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The Need to Change the Concept of Water-related Disaster Prevention

Improved Research Institute Productivity due to the Contribution of Foreign Researchers

Shifting from Emergency Food to Disaster Preparation Food to Help Disaster Survivors

Science & Technology Foresight Center of NISTEP

Executive Summary

1 The Need to Change the Concept of Water-related Disaster Prevention

p. 8

Frequent seismic and volcanic activities cause intense geomorphic changes in Japan, while the low-pressure systems of typhoons and weather fronts cause heavy rainfall and storm surges. These make Japan physically vulnerable to water-related disasters.

From the beginning of modern era in the history of Japan, structural measures such as dams, levees, breakwaters and coastal revetments have been adopted to cope with water-related disasters based on the data and experiences of past events. In the mean time, small and medium-scale flood disasters have been decreased. However, these measures also led properties and population concentrated in floodplains along large rivers and coastal areas that had been originally at a high risk and vulnerable to water-related disasters. This means new risk of an unexpected disaster due to possibility of an abnormal phenomenon that exceeds the design criteria of the prevention measures. Moreover, changing the natural circulation systems and water-nature interaction due to structural measures will continue to worsen environmental degradation of coastal area and river ecosystem as well as their natural sceneries. It also should be taken into account that flood disaster prevention measures in a particular area may intensified disaster damages or related impacts in other areas.

More and more there is increasing discussion that climate change due to global warming will increase the frequency of heavy rains and more sever tropical cyclones due to future abnormal weather. Considering all the above, existing disaster prevention reliant upon structural measures to protect areas against water-related disasters has limit in terms of response ability for external force, economic cost and environmental impact. The abundance of daily life, preservation/restoration of the natural environment, and disaster prevention at abnormal conditions should be treated all in an integrated manner. We need to make efforts toward changing our concept of disaster prevention to utilize natural systems for example terrain and also keep water-nature circulation to deal with huge water-related disasters at a local community in a basin-wide scope.

(Original Japanese version: published in January/February 2012)

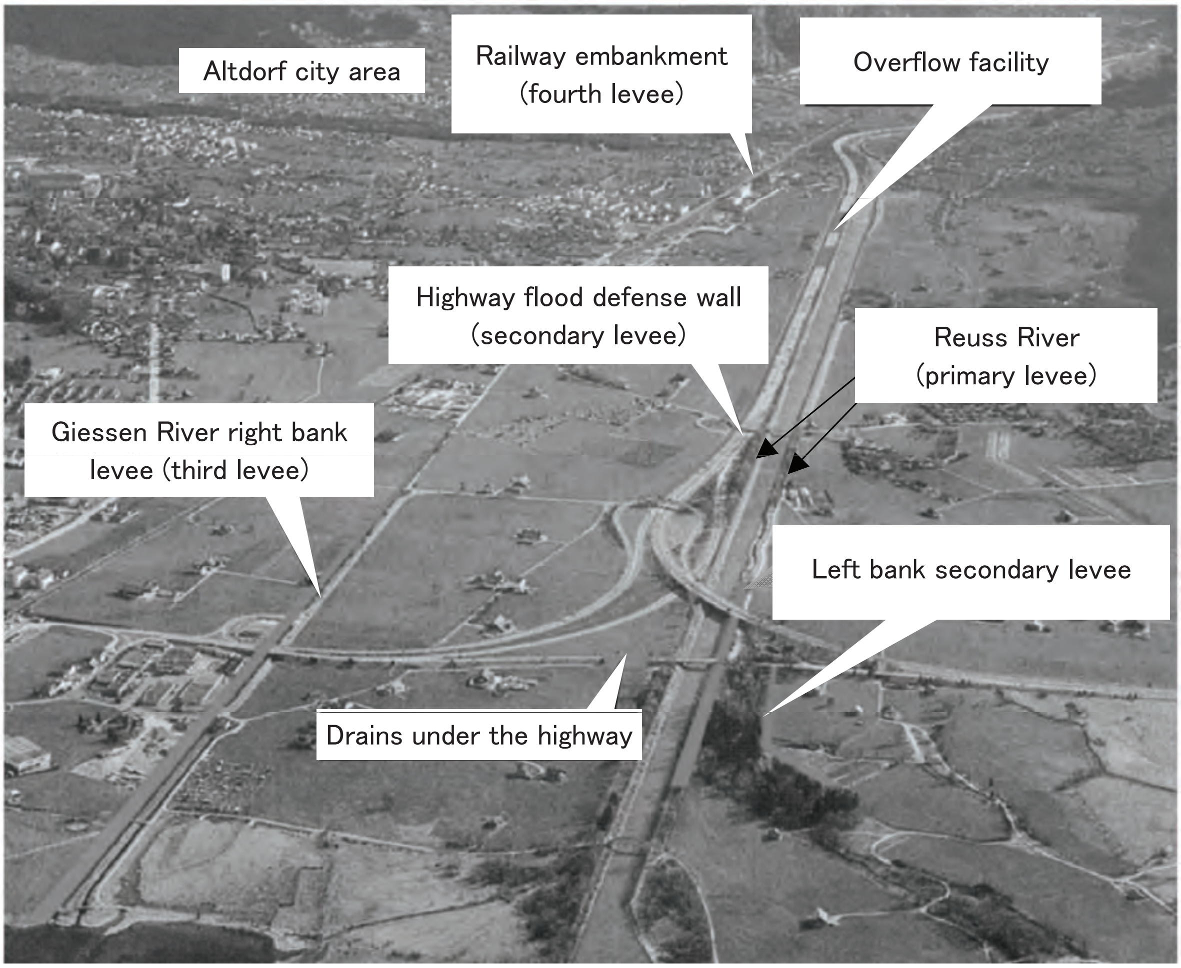


Figure : Multistage Flood Control in Switzerland's Reuss River
Compiled by the Science and Technology Foresight Center, based on Reference #26

2 Improved Research Institute Productivity due to the Contribution of Foreign Researchers

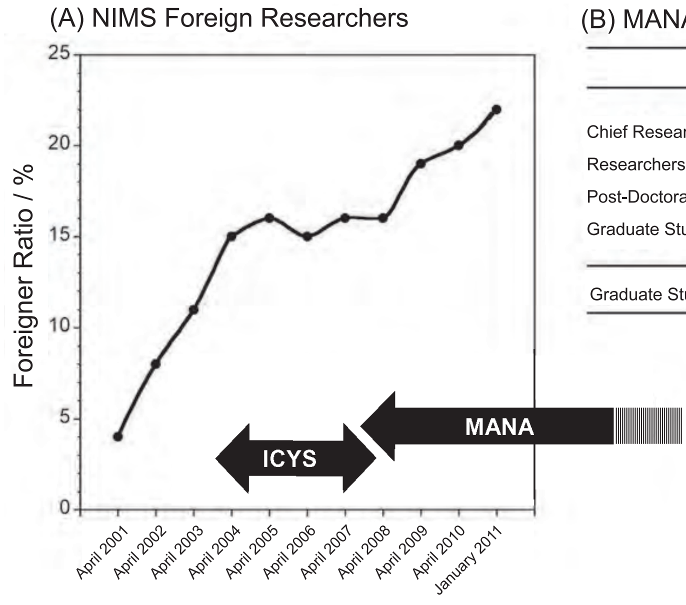
p.26

If Japanese universities and research institutes do not supplement their excellent research capabilities with foreign researchers, then they will not be able to compete internationally. A very high international character is needed to create a world class research institute/center, and it is very meaningful to refer to research institutes that have demonstrated success in inviting and training foreign researchers to improve research productivity. This paper analyses various data concerning the International Center for Materials Nanoarchitectonics (MANA) program and its predecessor, the International Center for Young Scientists (ICYS) program, at the National Institute for Materials Science (NIMS) as part of the World Premier International Research Center Initiative (WPI). The results of the analysis show that a higher ratio of foreigners was accompanied by a much higher world ranking (number of citations) for the host institute. In the past few years, the number of paper citations in the field of materials science has jumped from a rank of 18 before the start of the ICYS program to 4^{th} and 5^{th} place. Both the ICYS and MANA programs have covered a wide range of scientific fields and have done much to increase the ratio of foreign researchers. This experiment to bring exceptional foreign researchers to Japan to work has clearly resulted in the production of high-quality research papers.

Contributing to this success have been career paths for the researchers that allow them to move up to better positions at research institutes in Japan and abroad or to be hired by the host institute as permanent employees; the provision of a comfortable lifestyle for foreigners; and efforts to remove linguistic barriers and teach foreigners about Japanese culture. While the number of visitors to Japan from abroad dropped steeply after the Great East Japan Earthquake, over 90% of foreign researchers in these projects returned to work.

There are misgivings concerning the weak global presence of Japanese research institutes and those in emerging countries that are catching up, and Japan needs to work on making its research institutes more competitive internationally.

(Original Japanese version: published in March/April 2012)



(B) MANA Foreigner Ratios

	All	Foreigners
Chief Researchers	25	10
Researchers (Permanent)	68	10
Post-Doctoral	66	55
Graduate Students	41	34
Graduate Students	200	109 (55%)

October 2011

Program Names: MANA (International Center for Materials Nanoarchitectonics), ICYS (International Center for Young Scientists)

Figure : NIMS Foreign Researcher Ratios (A) and MANA Foreign Researcher Breakdown (B)
(Note: ICYS was downscaled in late-2007 and made part of MANA.)

Compiled by the Science and Technology Foresight Center

3 Mindset Change from Emergency Food to Disaster Preparation Food to Support Disaster Survivors

p.36

The Great East Japan Earthquake forced up to 470,000 survivors to evacuate their homes, who were provided with approximately 8.4 million meals of rations over a week's time. In the future, if a major earthquake strikes a highly populated region, creating evacuees an order of magnitude greater than this latest earthquake did—particularly should one occur in the Tokyo metropolitan area—then the survivors would need 75 million meals of rations or more for that first week afterward.

At present, emergency food stockpiled by local governments and households is low in absolute quantities and little of this food can be eaten without water or heat, which may be unavailable immediately after an earthquake. Furthermore, there are few cases of large, diverse stockpiles prepared with long-term emergency living conditions for survivors in mind, and much emergency food goes unused, as it is disposed of after its shelf life expires. It is important that we change the mind from conventional "Emergency food" that stockpilers assume will not be used, to "Disaster preparation food" (food prepared for disaster) that can be used in usual days as well as prove especially useful during a disaster.

Until now, no research on food has been conducted that takes the needs of survivors and nutrition during a disaster into consideration. It is important to do the following: 1) research on nutritional science as it applies during a disaster, 2) develop techniques to process food for disaster response, 3) develop packaging techniques for disaster preparation food and 4) develop cooking equipment for disaster preparation food. We also need to consider how to utilize the disaster preparation food in the daily life. The authors of this report recommend the advancement of this research and development and the creating of Disaster Food Certification Standards that incorporate the conditions required for disaster preparation food.

Conducting research and development and building infrastructure will require separate roles for the private sector, universities, government agencies, etc. upon incorporation within the Basic Disaster Prevention Plan, the government's fundamental plan for disaster response.

One of the pressing issues to prepare for major earthquakes and other disasters likely to occur in the future is to create disaster preparation food stockpiling systems and build substantial disaster preparation food stockpiles.

(Original Japanese version: published in March/April 2012)

Table : Disaster Preparation Food Coverage

Recipients	First Stage		Second Stage	Third Stage	Notes
	No Drinkables	w/ Drinkables			
Residents (General)	×	△	△	×	
Residents (Special Needs)	×	×	×	×	
Patients & Inmate	×	×	×	×	
Non-Residents (workers, stranded commuters, etc.)	×	△			
Relief Workers (General)	×	△	△		incl. residents responding to disaster
Relief Workers (Special)			△		firefighters, SDF, etc.

△: Current emergency food partially helps
×: Current emergency food mostly does not help

Compiled by the Science and Technology Foresight Center

1

The Need to Change the Concept of Water-related Disaster Prevention

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1 Introduction

This paper introduce recent trends in water-related disaster prevention technologies with focus on floods and storm surges and discuss why Japan needs to change its approach for water-related disaster prevention.

We have to be aware that the high-density land use on vulnerable areas has served to increase the risk of water-related disasters. Fragile geographical features are distributed throughout Japan's steep terrain as a result of frequent seismic and volcanic activities. Furthermore, the country possesses conditions that allow for the occurrence of a wide variety of water-related disasters in each and every region. Included among these are the low-pressure systems of typhoons and weather fronts that cause heavy rainfall and storm surges. To support the industrial expansion and sudden population increase during Japan's rapid economic growth period, public infrastructure was put in place, and disaster prevention measures undertaken to suppress the threat of water-related disasters with structural measures. These measures resulted in a decrease of small and medium-scale disasters such as floods. On the other hand, they also led to the urbanization of river floodplains, coastal depressions, steep slopes, cliffs and other places that had originally been considered dangerous.

In September 2011, strong Typhoon No. 12 landed in Shikoku and caused extended bouts of rainfall everywhere from Shikoku to Hokkaido. Total rainfall exceeded 1,800 mm in the Kinki region, with record-setting rainfall observed in various areas throughout the country.[1] This intensive rainfall caused landslides and bank overtopping. Houses and railways has been damaged and 94 people lost their life or missing.[2]

In Thailand, the Chao Phraya River flooded from an extended periods of heavy rain. In addition to over 600 dead and missing, many industrial complexes were inundated, negatively impacting supply chains in ways that caused serious economic turmoil throughout the world.[3] The damage it caused to Japan's economy has been a cause for concern when compared with that from the Great East Japan Earthquake.

Although mother of nature bestows our daily life with rich blessings, it could be a major threat and bear down on us at the time of natural disasters in a society. There are increasing concerns that the climate change due to global warming will lead to an abnormal weather in the future. To this end, the idea of using levee lines and other stationary disaster prevention measures have reached their limit, and more new disaster prevention and damage reduction technologies are expected to enable regional communities coping water-related disasters. The 4th Science and Technology Basic Plan aims for the realization of sustainable nature-friendly and recycling-oriented societies as well as enrichment of people's lives. To achieve this, it calls for measures that will make public infrastructure more environment friendly, including "initiatives aimed at the creation of cities and regions that adapt to climate change and large scale natural disasters, preservation of natural environments and biodiversity, maintenance of the natural cycles of forests, natural disaster reduction, and sustainable cyclic food production."

2 The Vulnerability of Japanese Territory against Water-related Disasters

2-1 Changes in the Relationship between Local Communities and Water-Related Disaster Prevention

(1) Development of disaster prevention projects and the concentration of populations and property on floodplains

Since the Meiji period (1866-1912), Japan had the ability to establish nationwide regulations and actively incorporated flood control measures that utilize Western technology to channelize rivers into structures that allow floods to flow more easily. However, immediately following its defeat at the end of the World War II in 1945, deforestation due to overharvesting of mountain forests and inadequate maintenance of levees left again the country extremely vulnerable to water-related disasters. With the frequent occurrence of disasters like Typhoon Kathleen (1947) resulting over thousand deaths, Japanese at the time had no greater desire than the construction of rivers capable of withstanding water-related disasters. In the aftermath of the typhoon, river levees were strengthened to make rivers safer, and the country worked hard to level mountainous areas and construct erosion controls.

On the other hand, floodplains and other low-lying land originally thought to be at risk of water-related disasters have been rapidly urbanized to support the sudden sharp population increase and economic growth following World War II. Measures to strengthen disaster-prevention structures like erosion controls, dams, levees, coastal revetments and slopes stabilizing were either systematically implemented or included as part of the reconstruction efforts following disasters. These disaster prevention facilities also helped support efficient land use and resulted in a dramatic decrease in death tolls due to medium and small-scale water-related disasters. Ironically, this use of structures to forcefully prevent disasters not only led to additional population increases and asset accumulation in areas originally considered dangerous, but also declined disaster prevention awareness among the general public. Currently, approximately 50% of Japan's population and 75% of its assets reside on the floodplains that comprise roughly 10% of the country. For this reason, an abnormal situation that exceeds the scale assumed for a facility's design could potentially result in unprecedented damage to these areas.

There is a need for us to shift our attention to the growing risks due to both social and living environmental changes. Though construction of flood control facilities has led to a decline in the inundated land area, the total amount of water-related disaster, as well as the damage per unit area has increased annually. In addition, new types of urban damage have emerged, including the inundation of underground space and the expansion of dense urban zones standing at sea level due to land subsidence caused by the pumping of groundwater.[4]

In the past, if heavy flooding exceeded the capacity of levees, self-defense flood prevention systems and traditional damage control measures, which were based on each region's natural environment, social characteristics, and long years of disaster experience, functioned by using the land to save human life. For example secondary levee lines or ditches dug into levees to divert flood water away the flooded areas and also riverside forests that existed to reduce damage from flooding. Nowadays, however, construction of disaster prevention facilities and also increasingly sophisticated land use have reached the point where it is now impossible to perform cross-sectional check and set up a management systems for each organization. The result is that there is no regulatory system for efficient land use, and construction can now be built near slopes, beaches, mountain stream outlets and other vulnerable places where people traditionally did not live.

The preparedness of flood control facilities on Japan's rivers is still only 60% of the current target to prepare against floods occurring on medium or small-sized rivers once every 5-10 years (5-10 year return period of floods) and 30-40 year for floods on large rivers.[5]

(2) Environmental Impact

A variety of environmental impacts have been observed as the result of large-scale disaster measures.

We need to pay attention to the construction of dams and dikes as an erosion control in mountainous areas. It has prevented fishes from swimming upstream to spawn. The less amount of sediment transported by river flow also has led to a loss in active river dynamism in some part of Japan. This has had a number of negative impacts, including the degradation of plant and animal habitats due to downstream river beds becoming course/fixed, the erosion of levees, bridge piers that is also affected by regulations on the extraction of gravel resources from dry riverbeds, and the deterioration of water quality due to the eutrophication of reservoirs and prolonged periods of muddy water in rivers following floods.[6]

In the flood plain, rivers have been straightened and riverbeds have been dug. The result has been a decrease in the dampness of riversides and a loss of naturally rich waterfront environments that serve as controls against overtopping, water quality maintenance, ground water recharge, habitats for plants and animals and recreational areas. Additionally, in dense urban areas, waterfront scenery has deteriorated due to the construction of vertical concrete revetments and the concealment of rivers with culverts.

In estuaries and coastal areas, the development of afforestation/flood control projects has been accompanied by a decline in sand supply, while the construction of large coastal structures like breakwaters has been inhibiting sediment continuity toward the coast. As a result, the erosion of tidal flats and gravel beaches has continued. This not only decreases disaster prevention's ability to attenuate high waves, but also causes a decline in available environments for ocean water purification operations and the raising of juvenile fish.[6] There are concerns that combatting coastline erosion with makeshift man-made structures is actually accelerating the erosion of neighboring beaches. Nearly 9,500 km of Japan's 35,000 km coastline is equipped with coastal protection facilities. Although these facilities protect human life and property from storm surges, this increase in artificial beaches is seriously damaging Japan natural landscapes. The burden of maintaining/improving such huge artificial structures will fall on the local governments in the future that preserve the coastline.

2-2 The Frequency of Abnormal Weather in Recent Years

From extremely heavy rainfall that continues for long periods of time, the occurrence of abnormal rainfall has been increasingly confirmed in recent years. According to statistics compiled by the Japanese Meteorological Agency, frequency of extremely heavy rainfall with intensity of 50 mm per hour or more has increased by a factor of about 1.5 over the past 30 years.[7] Additionally, heavy daily rainfall of over 400 mm per day has increased by a factor of two (see Figure 1).[8] As it will be discussed in a following chapter, future climate change due to global warming will cause more sever tropical cyclones, and sea levels rise will lead to an increase in wave height. Thus climate change also increasing fears that water-related disasters will continue to expand in magnitude.[5]

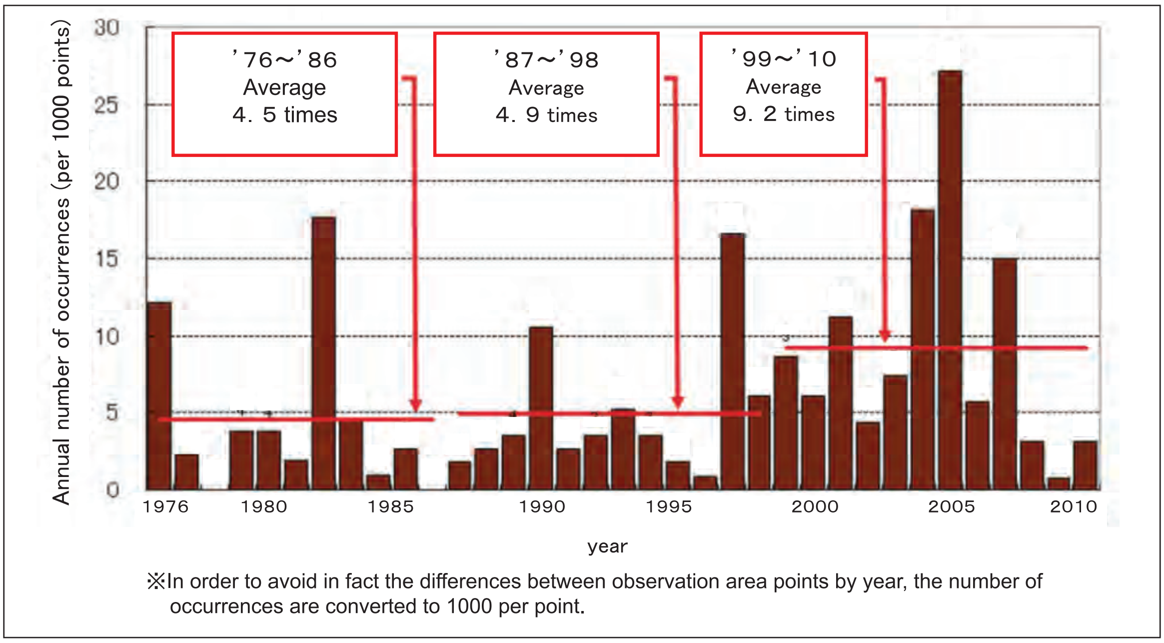


Figure 1 : Annual number of occurrences of daily precipitation over 400mm

Compiled by the Science and Technology Foresight Center, based on Reference #8

3 The Trend toward Nature- friendly Disaster Prevention Technologies

3-1 Changing Perceptions of Disaster Prevention and Reduction

Conventional water-related disaster prevention measures are designed based on the past experiences of damage scale. Disaster prevention facilities are planned to prevent flooding up to that scale of damage. Japan's decreasing birthrate and aging population has been increasing the cost of social security. The prolong national debt of Japan and its local governments, coupled with increases in the administrative expenses necessary to maintain social capital stocks up to now, are gradually chipping away at the amount of funding available for construction.[9]

We also need to concern that the abnormal weather caused by global warming is increasing severity of typhoons and increasing rainfall beyond that of conventional rates. In recent years, there has been greater recognition that the perceptions that have persisted up to now regarding the ability of disaster prevention facilities to prevent flooding in the event of abnormal phenomena that are extremely rare has reached their limit in terms of response ability, economic cost and environmental impact. Accordingly, a gradual shift toward land development that is extremely flexible in the face of water-related disasters and takes into account the total package of regional livelihood and environmental preservation and restoration is taking place, as can be seen in the enactment of the National Spatial Planning Act and in revisions to the Urban Green Space Conservation Act. This shift reflects the dawn of an era where the preservation of vitality and living assistance for local residents, the improvement of regional and river basin environments, and the preservation/enhancement of biodiversity through the symbiosis of people and nature are all in demand (see Table 1). In the future, it will be increasingly important to introduce flood damage reduction methods that enable best use of entire regions and basins and as well as preserve and/or restore the environment. Concerns have been raised that water-related disasters will increase in severity due to the emergence of stronger tropical cyclones brought on by the climate change as well as surging tidal waves as sea levels.

3-2 Trends in Research and Investigation that are Reflecting Changes in Perspectives

3-2-1 Investigations on Predictions of Abnormally Catastrophic Events and Damage Estimation

(1) Investigations of Abnormally Catastrophic Events Prediction

1) Abnormal Rainfall

Based on the average scenario (A1B scenario) indicated in the Intergovernmental Panel on Climate Change Assessment Report 4 (IPCC-AR4), in 100 years from now, the highest precipitation in a year comes to 1.1-1.5 times higher than that in 2009 in Japan. It has been estimated that this change in precipitation will cause devastating floods that currently occur once every 200 years to occur once every 90-145 years and floods that currently occur once every 100 years to occur once every 25-90 years.[5]

2) Rising Sea Levels

The risk of disasters due to storm surges and beach erosion will continue to rise as wind gusts increase and sea levels rise due to the drop in atmospheric pressure that will occur as typhoons intensify.[5] Predictions indicate that the frequency of extremely strong tropical cyclones with peak wind speeds in excess of 45 m/second will continue to increase from here on out.10 If sea level rises 59 cm in the future, the total land area and the populations of areas at sea level in Tokyo, Osaka and Nagoya are estimated to increase by approximately 50%.[11]

3) Regional Water-related Disasters

Researchers recognized that our ancestors could manage both benefits and threat of rivers. In the Shinano River drainage system and Chikuma River basin in Nagano Prefecture, for example, researchers with backgrounds in archeology, geology, river engineering and other fields collaborated on research into the changes of the rivers and levees that have occurred since the Jomon period (10,000 B.C.-300 B.C.) Based on data from historical excavations and numerical analysis of floods in each of the areas, the researchers came to understand that our ancestors leaned from traces of past flooding. Our ancestors cleverly used the range of flooding, the scale of river flow rates and slightly elevated land such as natural

Table 1 : The Implementation Status of Laws and Plans Concerned with Environmental Preservation/Restoration or Comprehensive Disaster Prevention in Regions/River Basins

Laws/Plans	Contents
National Spatial Planning Act (National Plan/2008)	The objective of this act is to "form a country that is strong and flexible against disasters" in the face of the ever increasing risks of global warming. It views the future, full-scale depopulation of Japan and the resulting surplus of land as a good opportunity to reconstruct Japan's structural make-up and make it stronger against disasters. A number of organizations, including green earth communities, individuals, NPOs, corporations, educational institutions, and administrations, will work together to develop regions in way that both maintains their vitality and supports the livelihoods of area residents
Urban Green Space Conservation Act (Revised/2008) A basic plan to encourage greening and the preservation of green spaces.	The Urban Green Space Conservation Act is illustrated as a strategic program concerned with greening and the preservation of green spaces in cities, towns, and villages based on a number of functions, including "environmental preservation through urban greenery," "recreation," "protection through firebreak belts, emergency evacuation, and flood regulation/retardation," and "landscape structure."
Basic Act on Biodiversity (2008)	In National Biodiversity Strategy 2010, the enrichment of biodiversity beyond current levels and the realization of greater symbiosis between people and nature on both national and regional levels are mid-range goals to be achieved by 2050.
The Third Basic Environment Plan (2006)	Put in place as a political program that prioritizes "efforts to ensure a healthy water cycle in terms of environmental protection," this plan points out the need for river basins to be considered in their entirety. The plan establishes "water quality," "water volume," "aquatic life," and "waterfronts" as four areas to be targeted.
Flood Control Act (Revised/2005)	Municipalities are obliged to designate areas along large rivers and major small/medium rivers that are hypothesized to be susceptible to flooding and inform citizens about communication methods for flood forecasts, shelters, and other information by means of hazard maps, etc.
Act on Countermeasures against Flood Damage of Specified Rivers Running Across Cities (2003)	This act was created to combat urban flooding stemming from considerable urbanization. It establishes flood control measures that seek to improve the preservative and water retarding abilities of entire river basins by servicing existing rivers and drainage systems, increasing the permeability of road surfaces and residential areas, and establishing regulating ponds in developing areas.
Act on the Promotion of Nature Restoration (2002)	This act aims to restore the natural environments of rivers, wetlands, tidal flats, seaweed beds, woodlands, rural mountains, rural lands, forests, and other areas lost due to past projects or human activity. Based on the previous promotion act, it promotes initiatives in 22 areas across the country (as of March 2011), including restoration of the meandering rivers of Kushiro Marsh.

Created by the Science and Technology Foresight Center

levees along rivers to extract benefits from rivers, avoid the threat of flooding and ultimately, find a wisdom way to survive.[12]

4) Combined Disasters Involving Earthquakes and Floods

There is a need to develop explanations and verification methods for the specific mechanisms behind the phenomenon of levee liquefaction.[13] The Koto Delta area in Tokyo, for example, is soft ground that sits right at sea level. If the ground were to liquefy during an earthquake and a flood or storm surge were to occur after the levees take damage, great harm could potentially be inflicted upon the elderly and other vulnerable individuals due to extensive flooding in dense urban areas.

(2) Flood Damage Estimation

1) Simulations of Flood Damage in the Metropolitan Area

Simulations results have been predicted a huge flood damages in Tokyo. If the Tone River were to burst open in an area similar to the one that did due to Typhoon Kathleen in 1947, estimates show that flooding would reach Tokyo in 48 hours and that Edogawa, Katsushika and other wards in Tokyo would remain flooded for over 14 continues days. Damage estimates are approximately 2,600 dead, 860,000 homes flooded and serious damage to lifelines over a wide area. If the Arakawa River that flows through Tokyo and Saitama Prefecture were to burst open near Shimo in Tokyo’s Kita Ward, 110 km^2 of Arakawa, Itabashi, Taito, Chuo and other wards in Tokyo would be flooded, and the death toll would rise to approximately 2,000. If flooding were to reach the subway lines, it is estimated that 17 of 22 lines and 97 of 130 stations would be inundated 72 hours after levees are broken.[14]

2) Storm Surge Disasters

In a simulation of storm surges and high waves in Ise Bay based on the terms of the medium-scale scenario laid out in the aforementioned IPCC-AR4, it is estimated that, due to the enormity of typhoons 100 years from now, Chubu International Airport will be flooded by storm surges reaching as high as 6.9 m. This figure greatly exceeds the 3.5 m storm surges observed in the Port of Nagoya during Ise Bay Typhoon in 1959, which is thought to have been the worst disaster of its kind up to this point.

3-2-2 Flood Mitigation in Flood Plains

1) Disaster Management Plans for Flood Plains and their Evaluation.

Disaster management plans are increasingly emphasizing how safe flood sites are in terms of both human loss and properties damage. Rather than follow the conventional wisdom of placing the focus of disaster prevention and management on how safe flood control facilities are. For example, development is underway on a model that would quantitatively evaluate the effectiveness of disaster management plans and cover measures taken at flood plains as well as at river basin dams and levees. Because much time is required to actually implement measures, this model also takes implementation sequence into consideration.[16]

2) Retarding and Retention of Floods Flow.

The scale assumed for agricultural drainage pumps installed in a paddy fields is generally set for ten-year floods. However, facilities at river drainage sites are designed for 100 to 200-year floods and indicate the water retention/retarding in basins by retaining flood water on rice fields when the inflow exceeds the capacity of agricultural drainage pumps. Considering this, the possibility of using paddy fields for flood control in a variety of land for different flood scales has been investigated.[17]

3) Guidelines for Water-related Disaster Risk Management

The World Federation of Engineering Organizations (WFEO) has been systemically compiled accumulated lessons learned and experiences in water-related disasters around the world due to floods, storm surges, etc. When managing risks of a hazard, it is necessary to apply a method that is inexpensive and sustainable. The applied method also should be able to operate using simple techniques that minimize the impact of risk management on natural environments and landscapes.

It is necessary to improve the function of disaster prevention facilities so that they can be used for a variety of purposes, even under normal circumstances. It is also necessary to proactively utilize nature's inherent water retarding and flood retention capacities. Additionally, managing floodplains on a basin-wide scale, regulating land use in compliance with the degree of danger involved, suppressing and guiding the flow of floods, and defending focal points are all necessary as well. Attention is also being given to the modern implications of traditional Japanese techniques like overflow levees and ring levees.[18]

3-2-3 Examples of Measures Utilizing Research Results

(1) Creating Water Retardation Capacities through the Restoration of River Wetlands[19]

In a combined flood control and environmental restoration effort, Saga Prefecture authorities implemented the Matsuura River Azame-no-se Natural Restoration Project in accordance with the Law for the Promotion of Environment Restoration. This project was launched in 2002 to "restore the flood plain wetlands that once existed in the Matsuura River basin" and to "restore the relationship between humans and other living things."(See Figure 2)

Citizens, NPOs, scholars, the Ministry of Land, Infrastructure, Transport and Tourism, and the municipality of Ochicho organized the Azame-no-se Investigative Commission and settled on a project plan. Scholars provided research results on flood behavior, wetland ecosystems and landscapes. The approximately 6 hectares of Azame-no-se acquired by the country for flood control measures were dug down to depths normal for the Matsuura River and the area's wetlands were restored. Creating floodplain forests alongside the river, wetland vegetation was restored using the site's soil seed bank and living/spawning environments for insects, fish and other living things were added along with flood shelters. The site was also provided with the ability to allow floodwaters in and regulate river flow rate as a retarding basin. Wetlands are maintained and the flood pattern that had persisted up until now has been restored because the ground is low.

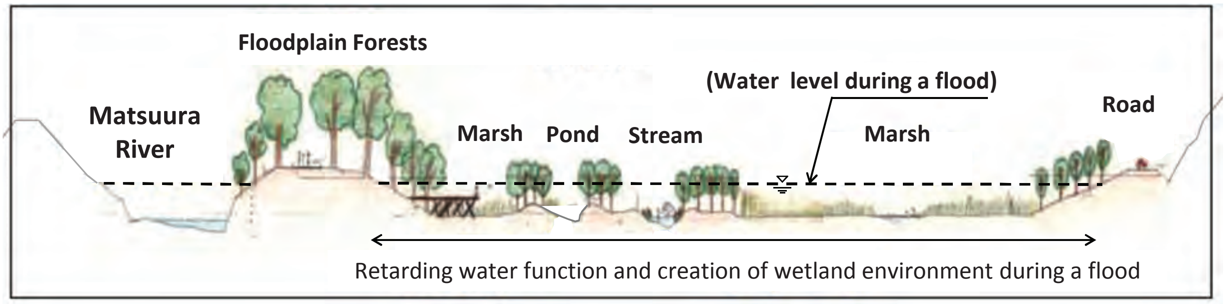


Figure 2 : Restoration of Wetlands with Water Retarding Abilities in Saga Prefecture's Matsuura River (cross-section view)

Compiled by the Science and Technology Foresight Center, based on Reference #19.

(2) Ensuring Disaster Prevention Capacities while Restoring and Preserving Fisheries and Other Coastal Environments through Artificial Reef Restoration.

A beach restoring plan was carried out in Aomori prefecture, in which seaside habitats, coastal erosion and disaster prevention are considered together. The rocky beach areas on the Kinoppe Coast of Aomori Prefecture's Shimokita Peninsula, which is defined by the Tsugaru Strait, were rich in nature, inhabited by a variety of creatures, and a thriving coastal fishery up until 1955. With the construction of a fishing harbor and a variety of coastal protection structures, the rocky beaches were lost and fish catches declined. Local citizens dug up pictures from around 1955 and, hoping something could be done to restore the once thriving beach, held a social gathering attended by citizens, NPOs, coastal specialists, and administrations from both Aomori Prefecture and Ohata town to seriously discuss the issue. Utilizing the experience of people living in the region, specialists presented research results on seaside habitats and coastal erosion and with each side in agreement, plans were finalized for a rocky beach restoration project that would also function as disaster prevention. Based on this plan, the blocks that formed the sloping revetments protecting the coastline were demolished/removed and diverted for use on an offshore foundation mound. Large stones were then placed irregularly on top of an artificial reef, which was completed in 2003 (see Figure 3).[20]

Reconstruction of existing revetments that takes environmental restoration into consideration was unprecedented in terms of coastal projects at the time. However, the project has been realized thanks to the enthusiasm and cooperation of all involved parties. By effectively neutralizing waves and suppressing the flow rate of coastal currents, the sandy areas of beach expanded and the scenery of the rocky beach of the past was restored, with seaweed (rock laver) and abalone becoming available for harvesting. In January 2004 and October 2006, unusually low atmospheric pressure generated high waves that severely damaged structures like the fish harbor's concrete-block breakwaters and detached breakwaters. Despite this, the artificial reef demonstrated the ability to neutralize waves.

Artificial reefs are soft coastal public works technology that will change over time. People in

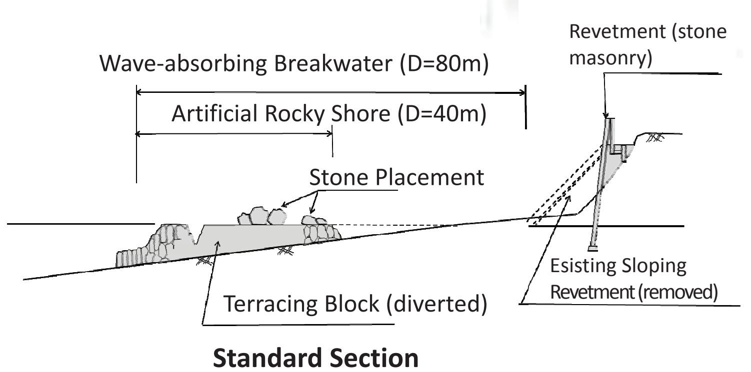


Figure 3 : Restoration of Revetments with Disaster Prevention Abilities on the Kinoppu Coast
(Artificial rocky shore is the central and slightly offshore parts of the photograph that are dotted with rocks)

Compiled by the Science and Technology Foresight Center based on Reference #20 the region have been conducting independent and continuous monitoring of the reef to ascertain its effects in terms of terrain alteration, wave attenuation, and habitat.

In addition, whenever disaster prevention revetments are installed in the Nakatsu Tidal Flat of Oita Prefecture, they are not placed at conventional sites such as at water's edge, but rather, are pushed back toward the vicinity of communities. This is conducted in collaboration with individuals who possess knowledge of or have experience with ecosystems and coastal disaster prevention in order to satisfy the demand of local residents that the tidal flat be protected. Preservation of natural tidal flats and their rich ecosystems, as well as the small sand dunes behind them, wetlands, and maritime forests, maintains their natural wave attenuation capabilities. These coupled with the placement of small levees, also helps protecting local communities.[21]

(3) Environment-friendly Disaster Prevention Technologies Applied to Basins Utilizing Existing Infrastructure and Facilities.

1) Sediment Transport System Improvements combined Forest Preservation with Dam Modification

A plan which seeks to simultaneously achieve continuous hydroelectric power generation, water damage prevention upstream of the dam, restoration of downstream riverbed environments, and the prevention of coastal erosion has been carried out in Miyazki prefecture.[22] A total collapse across the slopes of the basin Mimigawa River was caused by a typhoon in 2005 and led to a huge influx of sediment into the dams. This influx in turn caused riverbeds upstream of the dams to rise, resulting in flood damage to the area as well as a great deal of damage to the power plants. In response, river administrator, regional representatives, local governments, dam employers, and individuals with relevant knowledge/experience collaborated to control sediment runoff through forest conservation and significantly remodel the dams and in 2009, began creating a system that would allow sediment to continuously flow downriver from the dam into the foreseeable future. Experienced and knowledgeable individuals, in addition to presenting a variety of research results pertaining to forest conservation, river engineering, coastal engineering, ecosystem preservation/restoration, and other fields, took on leadership roles in a variety of investigative commissions.

2) Synthetic Use of Existing Dams through Dam Restructuring Project

Specialists are currently investigating ways to maintain flood control capacity, ways to ensure continuous removal of sediment, downstream waterways and sediment drainage, and changes to natural ocean environments in Shizuoka prefecture.[23] A large amount of sediment is accumulated at the Sakuma Dam on Shizuoka Prefecture's Tenryu River, and a direct consequence of this accumulation has been the progression of severe erosion at Enshunada coast. Carrying out permanent measures aimed at draining accumulated sediment from the Sakuma Dam, which is used exclusively for hydropower and irrigation, while also secure the dam's flood control capacity. The dam restructuring project has exercised since 2009 to find ways to integrate other features. These include the improvement of downstream flood control safety, the preservation of future power generation, and coastal erosion controls.

Additionally, research is being conducted into how to improve the performance of existing dams by using them more effectively. Efforts are being made to improve the flood control capabilities of dams while paying close attention to the runoff characteristics in dam basins in order to release water from the reservoir before flood inflow. The advancement of research such as this will allow the flood control capacity of dams that are up to now empty in the rainy season to be more effectively used at normal times for hydropower generation, water supply, and environmental discharge.[24]

3) The Recovery of Sediment Transport Continuity in Coastal Areas

At the Fukude fishing port near the mouth of Shizuoka Prefecture's Tenryu River, a plan has been in place since 2007 to recover sediment transport continuity along coastlines by constructing a permanent sand bypass system using pipes to control coastal erosion and preserve the port's functionality.[25]

3-3 Trends in other Countries

3-3-1 Examples of Multi-stage Flood Control[26]

In Europe and the United States, it has widely accepted the limits of structural measures with respect to their cost and also in terms of environmental impacts. Therefore, there has been debate over which combination of structural and non-structural measures—such as those that deal with land use planning or building code—is the best when it comes to the institutionalization of a variety of disaster management systems. In Japan, which land use is sophisticated in floodplains, it is thought that consultation should occur after investigating disaster management for future societies that can co-exist with nature, even if those techniques are difficult to implement. For example, on the Reuss River, which pours into Lake Lucerne in Switzerland and is a tributary of the Rhine, a degree of flood control safety has been established in accordance with land use and multi-stage flood measures that utilize river levees, roads, and other structures are in effect. (See figure 4) Their purpose is to provide water-related disaster protection to Altdorf, the capital of the Swiss Canton of URI. It is located near the convergence point of the Reuss River and Lake Lucerne. The levees on the Reuss River are the first line of flood protection and flood water with the return period of more than 50 years may overflow them. If a flood with return period of more than 50-year happened, floodwaters are allowed to overflow and traffic will be restricted in the parallel highway beforehand of overflow. The height of the highway's flood protection wall allows it to handle floods as large as 250-year floods and is the second line of flood protection. In the event that the flooding exceeded that of a 250-year return period, the floodwaters would be stored in the agricultural land between the highway and the adjacent Giessen River. The Giessen River levees are in place to be the Reuss River's third line of protection. If faced

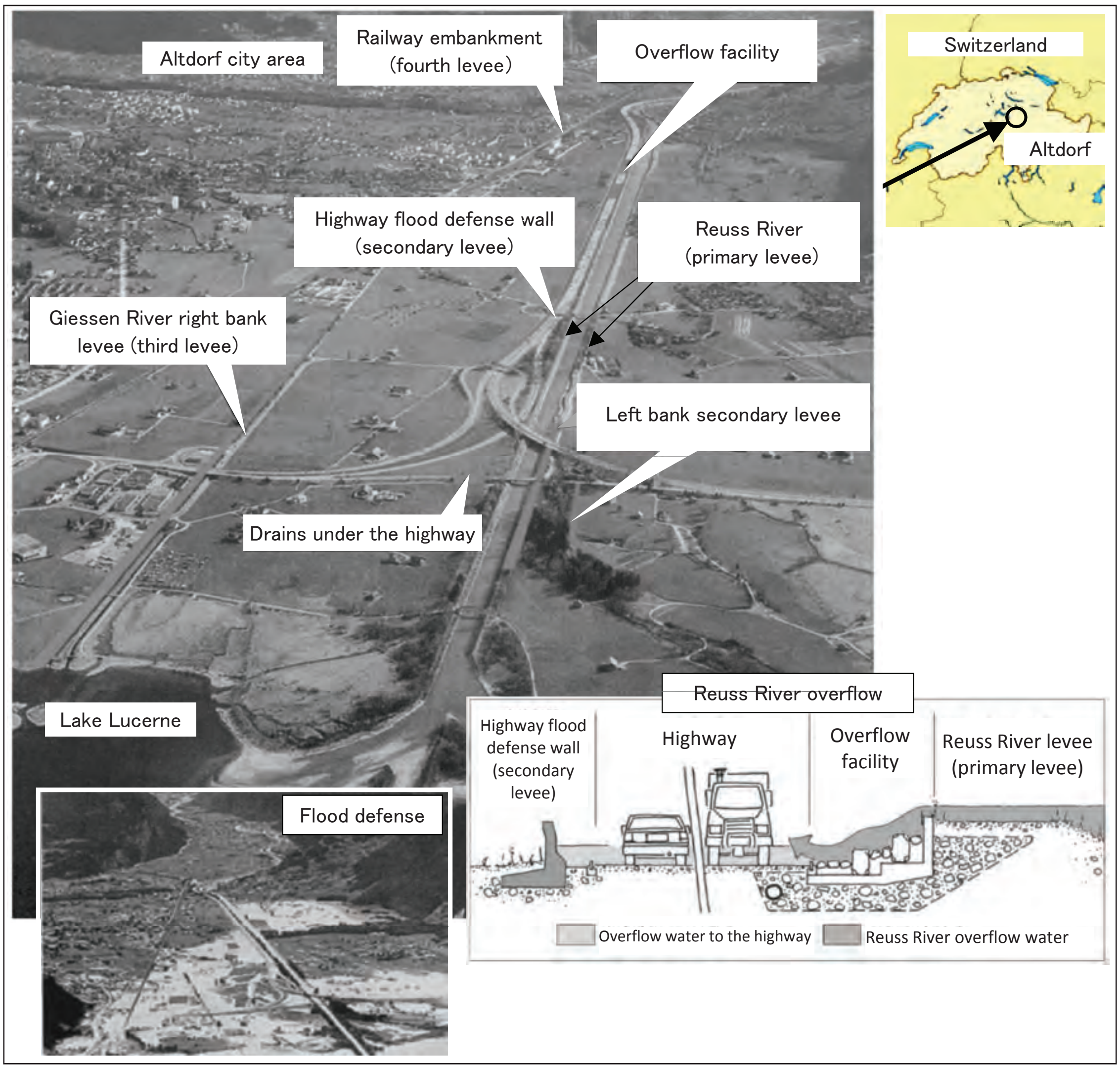
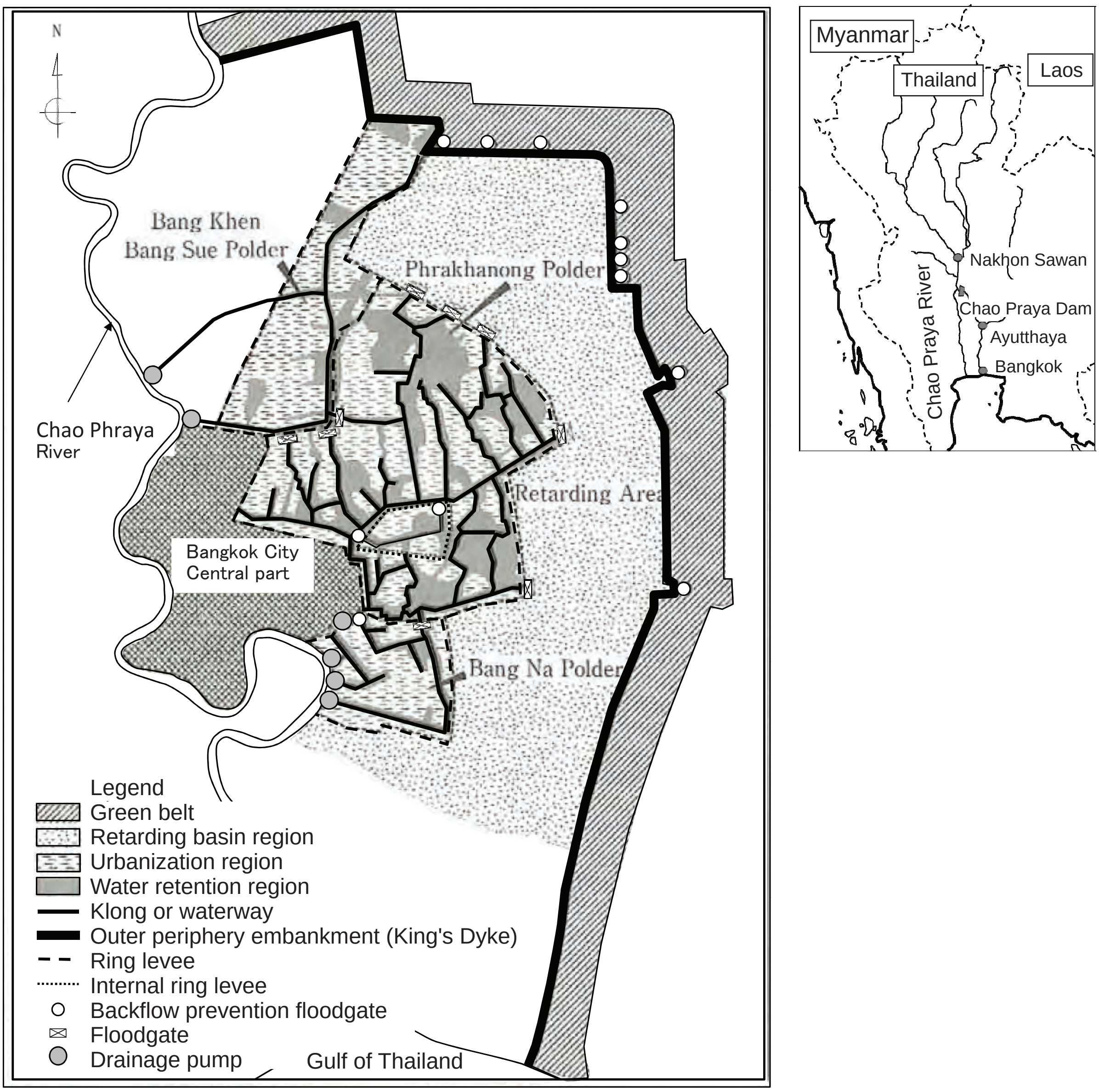


Figure 4 : Multistage Flood Control in Switzerland's Reuss River
Compiled by the Science and Technology Foresight Center, based on Reference #26.

with an even stronger 1000-year flood, the series of railroad embankment would protect the most densely populated areas of Altdorf.

3-3-2 Thailand's Comprehensive Flood Control Measures and Flooding in the Chao Phraya River

The frequent flood of Chao Phraya River of Bangkok is serious problem. Bangkok, the capital of Thailand, is located in the lower basin of the Chao Phraya River, which takes up a total area of 163,000km^2. In recent years, population and economic growth have led to the urbanization of the flood-heavy lowlands. Additionally, land subsidence has been caused suddenly by the excessive pumping of groundwater, and the frequent occurrence of water damage from flooding on the Chao Phraya River is now a serious problem. In 1983, the Bangkok Metropolitan Administration settled on the "Master Plan on Flood Protection/Drainage Project in Eastern Suburban-Bangkok." (see Figure 5).[27] The plan protected



Structural support	• Installation of outer periphery embankment prevent flood inflow from the northeast (Kings Dyke) and a floodgate to the waterway
	• Installation of drainage pump for rain water to drain into the Chao Phraya River and the canal leading to it
	• Levees to prevent flooding from the Chao Phraya River and installation of a floodgate to the waterway
Non-structural support	• Paddy fields outside of the King's Dyke as a greenbelt areas to ensure conservation and water retarding functions
	• Area between the urban areas and the King's Dyke is a preserved as a water retarding basin area
	• Specified in a water retention region that is relatively low and also in an urbanized area (Development cannot occur in the region without permission from the government)
	• Guidance/regulation of urbanization
	• Installation of flood information systems for rivers and flood response centers

Figure 5 : Flood Control Measures in Eastern Suburban-Bangkok, Thailand

Compiled by the Science and Technology Foresight Center, based on Reference #27.

central Bangkok from flooding from the northeast and allowed the water to flow east by creating the King's Dyke, an external levee that surrounded Bangkok from north to east, and by making the exterior into a green belt.

In addition, a second levee was established within the King's Dyke and land use regulations were incorporated to preserve the space between two levees as a flood retarding basin. Furthermore, drainage pumps and sluice gates were added to provide internal drainage within Bangkok. The low-lying city areas in risk of inundation are registered as water retention areas. A governmental permission is required to do any development in the area. However, it has been said that the political chaos that following the military coup in 2006 and the stresses on land use and rapid urbanization prevented implementation from proceeding as planned.[27]

In autumn of 2011, a large-scale flood damage happened in this area. Between May and October of 2011, the Chao Phraya River Basin experienced rainfall that was 143% of the average of the past 21 years. In early September, the Chao Phraya River's flow rate exceeded flow capacity, overtopping began between Nakhon Sawan and Ayutthaya, and from mid to late September, the left bank levee between the Chao Phraya Dam and Ayutthaya broke in eight places. It has been observed that this break down led to an influx of over 5 billion m^3 of water (1/4 of total flooding) into the left bank floodplains. Floodwaters reached an industrial park outside of Ayuthaya in early October, two weeks after breaking through the levee, and then flow further downstream, inundating seven industrial parks and the capital of Bangkok. 804 companies (approximately 449 of which were Japanese) damaged.[3] It has been estimated that, nationwide, approximately 5.05 million people living in approximately 1.88 million households were affected. The dead and missing currently stand at 609 as of November 2011, and the total area of agricultural land damage has reached 170,000km^2 (virtually the same size as the Kanto Plain area).[28] It is anticipated that detailed investigation will be undertaken into the functional and practical problems of disaster management infrastructure, systems and application of land use regulations needed to manage floodplains, disaster management information, plans for warnings and evacuations, and a system able to support it all.

Populations are now concentrated due to the rapid urbanization of floodplains, and as a result of that, there have cases of increased damage all across Asia. Besides flooding, storm surges were caused by Cyclone Sidr in Bangladesh in 2007 resulted over 4,000 dead or missing,[29] Cyclone Nargis in Myanmar in 2008 also resulted over 70,000 dead or missing.[30] Instruction based on investigations into these disasters will need to be used in order to help future disasters management.

3-3-3 Institutionalization and Implementation of Floodplain Management

(1) France's System

The basic idea behind flood defense in France is "local control." Straightening rivers and protecting them with continuous levees is not a good idea as they raises flood levels in downstream, and increasing water damage risk. The preservation of as many natural flood retarding basins as possible prevents the increase of flood flow, and the institutionalized way of thinking in France is that areas that possess important hinterlands should be protected by local levees. In regard to flood damage reduction measures for floodplains and measures against excess flooding, France provides effective information on flood forecasting and defines the areas that are at risk of inundation. It also prohibits all construction within those at-risk areas (flood retarding basins).[31]

(2) The United Kingdom's System

In the UK, serious consideration is given to protections against storm surges that cause severe damage by rapidly raising water level. With the exception of the Thames Barrier (protective wall), which was built in the downstream areas of London to protect against 1000-year storm surges, using embankments to defend against flooding has not been the norm in recent years. Instead, progress has been made with non-structural measures, such as regulating limited development in floodplains along waterways. Intended for the benefit of safe water environments as well as the users of those environments and all related agencies, progress has also been made on the establishment of the water drainage unit from the "River Basin Management Plan." Consideration for the environment has become prerequisite for all urban planning in UK flood control projects, and flood control projects themselves are often found to a part of environmental conservation projects. The contents of the flood defense in these plans include regulations for floodplain development, investigations into the degree of safety basins offer against floods, flood forecasting and warnings, and maintenance management of flood control facilities. Project plans emphasize land use assessments and the development of flood defense strategies, as well as guidelines development based on those assessments.[31]

(3) Germany's System

In Germany, land use planning is believed to be the foundation of the country's floodplain management. In addition to specifying floodplains, construction and land use within them is regulated. For example, constructor of structures like oil tanks and power facilities are asked to choose construction methods that ensure safety against floods. In addition to the inspection and repair of deteriorated levees, the establishment of areas that will allow water to overflow through changes to the form of land use, the restoration of wetland environments with water retarding capabilities, and other measures are taken across the whole of river basins in a comprehensive manner.[31]

In the case of the Elbe River, approximately double the size of the area damaged by flooding in 2002 has been designated for water retarding basins and flood control plans have been established to protect major cities.[31]

(4) The Netherlands' System

With 27% of the country's territory below sea level and 60% of the country's population residing in those areas, the Netherlands have undertaken protection measures that use large-scale embankments to counter the enormous threat of damage from storm surges. Flood control projects are implemented incorporating the perspectives of scenery, nature, and culture in accordance with LNC policy. The country does not have a special system in place to deal with floodplain management, but the city of Amsterdam is situated on slightly elevated land like hills and sand dunes that serve as natural levees and make it difficult for storm surges to land a direct hit. The coastal areas and deltas that are vulnerable to extreme damage from storm surges are lightly populated and no large cities exist there. In regard to river floods, the protection level of upstream areas is low. However, flooding that occurs in upstream agricultural area will not reach the larger cities downstream.[31]

(5) The United States' System

In response to the heavy flooding that occurred in Missouri River in 1993 and damaged 37,000 homes, the U.S. federal government has greatly shifted its river management policies. With dams and levees judged to be weak against the power of stronger rivers, a buyout system was introduced that allows the government to buy property and houses at-risk areas in order to create a buffer zone in times of flooding. Additionally, if a house is built on an area at risk of flooding from a 100-year or 500-year flood, building regulations that take waterproofing into account are applied, and flood insurance (with rates determined in accordance with the area's degree of danger) is mandatory. This limits the number of residences at-high risk areas and reduces the risk of flood damage.[31]

4 Constructing Disaster Prevention for a New Era in Japan

4-1 Problems with Japan's Water-Related Disaster Prevention Measures

In Japan, population and property are concentrated on low-lying lands like coastlines, floodplains of large rivers, and other areas that are naturally susceptible to the threats of nature, because water-related disaster prevention and regional plans are carried out separately. Additionally, a number of established underground facilities, industrial facilities, and other facilities are susceptible to secondary disasters.

Based on many years of experience with disasters and working off of the presumption of water-related disasters that regions had been hit by, the Japan of the past specified land use in an attempt to reduce damage. In order to protect higher priority areas, water retarding basins and overflow levees were established to guide floods elsewhere. Meanwhile, traditional countermeasures like ring levees and Elevated housing for flood prevention (Mizuya), as well as regional flood prevention organizations, served to protect settlements and houses from floods (see Table 2). However, from the Meiji era (1868-1912), disaster prevention became a field of specialized expertise within the administration and progress was made on the development of disaster prevention facilities that would serve as a line of defense for regions. Also, as land use in regional planning grew increasingly sophisticated, the preparedness of local residents to deal personally with water-related disasters waned and systems/ideas for how to deal with the risk management of disaster prevention/reduction that were based on wisdom and mutual understanding disappeared or at least were severely weakened, bringing us to the present. For this reason, there is almost no research dealing with land use as the essence of flood control.[27] If a disaster prevention facility degrades or is damaged, or if an external force generated by an abnormal phenomenon exceeds the assumed scale for that facility's design, it would give rise to new risks of large-scale disaster.

Additionally, degradation of river and coastal habits for plants and animals, landscapes, and other environments is taking place. This is a result of changes to the natural cycles of water and materials brought on by the reshaping of nature that accompanies large-scale installation of infrastructure and facilities. Furthermore, negative links have been observed, including disaster prevention measures that unintentionally promote the occurrence of disasters in other areas. As was mentioned in section 2-2, there is a growing fear that abnormal weather will occur due to global warming and that habitats of ecosystems will continue to deteriorate from now into the future.

4-2 Problems to be solved

4-2-1 Clarification of Problems Facing Regional Disaster Prevention and the Environment

Japan is long from north to south and differs greatly in terrain/geological features, weather, and other natural conditions depending on the region. There are also a variety of regional conditions for land use. Naturally, the variety, scale, and likelihood of the natural disasters in Japan are also different depending on region.

In recent years, hazard maps have been under development to help share risk information about a variety of disasters, including the range of floods and debris flows. Nevertheless, the target range of the scale of external force assumed in the risk information is imprecise. Because natural phenomena are complex and the time scale of occurrence of large-scale disasters is long, an adequate amount of quantitative data on the geological features of regions, long-term rainfall, and other information has not been organized/accumulated.[32] In addition, both sediment discharges and damage to facilities due to earthquakes/volcanic activity and complex disasters such as torrential rainfall or storm surges caused by typhoons or weather fronts/low atmospheric pressure have yet to be targets for study. There are a variety of challenges when it comes to dealing with the uncertainty of disaster causes. In the future, it will first be necessary for research to use data from folklore and ancient documents to gain a long-term understanding of disaster history, nature-friendly land use, living culture, environment changes, and other information as it applies to each and every region. Also, it will be necessary for us to combine the scientific expertise of meteorology, topographical geology, and civil engineering with expertise from the past and clarify the issues surrounding regional mechanisms for disasters and disaster prevention/environment.

Table 2 : Examples of Traditional Water-related Disaster Prevention Countermeasures

Name	Structure/Function
Discontinuous Levees (Kasumitei)	Discontinuous levees have an opening. During a flood, the flow amount of mainstream goes out from an opening in order to decrease downstream. The floodwater is promptly discharged with the decreasing mainstream water level.
Overflow Levee (Nogosi)	An embankment which is partially lower than a normal embankment. A certain amount over the mainstream water level is allowed to overflow, which reduces the mainstream water level.
Protection Forest	A forest zone prevents the spread of sediment and driftwood along with weakening the energy of the water flow against flooding. Protection forest from tide is established along the coastline, anti-debris forest protection is in the mountains and protection forest from flood is along the river.
Setback Levee	An embankment has been constructed on the protected inland behind the primary embankment, and if this embankment collapses it prevents the spread of flood inundation. This secondary levees is also referred to as a two line embankment.
Ring Levee	There is an embankment that has been constructed around the periphery of the village, and this embankment defends the houses and the life from flooding.
Elevated housing for flood preventation (Mizuya, Mizutsuka)	The type of houses(Mizuya) built on a high embankment prepare against internal and external flooding in a flood prone zone. Mizutsuka is able to provide shelter for a long period of time and are stockpiled with wells, food and bedding. A boat is also available as a means of transportation during a flood.

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4-2-2 Construction of Disaster Prevention Technologies Integrated with Regional Livelihood and Land Use

(1) Changes in Concept toward the Co-existence of Nature and Disaster Prevention Technologies

The primary disaster prevention measures of river managers, coastal managers, and other disaster prevention department authorities up until now has depended on the extent to which protective facilities can handle their attempts to contain design floods in water ways with dams or levees before discharging them toward the sea and to protect coastlines with revetments. However, as was previously mentioned, there are limits to the extent of which these strategies can be used for future disaster prevention. In order to make future efforts toward a sustainable coexistence between Japanese regional communities and nature, as well as to integrate livelihoods with disaster prevention/reduction, big changes in the concept toward disaster prevention will need to occur. Namely, the thinking behind disaster prevention attempts that rely on the strength of structures to counter the energy generated by disasters will need to be revised. Facilities will need to nullify all harm from frequently occurring external forces, while human life will need to be protected from external forces that are exceedingly rare. To achieve this, a move toward a more flexible approach to controlling the size and varieties of damage throughout the entirety of an area or basin is necessary, as is an acceptable degree of structural damage or temporary loss of functionality. This kind of thinking is rather similar to the approach that Japan had been adopting as its ultimate crisis management techniques to protect regional communities from water-related disasters prior to modern times. For example, once when there was a large-scale flood, floodwaters flowed over or broke through the levees and damage was dramatically spread over a wide area. Because the place where the levee would be compromised had been determined ahead of time, however, the surrounding areas were allowed to flood and the damage was localized. In the future, places such as these will be clearly established. In ordinary circumstances, they will be areas that are naturally restored to be wetlands or fields or places that are used for food production, recreation, or sightseeing. In times of distress, however, they will be used to prevent catastrophic disasters. At the same time, preferential treatment in terms of compensation and taxation will come into effect when disaster strikes. As for conditions for land use or evacuation, continuous changes will need to be made with regard to mechanism creation under the assumption that floods will occur.

With a variety of land use and facility development already in place, abandoning these designs to start anew will by no means be easy. However, if considered in terms of Japan's declining birthrate/aging population, Japan will need to change its long-term perspective on how to prevent disasters. The nation make the move toward the construction of a low carbon society with a reduced population. More specifically, Japan will need to introduce multistage disaster control technologies that include reviews of land use in accordance with the scale of catastrophic disaster events. In order to achieve this, evaluations of the flood control capabilities of forests and fields during abnormal weather, the human and material damage that accompanies flooding, the indirect ripple effect of damage, and environmental impact will all be necessary. Also, the technology used for disaster prevention/reduction measures needs to be durable in the face of devastating phenomena, and the entire system from hardware to software needs to be linked reliably. Finally, consensus methodologies need to be crafted in each region.

It is necessary to enhance areas of research that will allow for more comprehensive regional planning. In particular, regional topography, living environments rooted in history, energy, resources for food, economy, and culture could all be merged with disaster prevention in these plans. With regard to the necessity of isolating disaster chains in urban systems and improving redundancy, for example, there is a need for approaches that considers surplus space from the perspective of environmental disaster prevention as well as research approach that adopts a basin-wide scheme.

It is also necessary to establish regional disaster prevention cultures that include educational instruction and disaster prediction/evacuation systems utilizing a variety of data on weather/flow rates to allow for precision evacuation prior to disasters. With all of these ideas, the collaborative support of experts in disaster prevention, environment, social sciences, and numerous other fields will be required.

(2) Challenges in Research on Effective Use of Existing Infrastructure and Facilities

Considering the future increases to the cost of social security, the effective use of existing infrastructure and facilities is an important challenge facing Japan. Beyond simply maintaining the functionality that has persisted up to now, it is vital to capitalize on the many years of operational experience of these facilities and to reconstruct them from a longevity standpoint. This means reconstructing them to be utilized in a more comprehensive manner that will benefit the nature-friendly societies of the future or perhaps help in the creation of regions that are strong against disasters.

Dams, in addition to being able to use stored water for hydraulic energy and a variety of other uses, are able to temporarily dissuade floods and sediment runoff in times of abnormal rainfall and prevent disasters downstream. On the other hand, large amounts of sediment accumulation in the reservoirs forces the dams unable to operate sustainably. Depending on the characteristics of the basin or the facilities used, large amount of sediment is captured and deposited in dam resevoir, changing the water quality or hydrological regime downstream and impacting the environments of flora and fauna as well as the terrain of rivers and coasts. In order to use dams more effectively and more continuously, downstream hydrological regimes and sediment discharge from dams need to be improved. Comprehensive research that takes into consideration of the safety based on local characteristics, the continuous use of resources, and the preservation/restoration of the natural environments is necessary to overcome this challenge, which extends far beyond mere expertise in mountains, rivers or oceans.[6]

Although levees are indispensable when it comes to protecting their surroundings from flooding, construction and improvements to them have taken place in various periods, and they have also been installed over old riverved. Consequently, the structures and materials from which were made lack uniformity, and the protective strength of many of these levees remains uncertain. An accurate evaluation of facility vulnerability is the first thing that needs to be done. Research and development is then necessary to develop inspection/diagnosis technologies for precision maintenance, reinforcement technologies that utilize durable materials/structures to defend collapse by overflow during heavy flooding, and reinforcement technologies harmonize to the restoration of rivers and surrounding environments.

On sandy beaches, numerous tetrapod breakwaters and detached breakwaters have been installed to combat coastal erosion, which is a result of the blockage of drift sand toward the coast caused by coastal structures and a reduction in sediment supply from rivers. However, there are many cases where erosion prevention facilities are nothing more than a basic block. In addition to appropriate sediment supply from rivers, technical solutions conducive to environmental restoration, such as shore reclamation techniques using sand bypasses and the concentration of fishing ports, need to be proposed.

4-2-3 Promotion of Problem-Solving Research through Pilot Projects

Efforts to prevent water-related disasters and restore environments are a complex intermingling of independent natural and social conditions. In addition to investigations into systems and unique technologies by Japan and its local authorities, the accumulation of practical studies that endeavor to place focus on individual regions is also necessary. It is believed that, by clarifying environmental and disaster prevention issues from a regional/basin-wide perspective and discussing each and every path/route of study to solve problems, scientific knowledge will accumulate and will emerge new problem solving technologies and institutional solutions. However, it is impossible to conduct research on every single local area. It is necessary for regions and individuals knowledgeable/experienced in a variety of fields to work closely in order to bring together the wisdom of Japan and conduct project research targeting pilot sites.

5 Final Remarks

We believe studying disaster prevention wisdom from the past and establishing a new era of disaster prevention technologies will contribute to cope with tragic and repeated disasters happened in a region. The “best policy” for the Yellow River continues to be a topic of debate. The river flow and large amounts of sediment caused damage to people living in the alluvial fan. Political dynasties from every period have tried to combat the Yellow River’s behavior in a variety of different ways, such as diverting the river into tributaries to ease its force or heightening levees to raise the flow strength of the river to flush the sediment. The best policy was said to be reading into the tendency of nature by observing the direction in which the stream leaned, then moving the people from that area, tearing down artificial structures in advance, and letting the stream go where it may. At the same time, plains were developed and simple improvements were made.[33] Ideas such as these are thought highly suggestive in terms of regional disaster prevention that is in harmony with nature.

Japan has been blessed with the ability to enjoy rich and plentiful nature that changes with each distinct season thanks in part to large-scale earthquakes, volcanic activity, typhoons, low atmospheric pressure, winter snowfall, and other changes in the natural environment. However, when there is an abnormality, nature suddenly changes, and the weather goes crazy as if to attack us. The Japanese people who inhabited a country such as this must have originally included preparedness and provisions for disasters as part of their daily life. 100 years have passed since modern technology was introduced in the Meiji era, and we are now faced with new challenges. Once more, we need to start at the beginning, correctly understand the nature of each region, and from a comprehensive and long-term perspective, use human intelligence and science to clear a new path that allows us to live in the harmony with nature.

Furthermore, if we shift our attention to the world, we see that over half of the world's natural disaster casualties are a result of floods. Also, 90% of the world's water-related disaster victims are in Asia. Asian countries are a growth center for the world economy. By inspecting disaster prevention measures from the past and establishing a new era of disaster prevention technologies for societies that will coexist with nature, we can make international contributions to countries that have been repeatedly plagued by tragic disasters through the development of infrastructure in countries all across Asia.

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2

Improved Research Institute Productivity due to the Contribution of Foreign Researchers

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1 Introduction

If Japanese universities and research institutes do not supplement their excellent research capabilities with foreign researchers, then they will not be able to compete internationally. Although supplementation with foreign researchers is helped by individual researchers' efforts, in addition to arrangements such as systems that assist foreigners, passive efforts that wait for foreign researchers to come on their own initiative have not necessarily successful. Organizational and proactive efforts, plus the accumulation of detailed knowledge on how to deal with implementation-related problems, are in need. At present, research institutes have not built up this body of knowledge and, if they do not change, their efforts will only continue to grope in the dark. One way to make a breakthrough in solving these problems would be to show research institutes examples of how others have enjoyed success by inviting and training foreign researchers, and for these institutes to take note.

For example, the National Institute for Materials Science (NIMS) has an extremely high ratio of foreigners for a Japanese research institute. Two programs are a big reason for this: the International Center for Young Scientists (ICYS), and the International Center for Materials Nanoarchitectonics (MANA), which inherited the knowhow of the former. This report will compile numerical data on these programs—i.e. foreign researcher trends and career paths and how they have improved research at institutes—and formulates ways to treat foreign researchers. It will then extract conditions for research institutes to attract foreign researchers. Furthermore, this report will discuss how a high ratio of foreigners correlates to a research institute enjoying greater productivity by considering ways to improve research quality, such as the number of research paper citations. Moreover, it will inquire into frameworks needed in times of emergency, in addition to data on the state of foreign researchers' visits to Japan before and after the Great East Japan Earthquake, and on their flight from and subsequent return to Japan.

2 The Need for More Foreign Researchers and the Benefits Thereof

2-1 Requirements for a World Class Research Center

We know that it takes a very international nature to create a world class research institute/center. For example, the final conclusion of the Study on the World's Top Class Research Centers in the U.S.[1] finds that what is needed to become a world class research center is to "have the ability to attract top class, superior talent from around the world." According to this report, a point shared by a representative class of research centers with diverse characteristics participating in the study is that "world top class research centers make themselves attractive so that top talent from around the world (including engineers and graduate students, not only researchers), not just those from the same country, want to research and work there." Top class American research centers have scouted the best talent and recruited them. As a result, they have made their institutes more international. Paradoxically, the appropriate line of thought may be that a world class center cannot be made in a location that lacks an international setting. Thus, we need to push forward with programs in Japan such as the World Premier International Research Center Initiative (WPI) in order to foster highly productive research institutes that can compete globally.

2-2 Stimulating Local Internationalization ~ Expectations from Tsukuba City ~

Having more foreign researchers not only benefits a research institute/center: it also helps the surrounding community. According to the “Proposal to Make Tsukuba Science City an International Center”[2] from Tsukuba City, an approach of “recruiting talented minds from around the world, producing advanced research and using those results for business development” has reportedly produced major results. The Declaration also states: “It is common knowledge that in order to make a project successful, it is essential to have an environment in which foreign researchers and their families, etc. can live comfortably, in addition to a top caliber setting.” Creating an international research center/institute does more than just deal with specific problems such as making research more productive: it also makes a great contribution throughout the surrounding community, rather than simply answering that community’s needs and expectations.

3 Purposes of Research Programs Presented

This paper cites programs from the World Premier International Research Center Initiative (WPI)—in particular the International Center for Materials Nanoarchitectonics (MANA) and its predecessor, the International Center for Young Scientists (ICYS)—as examples of productive programs to build research organizations with a high ratio of foreigners. To start, let us first discuss the purpose of each of these programs.

3-1 Purpose of the World Premier International Research Center Initiative (WPI)

The WPI program was started up in 2007 to create world class research centers in Japan. Here the reader will find a brief introduction to the purpose behind the WPI’s establishment. (A more detailed description can be found at the WPI website.) The “Message from Program Committee of the World Premier International Research Center (WPI) Initiative” gives the following intent and expectations for this research support program.[3]

“Over recent years, global competition in recruiting the best and brightest researchers has intensified. To maintain and improve Japan’s scientific and technological standing, we will need to position ourselves within the global flow of outstanding human resources while creating research platforms that will naturally attract and amass such human resources in Japan. Given this imperative, it is the aim of the WPI Initiative to establish research centers of a caliber that will win high esteem throughout the world for the outstanding results they produce. Like Bio- at Stanford University, the Robotics Institute at Carnegie Mellon University, Janelia Farm at Howard Hughes Medical Institute (HHMI), or MRC Laboratory of Molecular Biology in the United Kingdom, these research centers should be capable of attracting frontline researchers from around the world and of advancing research that integrates cutting-edge fields while pioneering new domains of scientific pursuit. Doing so will require the realization of high level of research, done by physical assembly of outstanding researchers over a critical mass, and an excellent research environment. The WPI Initiative will provide financial support for measures aimed at realizing such a research environment free of conventional systemic constraints and achieving a critical mass of outstanding researchers in fields in which Japan's expertise excels. In this sense, it should be understood that this program is of a completely different nature from the usual funding programs operated mainly to provide support for research projects.”

3-2 Purpose of the international Center for Material Nanoarchitectonics (MANA)

A part of the WPI program, the International Center for Materials Nanoarchitectonics (MANA) program has been adopted by Tohoku University, the University of Tokyo, Kyoto University, Osaka University (and later Kyushu University), in addition to one incorporated administrative agency: the National Institute for Materials Science. The purpose of MANA is to create international research centers that produce new paradigms in nanotechnology and materials science. This research center’s vision is given in the proposal below.[4]

“However, doubt as to whether nanotechnology has made the expected progresses has recently been cast. This reflects the recent recognition of materials researchers that some breakthrough is necessary for nanotechnology to break out of the shell of nanoscience to become a truly practical technology. Nanoscience and nanotechnology have been developed as a science or technology in limited nanospace. Demonstrations that have surprised material scientists have been presented one after another; however, these concerned only a small number of atoms or molecules in limited spaces at the nanoscale. However, for practical applications, the scaling up or improvement of the creation and fabrication methods and the organic integration and mutual linking of individual functional molecules and structures are required. We call this technological system "nanoarchitectonics*", and explore it at this research center. We will explore new paradigms for materials research on the basis of nanoarchitectonics, which is based on the above-described technological development, and create innovative materials that will enable the development of the new technologies required for sustainable growth in the 21st century."

3-3 Purpose and Significance of the International Center for Young Scientists (ICYS)

Since 2003, the National Institute for Materials Science has been implementing the International Center for Young Scientists (ICYS) program, the predecessor to the above-mentioned MANA program that built the foundation upon which MANA is run. The ICYS program provided instruction to competent young researchers regardless of their nationality. Its purpose was as below.

"This program has taken up the issues addressed by the FY2003 Strategic Research Centers Development (Super COE) program to accomplish the program's purpose, which is to bring together highly creative young researchers from around the world, transcend national and linguistic differences and create an appealing environment in which they can immerse themselves in independent research based on their own ideas, thus systematically producing research results by optimally demonstrating those young researchers' abilities and blending different fields of study and cultures."

In other words, one could say that the purpose of the ICYS program—in contrast to MANA's goal of creating a global nanotechnology and materials science center in a very international environment—was to recruit the international talent that make up the heart of such a center and to foster educational knowhow.

4 Data Showing Research Program Results

4-1 Higher Ratio of Foreigners ~ Tsukuba City Research Institute Foreigner Ratios ~

First, Table 1, showing the ratio of foreigners at public research institutes in Tsukuba City, offers an objective look at the situation. Although the figures are affected by the size of the institute in question, we can see from Table 1 that the National Institute of Materials Science (NIMS), the National Institute of Advanced Industrial Science and Technology (AIST) and the High Energy Accelerator Research Organization (KEK) have a notably higher number of foreign researchers. The authors believe that compared to institutes that are relatively limited to narrow subjects or matters relating to Japan's land and meteorology, the AIST (which deals with science and technology in a more general sense), the KEK (which is founded on facilities and original technologies with widespread potential applications) and the NIMS (which deals with materials science and nanotechnology, subjects that countries around the world are engaged in) are comparatively more receptive to accepting foreigners. However, the AIST has around three times as many total researchers as the NIMS, giving the latter an overwhelmingly higher ratio of foreign researchers. Meanwhile, the NIMS is engaged in science in a wide range of fields, and its high ratio of foreign researchers demonstrates, as shown in Figure 1, the effect of the ICYS and MANA programs. Within the MANA program by itself, over half the researchers are foreigners. One could perhaps speculate that there is no other setting like this at any other research institute in Japan. We can see that a combination of both the ICYS and MANA programs has played a major role in raising the ratio of foreign researchers to a level unseen elsewhere in Japan.

4-2 Improving Research Activity

This is how the authors would like to prove, from a number of concrete numerical data sets concerning the present state of affairs, that an environment with a high ratio of foreign researchers leads to improved research productivity. Table 2 shows a world ranking of citations from Thomson Reuters' Essential Science Indicators in the materials science field, in which

Table 1 : Foreigners at Tsukuba City Public Research Institutes (as of March 2011)

Research Institute	Foreign Researchers
Nat'l Institute of Materials Science	585
Nat'l Inst. of Advanced Industrial Science & Tech.	493
High Energy Accelerator Research Org.	305
Nat'l Institute for Environmental Studies	130
Nat'l Agriculture & Food Research Org.	64
Japan Int'l Research Center for Agr. Sci.	51
Nat'l Institute of Agrobiological Sciences	28
Nat'l Institute for Agro-Environmental Sciences	18
Public Works Research Institute	12
Meteorological Research Institute	10
Forestry and Forest Products Research Institute	6
Building Research Institute	3
Nat'l Institute for Land & Infrastructure Mgt.	1
Geospatial Information Authority of Japan	1

(excluding trainees)

Source: Tsukuba Science City "Foreign Researcher Study Report"[5]

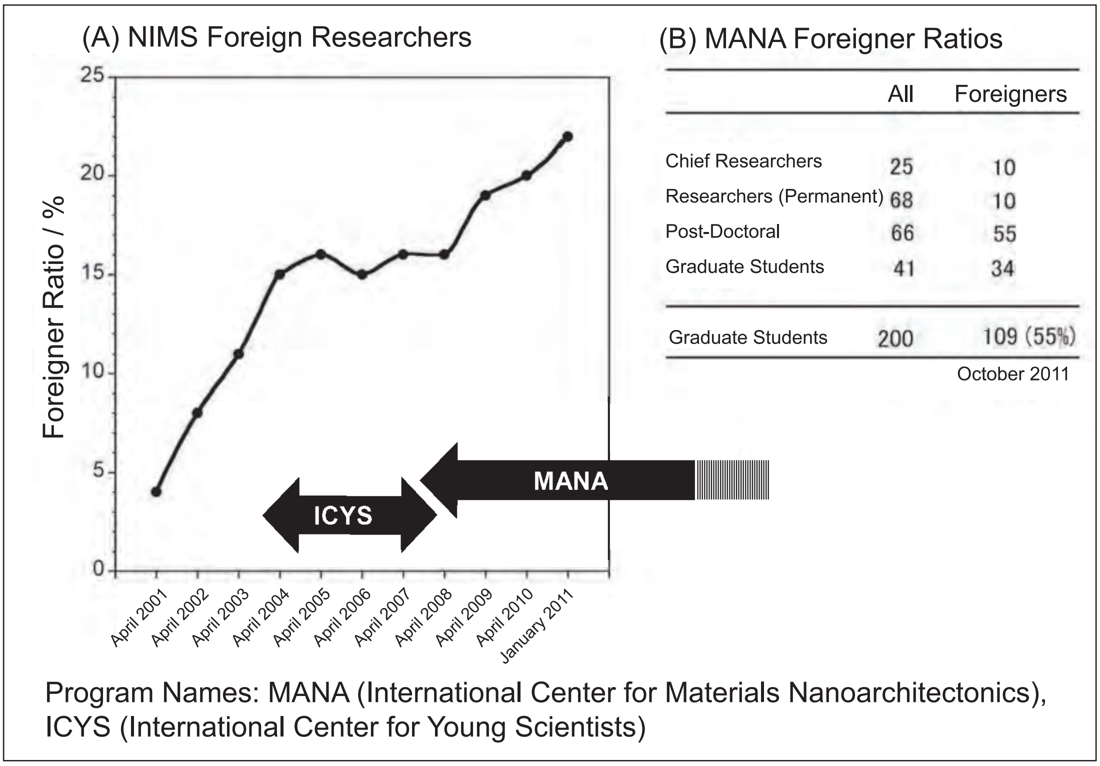

Figure 1 : Figure 1: NIMS Foreign Researcher Ratios (A) and MANA Foreign Researcher Breakdown (B)
(Note: ICYS was downscaled in late-2007 and made part of MANA.)

Compiled by the Science and Technology Foresight Center

NIMS, the host institute, appears. Before the ICYS program to raise the ratio of foreign researchers got started, NIMS' world ranking never rose above 18th. But in the past five years, after the ICYS and MANA programs, NIMS' ranking has risen to 4th. Note that two other research institutes in Table 2, the Chinese Academy of Sciences and the Max Planck Society, are groups of research institutes, not single entities like NIMS. Thus, in a real sense NIMS is second among the world's research institutes, trailing only the Massachusetts Institute of Technology (MIT).

Table 3 shows a breakdown of citations that demonstrates the MANA program's level of contribution to NIMS overall. NIMS published 38% of its papers in 2007 when the MANA program began, and 52% of those cited were contributed by MANA

Table 2 : World Ranking of Citations in Materials Science (Institute names are abbreviated.)

	11 Years Prior to ICYS/MANA Start (Jan. 1994 to Dec. 2004)		5 Years After (Jan. 2007 to Jan. 2011)	
	Institute	Citation	Institute	Citation
1	Max Planck Society	25739	Chin. Acad. Sci.	45576
2	Tohoku Univ.	23891	Max Planck Soc.	16318
3	MIT	18568	MIT	11514
4	UC Santa Barbara	17338	**NIMS**	**11266**
5	Penn. State Univ.	15503	Natl. Univ. Singapore	11209
6	Chin. Acad. Sci.	15101	Tsing Hua Univ.	10436
7	Univ. Cambridge	14977	Tohoku Univ.	10291
8	Kyoto Univ.	13301	Georgia Tech.	9463
9	Osaka Univ.	12575	Ind. Inst. Tech.	9459
10	Russ. Acad. Sci.	12556	Univ. Manchester	9197
……				
……				
……				
18	**NIMS**	**10474**		

Compiled by the Science and Technology Foresight Center

Table 3 : MANA's Contribution to Published NIMS Papers

(A) MANA's Share of NIMS Papers and Citations (2007-2010)

分野	Papers					Citations				
	2007	2008	2009	2010	2007–2010	2007	2008	2009	2010	2007–2010
Chemistry	49%	47%	58%	63%	55%	68%	69%	63%	66%	65%
Materials Science	32%	32%	40%	44%	37%	33%	45%	49%	55%	51%
Physics	29%	28%	34%	29%	30%	63%	54%	60%	58%	58%
total	33%	33%	41%	43%	38%	48%	49%	51%	53%	52%

(B) Citation Rankings of Papers Published Since 2007 (22 of top 31 from MANA. Bold font indicates foreigners among authors.)

	Authors	MANA	Source Title	Category	Year	サイテーション
1	**Waser, R; Aono, M**	○	NATURE MATERIALS	Materials Science	2007	513
2	**Ariga, K; Hill, JP; Lee, MV; et al.**	○	SCIENCE AND TECHNOLOGY OF ADVANCED MATERIALS	Materials Science	2008	281
3	**Ariga, K; Hill, JP; Ji, QM**	○	PHYSICAL CHEMISTRY CHEMICAL PHYSICS	Chemistry	2007	272
4	Mizuguchi, Y; Tomioka, F; Tsuda, S; et al.	○	APPLIED PHYSICS LETTERS	Physics	2008	200
5	**Yoo, E; Kim, J; Hosono, E; et al.**		NANO LETTERS	Chemistry	2008	199
6	**Fang, XS; Bando, Y; Gautam, UK; et al.**	○	JOURNAL OF MATERIALS CHEMISTRY	Materials Science	2008	179
7	**Golberg, D; Bando, Y; Tang, CC; et al.**	○	ADVANCED MATERIALS	Materials Science	2007	171
8	**Pumera, M; Sanchez, S; Ichinose, I; et al.**	○	SENSORS AND ACTUATORS B-CHEMICAL	Engineering	2007	141
9	Kuroda, S; Nishizawa, N; Takita, K; et al.	○	NATURE MATERIALS	Materials Science	2007	123
10	**Xie, RJ; Hirosaki, N**		SCIENCE AND TECHNOLOGY OF ADVANCED MATERIALS	Materials Science	2007	99
11	**Margadonna, S; Takabayashi, Y; Ohishi, Y; et al.**		PHYSICAL REVIEW B	Physics	2009	97
12	**Ariga, K; Vinu, A; Hill, JP; et al.**	○	COORDINATION CHEMISTRY REVIEWS	Chemistry	2007	92
13	**Margadonna, S; Takabayashi, Y; McDonald, MT; et a**		CHEMICAL COMMUNICATIONS	Chemistry	2008	84
13	Kimoto, K; Asaka, T; Nagai, T; et al.		NATURE	Multidisciplinary	2007	84
15	**Yuan, JK; Liu, XG; Akbulut, O; et al.**		NATURE NANOTECHNOLOGY	Materials Science	2008	83
16	**Fang, XS; Bando, Y; Shen, GZ; et al.**	○	ADVANCED MATERIALS	Materials Science	2007	81
17	**Fang, XS; Bando, Y; Liao, MY; et al.**	○	ADVANCED MATERIALS	Materials Science	2009	80
18	**Pumera, M**	○	LANGMUIR	Chemistry	2007	76
19	Mizuguchi, Y; Tomioka, F; Tsuda, S; et al.	○	APPLIED PHYSICS LETTERS	Physics	2009	68
19	Honma, T; Ohkubo, T; Kamado, S; et al.	○	ACTA MATERIALIA	Materials Science	2007	68
19	**Xie, RJ; Hirosaki, N; Kimura, N; et al.**		APPLIED PHYSICS LETTERS	Physics	2007	68
22	Maeda, H; Haketa, Y; Nakanishi, T		JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2007	65
22	**Li, L; Ma, RZ; Ebina, Y; et al.**	○	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2007	65
24	**Belik, AA; Iikubo, S; Yokosawa, T; et al.**	○	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2007	63
25	**Ma, RZ; Liu, ZP; Takada, K; et al.**	○	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2007	62
26	Yamauchi, Y; Kuroda, K	○	CHEMISTRY-AN ASIAN JOURNAL	Chemistry	2008	61
27	**Takakura, H; Gomez, CP; Yamamoto, A; et al.**	○	NATURE MATERIALS	Materials Science	2007	60
28	**Pumera, M**	○	CHEMISTRY-A EUROPEAN JOURNAL	Chemistry	2009	59
28	**Ji, Q; Miyahara, M; Hill, JP; et al.**	○	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2008	59
28	**Wang, DF; Kako, T; Ye, JH**	○	JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2008	59
28	**Okubo, M; Hosono, E; Kim, J; et al.**		JOURNAL OF THE AMERICAN CHEMICAL SOCIETY	Chemistry	2007	59

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(see Table 3 (A)). Furthermore, 22 of the 31 papers with the most citations were from MANA (see Table 3 (B)). The contribution of citations from MANA is extremely high because only 18% of researchers are affiliated with the program.

This data shows that programs which actively recruit foreign researchers contribute greatly to improving an organization's achievements. Their effect is not merely cosmetic, simply raising the ratio of foreign researchers: they also have an undisputable effect on research quality. MANA and ICYS recruit exceptional researchers who are capable of high productivity by setting standards such as whether applicants can, as lead authors, produce papers with high impact factors. What is more, they dramatically increase a research institute's chance of recruiting highly capable researchers from at home and abroad by not limiting their screening process to Japanese applicants, but rather by making their recruitment efforts international. In other words, increasing the number of foreign researchers (i.e. internationalizing) raises the overall (i.e. average) level of an institute's researchers.

Another point worth noting is that foreign researchers are proactive about engaging in joint research. The fact that many of the top papers by the researchers in Table 4 (B) were jointly written by authors of different nationalities clearly shows this to be the case, as 20 of the top 31 papers were written by multinational teams of authors, while 2 were written by a single foreign author. This also shows that in terms of raising research mobility both within and without an organization, improving competitiveness by bringing in research from multiple countries has a major impact. We can certainly expect from these points that adopting such a policy would also raise the level of Japanese researchers.

4-3 Improved Career Paths for Foreign Researchers

Foreign researchers who work in other countries are more mobile compared to those who work in their own countries. In many cases, they transfer to other positions within institutes from their homelands after completing the research in their research programs. On the other hand, Japanese research institutes can

Table 4 : ICYS and MANA Researchers Advancing Careers (All researchers, including foreigners)

(A) Positions after ICYS

Fiscal year	All Researchers Advancing Careers				
	Abroad	Japan			
	Research Institute	University / Company	NIMS (Permanent)	MANA Researcher	NIMS (Post-Doc)
2004	3	0	0		
2005	9	0	3	5	
2006	4	3	1		
2007	16	1	3	2	
2008	2				
2009	2		1	1	
2010	8		2		2
Total	44	4	10	8	2

(B) MANA Researchers Advancing Careers

Fiscal year	All Researchers Advancing Careers				
	Abroad	Japan			
	Research Institute	University / Company	NIMS (Permanent)	MANA Researcher	NIMS (Post-Doc)
2008	4				
2009	7	2	1		
2010	22	2	2	1	4
2011	13	4	1	2	1
Total	46	8	4	3	5

Compiled by the Science and Technology Foresight Center

rarely take on the responsibility of hiring foreign researchers so long as they do not offer such promising career paths. Table 4 shows the career paths of ICYS and MANA program researchers. They move up to outside institutes, as well as find jobs as personnel at NIMS, the host institute. Former ICYS and MANA researchers in particular get onto the tenure track better in NIMS.

The reasons that program members enjoy better career prospects are believed to be: (i) during hiring, research institutes screen and recruit with high standards for accomplishments and ability, and they hire highly talented individuals who will also be competitive in future job-hunting; (ii) many program researchers who are hired leave behind exceptional results from their research in the program; (iii) many of the senior researchers and program advisors with whom they conducted joint research are prominent researchers in their field who can help the program members find work through their personal networks.

5 Presentation of Unquantifiable Knowledge

Here the authors would like to refer to enacted policies as well as real yet abstract factors regarding the questions of what is actually happening in the programs' projects, and in particular, what factors keep foreign researchers within an organization and whether they lead to improved productivity.

ICYS and MANA employ the three policies below to provide a welcome environment in which foreigners can work. First we cite examples of more conventional attempts. (Please see References 6 and 7 for more on assisting foreigners living in Japan.)

5-1 Conventional Attempts at Internationalization

5-1-1 Creating International Environments Conducive to Research and Daily Living

- The international character of MANA's general affairs department (many staff in Tsukuba with international experience; knowledgeable about how to treat foreigners since the time of the ICYS program)
- Practice of regularly conducting orientation sessions and lab tours in English
- Contract with the Japan International Science and Technology Exchange Center (JISTEC) to assist foreign researchers living in Japan (alien registration procedures, opening bank accounts, finding housing, attending contract signings, accompanying on hospital visits, emergency assistance, etc.)
- Thorough arrangements for foreign researcher housing (Ninomiya House, Takezono House)

5-1-2 Removing Linguistic Barriers in International Settings

- English as a common language (seminars, meetings, accommodations, English emails, bulletin boards, notices)
- English intranet (information for foreign researchers, external grants, etc.)
- Bilingual (Japanese and English) forms (NIMS guidebook, document formats)
- Internationalized administration at NIMS (TOEIC test-taking, scaled communications training, foreign language training [6 weeks of language training at Montana State University], internships [6 months at UCLA])

5-1-3 Learning about Japan in an International Setting

- Setting up Japanese language classes (introductory and beginner classes)
- Setting up Japanese culture classes (karate, origami, yukata, acupuncture and moxibustion, Japanese drums, tea ceremony, haiku, seal cutting, furoshiki, indigo dyeing, Girls' Festival)

5-2 Keeping and Securing More Exceptional Foreigners

Next, measures to keep and secure more exceptional foreign researchers are divided into three categories: reasons why ICYS and MANA attract foreign research officers, reasons why foreign research officers stay, and research organization efforts regarding researchers in general.

● Reasons why ICYS and MANA attract foreign research officers

- NIMS is the premier organization in Japan for materials science and nanotechnology, and it has many applicants, including foreigners.
- Prominent researchers are assigned as chief researchers in relevant fields, thus leading to lots of exchanges and applications from overseas.
- The programs are enthusiastic about lobbying and advertising in Nature and other famous academic

journals.
- Advisers are leaders in their fields, making the organization known internationally as a prestigious one.
- Many introductions from foreign researchers who were in the programs (good reviews, long-lasting personal connections).
- The Open Research Institute and the Internship Program invite foreign faculty and graduate students for short stays, creating exchanges that lead to applications. Former program members also revisit Japan.
- The WPI program has set a goal for each research center to have a foreign researcher ratio of at least 30%.

● Reasons why foreign research officers stay
- The overall research level is high, so it is easier to produce research results while there.
- Office personnel are completely bilingual and provide sufficient attention to solve problems foreign researchers have living in Japan.
- This attention makes host researchers unnecessary and prevents them from being bothered by the foreigners. The result is that good host-guest relations are maintained.
- Foreign researchers can devote themselves to their research.
- The presence of a large, existing foreign population makes it easier for them to help each other. A small foreign population can be troublesome to care for, but when it rises to a certain point, that burden disappears because they can help each other.
- Japanese researchers also find it beneficial to work alongside highly skilled foreign researchers (for improving the quality of research, etc.).
- At present, foreign researchers may find the pay more beneficial due to the strong yen. (ICYS researchers had high salaries, but MANA post-doc pay scales have returned to those for regular posts. The effect is small, but it may offset the gain from the strong yen.)

● Research organization efforts regarding researchers in general
- There are opportunities for regular discussions and research exchanges with famous researchers, including Nobel Prize winners.
- There are systems for assignments to famous laboratories and double mentors, including with outside researchers.
- Salaries of permanently-employed researchers are reflective of annual assessments on research achievements. (This applies throughout NIMS.) Ability and pay are linked.
- There are internal research funds such as the Grand Challenge Program. These offer relief for foreign researchers who are at a disadvantage when competing for funding in Japan.

6 Effects of the Earthquake ~ Can foreign ratios be maintained after such unprecedented damage? ~

What foreigners in Japan did after last year's Great East Japan Earthquake is a key test for us to surmise whether foreign researchers truly are drawn to Japan. Figure 2 lists data to quantitatively show this. Figure 2 (A) compares the number of foreigners who visited Japan in April through September of 2010, the year before the earthquake, and the number who visited in April through September of 2011, after the earthquake. Foreign researchers took the same action as foreigners in general as the number of visits dropped dramatically in 2011 (especially among Europeans). Meanwhile, Figure 2 (B) shows the number of foreigners in the MANA program. Their number dropped by 30% in the first week after the earthquake, but factors such as evacuation calls from their home countries had a large effect. However, around 80% of foreign researchers returned a month after the earthquake, and six months after the earthquake 102 of the 114 who were in the program beforehand had returned. Among displaced researchers, although some had terms that ended at the end of March, after the earthquake almost all returned to Japan.

The data above shows that foreigners overseas who only had information from the media refused outright to come to Japan, but most of those who have experience living in Japan and have personal connections there tend to be attached to the country, despite the extreme circumstances due to the earthquake.

Moreover, Tsukuba City's "Proposal to Make Tsukuba Science City an International Center"[2] has compiled the below local trends and measures to take. Although this information concerns all research institutes in Tsukuba, we can presume that the same trends and positive effects from taking the measures

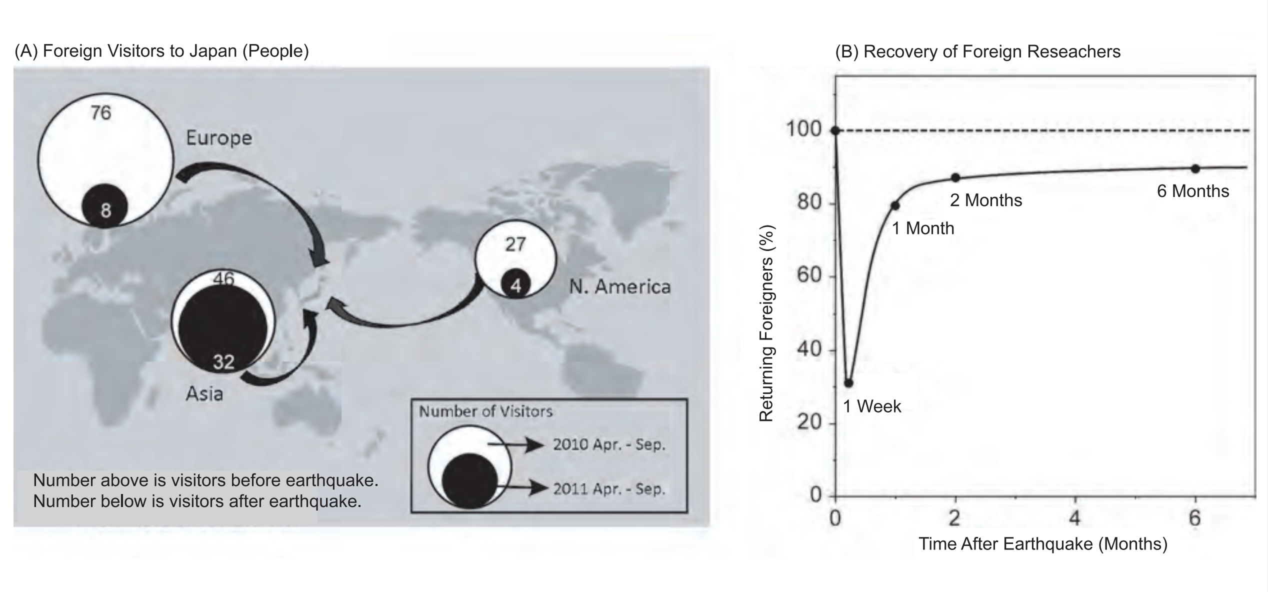

Figure 2 : Earthquake's Effect on Foreign Visitors: Change in Foreigner Visitors to MANA Before/After Earthquake (A) & Foreigner Researchers at MANA after Earthquake (B)

Compiled by the Science and Technology Foresight Center

also apply to MANA.

● Main reasons why foreigners return to their home countries

- Evacuation due to earthquake/nuclear accident (due to order from home country's embassy, etc.)
- Inability to sustain a normal lifestyle due to cut-off water, a lack of supplies, etc.
- Inability to continue research due to damaged research facilities/equipment

● Main reasons why foreigners come back to Japan

- Confirmation of the Tsukuba area's safety by environmental radiation data (area around public institutes)
- Confirmed restoration of access to the water supply and supply purchases
- Confirmed reopening of various businesses

● Measures taken concerning foreigners

- Six-language broadcasts on Radio Tsukuba (broadcasts in English, Chinese, Portuguese, Spanish, Korean and Arabic, contracted out by Tsukuba City, with information on radiation and daily concerns [purchases of water and food, etc.] from March 17 through April 15)
- (Open) lectures on radiation safety held in English
- Information provided at research institute websites, etc.
- Evacuation shelters opened for city residents, including foreigners
- Safety of individuals confirmed (by institutes)

7 Conclusion

This paper has cited the example of the Materials Nanoarchitectonics (MANA) program, part of the World Premier International Research Center Initiative (WPI), and its predecessor, the International Center for Young Scientists (ICYS) program, which have been implemented by the National Institute for Materials Science (NIMS), to analyze various data on the acceptance of foreign researchers and their research. The results revealed are as follows.

1) The application of these programs has made it possible to significantly increase the ratio of foreigners (to over half of all researchers).
2) These programs have greatly increased the host institute's world ranking (based on number of paper citations), and over half of the citations have been from papers produced by MANA projects, whose membership accounts for no more than one-fifth of all researchers.
3) These programs function as good career paths for researchers and they help the researchers transfer to better positions at other researcher institutes domestically and abroad, as well as get hired as permanent employees by the host institute.
4) While the number of foreign visitors to Japan dropped steeply after the Great East Japan Earthquake, over 90% of research officers in these projects returned to their workplace.
5) This trend was due to efforts to provide foreigners

with a comfortable lifestyle, remove linguistic barriers and teach foreign researchers about Japanese culture.

Although this experiment has only recently begun and it may yet be too early to make generalized conclusions, it certainly offers an extremely good reference. There are misgivings concerning the weak global presence of Japanese research institutes and those in emerging countries that are catching up, and pushing ahead further with research projects that create international settings as described in this paper should raise the rankings of many other research institutes in Japan. Japan should make its basic research more competitive internationally by strategically proceeding to create environments for international exchanges at research institutes.

Acknowledgements

The authors would like to extend their sincere gratitude to International Center for Materials Nanoarchitectonics Administrative Director Takahiro Fujita and all of his staff for providing internal data on the International Center for Young Scientists program and the International Center for Materials Nanoarchitectonics program, which was used to compile this report.

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Profile

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Engaging in research concerning supermolecular chemistry, surface science and nanotechnology, Ariga will turn 50 this year. He is continuously sharing novel ideas and informing the public about how science's value is not simply limited to its applications in everyday life, a mission that he feels is his destiny.

Hidenori GAMO
Visiting Researcher, Green Innovation Unit
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Gamo has engaged in research on display/lighting device applications and micro electron sources microfabricated from semiconductor film and carbon nanotubes at a corporate laboratory. During that time he has been involved in joint research as an outside/visiting researcher at the National Institute of Advanced Industrial Science and Technology, the National Institute of Materials Science and at universities. Gamo has served in his current post since April 2010. He was a member of the Japan Society for the Promotion of Science's 158th Committee on Vacuum Nanoelectronics and the Surface Finishing Society of Japan's scientific committee. PhD in engineering (Kyoto University).

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3

Shifting from Emergency Food to Disaster Preparation Food to Help Disaster Survivors

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1 Introduction

On March 11, 2011, a magnitude 9.0 earthquake struck off the Sanriku coast. Along Tohoku region's Pacific coast, eight prefectures experienced shaking of M6 weak or greater on the Japanese seismic intensity scale. The earthquake spawned a massive tsunami higher than anyone had predicted and that caused an accident at a nuclear power plant. The disaster, called the Great East Japan Earthquake, left 15,854 dead and 3,276 missing (as of March 1, 2012).[1]

As of March 14, 2011, the damage inflicted by the disaster affected some 470,000 people.[2] In the disaster zone, the Japanese government's disaster personnel who responded to the emergency were joined by the Self-Defense Forces, the Fire and Disaster Management Agency (FDMA), the National Police Agency and the Japan Coast Guard engaging in rescue and relief operations, alongside medical institutions providing emergency care. Others worked to restore utilities. In all there were up to hundreds of thousands of personnel handling these and other related tasks each day. Even if all these people were provided only two meals a day to carry out their work, that necessitated at least 1.2 million meals daily. The government's Emergency Disaster Response Headquarters procured and transported necessities on its own because of the disaster zone's extent and the impaired ability of local governments to function. In addition, various organizations engaged in rescue operations and other activities also distributed emergency supplies. Especially in the area affected by the tsunami, civilian emergency stockpiles and inventories were distributed, but interruptions to communications networks and damage to roads were widespread while fuel was in short supply, thus delaying aid from outside the region and complicating the provision of rations for disaster survivors and emergency response personnel.

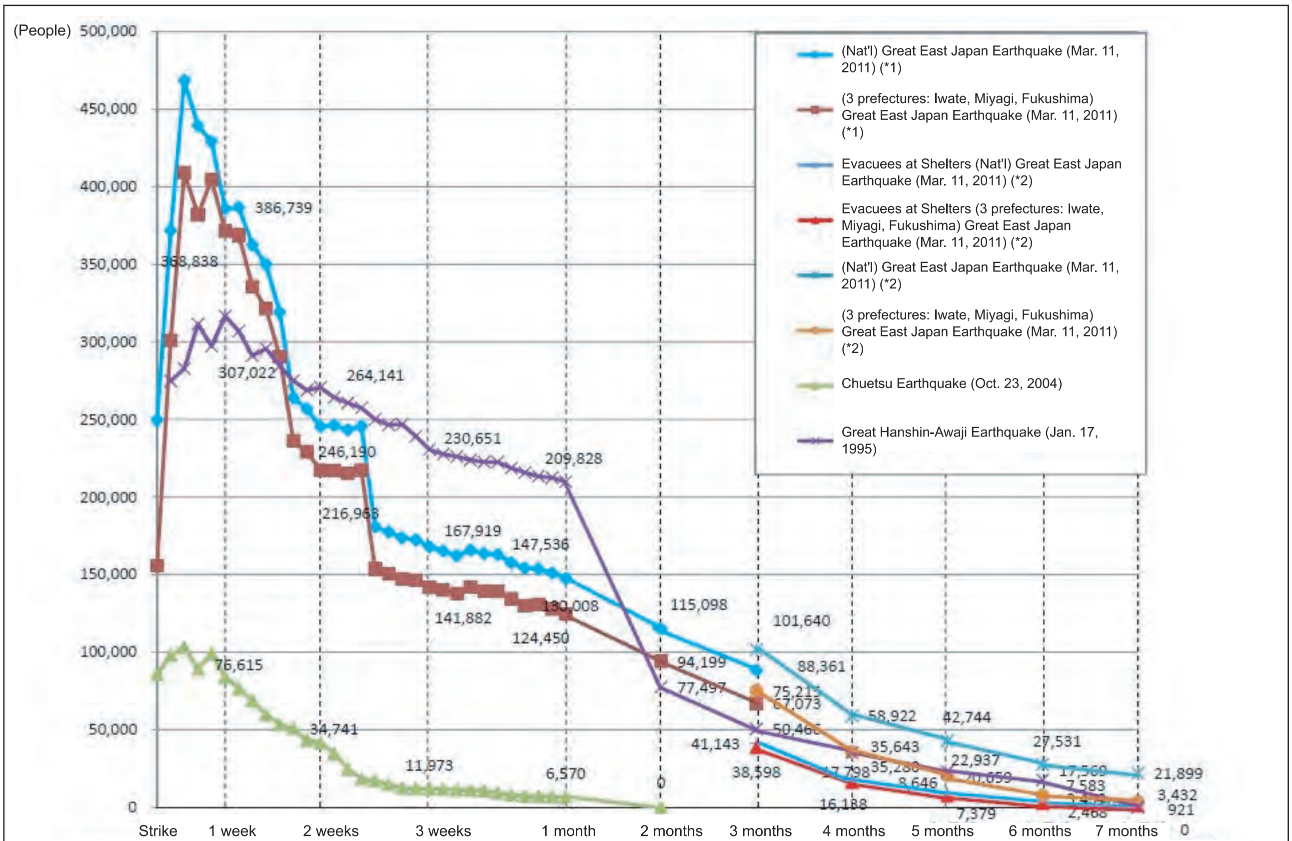
One of the emergency response measures taken thus far has been the recommendation of an approximately three-day stockpile of emergency food.[3] It is generally believed that appropriate food is emergency food (food for emergency use) that can be stored at room temperature and has a long shelf life, which allows disaster survivors to hold out until outside help arrives. However, many issues have been pointed out concerning emergency food in the aftermath of an earthquake. After the Great Hanshin-Awaji Earthquake, it was shown that decisions made prior to the earthquake on preparing stockpiles were based solely on the perceived convenience of long shelf lives, while inadequate attention was paid to helping survivors and relief workers in disaster zones that lack access to utilities. Furthermore, after the Niigata Chuetsu Earthquake and the Niigata Chuetsu-oki Earthquake, it was determined that there was a need to consider the quality of food, including variety (due to the distress of continuously eating the same thing), as well as warm foods, rather than simply the quantity of food distributed to disaster survivors. It became clear that food relief to those who require it must provide food that meets the recipients' needs.[4] In addition, it was pointed out that the large number of people affected by the Great East Japan Earthquake and extended periods of living under emergency living conditions in isolated areas led to both insufficient quantities and quality.[5]

Earthquakes are expected to continue to strike Japan in the future. There are many issues concerning the inability to respond to earthquakes: the way emergency food is handled, the way we think about emergency stockpiles, and post-earthquake response. We need to rethink our ideas about emergency food in accordance with the purpose of facilitating secondary disaster prevention and recovery in terms of survivors' health. When arranging for rations in a disaster zone, it is essential to consider water and heating—not just the food itself—in addition to the effects of inaccessibility to water and heated/boiled water due to utility disruptions. Rations must be examined in a concrete and gradual manner. Moreover, the authors would also like to see disaster mitigation shift from the conventional concept of emergency food to one of "disaster preparation food" (food prepared for disaster) that is based on appropriate ways for households and companies to provide their own stockpiles and for the government to provide public stockpiles and assistance.

Table 1 : Damage by Major Disasters (Real & Projected)

Disaster Name	"Deaths (incl. missing)"	Evacuees	"Procurements (Rations)"	"Shortages (Rice)"
Great Hanshin-Awaji Earthquake	6,437	320,000 (Peak time: 1 week later)		
Great East Japan Earthquake	19,225[1]	470,000 (Peak time: 3 days later)	"8,400,000 meals/ week"	
Tokai Earthquake	7,900 - 9,200	1,900,000/1 week later	"23,510,000 meals/ week"	"Max 410,000 kg"
Tonankai/Tokai Earthquake	12,000 - 18,000	5,000,000/1 week later		"Max 2,500,000 kg"
Tokyo Metropolitan Area Earthquake	11,000	7,000,000/max	"75,100,000 meals/ week"	
Tokai/Tonankai/ Nankai Earthquake	28,000			

Source: Compiled by the Science & Technology Foresight Center based on Reference #2, #6, #7



*1 The NPA mainly counted evacuees at "community centers, schools and other public buildings" and at "inns and hotels."
*2 The authors' team counted evacuees at 1) evacuation shelters (community centers, schools, etc.), 2) inns/hotels and 3) elsewhere (homes of family members or acquaintances, etc.)

Source: For the Great East Japan Earthquake: documents released by the NPA (*1) and the authors' team's survey results (*2). For the Chuetsu Earthquake: Niigate Prefecture's official website. For the Great Hanshin-Awaji Earthquake: "One Year of Hyogo Prefecture Records on the Great Hanshin-Awaji Earthquake."

Figure 1 : Evacuees from the Great Hanshin-Awaji, Great East Japan and Chuetsu Earthquakes

Source: Reference #2

2 Numbers of Evacuees in Recent Earthquakes and Future Estimates

The maximum number of evacuees (those living in evacuation shelters) from the Great Hanshin-Awaji Earthquake was 320,000 people and from the Great East Japan Earthquake 470,000 people. In the case of future earthquakes, such as a Tokai, Tonankai, Nankai or Tokyo metropolitan area earthquake, an estimated peak of 1.9 million to 7 million evacuees—around 10 times as many—will be created. While there was a need for a weekly provision of approximately 8.4 million meals after the Great East Japan Earthquake, a Tokyo metropolitan area earthquake would necessitate an estimated 75 million meals a week (see Table 1).

In addition, while evacuee numbers after the Great Hanshin-Awaji Earthquake and Great East Japan Earthquake peaked one week afterward and three days afterward, respectively, some were forced to continue living in evacuee conditions for half a year or longer (see Figure 1).

3 Food-Related Problems in Times of Emergency

Here we address food in terms of disaster response by giving dedicated attention to each situational concern and food stockpile problem.

3-1 Concerns over Food

(1) Concern over Delayed Restoration of Utilities

Power was fully restored five days after the Great Hanshin-Awaji Earthquake (see Figure 2). While 90% was restored five days after the Great East Japan Earthquake, more than a month was required to bring it completely back on line. Contrarily, it took 83 days to restore gas after the Great Hanshin-Awaji Earthquake, but only 44 days after the Great East Japan Earthquake.

It took about three months to fully repair water mains after the Great Hanshin-Awaji Earthquake, but due to the destruction wrought by the Great East Japan Earthquake, gas services were not fully restored even

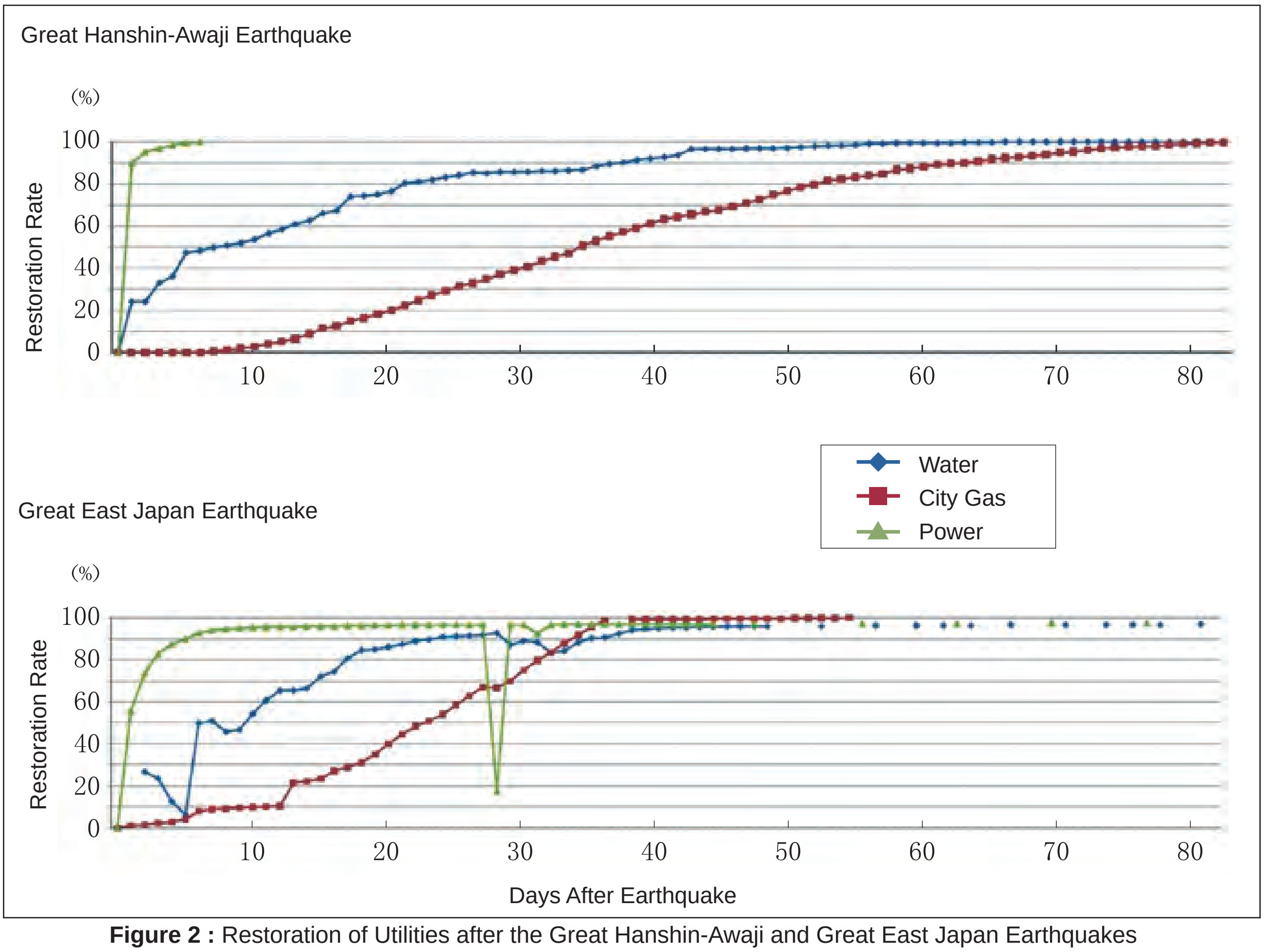


Figure 2 : Restoration of Utilities after the Great Hanshin-Awaji and Great East Japan Earthquakes

Source: Reference #9

a year afterward.[8]

Food is stockpiled under the assumption that utilities will be restored soon after a disaster. This is exemplified by stockpiled food requiring hot water to consume. However, restoring utilities after a large-scale disaster covering a widespread area or in a major city requires more time, thus invalidating this assumption.

(2) Concern over Delayed Food Assistance

Starting a week after the Great Hanshin-Awaji Earthquake struck, the number of bentos (portable boxed meals) distributed to evacuation shelters exceeded the number needed to feed the evacuees housed there. The idea was for disaster survivors who had remained in their homes but depleted their stockpiles to come pick them up at the shelters, but distribution peaked on February 28, over a month after the earthquake. In other words, this shows that there were many people who still could not procure sufficient rations for themselves even after a month had passed since the earthquake struck.[4]

After the Great East Japan Earthquake, the distribution and delivery of rations were still not well organized, even after utilities had been restored to allow the transport of said supplies. In many cases, there was no place to put the needed rations. There were cases when rice balls, bread and some of the other such food that spoils soon and was brought to the disaster zone from the outside took time to reach their destinations due to damaged and congested roads, thus failing to achieve the goal of such efforts.

This explains the risk that it may take a long time to go and deliver relief supplies to survivors of a disaster occurring in a major city or over a widespread area, as well as the risk that inadequate food stockpiles may lead to food shortages.

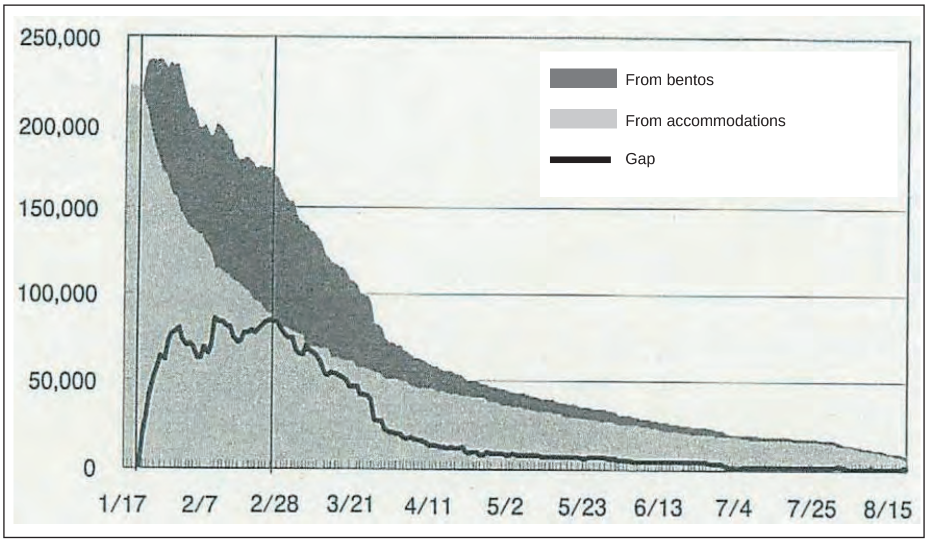


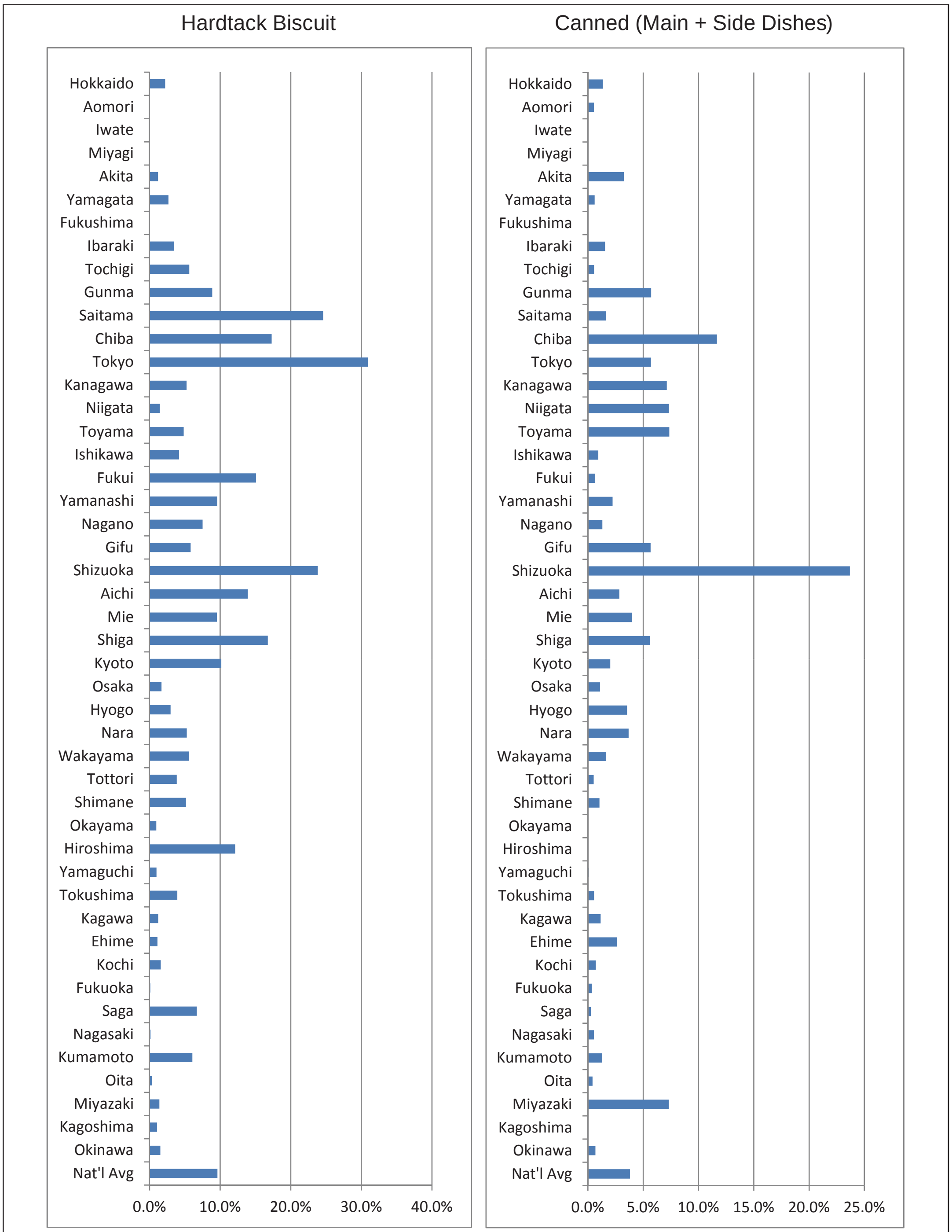
Figure 3 : Calculations of Evacuee Numbers after the Great Hanshin-Awaji Earthquake

Source: Reference #2

Table 2 : Examples of Regional/Local Government Food Stockpiles (Current Stockpiles)

Category	Food Name	Prefectures									Cities					
		Osaka	Shiga	Toyama	Yamanashi	Tokyo	Saitama	Chiba	Gunma	Ibaraki	Kumamoto	Kobe	Nishinomiya	Kyoto	Kanazawa	Hiratsuka
A	Canned Rice Porridge			○					○	○						
B	**Hardtack Biscuits**		○	○	○		○	○	○		○		○	○		
	Crackers					○		○		○		○				
	Biscuits							○								
	Canned Bread								○	○						
	Dietary Supplements										○					
B or C	Canned (Main/Side Dishes)		○	○						○		○				
C	**Pregelatinized Rice**	○	○	○		○	○		○		○	○	○	○	○	
	Canned Freeze-Dried Emergency Food (veg. stew, etc.)		○	○	○										○	○
	Powdered Milk	○									○	○	○	○	○	
	Instant Noodles					○										
D	Rice	○	○	○		○	○	○	○							
	Drinking Water (Ref.)	○		○	○			○	○	○						

Compiled by the Science and Technology Foresight Center based on References #4, #10



(Figures are the sum of each prefecture's stockpiles and those of its municipalities. Note there is no data for Iwate, Miyagi or Fukushima prefectures.)

Figure 4 : Ration Stockpiles by Prefecture

Compiled by the Science and Technology Foresight Center based on Reference #11

[NOTE 1] Although this topic is not addressed by this report, providing water that humans need to live is even more important than food. Potable water and other drinkables must by all means be stockpiled.

Furthermore, stockpiles come in two forms: "actual stockpiles" and "distributable stockpiles." As the names imply, actual stockpiles are rations that are in storehouses, etc. belonging to the government that would use them, while distributable stockpiles are rations kept in storehouses by traders for use in case of a disaster and are subject to contracts concluded in advance between the trader and a local government. This report generally addresses the former: actual stockpiles. While many local governments have distributable stockpiles, a major disaster such as the Great East Japan Earthquake can make distribution channels grind to a halt and inflict damage on trader storehouses, thus posing the risk that these stockpiles will not function.

3-2 Ration Stockpile Problems

3-2-1 Categories

Rations stockpiled for disasters and other such emergencies (i.e. emergency food) can be categorized as follows according to differences in their ease of consumption.

Category A: Food requiring no preparation and consumed without a drinkable
Food such as rice porridge and jelly drinks that can be eaten as is, is easy to swallow and does not require an accompanying drinkable during consumption.

Category B: Food requiring no preparation and consumed with a drinkable
Food such as bread and crackers that can be eaten as is, but requires an accompanying drinkable. Includes some canned/retort pouch food servings requiring no preparation and dried foods that can be eaten after only adding water (e.g. freeze-dried rice cakes).

Category C: Food eaten after adding or immersing in hot water
Food such as freeze-dried foods and pregelatinized rice to which hot water is added when consumed, or food such as retort pouch curry and retort pouch food servings that are immersed in hot water prior to consumption. This includes instant noodles prepared by adding hot water.

Category D: Food that must be cooked
Food such as polished rice and spaghetti that must be cooked using a heat source.

A look at examples of food stockpiles belonging to local governments (see Table 2) shows that a number of governments stockpile rice porridge, a Category A food, and many stockpile typical hardtack biscuits, a Category B food. Among Category C foods, a number of local governments stockpile canned and freeze-dried emergency food that can stay in storage for a long time (10 years at room temperature) because of special canning processes or freeze-drying that reduces moisture to an extremely low level, as well as pre-cooked rice dried with hot air for long-term storage. Many prefectures stockpile rice, a Category D food. Food in Categories B through D requires a certain amount of water to consume, and there are cases in which such foods are not stockpiled together with water supplies.

3-2-2 Ration Stockpiling Problems

(1) Low Absolute Quantities of Stockpiles

According to an FDMA survey of the current state of rations stockpiled by prefectural and municipal governments across Japan (current as of April 1, 2011),[10] the most commonly stockpiled food is hardtack biscuits, with approximately 12.3 million servings, followed by 4.85 million servings of canned food (main and side dishes) and roughly 1.3 million servings of instant noodles.

A look at stockpiles of hardtack biscuits and canned food (see Figure 4) shows that there are enough hardtack biscuit stockpiles on average to feed a little less than 10% of the Japanese population. Approaches vary among local governments, some of which do not stockpile hardtack biscuits at all, but Tokyo stockpiles enough of them to feed 30% or more of its residents. There are also some local governments that do not stockpile canned food, but Shizuoka Prefecture stockpiles enough to feed 23% of its residents.

In general, the thinking behind determining the size of stockpiles is based on the assumption of providing a portion of survivors with two to three meals a day to satisfy their immediate needs, while relying on outside assistance to deliver the stockpiles to provide the rest.

However, in Miyagi Prefecture, which had the highest number of evacuees in the wake of the Great East Japan Earthquake (see Figure 5), they peaked at around 320,000 people three days after the earthquake (about 13.7% of the prefecture's population) and totaled 2.22 million evacuee-days (equivalent to around 95% of the prefecture's population) for the two weeks after the earthquake. If we look at individual cities we see that Ishinomaki, which had the highest proportion of its population evacuate, peaked at around 110,000 evacuees (about 69% of the population) three days after the earthquake and totaled around 570,000 evacuee-days (about 368% of the population) for the two weeks after the earthquake.

A future Tokyo metropolitan area, Tokai or Tonankai earthquake is expected to produce millions of evacuees (see Table 1). Current stockpiles are

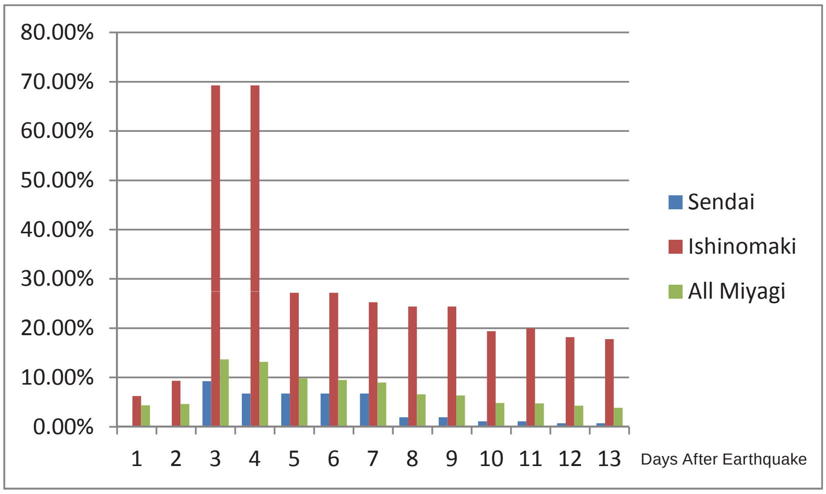


Figure 5 : Changes in Number of Great East Japan Earthquake Evacuees (% of Population in Miyagi Prefecture)

Prepared by the STFC based on Reference #12

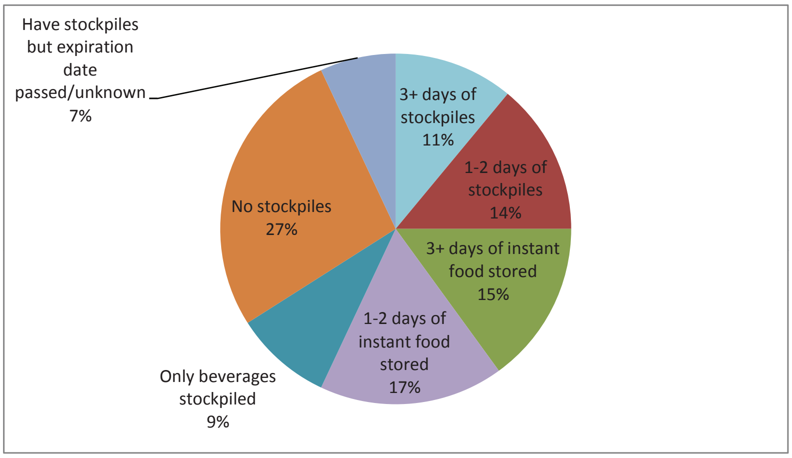


Figure 6 : Ration Stockpiles of Japanese Households

Compiled by the Science and Technology Foresight Center based on Reference #13

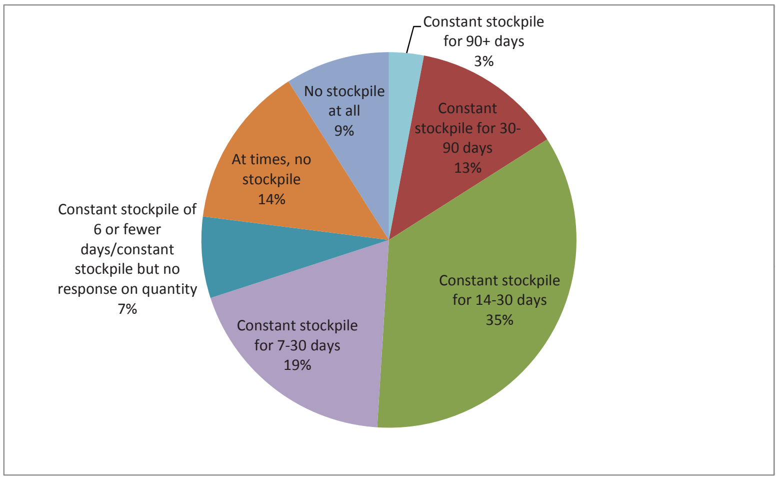


Figure 7 : State of Independent Stockpiles of Household Rations in Switzerland

Compiled by the Science and Technology Foresight Center based on Reference #14

[NOTE 2] Switzerland provides an example from outside Japan of well-prepared stockpiles. The country produces little of its own food, so the Swiss government prepares stockpiles in case foreign food supplies become unavailable. Comprising the country's emergency stockpiles are "compulsory stockpiles" governed by contracts between the Swiss Federal Council and private-sector food importers (four months' worth of rations for all citizens: sugar, rice, cooking oil, coffee and wheat), as well as household stockpiles (a recommended 14 days' worth per person including rice or pasta, cooking oil, sugar, cheese, meats, fish, canned fruits, vegetables, crackers, chocolate, soup, tea and coffee).[14] Seventy-seven percent of households stockpile the recommended amount, of which roughly two-thirds is enough to last two weeks or longer (see Figure 7).

Table 3 : State of Ration Stockpiles in Tokyo (2 Days after Earthquake)

Unit: 10,000 meals

Item	Category	Pref.	Ward	Munic.	Total	Pop. %
Crackers, etc.	B	45	185	81	311	23.9%
Pregelatinized Rice	C	100	328	203	631	48.6%
Instant Noodles (Cups)	C	120	0	0	120	9.2%
Other (Various)		0	353	99	452	34.8%
Total		265	866	383	1514	116.6%

Compiled by the Science and Technology Foresight Center based on References #17

Table 4 : Results of Miyagi Prefecture Evacuation Shelter Nutrition Survey

Item	Unit of Nutrition	Amount Needed	Evacuee Intake		
			1st Survey	2nd Survey	3rd Survey
			Apr	May	Jun
Energy	Kcal	2000	1546	1842	2019
Proteins	g	55	44.9	57.1	69.5
Vitamin B1	mg	1.1	0.72	0.87	1.36
Vitamin B2	mg	1.2	0.82	0.96	1.16
Vitamin C	mg	100	32	48.4	60.4
Notes		Data from a Ministry of Health, Labour and Welfare notification (Apr. 21, 2011)	Evacuee Intake is the average of all evacuation shelters at(the)sea-coase of Miyagi Prefecture		

Compiled by the Science and Technology Foresight Center based on press releases from the Health and Welfare Department, Miyagi Prefecture.

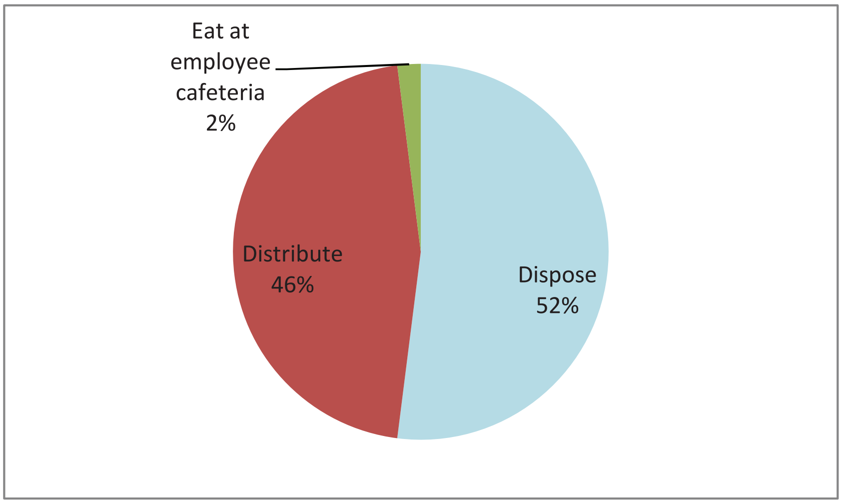


Figure 8 : Processing of Expired Emergency Food (Survey Results)
Compiled by the Science and Technology Foresight Center based on Reference #19

clearly insufficient even to temporarily provide the rations needed until outside assistance arrives.

At present, retail shops and distributor warehouses are keeping food inventories small to cut costs, etc. We cannot expect the large amount of stockpiled food from the private sector that can help disaster survivors to supplement government ration stockpiles.

According to a survey conducted prior to the Great East Japan Earthquake,[13] one in four households were stockpiling rations in case of a disaster, and over half of those did not stockpile more than one or two days' worth of food (see Figure 6).

The results of a public opinion survey conducted by a newspaper after the earthquake showed that the number of households stockpiling potable water and rations had particularly gone up to over 50% in the areas adjacent to the Tohoku region. However, even if a high proportion of households are stockpiling emergency supplies, this does not necessarily mean that they are adequately prepared to respond to a disaster.

While companies and schools in Japan still have small stockpiles,[15] more business continuity plans (BCPs) are recognizing the need for emergency stockpiles. The Tokyo Metropolitan Government (TMG) is now considering regulations that would oblige companies to stockpile supplies as a way to help stranded commuters.

(2) Little Food Suitable for Consumption after an Earthquake

In the chaos that follows an earthquake, survivors should have food requiring no hot water, heat or other such preparation to eat.

While hardtack biscuits, crackers, regular biscuits and the like meet these conditions, they are harder to swallow when eating without a drink (i.e. water). There are local governments that stockpile rice porridge, which is easy to swallow, but they are few in number. Furthermore, because rice porridge has a low concentration of energy, it poses the problem of having to stockpile more of it to provide people with sufficient calories.

Food requiring hot water to eat such as pregelatinized rice and instant noodles cannot be used if utilities are cut off, thus making it impossible to heat water. (Although pregelatinized rice can be returned to its original form by adding unheated water, it takes time and must still be eaten cold if there is no way to heat it.)

The TMG, for example, has crafted plans to prepare ration stockpiles to last for two days after a disaster[16] (after which it would distribute emergency supplies of precooked rice). According to the Tokyo Local Disaster Prevention Plan formulated in fiscal 2007, the TMG has ration stockpiles for a total of roughly 15 million meals (116% of Tokyo's population; see Table 3). Pregelatinized rice and instant noodles make up nearly 60% of these stockpiles.

(3) Local Governments Do Not Assume Extended Emergency Living Conditions

In many cases, emergency stockpiles are limited to a few different items selected based on their shelf life. Many local governments place a heavy emphasis on hardtack biscuits and flavored pregelatinized rice. Few dishes other than rice are stockpiled. In short, stockpiles are prepared with the rations needed only for short-term, temporary emergency living conditions in mind.

Much food relief delivered to disaster zones is heavy on carbohydrates, such as rice balls and hardtack biscuits. When survivors eat these on a continual basis, they tire of the same taste and sweetened flavoring and cannot bear to keep consuming them.

Looking at the results of a nutrition survey of evacuees after the Great East Japan Earthquake (the case of Miyagi Prefecture; see Table 4), we see that their energy intake one month after the disaster was insufficient and it did not return to the minimum required amount until two months had passed. We also find that there were problems with their nutritional balance due to an initial lack of proteins and vitamins.

In addition, there was a report that living under long-term emergency conditions increases the rate of people with high blood pressure and blood pressure levels in general.[18] On top of a lack of exercise and psychological stress, a poorly-balanced diet (high in sodium, low in calcium, lacking in dietary fiber, etc.) may have also been a cause of these symptoms. Living under long-term emergency conditions requires a rich diet with large proportions of low-salt, high-sodium foods (primarily main dishes other than rice) and fruits and vegetables that are rich in fiber, high in calcium and low in sodium.

(4) Food Waste in Normal Times (Disposal after Shelf Life Ends)

A high proportion of current stockpiles of rations (emergency food) is disposed of if there is no disaster because it is restricted to emergency use and not made available to eat otherwise (see Figure 8). This is why the authors have come to believe it preferable to use rations that can be used anytime—during an emergency or not—rather than emergency food that is restricted for use only during a major disaster.

4 Mindset Change from Emergency Food to Disaster Preparation Food

4-1 Post-Disaster Stages and Rations

Food can be categorized into the three stages below according to the status of utilities and other such conditions (see Table 5).[20]

Table 5 : Rations, etc. Needed after a Disaster

Stage		1st Stage	2nd Stage	3rd Stage
Period		Short-Term	Mid-Term	Long-Term
		Disaster - A Few Days	A Few Days - A Few Weeks	A Few Weeks - A Few Months
Situation		Need foods that do not require hot water or heat	Can useheated water with electricity, portable butane stove, etc.	Can cook ingredients using a heat source and cooking equipment
Utilities	(Drinking) Water	×	○	○
	Power	×	○	○
	Gas	×	×	○
Cooking facilities		×	△	○
Using Cooking		Stockpiled Rations	Stockpiled Rations	Stockpiled Rations
			Food Relief	Food Relief and Ingredients
				Self-Procured Ingredients

○: can use △: can use some ×: cannot use

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1. First Stage

Immediately after a disaster, power, gas and water utilities are cut off. Survivors need food that can be eaten without hot water or cooking and that is stored by households, companies, offices, evacuation shelters, etc.

2. Second Stage

Upon restoring power and other utilities, water can be heated. Survivors can make use of emergency/ instant food requiring hot water. Furthermore, ration stockpiles are supplemented by outside food relief during the Second Stage.

3. Third Stage

All utilities are back on line, allowing survivors to use cooking equipment and steam, boil, grill, fry and otherwise prepare food and ingredients sent as relief from outside the disaster zone. This removes most constraints on foods available to eat.

Table 5 provides a matrix showing the relationships between stages and living conditions.

4-2 The Differences between Emergency Food and Disaster Preparation Food

Emergency food now (see Table 6) is food with a long shelf life for use in a disaster. It is prepared just in case an emergency happens, so we could say it is "food that will presumably not be used." However, if we act on the presumption that a disaster will occur sometime, then we need to provide food for rescue/ emergency workers, medical staff and personnel working to restore utilities, in addition to infants, the elderly and people on a restricted dietary regimen. Food needs also vary according to the aforementioned Stages as well as location (evacuation shelter, private home, hospital, other facility, outdoor location, etc.).

In the aftermath of an earthquake, we need to have a broader concept than emergency food—"disaster preparation food" —that can respond to a variety of circumstances until living conditions return to normal (see Table 7).

Disaster preparation food includes seasoning as well as ingredients such as rice and flour in a broader sense. In the discussion that follows it mainly refers to precooked, processed food that can be eaten as is without adding cold water, hot water or requiring any other heating.

Table 8 shows the entire range of disaster preparation food envisaged by this report. Some of our current emergency food can be used to respond to a disaster in a way that qualifies it as disaster preparation food.

Other than the example of rice porridge, an emergency food that can be used without water in a Stage 1 situation, there are few other emergency foods that qualify as disaster preparation foods. By coordinating shelf lives, packaging and the like, thick liquid food for oral consumption used by hospitals and nursing homes as well as energy/sports drinks could be used as disaster preparation food.

However, other than rice porridge, there are few emergency foods that can be used by the sick, hospital patients and nursing home residents in all Stages.

4-3 Independent Assistance, Collaborative Assistance and Government Assistance

The question of who should be responsible for stockpiling disaster preparation food can be answered in terms of independent assistance, by which the organization to which one belongs (household,

Table 6 : Examples of Current Emergency Food

No.	Food Name	Shelf Life *1	Type of Production	Needed to Eat	Packaging	Calorie per Meal (Kcal)	Weight per Meal (g)	Price	Notes
First Stage Food (Group 1) (Edible as is)									
1	Rice Porridge	3 yrs	Canned	Nothing	Can	129	280	263	
First Stage Food (Group 2) (Edible as is, but needs water to swallow)									
2	Crackers A	10 yrs	Food in natural form	Nothing	Can	366	87	400	10 meals/can
3	Crackers B	10 yrs	Food in natural form	Nothing	Can	185	44	393	10 meals/can
4	Long-Lasting Bean Jelly	5 1/2 yrs	Food in natural form	Nothing	Polyethylene heavy duty bag + paper box	171	60	105	5 meals/box
5	Hardtack Biscuits	5 yrs	Food in natural form	Nothing	Can	468	110	315	incl. candy
6	Crackers	5 yrs	Food in natural form	Nothing	Can	681	132	315	
7	Bread	37 mths	Food in natural form	Nothing	Can	315	100	367	
8	Biscuits	3 yrs	Food in natural form	Nothing	Can	436	100	315	
9	Dietary Supplements	3 yrs	Food in natural form	Nothing	Aluminum foil + paper box	200	40	126	
10	Fish	3 yrs	Canned	Nothing	Can	246	100	150	
First Stage Food (Group 3) (Add water)									
11	Rice Cakes	5 yrs	Freeze-dried	Water	Polyethylene heavy duty bag	377	109	420	
Second Stage Food (Group 1) (Add hot water)									
12	Stew A	10 yrs	Freeze-dried	Hot (or cold*2) water	Canned (enamel coating on both sides)	196	44	760	10 meals/can
13	Stew B	10 yrs	Freeze-dried	Hot (or cold*2) water	Canned (enamel coating on both sides)	134	31	581	10 meals/can
14	Rice Porridge	5 yrs	Pregelatinized Rice	Hot (or cold*2) water	Polyethylene heavy duty bag	84	23	242	
15	Rice Balls	5 yrs	Pregelatinized Rice	Hot (or cold*2) water	Polyethylene heavy duty bag	145	40	262	
16	Cooked Rice	5 yrs	Pregelatinized Rice	Hot (or cold*2) water	Polyethylene heavy duty bag	281	77	357	
17	Ochazuke	2 yrs	Freeze-dried	Hot (or cold*2) water	Polyethylene heavy duty bag	166	46	294	
Second Stage Food (Group 2) (Heat with hot water, etc.)									
18	Beef Curry	3.5 yrs	Retort pouch	Exothermic agent/hot water/microwave oven	Polyethylene heavy duty bag	175	180	299	
19	Gyudon Stock	3.5 yrs	Retort pouch	Exothermic agent/hot water/microwave oven	Polyethylene heavy duty bag	355	180	420	
20	Cooked Rice	3.5 yrs	Retort pouch	Exothermic agent/hot water/microwave oven	Polyethylene heavy duty bag	314	200	241	

*1: Shelf Life: Period during which food can be consumed without losing flavor and still tastes good
*2: Takes time if no hot water, but can return to original state with cold water

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Table 7 : Comparison of Emergency Food and Disaster Preparation Food

Name	Definition	Used By	Stages of Use	(Possible) Requirements				
				Shelf Life	Non-Disaster Use	Ingredient Labeling	Labeling w/ Users & Applicable Stages	Packaged so No Separate Utensils Needed
Emergency Food	Long-lasting food stockpiled to prepare for disasters	Mainly general survivors	1st & 2nd Stages	Generally 3+ yrs	No (*1)	Yes	No	Some
Disaster Preparation Food	Food needed to maintain psychological and physical health for disaster survivors (incl. those in need of assistance and survivors on a restricted dietary regimen; also disaster response personnel) between the time a disaster occurs and when life returns to normal	General survivors; survivors with restricted dietary regimens (infants, dysphagia patients, people requiring low-protein meals, etc.); relief workers (FDMA, SDF, local gov't, volunteers, etc.)	1st through 3rd Stages	Depends on recipient and form of use (*2)	Yes (running stocks)	Yes	Yes	Should generally be taken into consideration for all emergency food

*1: Often does not compete well against regular food products when one considers both price and flavor.
*2: Food stockpiled for Government Assistance requires a certain shelf life, but a running stock maintained by a household, etc. should have graduated shelf lives as stockpiles are used.

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Table 8 : Disaster Preparation Food Coverage

Recipients	First Stage		Second Stage	Third Stage	Notes
	No Drinkables	w/ Drinkables			
Residents (General)	×	△	△	×	
Residents (Special Needs)	×	×	×	×	
Patients & Inmate	×	×	×	×	
Non-Residents (workers, stranded commuters, etc.)	×	△	/	/	
Relief Workers (General)	×	△	△	/	incl. residents responding to disaster
Relief Workers (Special)	/	/	△	/	firefighters, SDF, etc.

△: Current emergency food partially helps
×: Current emergency food mostly does not help

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Table 9 : Assistance Timing and Sources (Independent Assistance, Collaborative Assistance, Government Assistance) by Recipient

Location	Recipient	1st Stage	2nd Stage	3rd Stage
Damaged Housing	Resident (not needing aid)	I	I, C	I, C
	Resident (needing aid in disaster)	I	I, C	I, C
Hospital, Nursing Facility, etc.	Hospitalized patient/inmate	I	I, C	I, C
	Health care worker	I	I, C	I, C
Company, Local Gov't, etc.	Company employee, civil servant	I	I, C	I, C
Evacuation Shelter	Stranded commuter	I, G	/	/
	Local resident (needing aid in disaster)	I, G	G	G
	Local resident (not needing aid)	I, G	G	G
	Local resident (responding to disaster)	I, G	G	G
	Company/gov't worker (responding to disaster)	I	I	I
Temporary Housing	Local resident (needing aid in disaster)	/	/	I, C
	Local resident (not needing aid)	/	/	I, C

I: Disaster preparation food prepared by recipient's organization (household, company, local gov't, etc.)
C: Disaster preparation food shared among organizations affected by a disaster
G: Assistance from the government

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company, local government, etc.) provides assistance; collaborative assistance, by which organizations affected by a disaster share rations; and government assistance, by which the government provides assistance (see Table 9).

4-4 Disaster Prepartion Food Conditions

The authors believe the conditions that qualify food as disaster preparation food are the following.

(1) Preparation and Consumption

Disaster preparation food must be convenient (i.e. easy to eat) when it would presumably be used. It should also be easily swallowed, eatable without utensils, etc. out of consideration that it will be consumed in the wake of a disaster.

(2) Nutritional Considerations for Assumed Emergency Living Conditions

Living in emergency conditions is highly likely to subject survivors to an environment with low nutrition, high stress, etc. Considerations must be given to disaster food's nutritional value.

(3) Packaging

In the case of food requiring the use of utensils during consumption, packaging should contain utensils.

(4) Shelf Life

Because it is highly likely that refrigerators and freezers will be unusable during a disaster, disaster preparation food must be capable of continuous storage at room temperature. Food that assumedly will only be eaten during a disaster, and which is stored through government assistance, must be repurchased and replaced whenever an expiration date passes. Thus, because of the costs involved, shelf life should be as long as possible. On the other hand, since food stored through independent assistance (particularly by households) is also used to supplement daily diets, this food does not necessarily have to have a long shelf life.

(5) Price and Taste

Food stored through independent assistance may not prove helpful if it is food with a long shelf life, stored with the expectation that a disaster will not come. This is because expired shelf lives may go unnoticed until a disaster occurs, and also because it may not suit the palate if those consuming it are not accustomed to it. In order to avoid this—especially in the case of household food reserves—it is preferable to consume disaster preparation food on a regular basis by using a so-called running stock of food. Thus, the cost differs little from that of regular food and it will taste better.

Emergency food now generally has a shelf life of three or more years—longer than regular food. In proportion to consumable periods, the calorie cost (the cost per calorie) is high (see Figure 9). More specifically, the average calorie cost of regular food with a shelf life of one year is 0.5 Japanese yen (at 250 yen per meal, assuming each meal contains 500 calories), but this cost increases fivefold when shelf life is doubled. Because a running stock of reserves does not necessarily require long shelf lives, it needs to provide foods that have been selected out of consideration for a balance between cost and shelf life.

5 Researches and Development in Japan and Abroad

Hardtack biscuits and pregelatinized rice, which have long shelf lives, have been used as so-called "emergency food" in case of earthquakes, storm and flood damage and the like. While pregelatinized rice has been improved somewhat by shortening rehydration times and such, in the half-century since World War II, Japan has not experienced a major natural disaster affecting the entire country and the Japanese have not conducted serious research on food used in disaster response that considers the nutrition and the needs of survivors.

In recent years, companies that develop and produce ready-to-eat meals for the Japanese Self-Defense Forces (JSDF) have applied their techniques in new ways to start selling disaster preparation food. However, the purpose of developing foods for the JSDF has mostly been improved portability by switching from canned food to retort pouches.

In addition, cooked rice for emergency use has been produced in retort pouches to give it a long shelf life, but typically, regular, so-called sterilized cooked rice produced in a clean room has poor-quality flavor. Recently, production processes that ensure longer shelf life have improved the flavor of cooked rice for emergency use, and it is now being produced and sold.

The situation is the same outside of Japan, in that only food production techniques for military use have been applied to emergency food. In the United States, techniques for producing military food and space food for NASA have been applied to produce canned, freeze-dried emergency food that can be stored for 10 years at room temperature (or 25 years if stored within a certain temperature range), and some local governments and other entities in Japan have imported and stockpiled them.

6 Research and Development Issues

Below we individually address research and development issues concerning disaster preparation food, as well as matters related to the use of disaster preparation food that warrant further consideration.

6-1 Disaster Preparation Food Research and Development Issues

(1) Nutritional Science in Disasters

Since there has been little research yet conducted on nutritional conditions determining what one should consume in each Stage of a disaster, this research needs to begin now. Such research should focus on the following points.

- Specifying periods of fasting that pose little health risk
- The effect of low-calorie diets on health (short- and long-term)
- From a nutritional science perspective, set the target number of days to again provide food that includes a

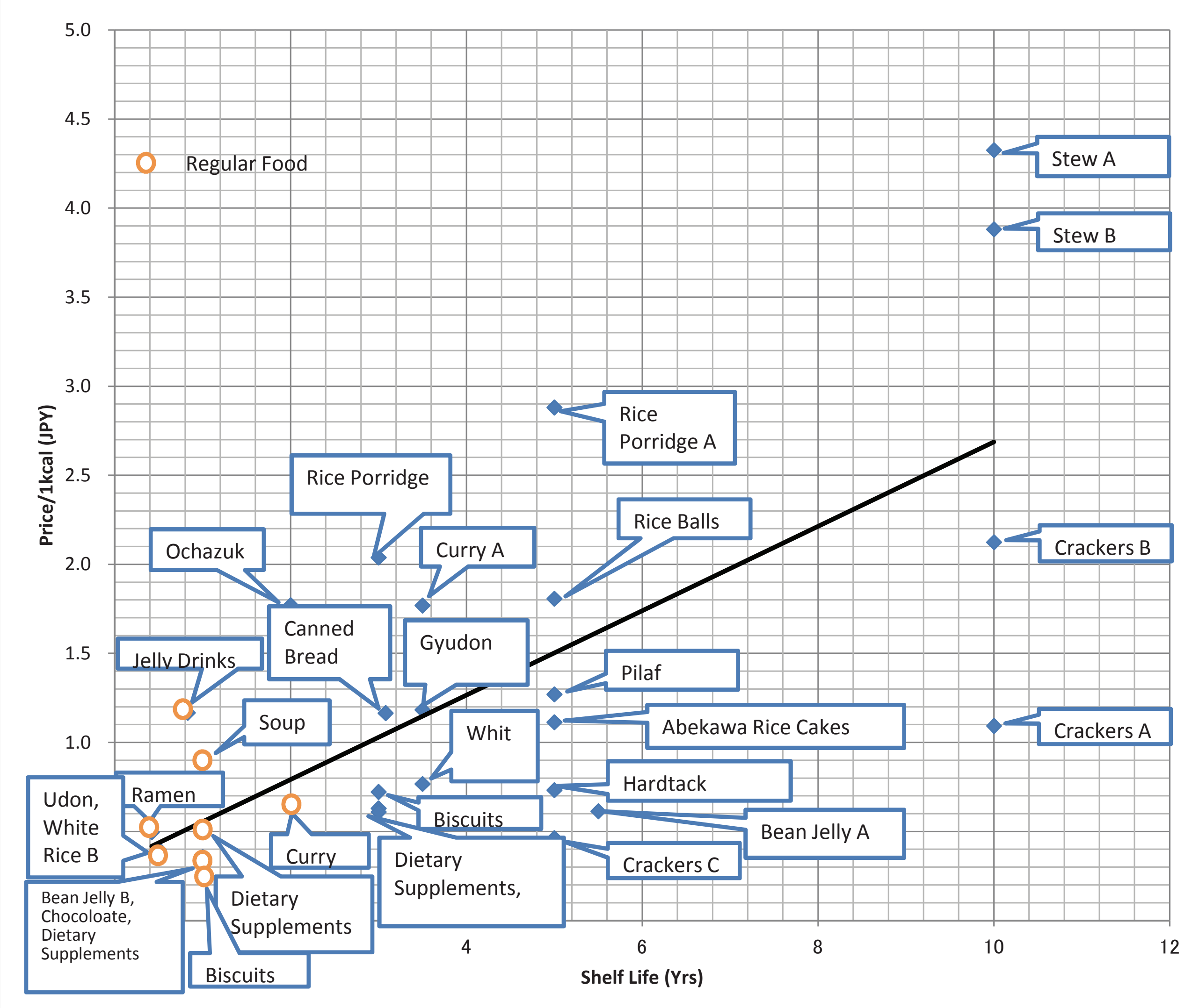

Figure 9 : Relationship between Shelf Life and Calorie Cost

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normal amount of energy and nutrition

- Meals and diets that allow for easy intake of nutrients in high-stress situations

(2) Processing Techniques of Food for Disaster Response

Research and development of the following kinds of food processing techniques are needed to respond to interruptions to utilities such as water and power.

- Development and popularization of processing techniques that provide both long shelf life and good flavor (e.g. techniques for producing cooked rice and bread [as main dishes] with good flavor and that meet the sterilization conditions for retort pouches, and techniques for producing vegetables and side dishes with long shelf life while maintaining flavor, color and shape)
- Consideration for the nutrition and forms of food to make the special meals required of infants, the elderly and people on a restricted dietary regimen
- Techniques for processing food that is easily consumed with little or no water

(3) Packaging Techniques for Disaster Preparation Food

Packaging/container development thus far has used shelf life, portability and robustness as benchmarks, mostly for use by the JSDF, but development for disaster response should be based on the following.

- Development of containers/packaging with dual use as utensils and that are compact and in containers storable in high temperatures
- Combined with food preparation functions
- Containers/packaging allowing preparation without any cooking equipment
- Containers/packaging that can be heated up inside a microwave oven
- Containers/packaging that can change a food's flavor

(4) Cooking Equipment for Disaster Preparation Food

A disaster survivor who prepares a portable butane stove and the like beforehand, and is able to heat water after a disaster, can skip the First Stage and move straight on to the Second Stage. If survivors—households in particular—cannot use electricity or gas as a heat source but can use a portable butane stove to heat water and cook food, it may still pose a safety problem, depending on the circumstances of the disaster, because the stove's combustion produces flames and high temperatures. In addition, heat sources that employ chemical reactions are disposable and expensive.

It would be desirable to develop disaster food cooking equipment that is very safe and reusable.

6-2 Matters Related to the Use of Disaster Preparation Food that Warrant Consideration

(1) Larger Stockpiles

Assuming the future occurrence of a large-scale disaster such as an earthquake, local governments, households and companies need to increase their stockpiles. Local governments in particular, whose financial situations make it difficult to increase spending, need to consider ways to expand actual stockpiles while holding down costs.

The following examples are methods that could possibly be adopted to achieve this.

- Example 1: Imbue distributor warehouses with disaster-prevention functions, store foods in them for a period of time during which they will not lose commercial value. While storing them there, they can be used as disaster preparation food in the event of a disaster, or shipped as commercial products should no disaster occur.

The TMG now stockpiles instant ramen in this manner.

- Example 2: Although convenience stores are being positioned more often these days as relief centers in times of disaster, we could go further by imbuing them with functions as disaster-prevention warehouses as well as disaster prevention centers to form a way of constantly maintaining at least a certain inventory of disaster preparation food.

(2) Broad Area Coordination of Stockpile Locations and Emergency Distribution Systems

Prefectural and municipal governments acting independently are clearly inadequate to respond to a disaster, such as the Great East Japan Earthquake, that covers a wide geographical area. Local governments across a broad area need to divide up the tasks of stockpiling disaster preparation food among themselves. Under this premise, each local government should share, over a broad area, its understanding of local information such as its residents' characteristics (proportions of elderly people and infants, population density, etc.) and nearby transportation networks and to develop algorithms determining optimal types, amounts and locations of foods to stockpile.

After utilities were restored and it again became possible to transport rations in the wake of the Great East Japan Earthquake, there were many cases in which the necessary rations were not delivered where they were needed. One reason is that instead of professionals (i.e. distribution/logistics companies), it was government officials and volunteers who were coordinating ration distribution, a task to which they were not accustomed. Local governments need to create systems in advance to figure out each area's ration needs in a timely manner, then decide, based on the status of stockpiles and food relief, where to send what and rapidly deliver it to disaster zones and evacuation shelters. Furthermore, they should consider matters such as backup plans in the event that the distribution systems they initially intend to employ are disrupted.

(3) Disaster Prevention Education that Considers Emergency Living Conditions

Even if an adult knows what preparations are important to make in case of a disaster, it is still difficult to actually do it when a disaster occurs. Especially in the First Stage of emergency living conditions, most aid is in the form of independent assistance, so people need to learn how to stockpile home rations in advance so that they can use them to survive until help arrives. To do this, disaster prevention education should start in elementary and junior high school. This education should consider what emergency living conditions are like and include content relating to disaster preparation food, such as the nutritional intake one needs in the event of a disaster, the rations one should stockpile and ways of obtaining food in a disaster.

6-3 Creating Disaster Preparation Food Certification Standards and a Certification System

In the long-term, Japan needs to encourage advances in the research and development discussed in Subsections 6-1 and 6-2, clarify the requirements demanded of disaster food, compile them in the form of Disaster Preparation Food Certification Standards, and create a national certification system for foods that satisfy these standards.

We expect that creating this system would produce the following results.

- It would become possible to produce disaster preparation food in accordance with the standards and to maintain the quality required of disaster preparation food.
- Providers (i.e. households, companies, local governments, etc.) would be able to consider the quantity and quality of the disaster preparation food they should provide, thus allowing them to stockpile more appropriately.
- Food producers would have a clear understanding of what is required and companies would have more incentive to produce a greater variety of foods.
- In the event of a disaster, the use of disaster preparation food would be simplified because instructions would be clearly printed on the food in a standard format.
- It would become possible to send relief supplies to individuals in a disaster zone more effectively by utilizing product numbers of the disaster preparation foods needed in the disaster zone, because distributors would know exactly what kinds of foods are stockpiled.

Disaster Preparation Food Certification Standards would have to incorporate the following information in order to clarify in which post-disaster stages each food can be used.

1. Disaster preparation food's nutritional information (especially caloric density, salt, vitamin and mineral content), measuring and labeling methods, etc.
2. Expiration date and assessment methods (including environmental conditions), labeling methods, etc.
3. Conditions for ingredients' edibleness
4. Package labeling methods indicating that a product is disaster preparation food, as well as its dimensions, shape, durability and openability (including how to use with preparation equipment/tools)
5. Other information such as certification methods, requirements for certification marks, etc.

It should also be noted that in order to popularize the use of disaster preparation food, the authors believe it would be effective for the national government to provide preferential treatment to companies that produce and/or sell certified disaster preparation food and/or its packaging, etc.

The Japan Aerospace Exploration Agency (JAXA) has created standards to certify Japanese space food[21] consumed by astronauts aboard the International Space Station (ISS). These standards comply with those prescribed by the Food Sanitation Law and other related laws and regulations to maintain food safety in Japan, as well as to additional standards to keep astronauts healthy and safe in a micro-gravity environment and in the enclosed environment aboard the ISS. JAXA's standards would make a good reference point when considering Disaster Preparation Food Certification Standards.

7 Conclusions

Figure 10 shows the relationships between the food-related problems addressed in Section 3 and the research and development issues addressed in Section 6.

In the event of a disaster, disaster preparation food that can deal with the issues discussed thus far is that which helps prevent secondary disasters relating to survivors' health, while also facilitating reconstruction by aiding independent disaster prevention organizations and firefighters, as well as evacuees and other residents engaged in volunteer activities, rather than simply responding to the disaster itself.

Moreover, because disaster food also functions and performs adequately for daily use (good nutritional balance, easy to consume in emergency conditions) and also imposes a low cost burden, popularizing the regular use of disaster preparation food under this new paradigm will contribute to a shift to healthier, richer dietary habits in everyday life, even when a disaster does not occur.

In addition, because disaster preparation food can be stored at room temperature and does not require energy to distribute and store to keep on a certain temperature, it could also contribute to cutting CO_2 and other emissions, thus possibly leading to a transformation in the way Japanese people view their lifestyle by aiming to lead lives that will provide better protection against disasters while also being environmentally friendly.

Conducting research and development and building infrastructure related to disaster food will require separate roles for the private sector, universities, government agencies, etc. upon incorporation within the Basic Disaster Prevention Plan[22], the government's fundamental plan for disaster response drafted by the Central Disaster Prevention Council in accordance with the Basic Act on Disaster Control Measures.

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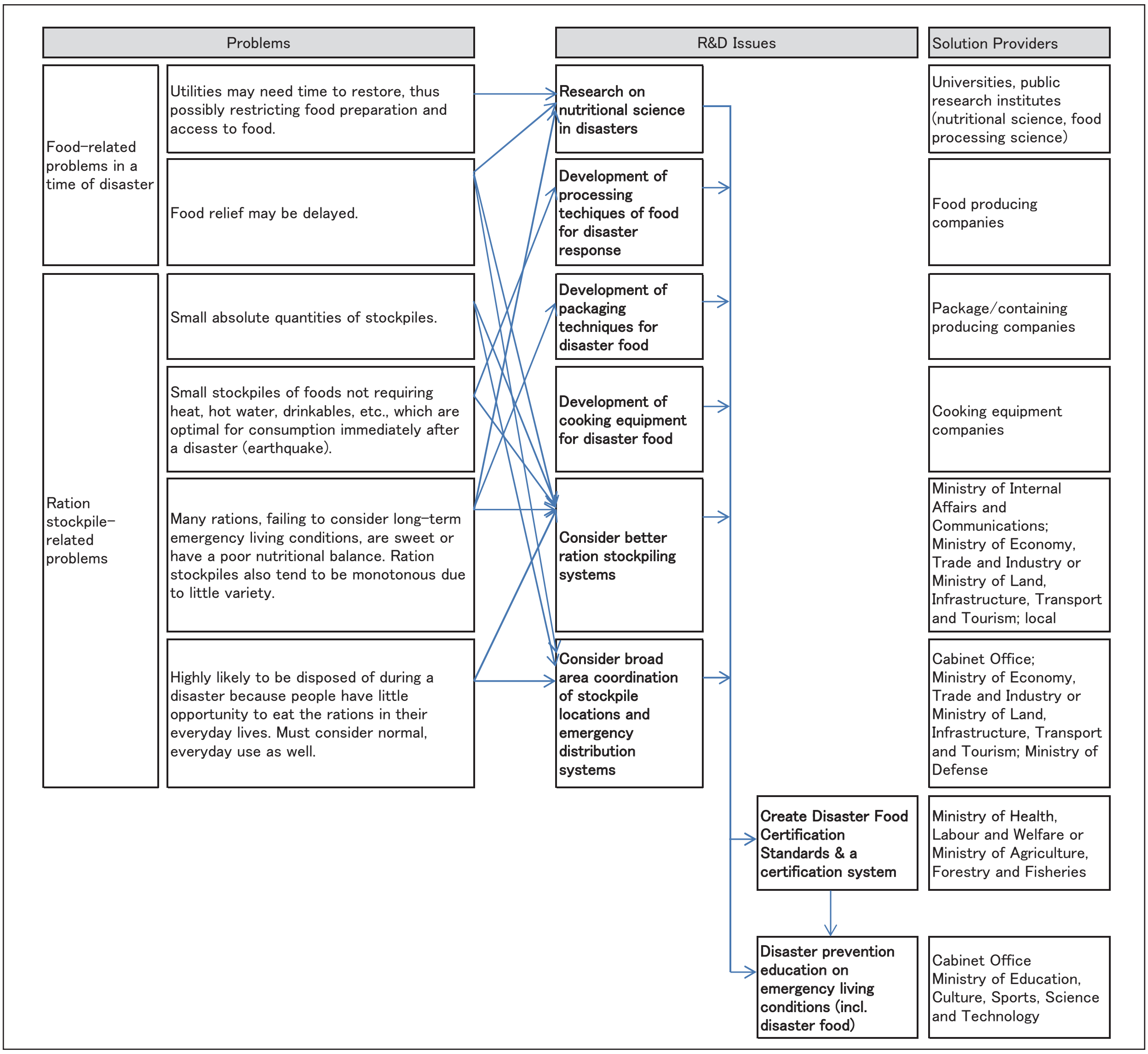

Fibure 10 : Relationship between Food-Related Problems and R&D Issues

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Born in Gunma Prefecture. After earning his Master's in Microwave Antennae, Nakazawa has been engaged in developing space food, creating astronaut training equipment and developing rocket-carried equipment for space agencies. Since June 2011, he has been working on research and analysis in the life sciences field. Nakazawa has an interest in extending people's health expectancy and his hobby is running.

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Beppu's area of expertise is food processing technology. While modern Japan does not suffer from a lack of food, he is engaged in efforts to eliminate inaccessibility to food in Japan caused by various obstacles such as dysphagia and the difficulties posed by disasters. Beppu is particularly engaged in research on matching obstacle causes with arrangements to provide food accessibility.

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Science and Technology Trends — Quarterly Review 2012. 10