

## 9. Survey Results in “Agriculture, Forestry and Fisheries”

### 9.1. Trends in areas of attention

In the “agriculture, forestry and fisheries” field, the following were selected as future areas of attention commonly applicable to agricultural, forestry and fisheries industries, and their present state and future outlook are examined in outline below:

1. Production activities harmonious with environment and sustainable
2. Stable supply of healthy and safe food and protection of living environment
3. Utilization of biological functions and new industrial uses

Since the last survey, the “agriculture, technological development in forestry and fisheries” field has undergone another major conceptual change. Namely, a switch from narrowly-focused food production to the provision of safe and healthy food and a quality living environment has been under way, and, amid progress in research on biotechnology and biological functions, a shift to programs that would contribute to the creation of biology-based industries has been occurring.

Agriculture, forestry and fisheries used to be industries that thrived in harmony with the environment. However, due to the single-minded pursuit of productivity and efficiency, techniques using large amounts of chemical fertilizers, pesticides, etc. have been favored in recent years, and this excess has undeniably caused water pollution and the disruption of biota. This has given rise to calls for technological development that would bring these industries back in harmony with the environment.

On the other hand, amid concerns over deterioration in the global environment due to rapid population growth towards the 10 billion mark and phenomena caused by excessive human activities, such as desertification and the depletion of the ozone layer, hopes are mounting for the potential of agricultural, forestry and fisheries industries to play a part in overcoming these problems. Future technological development in this field will focus more on technologies that support industries that ensure a comfortable living environment for humanity and promote the biological richness of the earth, instead of overemphasizing food production. Amid progress in internationalization and diversification in people's dietary life, interest in healthy and safe food is growing, making technological development in this area essential.

“Agriculture, forestry and fisheries” represents one of the research fields in which biotechnology have brought about a dramatic change. While hopes are pinned on the creation of new crops and varieties via genetic recombination, interest in their impact on ecosystems is also growing. Progress in the research aimed at elucidating biological functions, such as those of insects, is leading to the development of new materials, not restricted to the traditional boundary of the agriculture, forestry and fisheries field, thus foreshadowing the birth of a new industry in the near future.

Topics scoring high in terms of the degree of importance index in the “agriculture, forestry and fisheries” field concentrated in the area of “management and assessment of the environment and biological resources” (70.3 compared to the field average 60.5), and, regarding effective measures the government should adopt in Japan “, expectations for “human resource development” and “personnel exchanges among the industrial, academic and government sectors” scored high. This seems to illustrate the fact that researchers interest in this field has been gradually shifting to the above topics.

#### 9.1.1. Sustainable production activities harmonious with environment

As is symbolized by the “United Nations Conference on the Environment and Development” held in Brazil in June 1992, the importance of global environmental problems has won widespread recognition. In agriculture, forestry and fisheries, too, there are concerns such as the contribution to global warming of the rise in methane emissions from paddy fields and farm animals and fall in carbon dioxide absorption due to deforestation, and hopes are high for the development of technologies that can address these problems while maintaining productivity (topics 21 and 81). In response to the decline in forest area, international conventions

on the conservation of genetic resources, such as rare species, and biological diversity have been strengthened, and the elucidation of the environmental conservation function of forest ecosystems and establishment of their efficient management techniques have emerged as important tasks (topics 42, 80 and 82).

On the other hand, as a measure of stemming the advancement of desertification, hopes are pinned on the “Development of new plants and a cultivation system which enables the growing of plants in water-limited regions” (topic 71). There are also expectations for monitoring systems based on remote sensing etc. designed to monitor the impact of global-scale environmental changes on the agricultural, forestry and fisheries industries over a wide area with high accuracy (topics 50 and 78).

Calls for the advancement of science and technology aimed at sustainable productive activities and harmony with the local/global environment are increasing from the viewpoint of keeping up food production with population growth as well. The development of microorganisms that have a high nitrogen-fixing efficiency and symbiotic relationship with rice and those that enable crop plants to absorb phosphorus fixed in the soil efficiently based on biotechnology and other cutting-edge technologies are important as an environment protection measure aimed at preventing/controlling the eutrophication of the hydrosphere and pollution of groundwater through reduced fertilizer use, as well as from a viewpoint of tackling the depletion of natural resources (topics 04 and 07). The establishment of utilization technologies for waste originating in farm products and livestock as part of recycling efforts is also attracting attention (topic 35). Progress is desired in the “Practical use of resource management systems using artificial intelligence and computer simulation technologies aimed at environmental conservation and harmonization of the agricultural-forestry ecosystem” (topic 79) as well. In fisheries, the “Practical use of environmental restoration technologies and a pollution load removal system for polluted lakes, bays and other closed water bodies” is also eagerly awaited (topic 84).

These technologies are essential to make sustainable productive activities harmonious with the global environment possible, and their effects will hopefully spread across the globe. International research cooperation is indispensable for the development of these technologies, and the bolstering of research funding is strongly desired.

Against a background of increased consumer awareness of the environment and food safety, environmental quality standards and monitoring activities were strengthened for agricultural chemicals and other synthetic organic compounds, and the establishment of biological control, allelopathic control or integrated control based on the self-preservation functions of ecosystems, which do not depend on chemicals, is awaited (topics 08, 09 and 43).

As discussed above, the importance of the development of agricultural, forestry and fisheries technologies leading to harmony between production and the protection of the local/global environment will further increase in the future.

### **9.1.2. Stable supply of healthy and safe food and protection of living environment**

While the primary goal of agricultural, forestry and fisheries industries is the stable supply of healthy and safe food to the public, the conservation and provision of sound living environments is also important. In fact the two go hand in hand as goals these industries always strive to achieve.

However, food requirements are becoming increasingly complex. Firstly there has been a rapid increase in people's health-awareness. Rather than expecting a mere nutrient supply from food, people are demanding that food intake offer active health effects, such as the maintenance of health. Against this backdrop is the progress made in research on the impact of food ingredients on physiological functions. As a result, a specified health-food certification system has been introduced as a world first. The more advanced “67: Practical use of functional foods which help prevent diseases according to individual body characteristics” is forecasted to become reality by 2011, along with “34: Widespread use of allergy-free livestock product manufacturing techniques”. Namely, a major advance in health promotion is forecasted in a little more than 10 years. Secondly there is a diet-conscious trend, centering on young women. While this accompanies potential health problems, the supply of low-calorie food has become an important task for the food industry. The realization

time for “68: Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose” is forecasted as 2007. Thirdly there is the importance of elderly-oriented food due to a rapid increase in the old-age population. New types of foods that take into consideration senior citizens' reduced taste, smell and mastication ability are required, and this necessitates taste measuring equipment (sensors). The realization time of “75: Practical use of general-purpose taste measuring equipment provided with a taste sensor and a texture sensor” is forecasted as 2010. Fourthly there is an expansion in the demand for convenience. As people's lives become busier, cutting the time and effort needed for food preparation at home has become a major requirement for processed foods. For example, “18. Widespread use of a technology that keeps starch-based foods with a high water content from deteriorating for a prolonged period” has been forecasted to be realized by 2007, which is fairly soon. The respondent group with high levels of expertise unanimously thought that Japan was the leading country in this area, with great expectations expressed. The forecasted realization time for “77: Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle” was 2008, along with 76: Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods. In addition to technological innovations that would benefit consumers (demand side), there are calls for a number of those involving the production and distribution area (supply side). Firstly there is the development of new technologies that offer high added-value. While technologies such as extrusion cooking and the use of membranes, ultrahigh voltage and supercritical fluids having given birth to new types of foods, hopes are also pinned on the development of other technologies, such as the use of strong electric fields, strong magnetic fields and functional water. The realization time for “17: Widespread use of a full-sterilization continuous food processing technology involving high pressures of around 3,000 atm.” has been forecasted as 2006. Secondly there is the development of new ingredients that satisfy consumer taste. The development of low-calorie food ingredients, high water retention food ingredients, high quality preserving ingredients, etc. is under way. This makes the search for new microorganisms and the development of a new enzyme utilization technology indispensable. In this area, Japan has led the world with numerous achievements based on its time-weathered fermentation technologies, with the realization time for “16. Practical use of a technology capable of producing fermented foods within short periods of time through the use of artificial modified enzymes with high reaction rate” forecasted as 2005.

These forecasts show that respondents thought that many of the technological topics in the food area would be put to practical use by around 2010, with some in widespread use implying that the realization of these topics is fairly easy. Moreover, Japan was considered to be the world leader with regard to most topics, and this may be interpreted as reflecting Japan's relative advantage in applied technology areas.

The protection of living environments requires a comprehensive system. The realization time for “79: Practical use of environmental conservation and agricultural-forestry ecosystem harmonious management systems based on artificial intelligence, etc.” was forecasted as 2013. Along with farm villages, forests are important for the quality of life. The forecasted realization time for “83: Elucidation of the mechanism involved in the relationship between the environment and human physiology and psychology in 'forest bathing' etc.” was 2011.

### **9.1.3. Utilization of biological functions and new industrial uses**

The creation of biologically derived new materials and development of new technologies to mimic biological functions are attracting attention as important breakthroughs in dealing with unfolding global-scale environmental problems as well as population and food supply problems. Against this background, things like insects, the largest untapped resources on earth, and so-far-unexploited marine organisms are attracting attention, and the elucidation of their functions and development of utilization technologies have great significance with regard to the creation of new industries and new technologies in the 21st century. The advances in genetic engineering technologies and sophistication in analysis technologies for trace substances in recent years have been breath-taking, and have made the elucidation of complex cranial nerve mechanisms and the isolation of trace substances and genes possible.

With insects, R&D on the utilization of silk proteins as ingredients for contact lens materials, blood anticoagulants and leather-touch coating materials is making progress, taking advantage of accumulated past research experience in silk, and hopes are pinned on the development of “58: Artificial skin utilizing biomaterials from insects”. Lately, promising antibacterial agents with different action mechanisms from existing antibiotics have been discovered from a wide variety of insects such as *Oryctes rhinoceros* and silkworms, and some of them exhibit remarkable effectiveness against bacteria resistant to antibiotics. In addition, blood anticoagulants have been discovered in the saliva of blood sucking insects such as assassin bugs, which attack mammals, with relevant genes isolated. In the future, the elucidation of the biosynthesis mechanisms and functions involved in “57: Antibacterial proteins and blood anticoagulants obtained from insects” will make progress, giving rise to hopes for their practical application as new antibacterial drugs, food preservatives, environmentally-friendly agricultural chemicals, and myocardial infarction and cerebral infarction prevention/treatment drugs, after the establishment of artificial synthesis and volume production technologies.

Societies requirement for technological development in marine-organism production, which until recently merely dealt with conventional food production, has expanded to include tackling various other topics. Along these lines, hopes have been pinned on “61: Development of new materials for common daily life items, such as glues and fibers from marine organisms”, as well as “62: Development of a new material production technology based on the utilization of the physiological functions of deep-sea organisms” through an analysis of physiological functions of organisms living in deep seas, which have been outside the scope of traditional fisheries production.

Moreover, based on advances in gene engineering technology, the development of “64: Transgenic animals that make cross-species organ transplants possible” is desired by society as a new role for technological development in animal husbandry, while there are hopes for the establishment of other new technologies such as “63: Livestock feed intake management techniques based on the understanding of the brain-nervous system of livestock animals” and “59: Production technology for useful materials based on insect cultured cells”, which allows external control.

As a basic research area that supports the development of such new materials and technologies, the importance of the study of genomes has been recognized.

From the next section onwards, trends in individual technology areas will be examined in overview.

#### **9.1.4. Agriculture Biotechnology/crop production**

With crops developed using genetic recombination technology by overseas companies being imported, the use of biotechnology, which was until recently considered a 21st century technology, is starting to sweep through the community. Japans biotechnological development in agriculture has fallen behind a little in terms of final product development due to factors such as a relatively slow entry and the existence of few major agriculture-oriented companies in the country. In this area, a large market is expected to develop in the future, and, in light of the fierce worldwide competition for development through patent acquisition etc., Japan is faced with an urgent need to step up its R&D efforts.

Rice farming is starting to be exposed to fierce competition with imported rice as a result of the conclusion of the GATT Uruguay Round of negotiations, introduction of the Food Law, etc., and competition between domestic production centers is also intensifying. Securing stable production against weather changes, such as the cold weather that caused major crop damage in FY 1993, has become an important task.

Against this background, the establishment of low-cost, upward-stable rice farming through larger-scale farm operation based on new enterprise units is strongly desired. For this purpose, the development of technologies such as those which support the sophistication of a paddy farming system combining rice and other crops, new varieties of paddy rice with multiple disease and pest resistance, fostering of varieties suitable for Japanese-style direct sowing, innovative paddy rice growing techniques, and efficient and pleasant farming techniques will be important research areas in the future.

In the latest survey, the importance of “10: Development of cold-weather crop damage prevention systems that respond to weather forecasts” and “14: Development of multi-purpose agricultural robots, which can be easily operated by aged people” was highly rated.

Dry-field crop farming represents intensive agriculture involving large quantities of labor input and a concentrated use of chemical fertilizers, agricultural chemicals and other materials within small plots. As a result, stunting in vegetative growth due to the excessive accumulation of nutrients in the field soil and plant injury caused by continuous cropping, as well as environmental loading due to groundwater pollution by fertilizer ingredients, etc., are posing a problem. On the other hand, safety and quality, apart from price, have become important criteria in the production of farm products, as consumer interest in and requirements for them intensify.

Against this back ground, the establishment of high-profit and sustainable dry-field crop farming is strongly desired. For this reason, R&D activities such as the following will become important future technological tasks: fostering of varieties highly amenable to mechanization and resistant to disease, pests and weather stress; elucidation of the development mechanisms for production-disrupting disease and pest infestation; development of new pest control techniques that do not depend on agricultural chemicals; development of a system of mechanized farm work for open-field vegetable farming; and development of a technology to optimize the cultivation environment without causing environmental pollution through the sophistication of diagnostic techniques for dry-field soils and crops.

The results of the latest survey clearly underscored the importance of agricultural technologies utilizing the functions of living organisms and ecosystems, such as “08: Allelopathy”, “09: Microbes, pheromones, etc.” and techniques utilizing “15: Weather and soil information” in a sophisticated manner ó rather than that of the widespread use of “11: Vegetable processing plants”.

#### **9.1.5. Livestock farming and grasslands**

In livestock farming, imported livestock industry products increased rapidly following the conclusion of the GATT Uruguay Round of negotiations, with hog raising and cattle fattening particularly severely affected. For this reason, cutting production costs has become the utmost task, and ever greater hopes are pinned on the development of cutting-edge technologies, centering on biotechnology. With health-conscious attitudes towards livestock products becoming entrenched, technological development to raise the quality of these products has also become important. In addition, great hopes are pinned on labor-saving technologies to help establish less demanding livestock farming operations in terms of time and effort. Environmental problems stemming from livestock animal waste have been increasing in seriousness every year, necessitating innovative technological development, encompassing, among other things, greenhouse gas reduction technologies aimed at the methane released from the rumens of ruminating animals.

Against this background, progress in biotechnology research centers on livestock reproduction technologies, with topics such as the following recognized as particularly important: “22: Genetic improvement of domestic animals through the introduction of genes into fertilized ova or embryos”, “23: Production of copies of superior cattle by nuclear transplantation”, “24: Livestock production technology that utilizes embryonic stem (ES) cells” and “29: Establishment of a sperm sex identification technique”. Many of these topics are forecasted to be realized within 10 years, with the fostering of human resources etc. identified as effective measures that the government should adopt in this regard. On the other hand, just as the advent of a cloned sheep\* has led to stringent restrictions on the application of the results of such research, the proportion of respondents citing “adverse effect on morals, culture or society” has increased. In pursuing research, adequate consideration sho\*uld be given to this aspect.

In feeding management, topics such as “30: Labor-saving grazing livestock management based on computers, mechatronics devices, etc.” and “31: Advanced sustainable grazing techniques that take advantage

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\* The successful cloning of a sheep by a group of researchers led by Dr. Ian Wilmut at Roslin Institute, U.K., was reported in the science journal “Nature” (February 27, 1997).

of the functions of living organisms” were recognized as relatively important, with the remaining question being whether cost reductions can be achieved. Hopes are also pinned on “27: Development of a technology to control milk and beef qualitatively and quantitatively through gene manipulation on rumen microorganisms” as a means of extracting maximum performance from superior livestock animals.

In livestock disease prevention, “73: Development of rapid disease diagnostic systems based on the PCR technique etc.” and “28: Practical use of synthetic vaccines for livestock based on molecular designs” have emerged as important topics, with a contribution to production cost reductions as their expected benefit.

Regarding worsening livestock-related environmental problems, “35: Utilization of animal waste through decomposition into constituents” was identified as an important research topic, although it was indicated that its success depended on integration with cultivation-related technologies, etc.

### **9.1.6. Forests and forestry industry**

Due to an economic downturn in the fisheries industry in Japan, there has not been any significant technological progress over the last 10 years. As interest in environmental problems grew following the Rio Declaration, hopes mounted in the forestry area, and the introduction of new technologies was believed to be a certainty. Nevertheless, the degree of importance index of the elucidation of the functions of forest ecosystems in tropical regions and practical use of their efficient management and utilization technologies (topic 80) fell sharply from 69% in the last survey to 18% in the latest survey. However, this seems to be more a consequence of the realization of the enormity of the associated socioeconomic problems, which cannot be overcome with progress in science and technology, than a drop in their perceived importance. Alternatively, it may be interpreted as “resignation” over the realization that technological innovation was too slow to stop the rapid progress in the destruction of tropical rain forests. The development of forest tree breeding technologies based on cell fusion etc. (topic 36) has further increased the value of tropical rainforests as the treasure-trove of genetic resources (topic 82).

Present political and social circumstances place an enormous demand on forests and the forestry industry, and conditions are rife for the field application of individually developed technologies. Namely, many critical problems such as diminishing forestry resources worldwide (topics 37 and 39), excessive dependence on fossil fuels and global warming demand technological innovation in the forests and forestry industry field. Nevertheless, against a background of people's general tendency to prefer cheaper petrochemical products over timber, and virgin pulp over recycled paper, in Japan, the supply of cheap imported timber has been continuing, thus hindering the practical use and spread of new technologies (topics 40 and 41). The same applies to reforestation technologies for tropical regions and developing countries. Large-scale afforestation utilizing new technologies (topic 38) may not be able to catch up with the overgrazing by livestock and ravaging by residents looking for firewood (topics 42 and 71). Rather, Japanese conventional technologies, after being adapted to the specific conditions of each local community, would be more effective. The fact that many new technologies presuppose the existence and availability of high-tech equipment, such as computers, (topics 44 and 79) and plenty of energy is also a problem. While energy conservation technologies are important in developed countries, they are meaningless in regions where energy consumption is very low in the first place. Technologies that should be applied to such areas may be somewhat old-fashioned Japanese conventional technologies that were developed before the country's high economic growth era.

In Japan, despite the fact that domestically-grown timber is in over supply, the inflow of imported timber looks set to continue. This is quite a peculiar phenomenon by international standards. Timber imports from tropical countries at least must be reduced, and technological development must be undertaken on the premise that the time will come when domestically-grown timber will be needed. For this to happen, forestry workers must be able to obtain similar levels of incomes to those of urban salaried workers for similar amounts of work. Mechanization at felling sites means liberation from harsh labor and danger. In fact, the introduction of chain saws at such job sites dramatically reduced serious labor accidents involving axes and saws. However, they were also used as a means of increasing labor productivity, and this gave rise to tragic incidents of Raynaud's syndrome. The level of mechanization achieved in Scandinavian countries is not applicable to Japan. This is

not only because of the existence of numerous steep slopes, one of the countries typical topographic features, but is also due to the absence of a system that secures a year-round work load that justifies the investment. It should therefore be noted that technologies can only be applied where suitable social conditions exist. Cries voicing the importance of the natural environment and warnings issued against the danger of chemical substances in the living environment have not translated into the use of timber resources. However, this may be interpreted as a consequence of the inadequacy of Japan's economic infrastructure, which has failed to make people feel secure enough to pursue greater comfort in their lives. It must be stressed again that new technologies should promote safety and comfort, rather than pursuing cost reductions. It is hoped that the fostering of consumer preference for recycled paper despite its price disadvantage will become the catalyst for true technological innovation.

### **9.1.7. Fisheries industry**

In November 1994, the United Nations Convention on the Law of the Sea came to force after a marathon discussion spanning a quarter of a century, and Japan signed the convention in July 1996, giving rise to the need for it to develop a new order for its fisheries industry. According to the convention, the sea area within 200 nautical miles of the shore of a coastal nation is designated as an exclusive economic zone, over which the nation is entitled to undertake, among other things, economic development involving natural resources etc. as its sovereign right, while there is an obligation to take responsibility for the conservation and management of fisheries resources by setting a total allowable catch (TAC) for each fish species every year. On this basis, the Japanese Government has set TACs for six fish species including Pacific saury, walleye pollack, horse mackerel, *Sardinops melanosticta* (kind of sardine) and mackerel in 1997. The convention also obligates each coastal nation to conserve the sea environment within 200 nautical miles of its shores.

While the available resources of *Sardinops melanosticta*, of which up to 4.5 million tons used to be caught, have declined significantly, international controls over fisheries resources have become more stringent, and Japan's TAC fell dramatically, from a one-time 12 million to 7 million ton level, for the first time in 30 years. International interest in the status of fisheries resources as food sources is high, and 95 countries and 11 international organizations took part in the "International Conference on the Sustainable Contribution of Fisheries to Food Security", held in December 1995 in Kyoto, Japan.

Against this background, the establishment by Japan of a sustainable fisheries industry based on fisheries resources within its 200 nautical economic zone is becoming ever more important, and the promotion of fish-farm or resource-management-type fisheries operations must continue to be the backbone of future policy measures.

Even today, when TACs are set, "54. Development of an estimation technique for an optimum fisheries production level" and "55. Development of production regulation systems based on the prediction of long term (10 to 20 years) changes in major fishery resources" within the 200 nautical-mile economic zone take a long time, with their realization times forecasted as 2014 and 2016, respectively.

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## 9.2. Forecast topic framework

In the course of compiling forecast topics, a framework representing the organization of technologies in tabulated matrix form was drawn up for each field, with objectives and technological domains defining the rows and columns of the table, respectively. The framework is designed to present an overall picture of technological development in each field in terms of future prospects, importance, etc. as seen from the present perspective, and is also used as a working framework for future reviews of forecast topics.

**Table 9.2-1 Forecast Topic Framework for Agriculture, Forestry and Fisheries Field**

Domain Objective	Agriculture		Forests/forestry industry	Fisheries industry	Other new industries based on living organisms	Common
	Crop production	Animal husbandry/grazing				
Breeding and development of biological functions	01 02 03 04 05 06	22 23 24 25 26	36	45	57 58 59 60 61 62 63 64 65	69 70 71
Cultivation and feeding management	07 08 09 10 11 12 13 14 15	27 28 29 30 31 32 33	37 38	46 47 48 49 50 51 52	66	72 73
Storage, distribution and processing	16 17 18 19 20	34	39 40 41		67 68	74 75 76 77
Management and assessment of environment and biological resources	21	35	42 43 44	53 54 55 56		78 79 80 81 82 83 84

\* Figures appearing in the table represent topic numbers.

## 9.3. Topics with high degree of importance

Degree of importance index scores (Note 1) averaged at 60.5 for topics in the agriculture, forestry and fisheries field as a whole. Topics considered of particular importance to Japan (top 20 topics in terms of degree of importance index score) are listed in the table below. Ten of the top 20 topics (50%) related to management and assessment of the environment and biological resources.

**Table 9.3-1 Top 20 Topics in Terms of Degree of Importance Index**

Topic	Degree of importance index	Forecasted realization time (year)
84 <u>Practical use</u> of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	88	2018
02 <u>Practical use</u> in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by <u>gene manipulation</u> .	87	2004
01 <u>Elucidation</u> of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87	2009
20 <u>Widespread use</u> of biodegradable containers and wrapping materials that use bio-oriented materials.	86	2005

55 <u>Development</u> of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84	2016
42 Establishment of a quantitative assessment technique for the environmental conservation functions of forest ecosystems, and <u>widespread use</u> of a forest management technique that makes the exploitation of timber resources, while still maintaining such functions.	83	2014
54 <u>Development</u> of an estimation technique for an optimum fisheries production level for each fishing area based on simulation techniques for the propagation of marine organisms of all forms, from primitive to advanced, inhabiting the coastal to offshore fishing zone.	80	2014
73 <u>Widespread use</u> of rapid disease diagnostic systems based on the PCR technique etc.	79	2004
09 <u>Widespread use</u> of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	78	2008
43 Elucidation of the mechanism whereby organisms belonging to forest ecosystems turn into pests, and <u>development</u> of a prediction technique for the outbreak of major pests and an integrated pest control technique that takes advantage of the self-maintenance functions of forests.	75	2014
81 <u>Development</u> of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale.	75	2016
78 <u>Practical use</u> of global monitoring systems that keep watch on the resource and environment of agriculture, forestry and fisheries using the next-generation remote sensing technologies with high-resolution ability.	75	2010
07 <u>Widespread use</u> of microbial mediated techniques to facilitate crop plant uptake of <u>phosphorus</u> fixed in the soil.	72	2011
51 <u>Practical use</u> of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72	2013
79 <u>Practical use</u> of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	72	2013
39 Extension of the service lives of wood resources and improvement of their recycling rates through <u>advancements</u> in their weatherability and recycling techniques, resulting in a <u>halving</u> of new tree requirements.	70	2015
65 <u>Development</u> of a bio-micromachining technology aiming for a drug delivery system to cancer tissue etc. featuring biodegradation after drug discharge.	70	2010
53 <u>Practical use</u> of a management technique for migratory fisheries-resource organisms with great traveling distances, based on a prediction system for the relationship between ocean-wide environmental changes and marine organism propagation.	70	2018
47 <u>Practical use</u> of technology to develop an algae-covered area to maximize the productivity potential of fisheries resources, targeting unutilized intertidal zones and shoal zones, centering on sand beaches.	69	2010
35 <u>Widespread use</u> of animal waste utilization techniques via decomposition into constituents.	68	2010

Note 1: Degree of importance index = (number of “high” responses × 100 + number of “medium” responses × 50 + number of “low” responses × 25 + number of “unnecessary” responses × 0) ÷ total number of degree of importance responses

### 9.4. Forecasted realization times

Forecasted realization times were distributed as shown in the diagram below. The distribution peaked earlier than the general trend covering all topics, with about 90% of the topics forecasted to be realized by 2015.

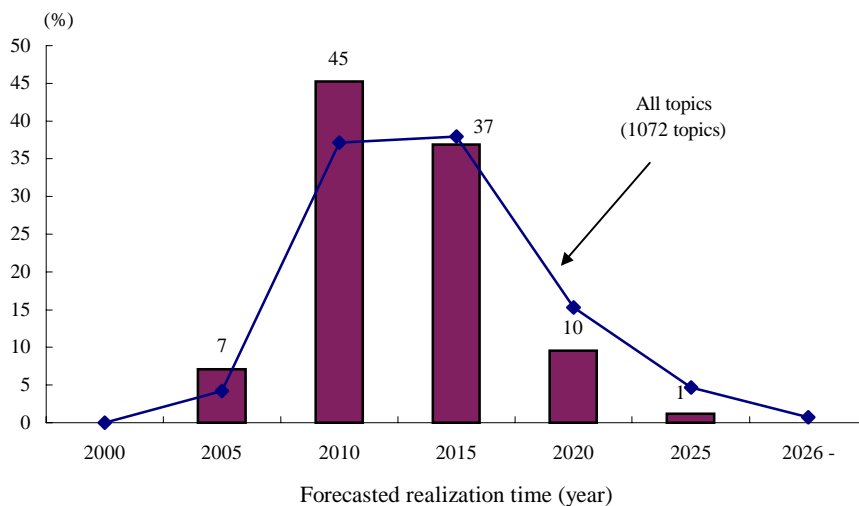


Fig. 9.4-1 Trends in Forecasted Realization Times

### 9.5. Current leading countries etc.

Responses to the question concerning current leading countries etc. were as shown in the diagram below.

Unlike other fields, the pattern of overwhelming dominance by the U.S. is absent in the agriculture, forestry and fisheries field, with Japan closely behind, followed by the EU.

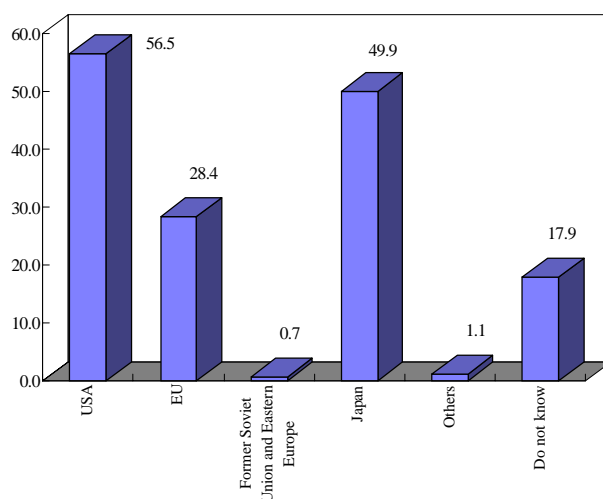


Fig. 9.5-1 Current Leading Countries etc. (%)

### 9.6. Comparison with the 5th Survey (previous survey)

Of the 84 topics included in the latest survey, 27 (32%) were identical to the previous survey, 16 (19%) were modified, and 41 (49%) were newly introduced. For identical topics, the results of the latest survey were compared with those of the previous survey in terms of degree of importance index scores and forecasted realization times, as shown in the table below.

Degree of importance index scores rose for 7 topics, fell for 19 topics and remained the same for 1 topic. 151. Practical use of selective fishing methods and of inductive fishing based on technologies that are able to control the behavior of a shoal of fish saw the greatest jump, up 12 points, while 180. Practical use of technologies for efficient management and use of tropical forest and the organisms living there saw the greatest drop, down 29 points.

From the 4th to the 5th Survey, forecasted realization times were pushed back for all but one topic. However, from the 5th to the 6th Survey, forecasted realization times were brought forward for 3 topics and remained the same for one, with 110. Development of prevention systems against crop damage by cold-weather, such as localized climate control having its forecasted realization time brought forward by 5 years. Four topics saw their forecasted realization times pushed back 7 years.

**Table 9.6-1 Comparison with 5th Survey for Identical Topics**

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
01 <u>Elucidation</u> of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	87/2009	84/2004
02 <u>Practical use</u> in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by <u>gene manipulation</u> .	87/2004	93/2002
06 <u>Development</u> of a new variety of the silkworm, <i>Bombyx mori</i> , that secretes silk fibroin proteins introduced of the characteristics of the silk fibroin proteins of the wild silkworm, <i>Antheraea yamamai</i> , through the introduction of fibroin gene of <i>A. Yamamai</i> into <i>B. mori</i> by <u>the gene manipulation</u> .	42/2008	49/2004
08 <u>Practical use</u> of technologies evading growth retardation by continuous cropping by treating the soil with microorganisms or allelopathic substances.	66/2011	67/2007
09 <u>Widespread use</u> of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	78/2008	82/2001
10 <u>Development</u> of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	63/2004	75/2009
12 <u>Practical use</u> of agricultural robots capable of harvesting and <u>simultaneous sorting of fruits according to quality</u> .	53/2007	57/2002
14 <u>Development</u> of remote-controlled, multi-purpose agricultural robots with artificial intelligence, that can make even aged people self-reliant in cultivation and harvesting of crops.	61/2011	62/2004
19 <u>Practical use</u> of a technology capable of cutting, isolating and utilizing nutritious sections in food proteins, through the use of proteases etc.	47/2009	71/2004
22 <u>Practical use</u> of techniques for genetic improvement of domestic animals whose disease resistance and fecundity are enhanced by introduction of genes with desirable traits into the fertilized ovum or embryo.	63/2009	81/2005
23 <u>Practical use</u> of production of copies of superior cattle by <u>nuclear transplantation</u> .	61/2007	77/2003
28 <u>Practical use</u> of synthetic vaccines for preventing diseases of livestock utilizing <u>molecular designs</u> by gene engineering and protein engineering.	63/2010	79/2005
36 <u>Development</u> of useful tree varieties with desirable characteristics using <u>gene manipulation, cell fusion</u> and other similar technologies in forest tree breeding.	56/2010	67/2008
37 <u>Realization</u> in Japan of systems enabling forest biomass to be used in a balanced manner in terms of energy and economic considerations through the practical use of technologies for efficiency raising and collecting broad-leaved trees, bamboo grass, slash and other yet-unused resources that are presently of relatively little economic importance.	65/2014	64/2008
41 <u>Practical use</u> of technologies for manufacturing paper and pulp by using the enzyme of wood decaying fungi.	57/2010	63/2006

Topic	Importance index / forecasted realization time	
	6th survey	5th survey
45 <u>Realization of the creation</u> of varieties of fisheries-resource aquatic organisms with traits advantageous for cultivation, such as high resistance to changes in water temperature and diseases, through <u>cell fusion, gene manipulation</u> , etc.	62/2010	65/2005
46 <u>Widespread use</u> of a management system for <u>the reproduction</u> of coastal fisheries resources based on an environmental control technology designed to guide fry from the nursery to an area more suitable for their growth, while <u>preventing their destruction or scattering of eggs</u> .	62/2015	63/2013
47 <u>Practical use</u> of technology to develop an algae-covered area to maximize the productivity potential of fisheries resources, targeting unutilized intertidal zones and shoal zones, centering on sand beaches.	69/2010	66/2004
48 <u>Practical use</u> of technologies for using a large volume of deep sea water for new fishing grounds in the open sea.	57/2013	51/2013
49 <u>Development</u> of a technology to utilize physiologically active substances derived from algae etc. to encourage the preferential propagation of useful algae in reef zones, while preventing the growth of miscellaneous algae and algae-eating organisms.	54/2013	54/2011
51 <u>Practical use</u> of selective fishing methods for catching desired size and species of fish, and of inductive fishing for catching in desirable area through the development of technologies that are able to control the behavior of a shoal of fish.	72/2013	60/2015
52 <u>Widespread use</u> of super labor-saving fishing boats designed to automate a series of operations from searching for shoals of fish, dragging and lifting nets. to sorting fish by size and storing them consequently allowing the crew to devote only to monitoring.	58/2014	57/2009
55 <u>Development</u> of production regulation systems as a step toward management of resources and fisheries once it becomes possible to predict the long term (10 to 20 years) changes major fishery resources.	84/2016	81/2018
69 <u>Elucidation</u> of the mechanisms of totipotency of plant cells.	66/2021	87/2014
75 <u>Practical use</u> of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing.	44/2010	51/2003
79 <u>Practical use</u> of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	72/2013	82/2011
80 <u>Practical use</u> of technologies for efficient management and use of <u>tropical forest and the organisms living there</u> through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	55/2016	84/2014

Note: Up until the 5th Survey, realization meant realization in Japan unless otherwise specified. However, this was changed to mean realization somewhere in the world in the 6th Survey. Therefore, care should be taken when comparing forecasted realization times from the two surveys.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)				Expected effect (%)			Forecasted realization time					Leading countries (%)					Measures the government should adopt (%)					Potential problems (%)															
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources	2001	2006	2011	2016	2021	2026	Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society	Other adverse effects				
																									2001	2006	2011	2016	2021	2026															
Agriculture (crop production)	1	Elucidation of the whole DNA sequences of crops (e.g. Rice) to isolate useful genes.	1	235	18	26	56	86	73	25	2	0	39	85	10	46		0	6	67	18	0	75	1	6	66	26	24	57	56	7	1	29	6	15	4									
			2	202	17	27	55	87	74	24	1	0	37	87	6	45		0	2	70	11	0	81	0	5	74	19	16	67	64	3	0	38	4	16	4									
			X	35	100	0	0	96	91	9	0	0	51	86	6	54		3	0	80	14	3	97	0	0	86	20	17	46	83	3	0	26	0	14	6									
	2	Practical use in Japan of crop varieties having the characteristics (higher yield and more disease- and cold-resistance) improved by gene manipulation.	1	242	25	23	52	84	71	25	4	0	43	93	14	11		1	2	86	35	0	38	2	7	54	41	22	45	41	28	2	54	8	28	3									
			2	213	25	22	53	87	75	22	3	0	44	92	11	10		1	1	92	33	0	45	2	3	69	37	14	47	48	22	1	60	6	23	2									
			X	53	100	0	0	96	92	8	0	0	51	98	9	6		0	0	98	47	0	43	4	0	74	40	25	32	55	28	2	43	6	26	4									
	3	Development of C <sub>3</sub> plants with modified photosynthesis systems through the techniques of biological/biochemical control or gene manipulation, etc.	1	191	14	32	54	67	42	46	12	1	23	93	4	25		3	11	75	28	1	25	2	20	67	28	25	25	53	8	2	42	8	12	3									
			2	169	12	32	56	64	35	53	12	1	18	88	2	22		2	7	84	27	1	25	0	13	81	23	17	21	65	2	1	50	4	9	2									
			X	21	100	0	0	81	67	24	10	0	24	95	0	24		0	0	95	33	5	33	0	0	86	19	29	10	71	0	0	43	0	0	5									
	4	Development of new rice cultivation techniques based on the development/utilization of highly efficient symbiotic N <sub>2</sub> -fixing microorganisms.	1	199	10	35	55	66	41	40	17	2	26	91	5	14		3	8	50	20	1	47	6	21	65	37	21	26	53	6	1	47	4	7	1									
			2	175	9	33	58	66	37	52	10	1	22	94	3	7		2	5	66	18	1	54	6	14	79	33	14	21	61	3	1	50	0	5	1									
			X	16	100	0	0	81	63	38	0	0	31	100	0	6		0	0	81	44	6	50	13	0	81	25	31	25	81	0	0	38	0	6	0									
	5	Practical use of uniform seeds of F1 varieties of crops such as maize through the introduction of apomixis genes via gene manipulation.	1	138	20	27	54	55	24	48	26	2	23	88	3	14		1	15	80	15	3	11	2	11	59	25	15	33	41	7	1	30	6	11	1									
			2	117	21	23	56	53	17	62	21	0	18	89	3	10		1	9	87	17	2	10	3	9	79	17	9	38	50	4	1	33	2	8	0									
			X	24	100	0	0	71	46	46	8	0	25	92	0	0		4	4	88	21	4	8	8	0	79	4	13	38	75	0	0	33	0	4	0									
	6	Development of a new variety of the silkworm, Bombyx mori, that secretes silk fibroin proteins introduced of the characteristics of the silk fibroin proteins of the wild silkworm, Antheraea yamamai, through the introduction of fibroin gene of A. Yamamai into B. mori by the gene manipulation.	1	123	9	18	73	43	10	46	39	5	64	20	20	16		1	9	11	9	2	69	0	22	48	40	12	22	46	9	0	33	5	10	2									
			2	109	7	19	73	42	7	49	40	4	71	13	17	13		0	6	14	8	1	78	0	13	59	43	7	19	50	3	0	32	2	7	2									
			X	8	100	0	0	53	13	75	13	0	88	0	13	13		0	13	25	25	0	75	0	13	50	63	0	0	75	0	0	38	13	0	0									
	7	Widespread use of microbial mediated techniques to facilitate crop plant uptake of phosphorus fixed in the soil.	1	188	18	22	61	70	47	39	14	1	23	95	6	9		0	12	46	28	1	35	3	31	65	41	19	10	50	6	1	46	3	4	3									
			2	170	16	20	64	72	49	43	8	0	22	94	4	6		0	8	55	25	1	46	2	24	74	39	10	6	57	2	1	49	1	3	2									
			X	27	100	0	0	87	74	26	0	0	30	93	7	7		0	4	70	52	4	70	7	0	89	30	22	4	63	0	0	41	0	0	0									
	8	Practical use of technologies evading growth retardation by continuous cropping by treating the soil with microorganisms or allelopathic substances.	1	187	14	28	58	67	41	45	13	1	25	89	10	9		2	12	50	34	1	34	2	26	62	42	18	10	49	7	1	51	4	3	2									
			2	162	12	31	57	66	35	59	5	0	20	94	4	6		1	7	68	35	1	45	2	18	77	40	10	8	60	4	1	51	1	2	1									
			X	19	100	0	0	76	58	32	11	0	37	100	0	5		0	5	74	42	0	47	5	5	84	37	11	0	63	0	0	47	0	0	5									
	9	Widespread use of the pest control method based mainly on the biological insecticides (natural microbial enemies, pheromones, etc.).	1	223	14	26	60	74	53	37	9	0	29	89	25	7		3	6	62	52	2	37	5	14	52	48	14	13	43	22	0	66	7	3	1									
			2	191	14	24	62	78	59	36	5	0	26	90	20	4		3	4	70	57	2	45	3	8	66	55	8	7	50	14	1	68	4	2	1									
			X	27	100	0	0	81	65	27	8	0	30	93	19	4		7	4	85	78	4	52	4	0	63	70	4	7	52	15	0	63	4	0	0									
	10	Development of prevention systems against crop damage by cold-weather, such as localized climate control, that respond to weather forecasts.	1	150	10	37	53	65	40	43	15	1	25	84	12	1		1	4	12	3	1	75	1	17	38	55	19	3	49	1	2	21	9	1	4									
			2	132	8	32	61	63	33	57	10	1	23	85	10	3		3	5	12	2	0	84	0	11	39	67	9	2	57	0	2	30	4	2	2									
			X	10	100	0	0	80	60	40	0	0	40	90	0	0		0	0	10	0	0	80	0	10	40	80	0	0	40	0	0	30	0	0	0									

(Note) See page 7 for the interpretation of the graphs.

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Other new industries based on living organisms	61 Development of new materials for common daily life items, such as glues and fibers from marine organisms.	1	107	6	17	78	57	27	50	20	3	75	41	26	14		1	10	38	12	2	43	1	32	54	54	15	7	54	3	2	29	6	5	1		
		2	94	4	13	83	55	18	63	18	0	74	35	22	6		0	6	45	11	0	61	1	27	70	65	6	4	60	1	0	39	6	2	0		
		X	4	100	0	0	69	50	25	25	0	100	50	0	0		0	0	50	0	0	50	0	50	50	25	0	100	0	0	50	0	0	0			
	62 Development of a new material production technology based on the physiological functions of deep-sea organisms existing at depths in excess of thousands of meters.	1	93	5	17	77	47	16	45	34	5	58	43	20	19		6	15	49	17	0	40	0	30	59	43	22	8	56	1	0	25	2	5	0		
		2	83	4	18	78	48	14	53	30	2	66	41	16	18		7	10	69	17	0	57	1	23	73	51	13	4	66	1	1	31	2	4	0		
		X	3	100	0	0	50	33	33	0	33	33	33	0	33		0	0	67	0	0	67	0	0	67	33	0	0	67	0	0	33	0	0	0		
	63 Advancements in the understanding of the brain-nervous system of livestock animals, leading to widespread use of feed intake improvement techniques and management techniques based on animal welfare.	1	106	12	18	70	51	21	46	31	3	28	58	19	25		4	22	56	40	1	19	2	29	58	35	21	11	42	0	2	16	3	24	4		
		2	94	10	20	70	51	17	55	26	2	29	73	13	23		3	12	71	46	0	14	1	21	77	37	12	5	65	0	2	11	2	31	2		
		X	9	100	0	0	78	67	22	0	11	33	78	11	44		11	0	89	33	0	33	0	11	78	33	33	22	67	0	11	11	11	44	11		
	64 Widespread use of cross-species organ transplantation based on transgenic animals created through the introduction of genes that alleviate or prevent organ rejection as part of organ transplant treatment.	1	99	14	20	66	65	39	46	11	3	41	13	82	23		2	14	77	45	1	27	3	15	58	42	16	14	52	12	1	8	23	58	1		
		2	86	14	17	69	65	36	51	12	1	37	6	92	15		1	10	85	45	0	26	1	12	74	47	12	6	66	10	1	2	19	62	0		
		X	12	100	0	0	92	83	17	0	0	58	8	100	33		0	0	92	67	0	25	0	0	58	58	17	8	75	33	0	0	25	92	0		
	65 Development of a bio-micromachining technology aiming for a drug delivery system to cancer tissue etc. featuring biodegradation after drug discharge.	1	67	6	27	67	68	44	42	11	3	45	7	85	18		1	6	69	37	3	33	0	22	63	49	13	7	51	7	0	7	24	16	3		
		2	60	5	23	72	70	46	44	8	2	50	2	85	5		0	2	80	38	0	40	0	15	75	60	12	2	58	3	0	3	33	13	3		
		X	3	100	0	0	83	67	33	0	0	0	33	100	33		0	0	100	100	0	100	0	0	67	33	67	0	100	0	0	0	33	100	0		
	66 Widespread use of the Internet systems to make the remote diagnoses of crop plants, livestock or farm household economy and recommend the appropriate preventing methods and countermeasures.	1	195	8	22	70	59	29	48	21	2	54	53	37	8		1	2	68	26	1	29	2	23	40	50	20	15	37	10	2	7	20	11	3		
		2	167	8	19	73	57	21	64	14	1	66	54	32	3		0	1	80	27	1	37	2	14	53	68	8	11	44	7	1	2	19	8	2		
		X	13	100	0	0	71	54	31	8	8	69	62	31	15		0	0	92	15	0	62	0	0	69	46	15	8	54	8	0	0	23	23	0		
	67 Practical use of functional foods which help prevent diseases according to individual body characteristics.	1	144	13	19	68	63	36	49	13	3	37	18	87	8		2	8	47	24	1	49	1	26	44	58	10	9	45	14	1	3	21	15	3		
		2	121	15	17	69	60	26	60	12	1	32	11	95	4		0	4	62	20	0	69	1	17	58	74	6	3	54	9	1	2	27	17	0		
		X	18	100	0	0	75	56	39	0	6	56	17	89	11		0	0	67	28	0	94	0	0	56	72	11	6	67	0	0	0	17	28	0		
	68 Practical use of artificial sugar substitutes with the same cooking characteristics as sucrose which are ideal for diet food preparation.	1	134	11	22	67	41	8	45	40	7	39	16	72	5		4	10	46	19	1	47	1	25	40	59	7	4	29	10	1	4	10	14	1		
		2	120	11	20	69	42	8	48	43	3	33	8	84	3		3	6	59	20	0	68	0	18	45	78	2	1	31	8	0	3	17	15	1		
		X	13	100	0	0	40	15	38	23	23	15	15	77	8		15	0	62	31	0	92	0	0	38	62	0	0	31	0	0	0	0	15	0		
Common	69 Elucidation of the mechanisms of totipotency of plant cells.	1	179	17	30	53	68	43	43	12	2	27	51	4	73		13	14	62	47	1	28	1	23	72	20	21	20	53	2	1	15	3	10	1		
		2	155	17	29	54	66	38	49	13	0	20	48	1	76		10	14	72	50	1	28	1	17	86	16	19	14	64	1	0	13	1	9	1		
		X	26	100	0	0	79	62	31	8	0	27	35	4	73		4	8	81	77	0	50	0	4	92	15	27	4	77	0	0	8	0	15	4		
70 Development of a technology capable of restoring animal functions from animal tissues having undergone long freeze-storage, through gene amplification.	1	152	11	18	71	52	22	48	26	4	33	53	24	45		9	21	63	30	3	23	1	27	53	28	17	22	45	7	1	18	11	36	1			
	2	128	11	17	72	52	15	63	19	2	24	59	18	46		9	16	78	32	0	23	1	17	77	24	11	19	60	2	0	13	10	43	0			
	X	14	100	0	0	82	64	36	0	0	29	64	21	43		7	0	93	43	0	36	0	7	71	21	14	21	64	7	0	7	21	50	0			

(Note) See page 7 for the interpretation of the graphs.

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Common	71	Development of new plants and its cultivation system which unable to grow plants in water-limited region.	1	168	11	19	70	47	17	44	32	8	23	96	4	11		1	11	54	21	5	24	7	30	61	30	15	24	59	1	4	40	3	3	1					
			2	145	8	20	72	42	7	54	34	5	18	97	3	8		1	4	62	17	5	26	7	28	74	26	10	20	71	0	3	46	2	1	1					
			X	11	100	0	0	59	27	55	18	0	9	100	0	18		0	0	73	18	18	45	18	0	55	36	18	27	73	0	9	18	0	0	0					
	72	Development of farming simulation systems that provide a virtual experience of the latest agricultural technologies to assist newly-engaged farmers and improve the conventional farm management.	1	121	9	23	68	42	11	43	39	8	44	41	24	10		3	5	38	12	1	31	1	35	46	43	19	12	33	1	2	7	7	8	3					
			2	109	7	17	75	44	10	50	36	4	61	40	23	6		1	3	47	11	0	47	0	33	61	61	8	7	34	1	0	7	5	6	2					
			X	8	100	0	0	66	38	50	13	0	63	38	13	38		13	0	50	38	0	63	0	25	38	50	0	25	38	0	0	0	13	25	0					
	73	Widespread use of rapid disease diagnostic systems based on the PCR technique etc.	1	176	16	28	56	73	50	42	7	1	30	28	78	9		1	2	77	40	1	45	1	16	47	40	21	30	41	7	1	9	22	23	1					
			2	157	17	26	57	79	60	36	4	0	31	21	85	5		0	3	86	39	0	53	1	10	61	45	16	27	45	4	1	3	17	25	1					
			X	26	100	0	0	85	69	31	0	0	35	31	81	4		0	0	100	58	0	69	0	0	58	46	23	31	54	8	0	4	15	31	0					
	74	Development of a technique capable of the higher order protein structure prediction from a given primary structure and new 3-D protein structure design.	1	138	9	26	64	63	35	49	15	1	57	32	29	54		1	9	73	45	1	30	1	18	60	37	33	26	49	2	1	12	8	11	3					
			2	124	8	27	65	61	28	63	10	0	61	16	20	62		2	9	81	45	1	31	0	12	77	30	27	23	62	0	0	10	7	7	2					
			X	10	100	0	0	85	70	30	0	0	60	10	20	70		0	10	100	80	0	50	0	0	70	30	60	20	80	0	0	10	10	40	0					
	75	Practical use of general-purpose taste measuring equipment provided with a taste sensor capable of sensing taste ingredients and a texture sensor capable of sensing physical	1	144	13	24	63	46	12	50	35	3	42	26	54	13		1	9	33	13	0	49	1	31	51	60	22	8	38	0	1	3	6	13	2					
			2	131	9	27	64	44	7	57	35	2	37	9	76	8		1	5	40	8	0	66	1	22	54	80	14	3	34	0	0	2	6	14	1					
			X	12	100	0	0	52	27	36	27	9	42	25	75	8		0	0	50	25	0	75	0	8	58	83	25	0	25	0	0	0	8	25	0					
	76	Development of household food testers capable of instantaneously determining freshness and microorganic contamination levels of foods.	1	157	13	20	67	59	31	45	22	2	37	30	80	4		2	10	44	17	1	43	1	31	46	67	19	11	42	4	1	6	17	12	2					
			2	147	8	24	68	54	20	58	22	0	29	17	93	3		1	6	51	11	1	56	1	27	50	78	7	4	44	3	1	3	19	8	1					
			X	12	100	0	0	65	33	58	8	0	33	25	92	0		8	8	58	8	0	67	0	25	58	50	17	0	25	0	0	0	25	0	0					
	77	Practical use of containers and packaging with in-built temperature control technology that obviates the need for refrigeration for processed foods aimed at the outdoor lifestyle.	1	99	11	20	69	41	12	34	48	6	41	33	63	3		10	6	48	11	0	33	0	27	33	62	17	2	18	7	1	15	11	10	1					
			2	90	6	21	73	35	3	32	63	2	37	17	79	2		6	7	64	10	0	47	1	23	34	78	9	1	13	6	1	17	8	9	0					
			X	5	100	0	0	25	0	20	60	20	60	0	40	0		0	0	40	0	0	20	0	40	20	80	0	0	20	0	0	0	0	20	0	0				
	78	Practical use of global monitoring systems that keep watch on the resource and environment of agriculture, forestry and fisheries using the next-generation remote sensing technologies with high-resolution ability.	1	183	8	17	74	72	50	39	9	2	29	91	10	10		2	6	76	28	5	31	2	16	51	51	28	9	64	2	1	22	9	7	2					
			2	156	7	14	79	75	54	38	8	1	22	92	5	5		1	3	87	22	2	36	1	10	60	53	19	6	71	1	1	20	2	4	0					
			X	11	100	0	0	95	91	9	0	0	27	91	9	9		0	0	100	36	9	55	0	0	64	45	9	9	64	0	0	36	0	18	0					
79	Practical use of resource management systems using artificial intelligence and computer simulation technologies to conserve forest, water, soil, and other natural environments and harmonize the agricultural-forestry ecosystem.	1	158	6	25	70	70	46	44	9	1	30	96	15	9		3	10	60	33	3	29	1	24	60	46	22	13	58	3	0	27	5	3	2						
		2	139	4	20	76	72	47	46	7	0	20	94	12	6		3	6	76	29	1	31	0	17	66	42	12	9	66	2	1	24	1	2	0						
		X	5	100	0	0	80	60	40	0	0	20	100	0	0		0	0	100	60	0	60	0	0	100	0	0	80	0	0	60	0	0	0	0	0					
80	Practical use of technologies for efficient management and use of tropical forest and the organisms living there through elucidation of the mechanisms of structure and functions of forest ecosystems in tropical regions.	1	144	7	11	82	56	26	50	20	4	19	97	3	13		6	19	52	35	1	21	3	32	64	36	10	11	62	3	5	38	2	5	2						
		2	123	5	12	83	55	18	66	15	1	11	95	2	11		5	12	66	39	2	22	2	26	77	32	4	8	78	1	3	37	1	4	0						
		X	6	100	0	0	75	50	50	0	0	0	100	0	33		0	17	67	33	17	50	0	0	100	33	17	17	67	0	17	50	0	0	0						

(Note) See page 7 for the interpretation of the graphs.

Division	Topic serial No.	Topic	Questionnaire round	Number of respondents	Degree of expertise (%)			Importance (index, %)				Expected effect (%)			Forecasted realization time				Leading countries (%)					Measures the government should adopt (%)					Potential problems (%)							
					High	Medium	Low	Index	High	Medium	Low	Unnecessary	Socioeconomic development	Resolution of global problems	People's needs	Expansion of intellectual resources					USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society
					Will not be realized (%)	Do not know (%)	USA	EU	Former Soviet Union and Eastern Europe	Japan	Other countries	Do not know	Foster human resources	Promote exchanges among industrial, academic and government sectors and different fields	Upgrade advanced facilities and equipment	Develop a research base	Increase government research funding	Adjust regulations (relax/toughen)	Others	Adverse effect on the natural environment	Adverse effect on safety	Adverse effect on morals, culture or society														
Common	81	Development of a forest management method that realizes the advanced use of forests, while maintaining sustainable forest operation, on a global scale.	1	105	10	11	79	70	49	36	13	2	26	96	8	5		5	17	43	44	6	25	4	33	58	32	16	15	57	10	3	38	2	5	1
			2	90	8	12	80	75	54	37	9	0	19	99	9	6		0	12	46	48	2	28	3	30	73	27	9	11	67	6	1	40	1	3	0
			X	7	100	0	0	92	83	17	0	0	57	100	0	14		0	0	57	86	0	86	0	0	100	43	14	29	43	14	0	86	0	14	0
	82	Development of an ecosystem management system that enables rare species of organisms dependent on forests to propagate according to their ecological conditions.	1	108	6	8	85	59	27	56	14	3	8	96	7	23		5	14	44	36	3	13	4	38	67	24	15	20	57	3	2	44	1	8	2
			2	97	4	11	85	59	24	65	11	0	7	94	4	20		5	8	53	42	1	10	2	36	81	18	8	15	69	2	1	39	2	6	0
			X	4	100	0	0	75	50	50	0	0	0	100	0	0		25	0	100	50	0	25	0	0	75	0	25	25	50	0	0	25	0	50	0
	83	Elucidation of the mode of action of "forest bathing" that gives favorable effect on human physiology and psychology from the surrounding environment.	1	134	5	11	84	54	22	52	24	2	17	35	81	19		2	13	31	34	3	22	1	42	68	41	15	5	46	1	1	22	4	19	2
			2	113	5	10	85	54	19	60	19	1	12	30	88	12		3	9	40	45	2	27	0	36	77	36	9	4	50	0	0	19	2	13	0
			X	6	100	0	0	67	33	67	0	0	17	50	83	17		0	0	67	33	0	83	0	0	50	17	0	0	67	0	0	17	0	33	0
	84	Practical use of a system of removing almost the entire pollution load on lakes, bays and other closed water bodies that are suffering from water quality degradation by developing environmental restoration technology that utilizes ecosystems and biological functions.	1	191	13	20	67	83	69	26	4	1	30	94	34	9		7	12	43	41	2	39	1	31	64	52	24	5	70	10	1	40	3	9	1
			2	169	12	18	69	88	78	20	2	0	24	93	32	7		3	6	56	46	2	45	0	26	73	53	15	3	78	5	0	38	1	7	1
			X	21	100	0	0	100	100	0	0	0	29	95	24	24		5	10	71	62	0	76	0	5	76	71	19	5	67	10	0	38	0	10	5

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