demand and nutritional balance,
- "Strategic research" and "Impact study" to develop creative ideas, new knowledge, and innovative technology for revitalizing R4D in agriculture, forestry, and fisheries, and
- "Analysis of global research trend in agricultural sciences" to update, analyze, and exchange R4D information.

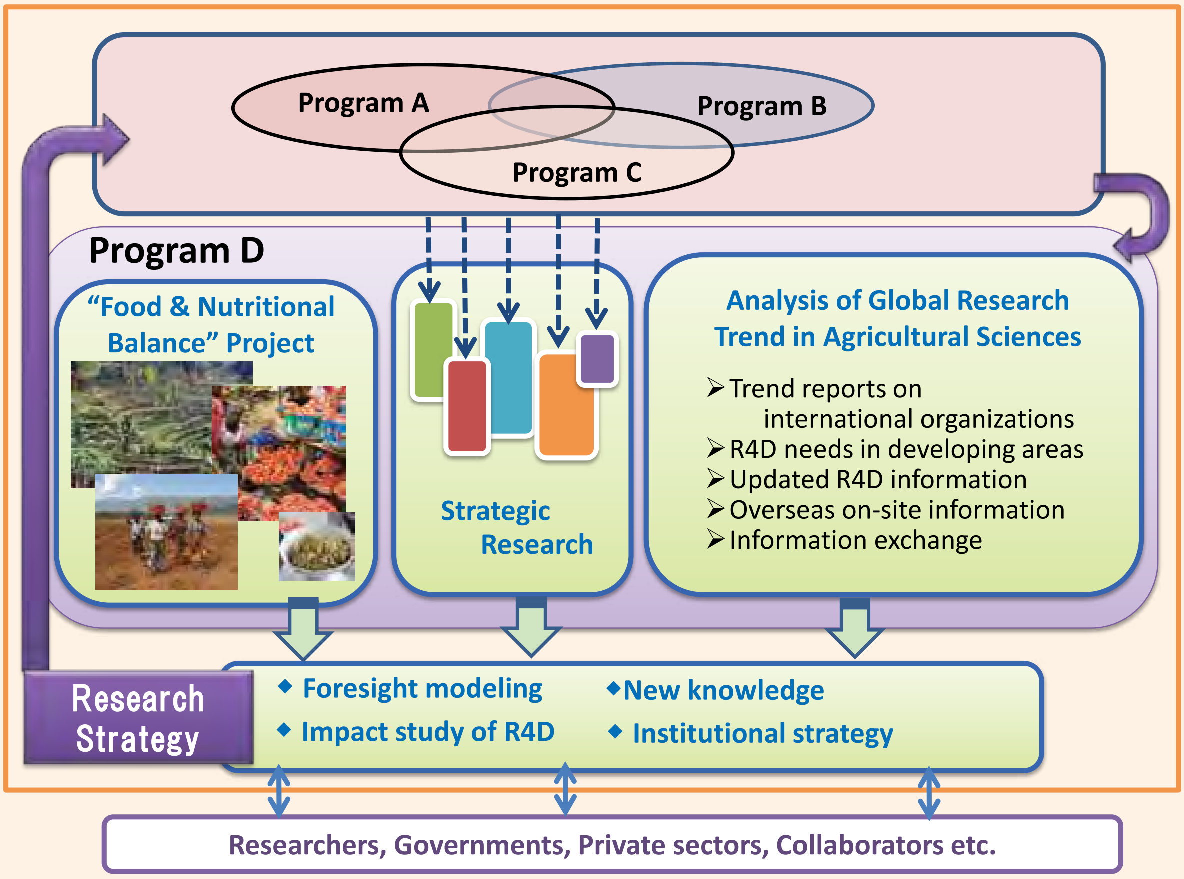


Fig. 1. Outline of the Information Analysis Program

Evaluation of global food supply-demand and nutritional balance

Unlike industrial products, agricultural products cannot be produced at a steady rate. To make things worse, unusual weather events such as droughts and floods have often caused serious damage to crops. Furthermore, the fluctuations in agricultural production have become erratic and more frequent in recent years because of climate change, continuous energy price change, growing demand for biofuels, and armed conflicts like civil wars or international terrorism. Hence, global food supply in the future is uncertain, and this uncertainty surrounding agriculture has left developing countries particularly vulnerable as they are more likely to lack basic infrastructure (such as roads and electricity), irrigation facilities, capital equipment, and adequate investment.

On the demand side, current food consumption and nutrient intake through food vary greatly by region. Hunger has been decreasing worldwide; however, the regional gap has been rather increasing. In developing countries, the situation is more complex as major problems that have emerged include not only energy deficiency but also micronutrient deficiency and obesity.

In this project, we will examine the current situation of agricultural production, food consumption, and nutrient supply. We will construct a foresight model of global supply-demand that will take into consideration uncertain factors, such as the effects of climate change, change in crop acreage, technological innovation, and socioeconomic characteristics, in order to predict future global food supply-demand. We will also analyze the nutritional balance both globally and regionally. Furthermore, we will measure and evaluate the impacts of past agricultural research and development projects from medium to long-term perspectives. Through analyses and evaluation, we will aim to contribute to the development of an effective strategy in agricultural research and technological innovation for global food security and nutritional improvement.

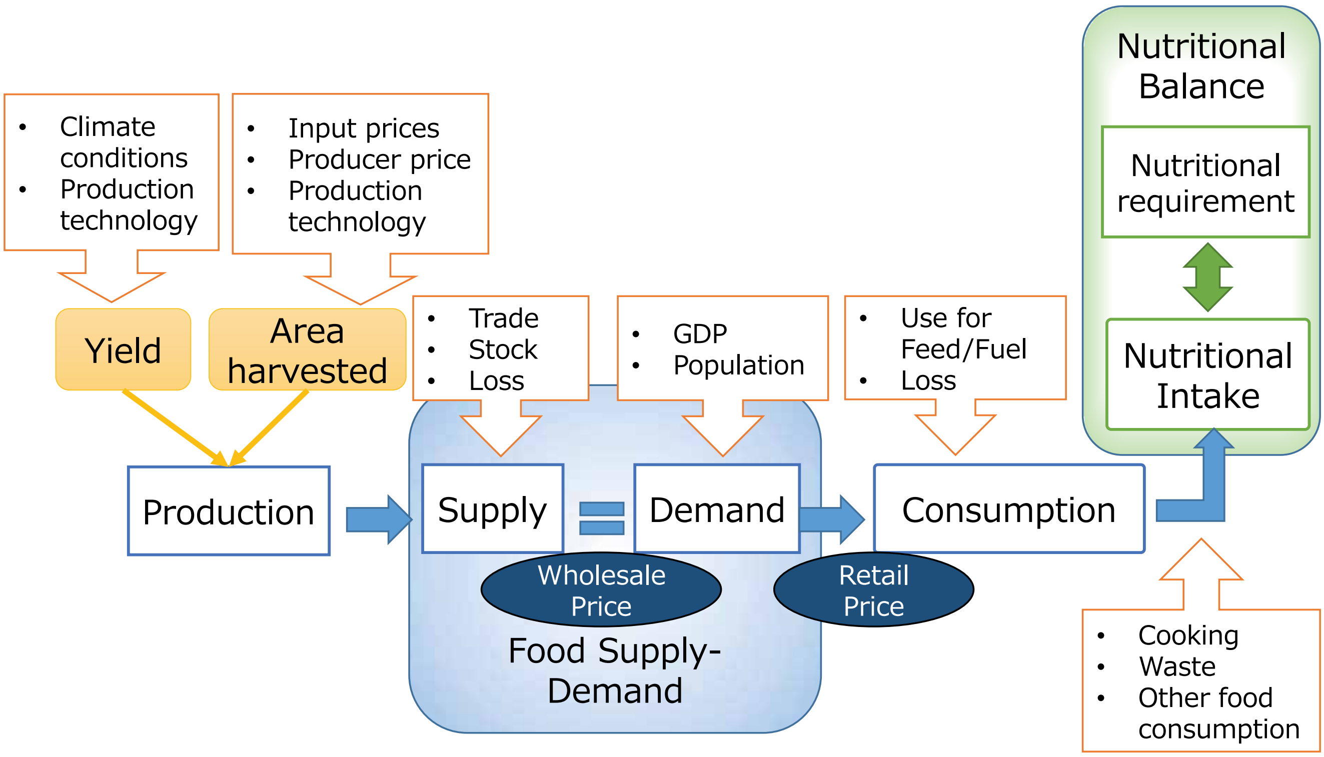


Fig. 2. Outline of the Food and Nutritional Balance Project

Tropical Agriculture Research Front (TARF)

【Location】

Ishigaki Island (24°1-35' N, 124°5-20' E), where the Tropical Agricultural Research Front (TARF) is located, is a subtropical island with a diverse ecosystem spread from the coral-rich seas to the deep green mountains. The island is about 2,100 km southwest of Tokyo and 270 km northeast of Taipei. It has an area of 221 km^2 and is surrounded by coral reefs. It has a humid subtropical climate with an annual average temperature of 24.3 °C. Although annual average precipitation is high (as much as 2,107 mm), droughts caused by high temperatures during the summer are not uncommon. Several typhoons every year bring not only blessed rain on the island but also severe wind and salinity damage due to strong sea breezes.

Upland fields on Ishigaki Island surrounded by coral reefs

【Roles】

TARF conducts research and development of agricultural production technologies that can be applied to developing regions and island regions in the tropics and subtropics, taking advantage of the area's climatic and geographical conditions. It implements basic and fundamental experiments that are difficult to perform at project sites overseas using its 21-hectare experimental field and various greenhouses as well as the open laboratory facilities (lysimeters). As the only national agricultural research organization located in the subtropics, TARF is thus entrusted with an important mission.

View of Mt. Omoto (526m) from the lysimeter facility

【Research Projects】

TARF implements the following research projects in cooperation with JIRCAS HQ as well as domestic and foreign research organizations:

◆ Environment and Natural Resource Management Program

・ Resource Management in Asia and Pacific Islands Project

The project focuses on developing a natural resource management system in islands wherein agricultural production coexists with environment and ecology conservation. To achieve this objective, we will develop 1) a recycling system that facilitates the reuse of deposited soil in the sedimentation basin of the purification plant, 2) a sustainable cropping and land management system that promotes utilization of local resources, and 3) a sustainable crop production system that reduces nutrient leaching into underground water in Pacific islands, like Palau and the Philippines, through utilization of lysimeters (the open research facilities) in TARF.

Sand basin installed in an upland field in Ishigaki Island

・ BNI Utilization Project (BNI: biological nitrification inhibition)

We are currently working on *Brachiaria* grass, among other BNI crops, at TARF. BNI substances, nitrogen dynamics, and microorganisms in the soil are periodically sampled and investigated in order to elucidate the effects of continuous cultivation of *Brachiaria* on BNI activities in the soil. Moreover, promising lines and populations of *Brachiaria* are being produced and evaluated for agronomic traits towards the development of a grass with high BNI capacity.

◆ Stable Agricultural Production Program

・ Food Security in Africa Project; Environmental Stress-Tolerant Crops Project; Pest and Disease Control Project

TARF is located at the subtropical Ishigaki Island where the climate is suitable for growing the Indica Group rice cultivars, enabling us to grow rice twice a year. The island's unique climate, therefore, has made it possible to investigate and evaluate the performance of various kinds of rice germplasm and breeding materials efficiently, and to conduct rice breeding and genetic research for developing countries in Asia, Africa, and other tropical regions.

A scientist from Bangladesh investigates the rice materials in the paddy field at TARF

Rice germplasm, including landraces and improved cultivars, were introduced from rice-producing countries around the world, and the genetic variation in agronomic traits were investigated to provide not only germplasm but also genetic and basic information to rice scientists in Japan and foreign countries. Particularly, breeding materials for high and stable rice production under various environment conditions are being developed to create a new rice plant type based on the genetic improvement of shoot and root types. Blast disease, which is distributed across all rice-producing regions in the world, is also a serious problem in rice cultivation. The identification of new resistance genes and production of resistant breeding materials are also being done to develop durable protection systems and stable resistant cultivars.

Yam is one of the most important traditional staple crops in tropical/subtropical regions especially in West Africa. TARF is working on the establishment of a genetic transformation system for yam to find candidate genes for useful agronomic traits through the African Food Security Project.

In arid and semi-arid areas in China and India, salinity damage has been identified as one of the most serious growth constraints on soybean production. TARF's role in the Environmental Stress-Tolerant Crops Project is to analyze the function of the salt-tolerance gene, *Ncl*, which has been isolated from a salt-tolerant soybean.

・ High-Yielding Biomass Crops Project

The objective of this project is to develop new sugarcane varieties that produce high biomass yield under severe unstable environments through intergeneric hybridization between sugarcane and *Erianthus*. In order to select good breeding materials, we will develop evaluation techniques for important traits related to biomass production as well as DNA markers for the selection of promising intergeneric hybrids. We can also contribute to sugarcane breeding in Japan because Ishigaki Island is a very appropriate location for sugarcane crossing.

Erianthus showing high biomass production at TARF

◆ Value-adding Technologies Program

・ Multiple Use of Regional Resources in Semi-Mountainous Villages Project

Fruits are important sources of cash income and nutrients in the semi-mountainous area of Indochina, hence the expansion of fruit production in the villages. The objectives of this project are the development and extension of techniques for improved sustainable production and effective utilization of native fruit resources in Laos. Preliminary and basic studies on multiplication, low-input farming systems, and variety identification by DNA markers are being conducted.

【Contribution to Domestic Agriculture】

Besides the research projects described above, TARF also contributes to domestic agriculture through the following activities by taking advantage of its location in the subtropics.

Sugarcane genetic resources

◆ The Genebank Project, National Agriculture and Food Research Organization (NARO)

TARF's role as the "tropical and subtropical crop sub-bank" of the Genebank Project, which is centrally coordinated by the Genetic Resources Center, NARO, is to conserve and maintain genetic resources of tropical fruits (approx. 150 accessions), pineapple and its wild relatives (approx. 120 acc.), and sugarcane and its wild relatives (approx. 530 acc.).

◆ Rapid Generation Advancement for Rice and Wheat Breeding

Ten or more years are required to release new rice or wheat varieties that are tolerant to global warming or resistant to pests and diseases. To shorten the breeding time, rapid generation advancement is being performed at TARF, taking advantage of its subtropical climate and mild winter. Early generation (i.e., F_1, F_2 or F_3) rice populations, sent from the six breeding stations of NARO, are grown twice or thrice a year in the paddy fields at TARF. Wheat populations are grown from November to March and then sent to Hokkaido to grow during the summer so that two generations are advanced per year. Rapid generation advancement in TARF contributes to the shortening of the breeding period in rice and wheat.

◆ Development of high quality varieties for the Southwestern Islands, Japan

Using the genetic resources at TARF, we have developed several high-quality fruit varieties, namely, the kidney beans 'Naribushi' and 'Haibushi' (heat tolerant), papaya 'Ishigaki Sango' (good taste and heat tolerant), and 'Ishigaki Wonderous' (good taste and large fruit), for the Southwestern Islands (i.e., the subtropical areas in Japan). The popular pineapple variety 'Soft Touch' originated from materials crossed at TARF, and were subsequently bred and registered by Okinawa Prefecture. At present, we are conducting evaluation and selection of passionfruit varieties with low acidity and heat tolerance.

Candidate to be registered as new passionfruit variety

Research Exchange Programs

2015 Japan International Award for Young Agricultural Researchers

Every year, JIRCAS invites around 70 researchers and research administrators from collaborative research organizations to conduct joint research projects (Collaborative Research Projects). JIRCAS also invites some 6 researchers from developing countries to stay for one year and perform collaborative experiments in the laboratories of Tsukuba Headquarters, in the Tropical Agriculture Research Front or other JIRCAS project sites to support the ongoing research activities and improve their research capabilities (JIRCAS Visiting Research Fellowship Program).

For young Japanese researchers who will take future roles in international researches, JIRCAS has a practical education program, which dispatches postdoctoral researchers and graduates students to the project sites and collaborative organizations in developing regions.

Furthermore, JIRCAS together with MAFF hosts an annual commendation ceremony to recognize three young researchers from overseas who show outstanding performance and research achievements. This award was initiated in 2007 to increase motivation among young researchers who are actively contributing to research and development in agriculture, forestry, fisheries and related industries in developing countries (Japan International Award for Young Agricultural Researchers).

International Symposia and Workshops

JIRCAS International Symposium 2015

JIRCAS organizes international symposia which are based around themes of central importance to international research. Symposium presentations and discussions deal with research topics aimed at solving problems in agriculture, forestry, fisheries and related industries towards sustainable development in developing countries.

JIRCAS also presents workshops and seminars, in Japan as well as in overseas research sites, on issues affecting global agriculture, food and the environment. The most recent trends in research are reported and introduced by the world's leading researchers and then discussed.

Budget and Personnel

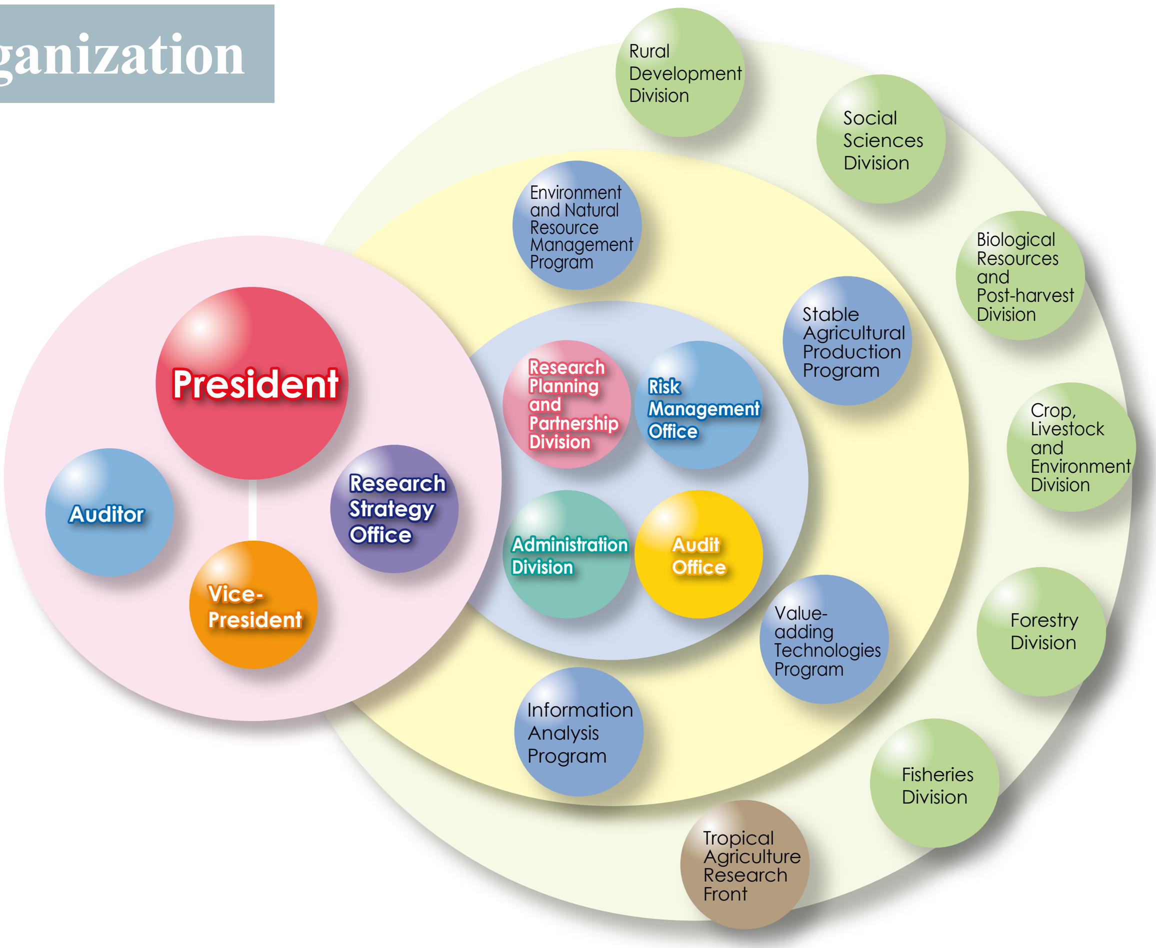
■Budget < FY2016 > (in million yen)

Operating Cost Subsidy	3,546
Facilities Management Grants	55
Commissioned Income	295
Miscellaneous Revenues	3
Total	3,899

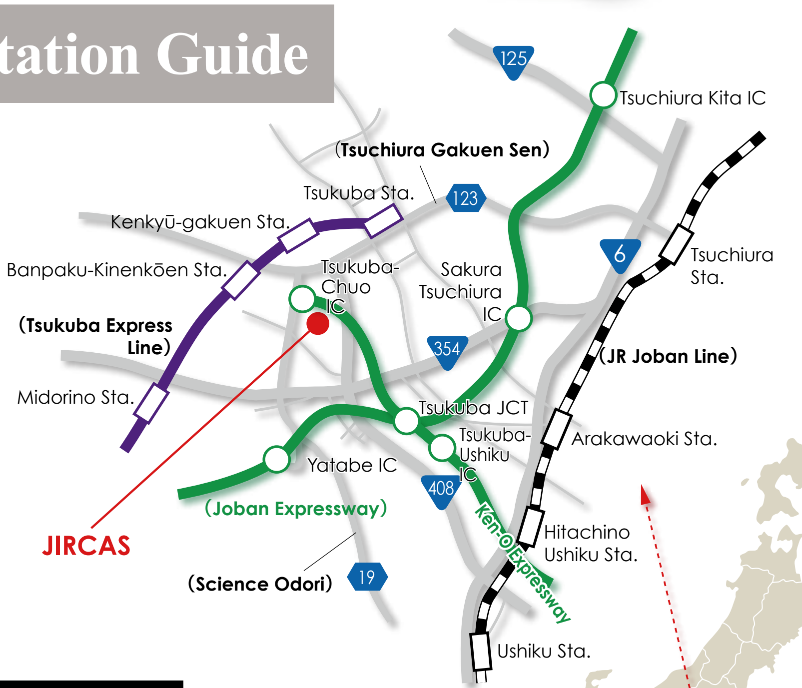
■Personnel < From April 1, 2016 > (No. of Employment)

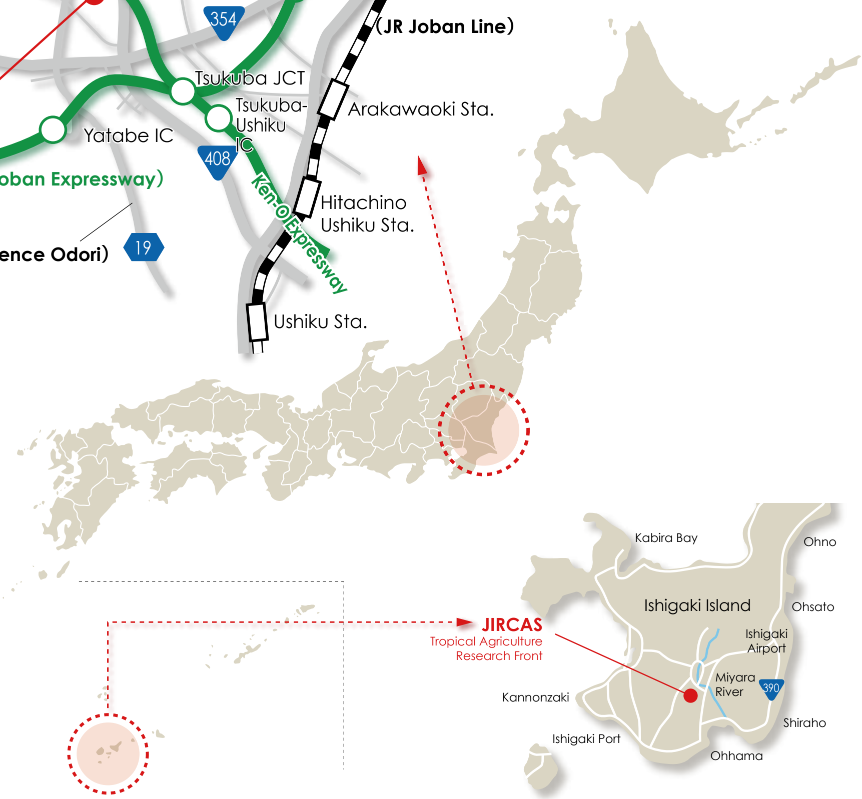
・Executives	4
・General Administrators	39
・Technical Staffs	9
・Researchers	122
・Fixed-term Staff	1
Total	175

Organization



Transportation Guide





Access		
Bus	Train	
Narita Airport	Tsukuba Express	JR Joban Line
Limousine for Tsuchiura about 80 min	Akihabara Sta. about 50 minutes	JR Ueno Sta. about 1 hour
TSUKUBA Center	Banpaku-Kinenkōen Sta.	JR Ushiku Sta.
Taxi about 10 minutes	Taxi about 10 minutes	Taxi about 20 minutes
JIRCAS		

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