Wise Adaptation to Climate Change

- Report by the Committee on Climate Change Impacts and Adaptation Research -

Part I: Wise Adaptation to Climate Change

(General Statement and Summary of Chapters)

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Introduction

In 2005, a hurricane struck the United States causing 1,700 people to lose their lives. In 2003, the death toll from a heat wave in Europe is alleged to have reached several ten thousand. In Australia, there are droughts that have lasted no less than six years. In 2007 and 2008, massive cyclones struck Bangladesh and Myanmar, causing extensive damage. While it is difficult to conclude the extent to which global warming has contributed to these extreme weather events, it has been scientifically predicted that if global warming continues, these types of extreme weather events will increase. Watching these news reports, there is likely to be a fair number of people who feel vaguely apprehensive that global warming will sooner or later cause considerable damage of some kind in Japan as well.

In addition to reports on damage attributable to extreme weather, in 2007, the IPCC periodically released the Working Group I, II and III Reports of its Fourth Assessment Report, before releasing the Synthesis Report in November. At around the same time, people the world over suddenly seem to have taken an increased interest in issues of global warming. Issues of climate change are not just discussed in relation to the United Nations Framework Convention on Climate Change. Today, they are discussed in various contexts, such as water resources, food, security and biodiversity.

Previously, it was thought that the impacts of global warming would be serious in vulnerable areas such as the leased developed countries of Africa, the Asian mega deltas and small island states, and that developed countries like Japan still had plenty of breathing space. However, the heat waves of Europe and the pine wilt and forest fires in North America are examples of how damage has become apparent even in developed countries. Nowadays, even in Japan, there is a growing recognition that global warming is an issue that is close to home.

Even in Japan, an event of recent memory was during summer in 2007, when 40.9 degrees Celsius was recorded in Kumagaya City and Tajimi City - the highest temperature on record since observations were first taken. Furthermore, according to a survey of public agricultural testing and research institutes, which was conducted by the Ministry of Agriculture, Forestry and Fisheries, respondents stated that there are already apparent impacts in all prefectures thought to be somehow caused by global warming. In recent years, there have also been reports on strange phenomena occurring to familiar living creatures and marine resources.

It has been predicted that, if our fossil fuel dependent civilization continues unchanged, by the year 2100, the global average temperature will have increased by approximately 4.0 degrees Celsius. What kind of adverse impacts will this global warming have on Japan? And, what preparations should we take to cope with these impacts?

In order to provide answers to these types of questions, 43 experts were gathered from various fields of study, and chaired by Professor Nobuo Mimura, they conducted intensive reviews and investigations for approximately eight months from October 2007. Global warming

affects all aspects of climate, the natural environment and social systems. Thus, we need to predict future situations and consider countermeasures by utilizing our scientific knowledge to the fullest extent.

The question of adaptation to the impacts of global warming is still a relatively new concept. Although there had not been any systematic reviews in Japan before, the cooperation of a large number of researchers were able to be secured for this new and challenging problem. As a result of this cooperation, this Report offers valuable suggestions for deliberating on the impacts of, and adaptation to, global warming in Japan.

In particular, the “wise adaptation” line of thinking, which is the crux of this Report, is an extremely important approach in Japan implementing effective and efficient adaptation measures. In examining adaptation measures in various fields, I believe it will be important to flesh out this “wise adaptation” approach. Furthermore, in developing countries which have insufficient adaptive capacity and are highly vulnerable, implementing adaptation measures to counter global warming is an urgent issue, and we expect that the “wise adaptation” approach will be more useful here the more severe the situation.

Adaptation measures become reality through cooperation with a broad range of relevant organizations. In order to implement “wise adaptation”, a perspective of the impacts of, and adaptation to, global warming needs to be incorporated into existing policies, and measures and projects need to be implemented in a systematic way. I hope that this Report will prove instrumental in adaptation measures being examined at various relevant organizations, and will serve as the foundation for thinking together about the question of the impacts of, and adaptation to, global warming.

Hideki Minamikawa
Director-General of the Global Environment Bureau, Ministry of the Environment

June 18, 2008

Committee Members and Working Group Members

The Committee on Climate Change Impacts and Adaptation Research is comprised of the 12 experts listed below, and was established for the purpose of conducting this review. Sectoral working groups were also established as a support structure for the purpose of reviewing each of the individual fields from a more technical viewpoint. (The working groups cover 7 sectors and comprise 38 members. The 7 persons chairing the working groups also serve as members of the Committee).

List of Members
Committee on Climate Change Impacts and Adaptation Research
Ministry of the Environment

(Titles omitted. General members listed in alphabetical order by surname. Correct as of June 18, 2008)

Chairperson	Nobuo Mimura	Professor and Special Assistant to the President, Center for Water Environment Studies, Ibaraki University
	Hideo Harasawa	Counselor to the Director-General for Policies (Environment & Energy), Cabinet Office (from April 2008) Division Director, Social and Environmental Systems Division, National Institute for Environmental Studies (until March 2008)
	Yousei Hayashi	Professor, Graduate School of Life and Environmental Sciences, University of Tsukuba
	Akira Hibiki	Head of the Environmental Economics and Policy Section, Social and Environmental Systems Division, National Institute for Environmental Studies
	Takahiko Hiraishi	Senior Consultant, Institute for Global Environmental Strategies (IGES)
	Masahiko Isobe	Professor, Graduate School of Frontier Sciences, The University of Tokyo
	Ichiro Kurane	Director, Department of Virology I, National Institute of Infectious Diseases
	Tohru Nakashizuka	Professor, Graduate School of Life Sciences, Tohoku University
	Shuzo Nishioka	Visiting Research Fellow, National Institute for Environmental Studies
	Shinichiro Ohgaki	Professor, School of Engineering, The University of Tokyo
	Teruyuki Ohno	Senior Director, Urban and Global Environment Division, Bureau of the Environment, Tokyo Metropolitan Government
	Mitsuru Tanaka	Professor, Hosei School of Policy Sciences

List of Working Group Members
Committee on Climate Change Impacts and Adaptation Research
Ministry of the Environment

(Titles omitted. General members listed in alphabetical order by surname. Correct as of June 18, 2008)

Food Working Group

Chairperson	Yousei Hayashi	Professor, Graduate School of Life and Environmental Sciences, University of Tsukuba
Vice Chairperson	Masayuki Yokozawa	Senior Researcher, Agro-Meteorology Division, National Institute for Agro-Environmental Sciences
	Satoshi Morita	Senior Researcher, National Agricultural Research Center for Kyushu Okinawa Region, National Agricultural Research Organization
	Kazufumi Takayanagi	(former position) Director, Seikai National Fisheries Research Institute, Fisheries Research Agency (new position) Director of the Project Management Division, National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research Agency

Water Environment and Water Resources Working Group

Chairperson	Shinichiro Ohgaki	Professor, School of Engineering, The University of Tokyo
Vice Chairperson	Hiroaki Furumai	Professor, School of Engineering, The University of Tokyo
	Koh-ichi Fujita	(former position) Division Chief, National Institute for Land and Infrastructure Management (new position) Research Coordinator for Environmental Affairs, National Institute for Land and Infrastructure Management
	So Kazama	Associate Professor, Graduate School of Environmental Studies, Tohoku University
	Taikan Oki	Professor, Institute of Industrial Science, The University of Tokyo
	Masahiro Otaki	Associate Professor, Graduate School of Humanities and Science, Ochanomizu University

Natural Ecosystems Working Group

Chairperson	Tohru Nakashizuka	Professor, Graduate School of Life Sciences, Tohoku University
Vice Chairperson	Jotaro Urabe	Professor, Graduate School of Life Sciences, Tohoku University
	Yoshiyuki Kiyono	Director, Bureau of Climate Change, Forestry and Forest Products Research Institute
	Kazuhiro Kogure	Professor, Marine Microbiology Lab., Marine Ecosystem Dynamics, Ocean Research Institute, The University of Tokyo
	Takehiro Masuzawa	Professor, Plant Biology Course, Graduate School of Science, Shizuoka University
	Masahiro Nakaoka	(former position) Associate Professor, Graduate School of Science, Chiba University (new position) Professor, Field Science Center for Northern Biosphere, Hokkaido University
	Yo Shimizu	Assistant Professor, Graduate School of Agricultural and Life Sciences, The University of Tokyo
	Nobuyuki Tanaka	Team Leader, Environmental Impacts Team, Department of Plant Ecology, Forestry and Forest Products Research Institute

Large Coastal Cities and Protection against Disasters Working Group

Chairperson	Masahiko Isobe	Dean and Professor, Graduate School of Frontier Sciences, The University of Tokyo
Vice Chairperson	Hiromune Yokoki	Associate Professor, Center for Water Environment Studies, Ibaraki University
	Masaya Fukuhama	(former position) Division Chief, National Institute for Land and Infrastructure Management, (MLIT) (new position) Head of the Kurobe Office of River, Ministry of Land, Infrastructure, Transport and Tourism Hokuriku Regional Development Bureau
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Health Working Group

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	Masaji Ono	Director, Environmental Health Sciences Division, National Institute for Environmental Studies
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National Lifestyles and Urban Life Working Group

Chairperson	Mitsuru Tanaka	Professor, Hosei School of Policy Sciences
Vice Chairperson	Takahiro Nakaguchi	Director, Research Institute for Environmental Policy, The Coalition of Local Government for Environmental Initiative Professor, Department of Architecture and Environment Systems, Faculty of Systems Engineering, Shibaura Institute of Technology
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	Hideo Shimada	(former position) Section Chief, Environmental Policy Section, Environmental Department, Kumagaya City (new position) Section Chief, Municipal Tax Section, General Affairs Department, Kumagaya City
	Kenro Taura	Secretary-General, Kiko Network (NPO)

Developing Countries Working Group

Chairperson	Hideo Harasawa	(former position) Division Director, Social and Environmental Systems Division, National Institute for Environmental Studies (new position) Counselor to the Director-General for Policies (Environment & Energy), Cabinet Office
Vice Chairperson	Kiyoshi Takahashi	Senior Researcher, Climate Risk Assessment Research Section, Center for Global Environmental Research, National Institute for Environmental Studies
	Masato Kawanishi	(former position) Senior Advisor, Institute for International Cooperation, Japan International Cooperation Agency (JICA) (new position) Senior Advisor, JICA
	Izumi Kubota	Researcher, Social and Environmental Systems Division, National Institute for Environmental Studies
	Hisamichi Nobuoka	Lecturer, Department of Urban and Civil Engineering, Faculty of Engineering, Ibaraki University
	Akinori Ogawa	Senior Fellow, United Nations University

Certain sections of Part II, Chapter 1 “Overview of Future Climate Scenarios and Social Scenarios” were written with the cooperation of Seita Emori (Director, Climate Risk Assessment Research Section, Center for Global Environmental Research, National Institute for Environmental Studies) and Kiyoshi Takahashi (Senior Researcher in the same Climate Risk Assessment Research Section) et al.

Conclusions of the Review

1. Impacts of climate change are already apparent in Japan. In particular, there has been a rapid emergence of impacts since the turn of this century.

In many parts of the world, there have been reports of heat waves, hurricanes, cyclones, floods, droughts and other disasters which are possibly affected by climate change. In Japan as well, especially since the turn of the 21st century, various impacts have come to light, which are potentially caused by climate change.

Specific examples include: reduced yields and lower quality agricultural produce due to high temperatures; a decline of Japanese beeches and other trees and a decrease in alpine plants; changes in ecosystems attributable to the sluggish vertical circulation of lakes; a reduction in the distribution of cold water fish in freshwater environments; an increase in heatstroke patients brought on by excessive heat; and a broader distribution of mosquitoes carrying infectious diseases. There have also been water cutoffs and other impediments to using water due to record low rainfalls, as well as damage caused by typhoon-induced storm surge and inundation damage caused by record intense rainfall, although at present, these cannot be clearly affirmed to be the impacts of climate change.

2. Further significant impacts are projected across a broad range of fields related to people's lives.

The impacts of climate change are closely related to the lives of each and every citizen, and it is expected that the impacts will be even greater in the future. These impacts extend to various aspects of people's lives, affecting the degree to which people can live securely, healthily, affluently and comfortably, and in a way that they can get a sense of culture and history.

Specific examples of the impacts include: increases in landslide damage, inundation damage and flood damage caused by intensification of typhoons and more frequent intense rainfall; increases in the risks of heatstroke, heat stress, infectious diseases and air pollution; increases in household spending due to higher agricultural commodity prices, air-conditioning costs and expenditures for adaptation measures; greater discomfort and stress brought about by an increase in hot days and hot nights; and forfeited views of natural scenery and recreational spaces, and the loss of a sense of season.

3. If these impacts of climate change are combined with the particular vulnerability of Japan's natural and social structures, then there is potential for severer consequences for social security and stability

Previously, most discussion on the impacts of climate change focused on developing countries that are highly vulnerable to climate change, such as the least developed countries of Africa, small island states and the Asian mega-deltas. However, despite having a well-developed social infrastructure and science and technology, and despite being regarded as having a certain adaptive capacity, even Japan has vulnerabilities attributable to the natural and social characteristics of the country, including a high frequency of typhoons, landslides and earthquakes, a reliance on overseas for food and resources, and an ageing population.

As the impacts of climate change pile up on these vulnerabilities, there is a risk that severe consequences will arise that threaten the security and stability of society.

4. "Wise adaptation (effective and efficient adaptation)" is needed to address the adverse affects of climate change.

The following undertakings are important for effective and efficient "wise adaptation" that appropriately counters the adverse impacts of climate change which have great bearing on the lives of Japanese people: (1) utilize the latest regional vulnerability assessments, monitoring and other results; (2) review and combine diverse optional adaptation measures; (3) from both a long-term and short-term perspective, consider the clearance against the temperature range that the adaptation measures can handle; (4) appropriately incorporate adaptation into existing disaster damage prevention plans and other policies if they exist; and (5) make natural and socioeconomic systems more flexible and adaptive. To achieve this, reviews need to be made from early stage as precaution.

In particular, in order to achieve wise adaptation, the perspective of adaptation to climate change needs to be incorporated into existing policy areas and related plans, including land-use plans, city planning, agricultural policies, nature conservation policies and local government environmental policies. In line with this philosophy, efforts need to be made for the effective use of all resources by implementing additional adaptation measures for existing measures and funds.

In addition to climate change, Japan faces various other challenges including an ageing and decreasing population. Advancing wise adaptation that is suited to local circumstances will ultimately change the local paradigm, and may lead to resolutions for these problems as well. From a comprehensive perspective that includes urban development, etc., in the long term, it is important to aim for national land development that enables people to lead safe, secure and more affluent lives.

5. In order to establish a framework that enable adaptation measures to be implemented, further reviews need to be accumulated and an adaptation plan for Japan needs to be formulated.

Some impacts of climate change have already come to light at the present point in time, and so now we need to urgently promote the implementation of adaptation measures. Furthermore, as mentioned above, we need to effectively utilize limited financial, human and temporal resources, and to implement measures for wise adaptation. Moreover, it is also important that we facilitate consensus-building by listening extensively to the views of the people, and that we conduct follow-ups on the policies.

Thus, when conducting future reviews, we need to conduct cross-sectoral and more policy-oriented examinations, securing the participation of relevant ministries and agencies. Moreover, we need to devise an “adaptation plan” at the national level based on the full findings of those examinations, and we need to establish a Plan, Do, Check, Act (PDCA) cycle.

6. Cooperation and assistance is needed for particularly vulnerable developing countries

The impacts of climate change in highly vulnerable developing countries are especially severe. Various impacts are forecast for the Asia-Pacific region, including: an increase in floods caused by glacier melts; an increase in the risk of starvation in some developing countries; an increase in floods in mega-delta areas where there are concentrated populations; and a decrease in the land areas of some small islands due to sea level rise. Furthermore, in some cases the impacts in developing countries will extend indirectly as far as Japan, such as the effects through countries from where food is imported as well as greater adverse health effects through overseas travel.

In view of these impacts, Japan is being called on, as a member of the international community and as a developed country with scientific knowledge and advanced technology, to promote appropriate support and cooperation for adaptation to address the problems faced by those developing countries that are especially highly vulnerable.

7. As well as consolidating the latest scientific knowledge, further research and investigations are needed.

In order to promote the "wise adaptation" outlined above, we first need to consolidate the knowledge and assessments of existing and projected impacts in Japan, and to organize this information both into major disciplines and also interdisciplinarily. For this purpose, there needs to be monitoring which serves as a basis for detecting impacts, the projection of future impacts, vulnerability assessments, as well as economic assessments of impacts (damage). Based on the findings, there also needs to be a presentation of how wise adaptation which addresses these impacts ought to be, as well as further research and investigation for giving shape to this wise adaptation.

Following are the expected current issues that will need to be addressed.

- Implementation of adaptation measures based on scientific assessment, and the accumulation and sharing of the relevant data, information and research findings
- Learning from past examples, and incorporating the adaptation viewpoint into various policies
- Systematic promotion of adaptation measures that should be implemented immediately
- Construction of an ongoing review structure, and regular communication of review findings
- Ongoing reviews related to adaptation support for developing countries
- Promotion of further research on the impacts of, and adaptation to, climate change

Background and Objectives of the Review

1. Background

● **Warming of the climate system is unequivocal.**

The IPCC Fourth Assessment Report, released in 2007, states that warming of the climate system is **unequivocal**, and is evident from observations of increases in global average air and ocean temperatures, wide spread melting of snow and ice, and rising global average sea level.

● **Further impacts of climate change is unavoidable.**

As to the adaptation to global warming, it is stated in its Working Group II Contribution: "Even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, which makes adaptation essential, particularly in addressing near-term impacts."[11]

● **Effects of climate change are emerging even in societies with high adaptive capacity**

The disasters such as heat waves, hurricanes, floods and droughts, of which the relationship with climate change is presumably suggested, have been reported from around the world, and also in Japan, various impacts presumed as those of climate change are emerging. The impacts of climate change are emerging not only as a gradual increase in mean temperature, but also as sudden attacks of increase of extreme events to our society.

Previously, most discussion on the impacts of climate change focused on developing countries that are highly vulnerable to climate change, such as the least developed countries of Africa, small island states. However, despite being regarded as having a certain adaptive capacity, even Japan has need review adaptation measure to cope with climate change as precaution.

2. Objectives

Against this background, the review was conducted with the following three objectives.

(1) Clarify the scientific knowledge to date that relates to the impacts of, and adaptation to, climate change in Japan and in developing countries.

(2) Present how wise adaptation (effective and efficient adaptation) ought to be.

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[1] The United Nations Framework Convention on Climate Change sets as its ultimate objective "the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2).
To achieve this ultimate objective, it is important to make maximum effort for mitigation above all. As indicated in the IPCC Fourth Assessment Report, neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change (IPCC AR4 SYR SPM,p.20).

(3) Through the investigations in (1) and (2) above, present the challenges and the direction for future research on the impacts of, and adaptation to, climate change in Japan and in developing countries.

3. Method of Review

In conducting this review, the Committee on Climate Change Impacts and Adaptation Research was established as an advisory panel to the Director General of the Global Environment Bureau at the Ministry of the Environment, and sectoral working groups were also established as a support structure for the purpose of reviewing each of the individual fields from a more technical viewpoint.

Each of the working groups focused on drawing together as much as possible existing research findings related to the impacts of, and adaptation to, climate change. They also undertook considerable discussion on vulnerability assessments, for which there is currently little knowledge, and on views about the implementation of adaptation measures, before collating those views.

4. Targeted Regions and Periods

In general, the review was targeted at Japan. Where necessary, consideration was also given to related countries and regions according to the relevant field of review. In the developing countries area, reviews targeted those countries in the Asia-Pacific region that have close relations with Japan.

Existing research knowledge on the impacts and adaptation in the respective fields of review was organized with a focus on the relatively short term of 2020-2030, being the intermediate point in time for considering adaptation measures, while also looking ahead to the long-term future of 2050 and 2100. Reviews on the direction for future research were also conducted, bearing in mind the type of research that ought to be conducted over the following three years or so.

1. Impacts

In this section, we first describe the “Observed Impacts”, or the characteristics of the impacts of climate change in each field of review, and we present examples of impact events that have been observed in the past. We then present the “Projected Impacts”, or examples of future impacts that are projected to occur as a result of climate change.

In particular, at present, with some of the examples given as “Observed Impacts”, it cannot be clearly affirmed that they are necessarily the result of climate change. However, in the future, if climate change progresses, it is feared that these events may occur more frequently, resulting in tremendous damage. For this reason, in order to help in the prediction of future impacts and the reviews of wise adaptation, in this section, we have decided to include events for which we cannot at present readily determine whether they are the result of climate change, but which would appear as being likely, and events that are believed will increase if climate changes advance. That is, readers should be mindful of the fact that not all of the examples of “Observed Impacts” given here are examples that have been affirmed to be the result of climate change.

More concrete details of the impact events in each field are given in the “Observed Impacts” and “Projected Impacts” sections contained in the sector-specific chapters in Part II.

1.1 Food

1.1.1 Observed Impacts

Impacts on food occur through impacts on the agriculture, livestock and fisheries industries. Past examples include: the incidence of white immature grains and cracked grains of rice, and reduced quality and taste caused by high temperatures; an increase in frost damage due to the earlier than usual wheat young panicle formation; reduced harvests brought about by shorter ripening periods; an increase in pest damage to soybeans; and damage caused by hot dry climates. In the fruit industry, reductions in quality and storability, increases in frost damage to tea plantations, and increases in pests have been observed. In the livestock industry, a decrease in impregnation rates, reduced milk yields and poor growth have emerged. In the fisheries industry, there has been an increase in southern (tropical and subtropical) fish, as well as changes in the fishing season and a slump in aquaculture.

- Incidence of white immature rice grains (cloudy hulled rice) in regions south of Tohoku [Chapter 2 2.2]
- High incidence of cracked rice grains (hulled rice with cracks) in the Tohoku and Hokuriku regions [Chapter 2 2.2]
- Accelerated wheat young panicle formation and stemming caused by higher winter temperatures, and subsequent increases in frost damage [Chapter 2 2.2]
- *Ukikawa* symptoms -detached fruit skin and flesh- in Mandarin oranges due to high temperatures and high rainfall, and poor coloration in grapes due to high temperatures [Chapter 2 2.2]
- Public agricultural testing and research institutes in all 47 prefectures nationwide were surveyed on the impact of global warming on agriculture. All prefectures responded that fruit trees were, in one way or another, being affected by impacts thought to be somehow attributable to global warming. 90% of prefectures thought the same for vegetables and flowers, and about 40% thought the same for livestock. [Chapter 2 2.2]
- Delayed seaweed harvests seasons due to water temperatures cooling down later than usual in autumn [Chapter 2 2.2], etc.

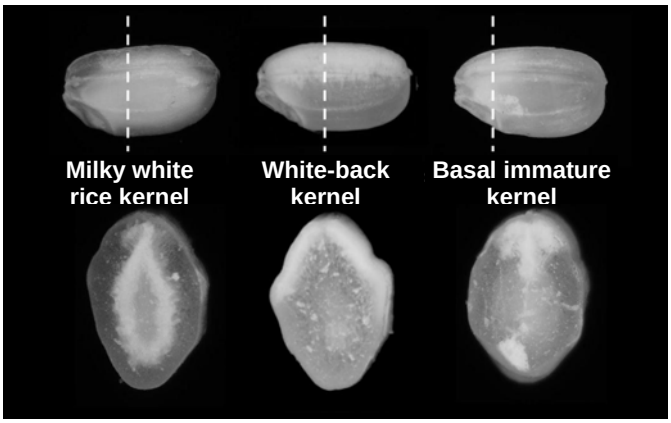


Figure 1 White immature grains from irrigated rice (Morita, 2005)

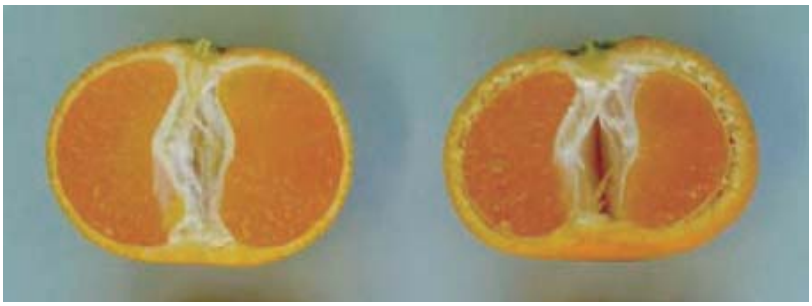


Figure 2 *Ukikawa* symptoms in mandarin oranges due to high temperatures and heavy rain

Photographs provided by: Fruit Tree Research Division, Agricultural Technology Research Center, Hiroshima Prefectural Technology Research Institute

1.1.2 Projected Impacts

In agriculture, as well as an even greater deterioration in rice quality, there is potential for the ideal sowing seasons in wet-rice cultivation to become bipolarized (the warmer areas of the Kanto region and to the southwest would drop back, and other areas would be earlier than usual), and it is predicted that there would be a subsequent decrease in the national average yield of rice. It is also predicted that there would be reduced harvests of wheat and soybeans due to higher temperatures, and that the suitable lands for fruit trees would shift. Furthermore, it is also possible that the increase in pests and the rampant growth of weeds would lead to an increase in the amount of labor required to control them. Moreover, it is also predicted that agricultural water resources would become depleted with lower snowfalls and earlier thaws, and that there would be an increase in damage caused by salty winds accompanying typhoons. In fisheries, predictions include the potential for the habitats of northern fish to shift northward and the habitats of southern (tropical and subtropical) fish to expand, as well as the potential for shifts in the suitable areas for aqua-farming and an increase in infectious diseases.

[Main examples of projected impacts]

- Significant exacerbation of the poor ripening of rice (lower quality and grain weight) [Chapter 2 2.3]
- Northward shift of suitable lands for apple cultivation (possibility of losing the ability to grow apples on the central plains of the Tohoku region) [Chapter 2 2.3]
- Northward shift of the damage and pest caused by high temperatures [Chapter 2 2.3]
- Water shortages during the rice-planting season due to lower snowfalls and greater snow melts [Chapter 2 2.3]
- Decrease in habitat for salmon, and a northward shift of the habitats for herring [Chapter 2 2.3]
- Slower growth of the Pacific saury -samma-due to a worsening of feeding environment, but an increase in spawning due to the improved feed environment during spawning season (the Pacific seaboard of eastern Japan) [Chapter 2 2.3]
- Northward shift for suitable aqua-farming of blowfish -Torafugu- [Chapter 2 2.3]

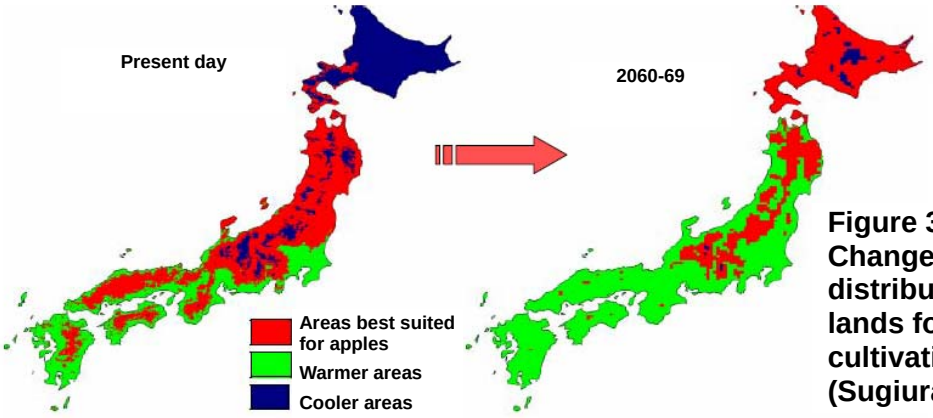


Figure 3
Change in the distribution of suitable lands for apple cultivation (Sugiura, et al., 2004)

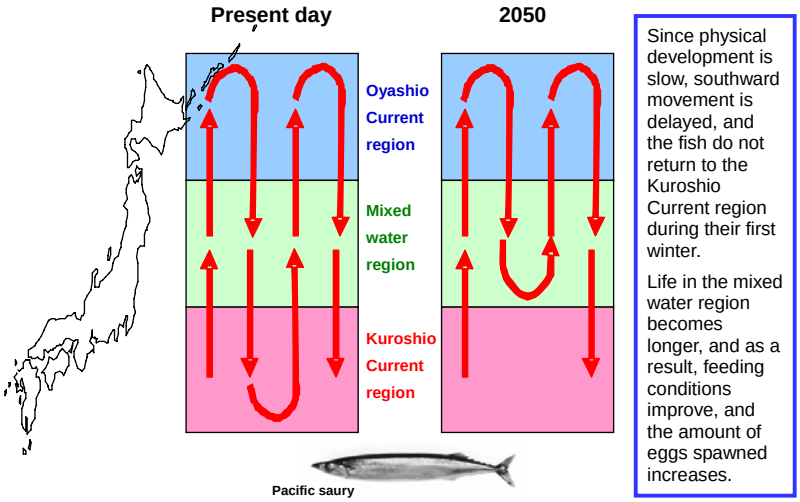


Figure 4
Migration route of the Pacific saury, calculated using a numerical model (adapted from Ito, 2007, a, b)

1.2 Water Environment and Water Resources

1.2.1 Observed Impacts

The direct impacts on the water environment and water resources appear as changes in the volume of water, water temperature and water quality of each type of water source, including river water, lakes, marshes, dammed lakes and groundwater. These changes influence natural ecosystems and society's water utilization systems and the structure of water demand. Whilst at present it cannot be clearly determined whether they are due to the effects of climate change, variations in the frequency of extreme weather events and changes in rainfall and snowfall trends have been recorded and reported, and there are concerns that if climate change advances, these variations will be further amplified. Furthermore, one of the features of the water environment and water resources sector is the fact that any changes in the volume of water or water quality also have flow-on effects to a broad range of other sectors, including agricultural production, natural ecosystems, protection against disasters and health.

- Incidence of restrictions on water-intake from drinking water sources, and restrictions and suspensions of water supply due to record low rainfall[Chapter 3 3.2]
- Abnormal blooms of blue-green algae in lakes and marshes (impact of water use and aquatic ecosystems) [Chapter 3 3.2]
- Increase in the use of groundwater as a consequence of water shortages, and the subsequent incidence of land subsidence [Chapter 3 3.2], etc.

Green: Examples related to the volume of water and water quality, etc. of rivers

Blue: Examples related to the volume of water and water quality, etc. of lakes, marshes and dammed lakes

Orange: Examples related to the volume of water and water quality, etc. of groundwater

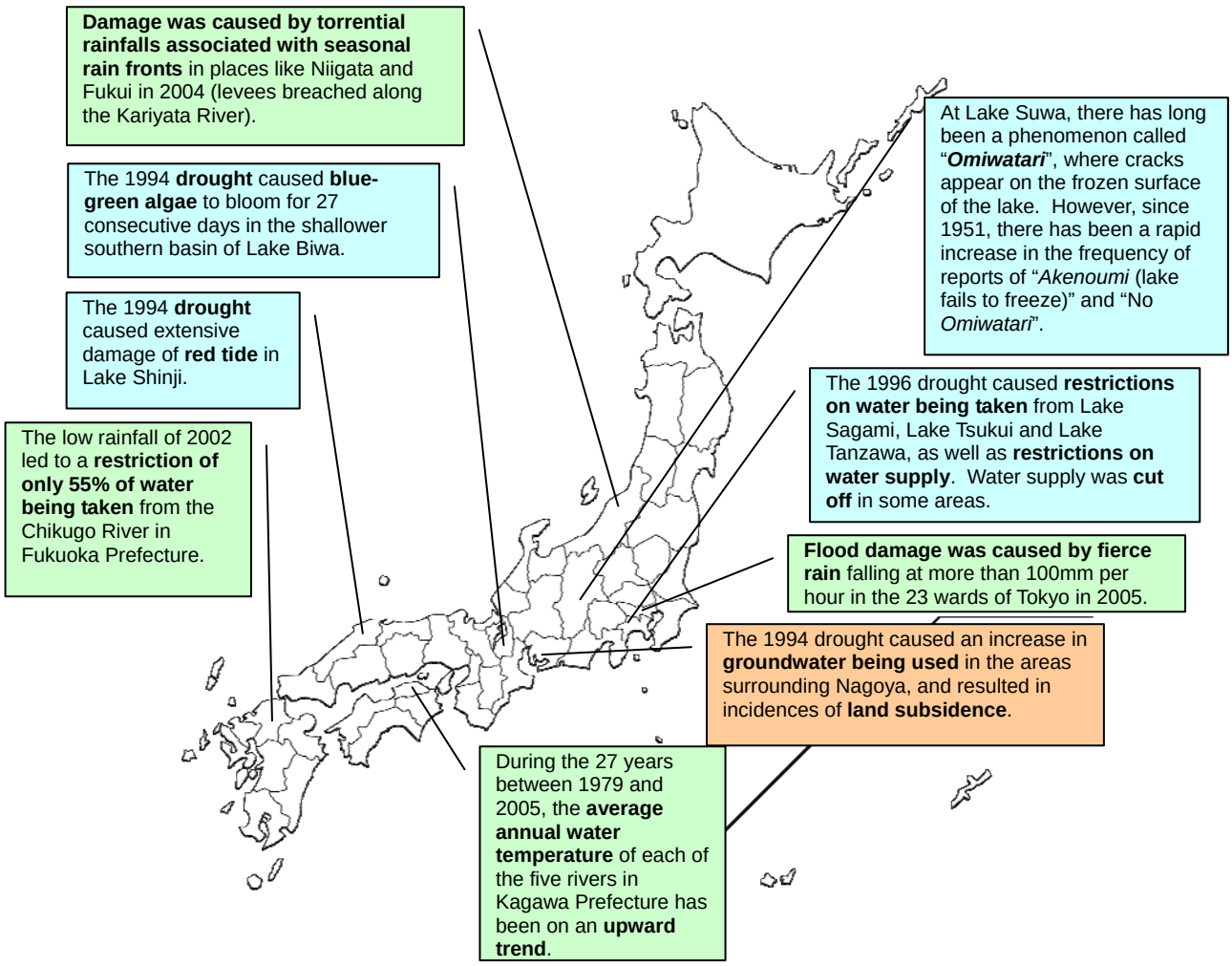


Figure 5 Past examples similar to the events that are feared will result from the advance of climate change

1.2.2 Projected Impacts

Some impacts arise from changes in ordinary phenomena, and others arise from changes in the frequency or intensity of extreme phenomena. There is concern that temporal changes and quantitative changes in the average values of water temperature and precipitation will lead to changes in river flows, reduced snowfalls, changes in the timing of snowmelts, changes in the water levels of lakes, and changes in water quality; and that water supply and ecosystems will be affected. Furthermore, there are also concerns that there will be effects in the form of an increased risk of drought brought about by increases in the frequency and intensity of extreme events, for instance, by more frequent and more seriously low rainfalls. On the other hand, the extreme phenomenon of unusually heavy rainfalls, for instance, an increase in the frequency and intensity of brief localized downpours, will have an impact in the form of an increase in the risk of floods. In cases where sea level rise are anticipated, another projected impact is the salinization of groundwater.

[Main examples of projected impacts]

- Increased risk of drought [Chapter 3 3.3]
- Increased landslide disasters due to higher frequency of short-term, concentrated extreme rainfalls [Chapter 3 3.3]
- Elevated water temperatures in rivers, lakes, dam reservoirs, and groundwater, and increased probability of blue-green algae blooms [Chapter 3 3.3]
- Salinization of groundwater associated with rising sea levels [Chapter 3 3.3], etc.

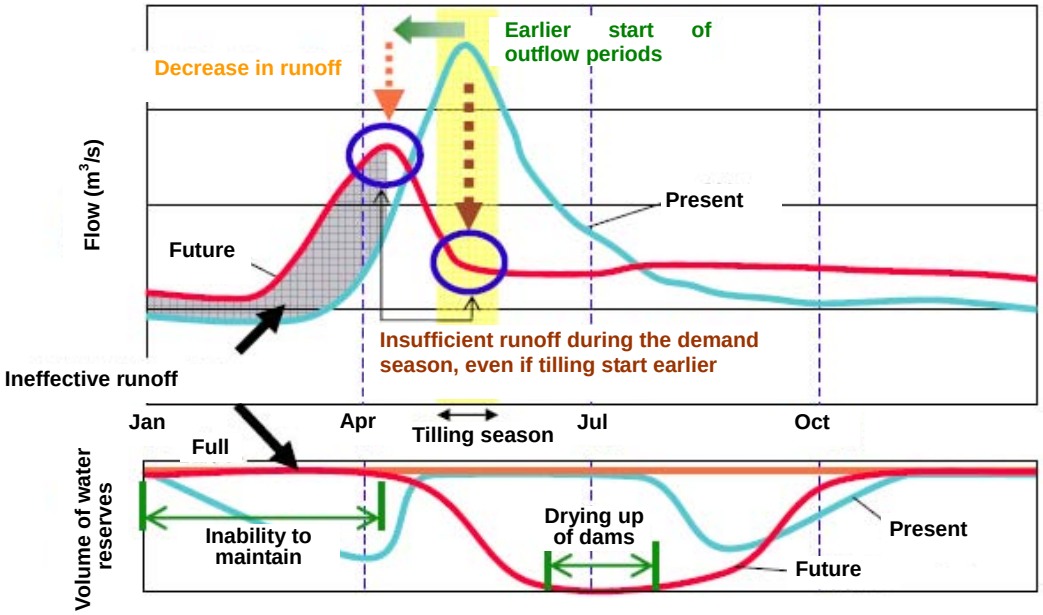


Figure 6 **The possible effects that a decrease in snow (caused by climate-change) might have on water resource security and annual stream-flow fluctuation patterns (impact on the latter is expressed using the volume of water available in dams)**
(Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2007)

1.3 Natural Ecosystems

1.3.1 Observed Impacts

Impacts on natural ecosystems can be broadly divided into effects on forest, alpine, freshwater, ocean, coast or moor ecosystems, and effects on biodiversity. Reports have included changes in vegetation and water areas that form the basis of each ecosystem, and changes in the distribution of living creatures. Moreover, even before the impacts of climate change, the natural ecosystems sector had been greatly affected by human activity, and there are fears that climate change could deliver the final blow to ecosystems that have already deteriorated due to the effects of human activity.

- Decline of Japanese beech forests, pine-tree decay in common wood, and decrease in flora in alpine regions [Chapter 4 4.2]
- Aridification of moors, and a decrease of vegetation in snowfields [Chapter 4 4.2]
- Dispersion of Japanese deer and other species. due to the decrease in snow cover [Chapter 4 4.2]
- Stagnation of vertical circulation of lakes and a reduction in dissolved oxygen at the bottom of lakes [Chapter 4 4.2]
- Reduction of distribution areas for cold-water fish in fresh-water regions [Chapter 4 4.2]
- An increase in southern species and a decrease in northern species along coastal regions, the bleaching and destruction of coral reefs [Chapter 4 4.2]
- Impacts on biological production caused by higher temperatures and lower levels of dissolved oxygen in the Okhotsk Sea and other areas [Chapter 4 4.2]
- Camellia, Japanese *ume*, dandelions and cherry trees, etc., earlier flowering periods; and ginkgo and maple trees etc., later stages of leaves turning yellow, red, and falling. [Chapter 4 4.2]
- Examples in Kyushu , late blooming due to insufficient “dormancy breaking” caused by low temperatures.[Chapter 4 4.2], etc.

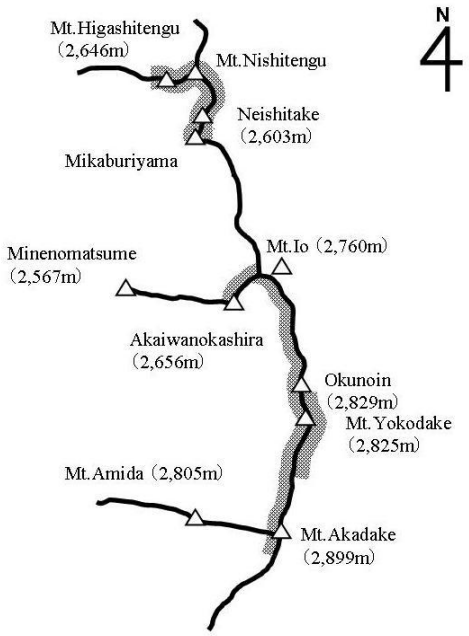


Figure 7 Distribution of alpine plant communities at Yatsugatake

(Masuzawa, 2005)

▒: Alpine plants communities
At present, alpine plant communities only remain along ridgeline areas.

Figure 8 Cases of alpine plants that have affected by climate change

Right: Cassiope
Photographs provided by: Professor Takehiro Masuzawa, Plant Biology Course, Graduate School of Science, Shizuoka University

1.3.2 Projected Impacts

In each of the forest, alpine, freshwater, ocean, coast and moor ecosystems, it is projected that the previously observed impacts will progress further. Although it is expected that the distribution of many organisms will shift northward, there is a strong possibility that the fragmentation of habitats and other factors will halt these northward shifts. There is also the possibility that, depending on the extent of climate change, there will be other irreversible effects, such as the extinction of species caused by the disappearance of places to where living creatures can seek refuge. In lakes, stagnation of vertical circulation will become more widespread, causing complex changes with water pollution and introduced species, and triggering complex changes. In oceans, acidification will continue, affecting plankton and calcified organisms.

[Main examples of projected impacts]

- Decrease in distribution areas suitable for Japanese beech-tree forests, subalpine belts and subarctic coniferous forests, and a rapid decrease in alpine plant communities in Hokkaido [Chapter 4 4.3]
- Expansion of bamboo groves in the Tohoku region, and increase of pine tree decay [Chapter 4 4.3]
- CO_2 Emissions from forest soil in cold districts [Chapter 4 4.3]
- Increased stagnation of vertical circulation in lakes and oceans [Chapter 4 4.3]
- Changes in species distribution in freshwater regions, and invasion of alien species [Chapter 4 4.3]
- Changes in food chain caused by diminishing sea ice in the Okhotsk Sea, and changes in the migration routes of migratory species of fish [Chapter 4 4.3]
- Escalation in the effects on plankton and calcified organisms caused by the ocean acidification [Chapter 4 4.3]
- Increase in coral breaching and disease, and reduce in sandy beach environment. [Chapter 4 4.3], etc.

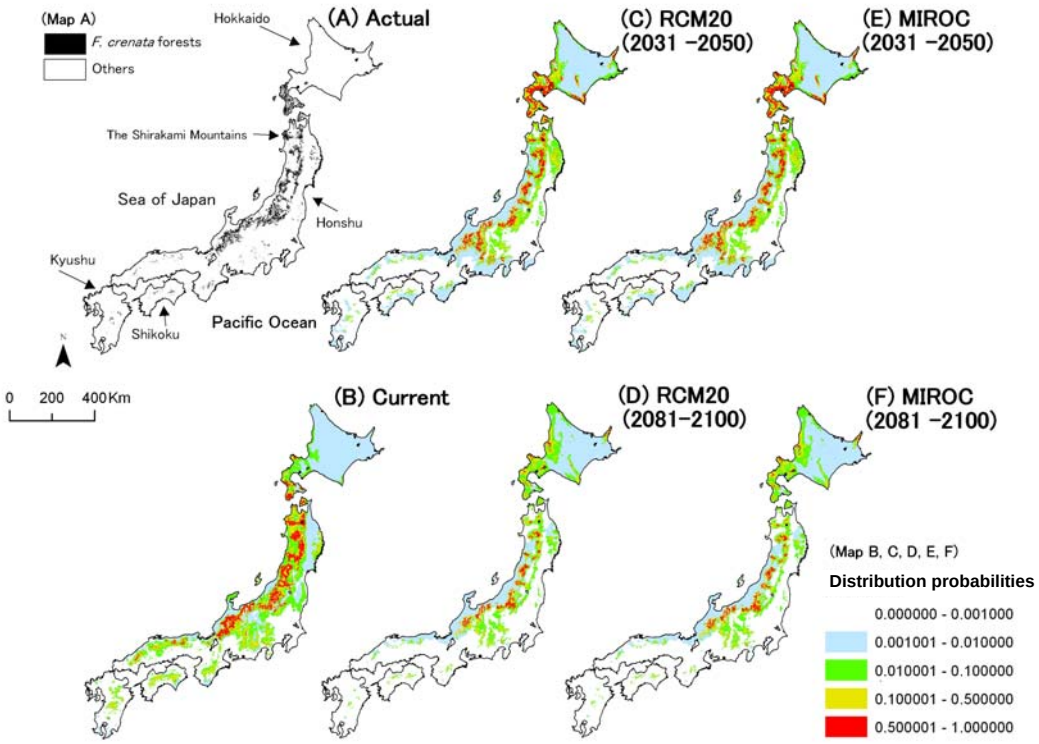


Figure 9 Projected distribution probabilities for Japanese beech forests based on RCM20 and MIROC climate scenarios (Project for the Integrated Prediction of the Impacts of Global Warming, 2008)

1.4 Disaster Prevention and large Coastal Cities

1.4.1 Observed Impacts

Impacts on large coastal cities and protection against disasters can be broadly divided into damage in coastal areas caused by storm surge and the effects of floods and landslides in river basins. Events are occurring which we cannot at present readily determine whether they result from climate change, but which would appear as being likely, or which are believed will increase if climate change advances. In terms of rainfall, in recent years, there has been an increase in the range of fluctuation in annual precipitation: while the overall trend is for lower rainfalls, the frequency of extreme rainfalls has been increasing.

- Damage along the Nabae Coast of Kochi Prefecture caused by storm surge associated with Typhoon No. 23 in 2004 [Chapter 5 5.2]
- Increased frequency of corridor submerging at Itsukushima Shrine [2] [Chapter 5 5.2]
- Inundation damage to underground space due to record levels of extreme rainfalls in northern Kyushu [Chapter 5 5.2]
- Increased frequency of short-term, concentrated extreme rainfalls [Chapter 5 5.2]
- Decrease in the amount of water able to be stably supplied from dams in the Kiso reservoirs [Chapter 5 5.2]

[2] Visual records contained in the shrine journals. Readers should be mindful that there are annual fluctuations.

Figure 10 Photograph of the damage caused along the Nabae Coast in Kochi Prefecture Kochi Prefecture

Photograph provided by: Masaya Fukuhama, Head of the Kurobe Office of River, Ministry of Land, Infrastructure, Transport and Tourism Hokuriku Regional Development Bureau

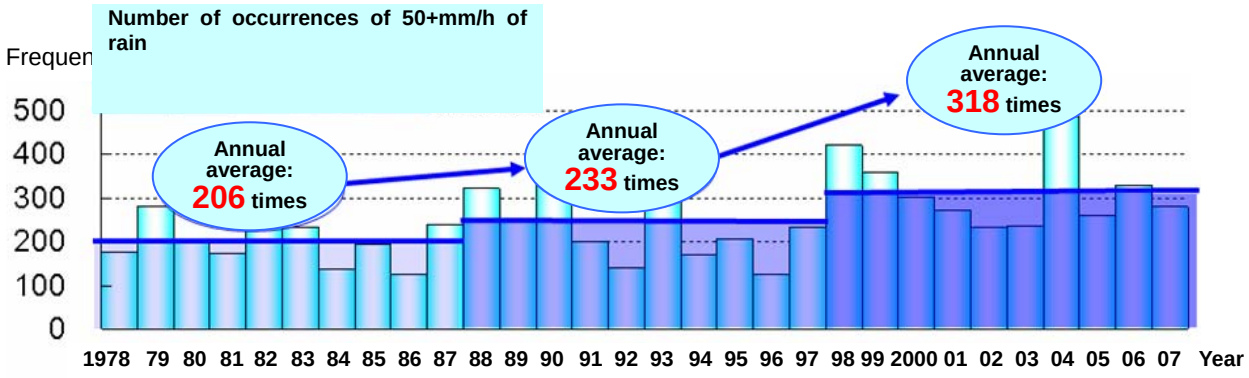


Figure 11 Number of cases of 50mm+ of hourly precipitation by decade (Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2007)

1.4.2 Projected Impacts

In coastal areas, predictions include an increase in damage caused by a combination of storm surge on top of sea level rise, and coastal erosion and the loss of sandy beaches due to sea level rise. Studies are currently underway on the effects of increased upstream river flows and sediment discharges on lower reaches and coastal areas, and the effects of flooding within leveed areas. The possibility has also been raised of shifts in typhoon movements leading to damage from storm surge being caused to areas previously not anticipated.

[Main examples of projected impacts]

- Increased intensity of typhoons [Chapter 5 5.3]
- Possible storm surge damage in bays facing southeast, as a result of shifts in typhoon course [Chapter 5 5.3]
- Increased wind speeds and ocean waves caused by typhoons
- Increase of wave overtopping rates and coastal erosion due to sea level rise [Chapter 5 5.3]
- Erosion and loss of sandy beaches due to sea level rise (disappearance of 90% of sandy beach will disappear with a one-meter rise in sea levels) [Chapter 5 5.3]
- Decrease in flood control safety levels for all of Japan's water systems [Chapter 5 5.3]
- Increased frequency of landslide disasters due to snowmelt [Chapter 5 5.3], etc.

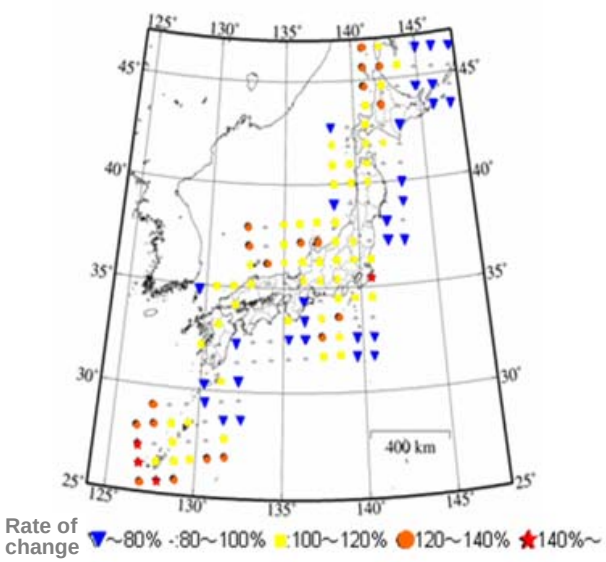


Figure 12 Changes in 100 year maximum daily precipitation (50 years later / at present)

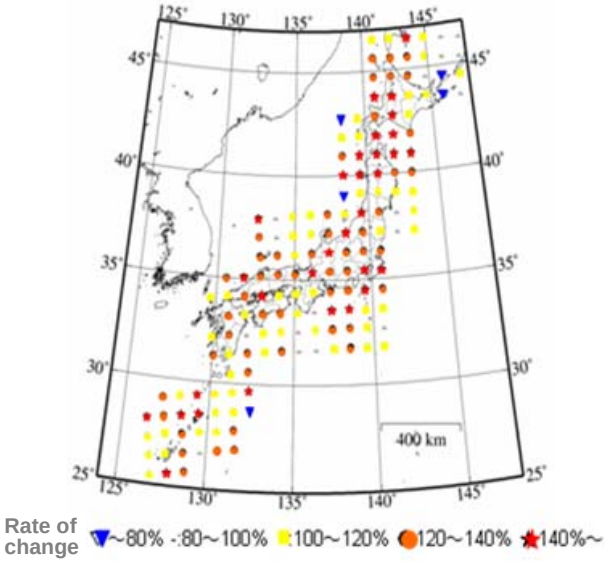


Figure 13 Changes in 100 year maximum daily precipitation (100 years later / at present)

1.5 Health

1.5.1 Observed Impacts

Impacts of climate change on human health can be broadly divided into: direct effects caused by summer heat; and indirect effects, such as through infectious diseases, air pollution, large-scale natural disasters, harmful insects, and so on. In terms of the effects caused by heat, there have been reports on an increase in the mortality rates of patients with cardiovascular and respiratory diseases, and an increase in the number of heatstroke patients. In terms of infectious diseases, there have been reports on changes in the distribution of vectors of infectious diseases, including a new penetration of mosquitoes transmitting Japanese encephalitis from Southeast Asia, and a northward shift in the domestic distribution of the Asian tiger mosquito, which is a mosquito that transmits such diseases as dengue fever. There have also been reports on a northward shift of areas where waterborne bacteria which cause infection have been detected in seawater.

- Increase in excess mortality due to heat stress [Chapter 6 6.2]
- Record high numbers of heat stroke patients[3] seen in many cities in 2007 (Total number of patients in Tokyo and 17 ordinance-designated cities exceeded 5,000) [Chapter 6 6.2]
- Expansion of distribution area of the Asian tiger mosquito transmitting dengue fever and other diseases, and a new invasion of mosquitoes transmitting Japanese encephalitis from Southeast Asia [Chapter 6 6.2]
- Northward shift of areas where *Vibrio vulnificus* is being detected in seawater [Chapter 6 6.2], etc.

[3] The number of heatstroke patients here refers to the number of patients who were transported by ambulance within a jurisdiction controlled by the Fire and Disaster Management Agency or Fire Department. It does not include the number of patients who went directly to the medical institution without using an ambulance, or the number of patients who did not go to a medical institution.

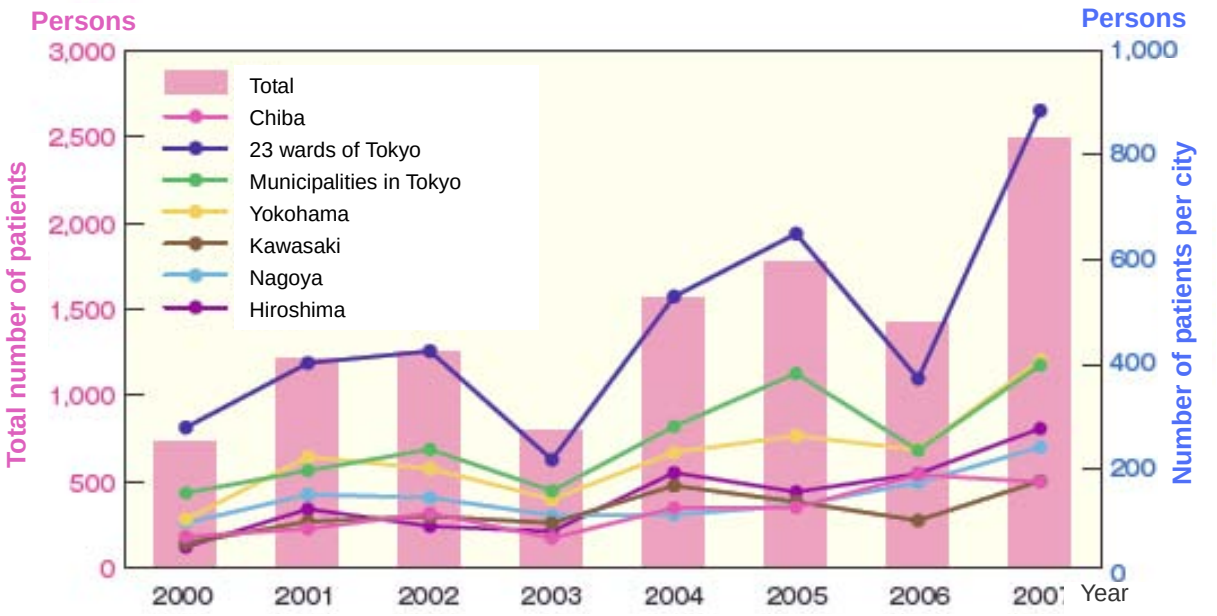


Figure 14　Trends in number of heat stroke patients per city

Data provided by: Masashi Ono, Director of the Integrated Health Risk Assessment Section, Environmental Health Sciences Division, National Institute for Environmental Studies

1.5.2 Projected Impacts

In terms of the impacts of summer heat, it is predicted that there will be an increase in the risk of death caused by heat stress, and in particular, an increase in the number of patients with cardiovascular disease. Other predictions include an increase in the number of heatstroke patients, and an increase in nighttime sleeping disorders associated with an increase in the number of tropical nights. It is expected that these heat induced impacts will be significant particularly among the elderly. In terms of infectious diseases, it is predicted that the northward shift in the distribution of the Asian tiger mosquito in the Tohoku and Hokkaido regions, plus the penetration of the yellow-fever mosquito into Japan, will lead to the whole of Japan becoming at risk of dengue fever and chikungunya fever epidemics. It is also predicted that the areas where cases of Japanese encephalitis arise will shift northward.

[Main examples of projected impacts]

- Increase in excess mortality due to heat stress [Chapter 6 6.3]
- Increase in number of heat stroke patients (Tokyo-based projection) [Chapter 6 6.3]
- Possible expansion of distribution area of dengue-transmitting Asian tiger mosquitoes and yellow-fever mosquitoes [Chapter 6 6.3], etc.

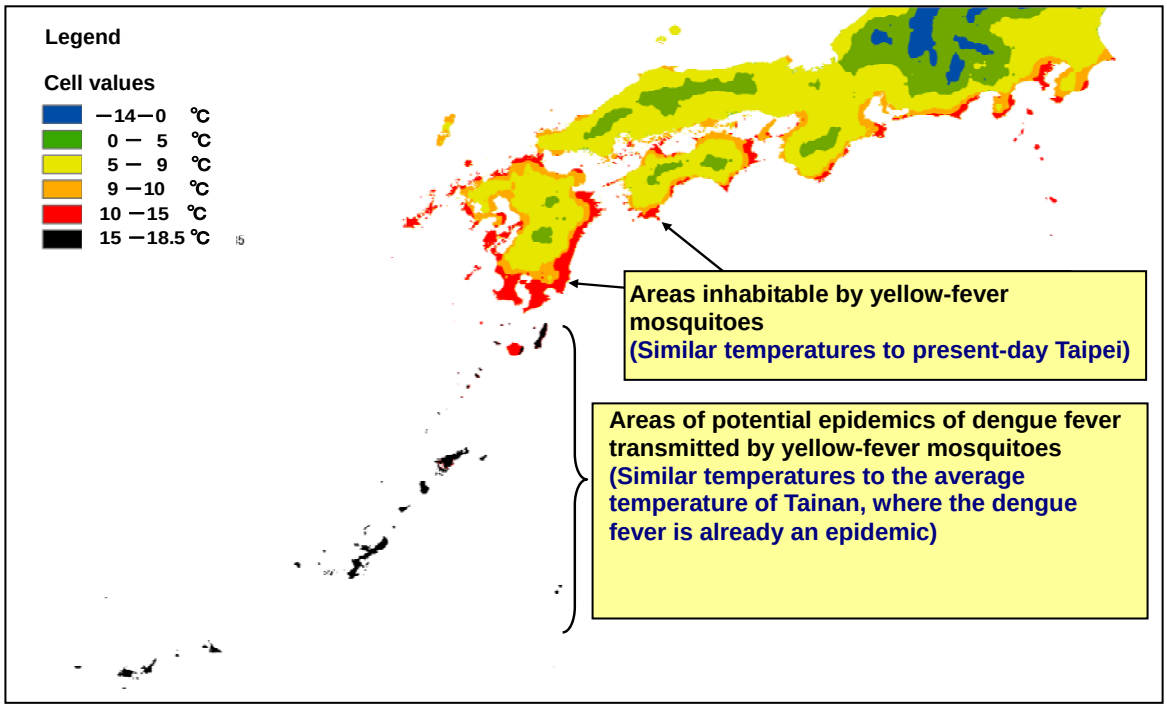


Figure 15 Projected average January temperatures and expanded distribution of the yellow-fever mosquitoes (2100)

(Kobayashi et al., 2008)

1.6 Citizen's Life and Urban Life

1.6.1 Observed Impacts

Impacts on citizen's life and urban life of Japan are closely related to the lives of each and every citizen, and are phenomena that people experience in their everyday lives. By focusing on phased classifications of people's lives, namely, whether they can live securely, healthily, affluently and comfortably and in a way that they can get a sense of culture and history, we can summarize impacts according to the effects described in sections 1.1 - 1.5 above and to the viewpoint of the extent characteristic phenomena affect people's lives.

- Rise international prices for wheat, corn, and soybeans, etc.[4] [Chapter 7 7.2]
- Earlier blossoming of Japanese *ume* and cherry trees, etc.; and deciduous trees turning colors and falling their leaves later [Chapter 7 7.2]
- Impact by changes of natural environment and climate condition in the tourist and sports industries [Chapter 7 7.2]
- Increased frequency of reports of "*Akenoumi* (lake fails to freeze)" and "No *Omiwatari*" at Lake Suwa, where there has long been a phenomenon called "*Omiwatari*", where cracks appear on the frozen surface of the lake [Chapter 7 7.2]
- Increased frequency of corridor submerging at Itsukushima Shrine [Chapter 7 7.2], etc.

Figure 16
View of the "*Omiwatari*" at Lake Suwa (circa 1980)

(Reproduced using a photogravure from the Historical Volumes of Suwa City)

[4] Rising international prices are not only affected by climate change. They are also related to various other factors including increases in the demand for food attributable to the economic development of population superpowers such as China and India, and increases in the global demand for cereals and other crops as sources of biofuel.

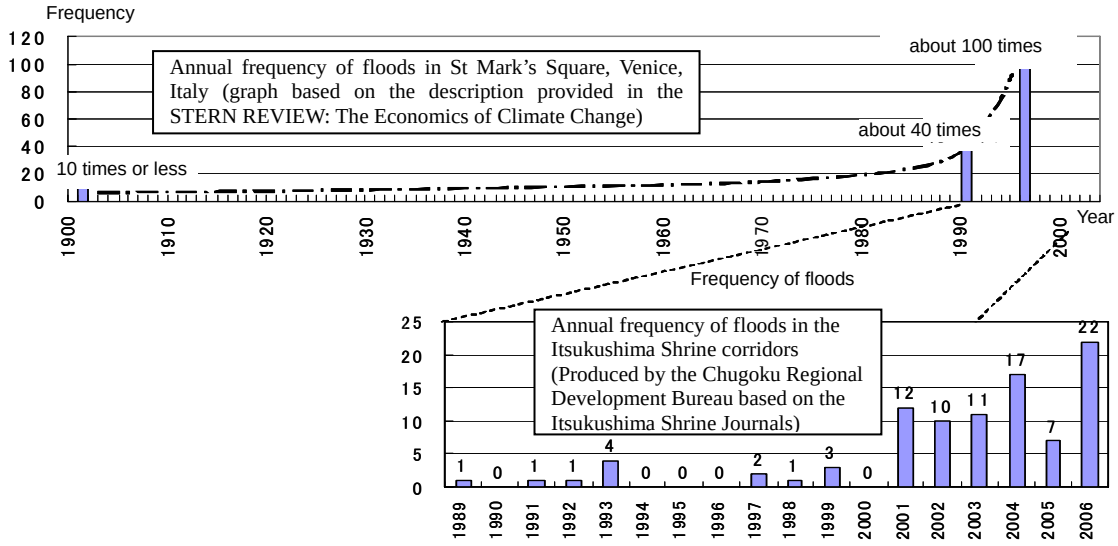


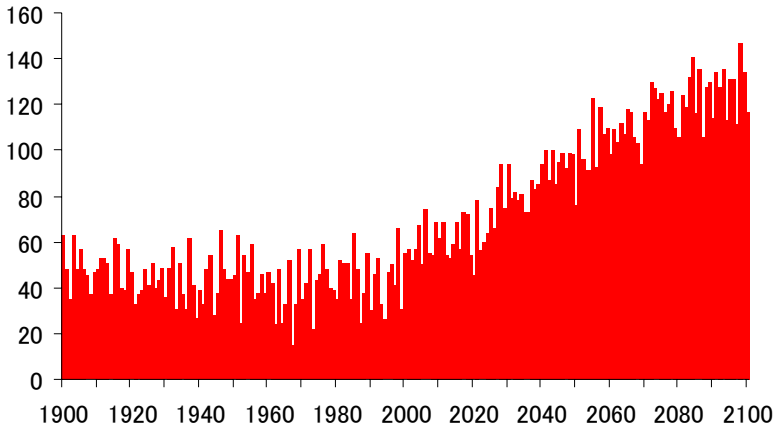
Figure 17 Increase in the frequency of the Itsukushima Shrine corridors being submerged
(Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2007)

1.6.2 Projected Impacts

It is projected that the impacts on citizen's life and urban life of Japan will affect people's lives in a wide range of areas, from impacts related to safety and human life, through to effects on economical lifestyles and effects related to more high-order emotional needs. It is thought that these effects will vary in type and degree depending on the habitat (urban area, rural area) and the subject (individual, household, elderly, educational institution, local government, etc.) being affected.

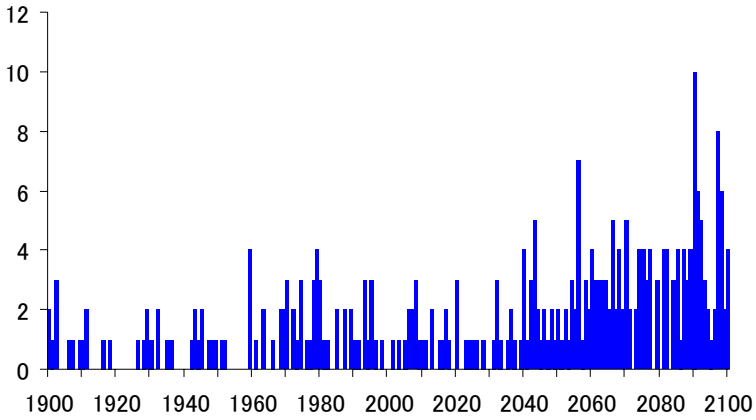
[Main examples of projected impacts]

- Loss of human life, property and human habitats, due to extreme weather damage [Chapter 7 7.3]
- Impacts on regional transportation and communications facilities due to extreme weather. [Chapter 7 7.3]
- Increases in deaths, heat stroke and infectious diseases caused by heat waves [Chapter 7 7.3]
- Increased burden on household budgets due to the increased prices of agricultural products and the extended use of air conditioning [Chapter 7 7.3]
- Increases of discomfort in everyday life due to an increase of extremely hot days and hot nights [Chapter 7 7.3]
- Impacts on tourist industries and opportunities for recreation, due to a decrease in alpine plants and other changes in ecosystems, and to the loss of sandy beaches, and the decrease in wetlands and other such factors [Chapter 7 7.3]
- Impacts on sports industry due to less snowfall and later snow seasons [Chapter 7 7.3]
- Impacts on local culture and loss of a sense of the seasons due to snow seasons shortages and changes in cherry blossom season [Chapter 7 7.3], etc.



Change in the number of tropical days calculated in Japan between 1900 and 2100 (results for 2001 and later use the "A1B" scenario). If even one of the cells covering the Japanese archipelago (approximately 100km x 100km) has a maximum temperature exceeding 30 degrees Celsius, it is counted as a tropical day. Since urbanization has not been taken into account, and since it is based on average values over broad areas, absolute values cannot be directly compared with observation data. Only relative changes are significant.

Figure 18 Number of hot days (maximum temperature is more than 30 C) in Japan (unit: days) (Combined research team(Tokyo University etc.),2004)



Change in the number of summer days (Jun-Aug) with torrential rains calculated in Japan between 1900 and 2100 (results for 2001 and later use the "A1B" scenario). If even one of the cells covering the Japanese archipelago (approximately 100km x 100km) has a daily precipitation exceeding 100mm, it is counted as a day with torrential rainfall. Since it is based on average values over broad areas, absolute values cannot be directly compared with observation data. Only relative changes are significant.

Figure 19 Number of summer days with extreme rainfalls in Japan (unit: days) (Combined research team(Tokyo University etc.),2004)

1.7 Developing Countries

1.7.1 Observed Impacts

Developing countries in the Asia-Pacific region have extremely diverse natural and social conditions. Impacts on these developing countries can be broadly divided into: effects on natural systems, such as cryospheres, water resources and ecosystems; and effects on social systems, such as human health and coastal/urban areas. In terms of natural systems, there have been reports on the rapid melting of permafrost and glaciers, increases in the intensity and scope of forest fires, deterioration of grasslands and wetlands, and shifts of many animal and plant species to higher and more northerly locations. In terms of social systems, there have been reports on the emergence of effects on human health, the effects of rising sea levels on coastal areas, and increases in the intensity and frequency of extreme weather events.

- Increases in the frequency of glacier lake outbursts as a result of the rapid melting of glaciers [Chapter 8 8.2]
- Incidence of water shortages in certain parts of China, caused by the depletion of lakes and rivers [Chapter 8 8.2]
- Severe deterioration of wetlands and other ecosystems in the delta regions of Pakistan, Bangladesh, India and China [Chapter 8 8.2]
- Considerable number of deaths in several states in India due to the heat waves of recent years [Chapter 8 8.2]
- Large numbers of cyclone victims in places like Bangladesh and Myanmar, etc.

settlement
(right bank of Bago river, at the 21km from the river mouth)
(parol evidence) flooded to around 15cm in a road.
2008.5.14 11:36

on a river
(left bank of Bago river, at the 43km from the a river mouth)
(parol evidence) The tide level of the storm surge was at the same level as the greatest tide level of the wet season..
2008.5.14 16:27

Figure 20 Damage caused by storm surge in Myanmar

Photographs provided by: Tomoya Shibayama and Hiroshi Takagi Laboratory, Yokohama National University

1.7.2 Projected Impacts

In terms of the impacts on developing countries in the Asia-Pacific region, it is predicted that there will be an increase in floods and debris avalanches caused by glacier melts, a decrease in available freshwater in the catchment areas of large rivers, adverse effects on ecosystems and biodiversity, risks of starvation in some developing countries, an increase in floods in densely populated mega-delta areas, and increases in morbidity and mortality rates arising from diarrheal diseases in the wake of floods and droughts. Particularly in small islands, it is predicted that rising sea levels will lead to a decrease in land area, damage caused by inundation, a decrease in freshwater lenses, effects on indigenous species and coral reefs, and a decline in the tourism industries.

[Main examples of projected impacts]

- Increase in floods, etc. caused by the melting of glaciers in the Himalayas [Chapter 8 8.3]
- Adverse effects on more than 1 billion people by 2050 as a result of a decrease in available freshwater [Chapter 8 8.3]
- By the middle of the 21st century, crop productions will increase by up to 20% in East Asia and Southeast Asia, but will decrease by up to 30% in Central Asia and South Asia [Chapter 8 8.3]
- In particular, the densely populated mega-deltas in South Asia, East Asia and Southeast Asia will be faced with the risk of increased floods [Chapter 8 8.3]
- Rising sea levels in small islands will lead to a decrease in land area, effects on infrastructure, and a decline in tourism industries, etc.

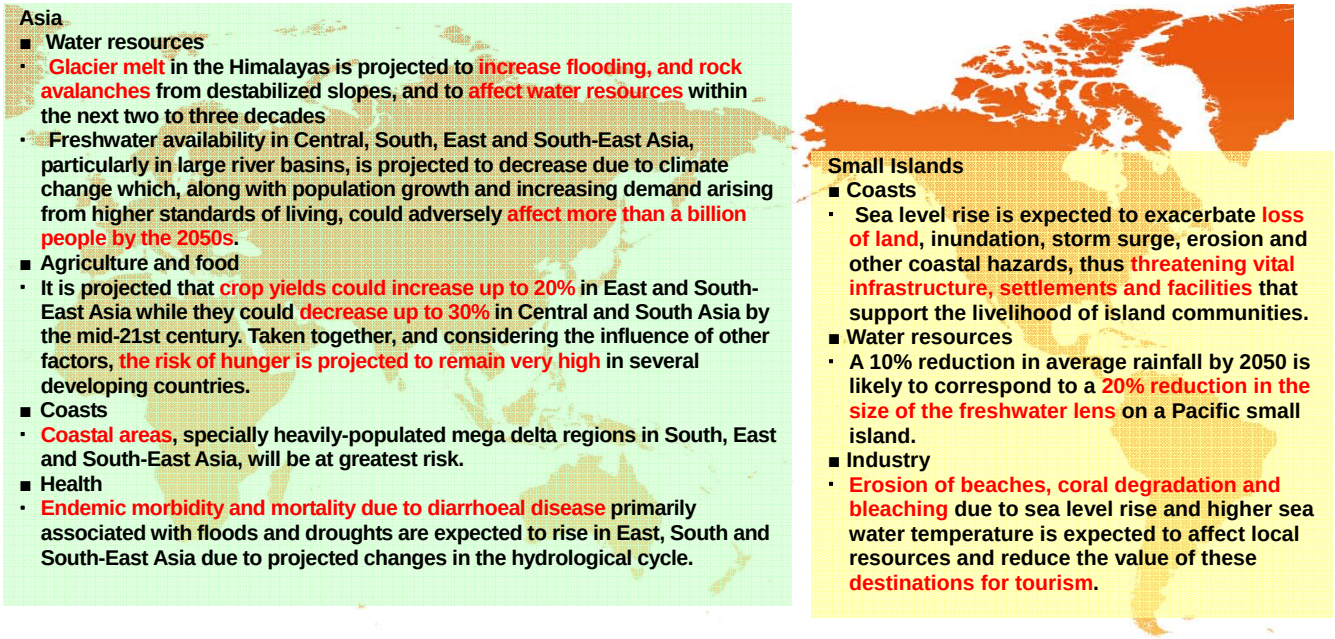


Figure 21 Examples of projected impacts in developing countries (Produced by the IPCC, 2007)

1.8 Other Impacts

Although a specific working group for the effects and adaptation in the industrial sector has not been established in this review, it is envisaged that climate change will also have various effects on industry. For example, there is potential for impacts on the manufacturing industry (such as changes in revenue from the sale of household appliances, clothing, food and beverages, etc., and the effects of extreme weather events on production lines and on facilities located along the coast), impacts on power producers (such as changes in power demands, and the effects of rising sea levels on facilities located along the coast), and impacts on the insurance industry (such as increases in the amounts paid on insurance claims as a result of disasters).

Furthermore, there are fears that, as climate change advances, geopolitical problems will arise which could develop into international disputes. For example, the emergence of new shipping routes as a result of melting sea ice in the Arctic Ocean, and the erosion and submergence of places like Okinotorishima Island due to rising sea levels have the potential to give rise to issues involving the territorial lands and seas of the nations concerned. Moreover, in regions where it is predicted that rising sea levels will lead to the disappearance of land, as in Tuvalu, there may be an emergence of environmental refugees.

2. Adaptation

2.1 What is "Adaptation"?

- **Adaptation refers to making adjustments in natural or human systems in response to climate change.**

The IPCC Fourth Assessment Report refers to "adaptation" as the "adjustment in natural or human systems in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities".[5]

The same report refers to "adaptive capacity" as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences".[6]

- **This review focuses on adaptation that is intentionally implemented by humans.**

In this review, a decision was made to focus on adaptation that is intentionally implemented by humans for the purpose of protecting social safety, human life, health, convenience, comfort and other such factors. In other words, the review has mostly targeted adaptation that is undertaken at the decision of policymakers in national and local governments, and adaptation that is intentionally undertaken by individuals or communities, etc. Further, in this review, it was decided to use the expression "adaptation measures" when referring to specific individual adaptation at the policy or measures level.

- **Although the review does not cover biological adaptation, it needs to be considered.**

In the fields of biology and ecology, an individual organism responding to an environmental change autonomously or through evolution is called "adaptation". In this review, this kind of adaptation has generally not been included within the scope of the review. However, when considering adaptation measures in the natural ecosystems sector, biological adaptation and acclimatization[7] by organisms adjusting of their own accord cannot be ignored. In view of this, in the natural ecosystems sector, it was decided to also take into account adaptation in the biological sense of the term, and attention was paid to using terminology appropriately so as not to cause misunderstanding.

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[5] Source: Glossary, Working Group II Report, IPCC Fourth Assessment Report
Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

[6] Source: End box 1, Summary for Policymakers, Working Group II Report, IPCC Fourth Assessment Report

[7] Changing of the functions, qualities or appearance of an organism in accordance with persistent changes of the external conditions to which it is subject.

2.2 What is “Wise Adaptation”?

2.2.1 Processes related to the Implementation of Adaptation Measures

In order to increase the effectiveness of adaptation, it is important to build a mechanism comprised of the following processes: understand the current situation (monitor, build databases, etc.) → predict impacts → formulate policies → implement → evaluate. Particularly in developing countries, even if we attempt to predict the impacts and formulate policies, in many cases, the data that forms the basis for such predictions and policies is not yet developed. Therefore, it is essential that we first put effort into understanding the current situation by monitoring and proceeding to accumulate data.

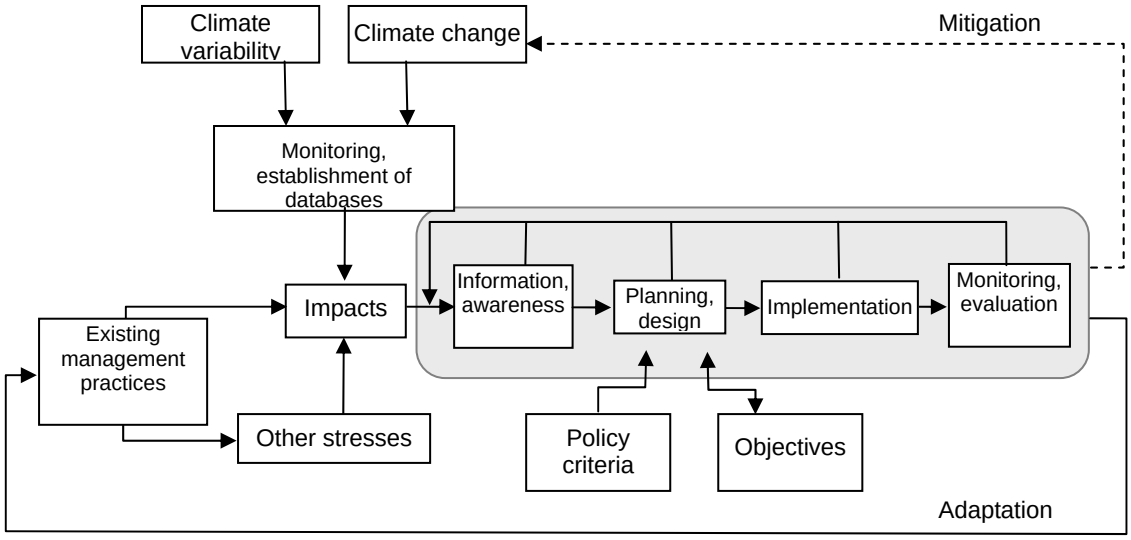

Figure 22 Processes in an adaptation measure (partially modified from Klein et al., 1999)

2.2.2 Specific Elements that Make up Wise Adaptation

(1) Promotion of regional vulnerability assessments

In implementing adaptation measures for climate change, it would be difficult to call the supplementation or expansion of a program in a way that just treats the symptoms "effective and efficient adaptation". What is needed is to systematically implement scientifically rational supplements and reviews of programs based on vulnerability assessments associated with climate change. It also needs to be kept in mind that it is possible that, as the result of a regional vulnerability assessment, it may be necessary to review the order of priority between program areas or the priority of regions within a single program.

In vulnerability assessments, it is also important to develop methods that are used in assessing vulnerability and risks, by utilizing information that exists locally. In particular, in least developed countries (LDC) and other such regions, it is important to secure the foundation for livelihood and achieve sustainable development by implementing adaptation measures that are based on appropriate vulnerability assessments and in a way that is centered on grassroots-level communities.

(2) Monitoring, and adoption of early warning systems that utilize monitoring

Monitoring the impacts of climate change is important for the regional vulnerability assessments raised in the preceding paragraph. Monitoring technologies and systems need to be developed which enable a more detailed understanding and assessment, such as the wide-area comprehension of data to allow a consistent assessment across an entire region, and the identification of fluctuations on a seasonal or daily basis.

Furthermore, in both Japan and developing countries alike, the introduction of systems that provide early warnings to the general public by making use of the data and information obtained through monitoring are important initiatives. In particular, responses such as issuing warnings against ensuing damage are effective ways of coping with the effects caused by extreme events. One of the premises for adopting these kinds of early warning systems is that it is necessary to clarify the level for a specific indicator at which damage will be realized.

In some cases, it takes time for positive effects to be produced from non-structural measures, such as monitoring and the development and introduction of early warning systems. In order to implement more effective and efficient adaptation from a long-term perspective, these kinds of non-structural measures need to be emphasized, and care needs to be taken so that structural programs that just treat symptoms are not simply rushed offhandedly.

(3) Utilization of a diverse range of options

Usually, there are various options for adaptation measures. Whilst there is infrastructure development and other structural measures on the one hand, there are also non-structural measures on the other. By focusing on the approaches of adaptation measures, we can divide the measures into several categories, including: technical measures, legal system development, insurance and other economical techniques, information preparation, and human resources development. Furthermore, in terms of the relationship between when effects are felt and when adaptation measures are implemented, there are those adaptation measures that are implemented preventively in order to minimize damage, and there are those that prepare for responses after damage has been suffered. From the perspective of risk management, we can also view adaptation measures as being divided between fundamental risk avoidance measures and risk mitigation measures, risk transfer measures, etc.

For example, in the disaster prevention sector, adaptation measures can be broadly divided into: protection, accommodation and retreat. Protection refers to preventing damage by means of structures, etc. In areas with high concentrations of people or assets, a high level of protection is needed against storm surges. Accommodation refers to such acts as devising life styles and building structures, or improving retreat systems through the production of hazard maps. Accommodation can be effective in situations where otherwise implementing protection is unrealistic in terms of costs, etc., or where there are concerns for the impact on the natural environment. Retreat refers to withdrawing from very sparsely populated areas without protection, and accepting high tides and coastal erosion, leaving nature to run its course. These measures are not merely adopted in an exclusive fashion: it is important to aim for a two-pronged or three-pronged combination of measures to protect against and mitigate the effects of disasters.

In wise adaptation, it is important to effectively combine and utilize adaptation measures according to time, place and opportunity, by systematically organizing the various options for adaptation measures in this way, and considering the applicability of effective options used in other areas from a cross-sectoral viewpoint.

(4) Utilization of both long-term and short-term perspectives

In recent years, with the melting of sea ice at the North Pole and other events, certain phenomena have been identified which suggest that the speed at which climate change is advancing is considerably faster than previously imagined. Furthermore, numerous phenomena have been observed which predict that the occurrence of extreme weather events in various parts of the world will increase in frequency as climate change advances. In this situation, we need to adopt a short-term viewpoint focused a few years into the future, and implement adaptation measures by making decisions with existing scientific knowledge and within a range of uncertainty.

On the other hand, adaptation measures for climate change also have certain elements that reshape territories and local communities on a comprehensive and long-term basis. Therefore, we also need to focus on responses from a long-term perspective, which are related to such issues as urban planning and social infrastructure development.

In implementing adaptation measures, it is important to look at both long-term responses and short-term responses, and to implement those adaptation measures that are necessary from each respective view in a way that, overall, measures are effective and efficient.

(5) Utilization of observation results, and introduction of adaptation measures that ensure a certain degree of clearance

Climate scenarios and the projected impacts in each sector involve uncertainty. In cases where a long-term adaptation plan has been formulated based on these scenarios and projections, then ultimately, at a certain point in formulating the adaptation plan, there is a risk that the previous investment will have been in vain and that inevitably the plan will have to be changed if predicted values are revised according to projections based on new scientific knowledge. Furthermore, with adaptation plans that are based on projections premised on uncertainty, there are difficulties in obtaining a consensus among the parties concerned, and if a situation arises that is more serious than first predicted, it is possible that budgetary and other measures will not be enough, and the response to the situation will be too late.

Based on this perspective, then for effective and efficient adaptation, rather than adaptation measures that rely too much on projections, more effective measures are those which maximize the use of previous observation results and which always ensure a certain degree of allowance by adding to the amount of change observed.

For example, in the protection against disasters sector, a possible approach would be to, when replacing structures or when carrying out post-disaster restoration, first design structures by incorporating the sea level rise that has actually been observed in the past, and

then when making further subsequent replacements, since climate change phenomena will have become clearer, as well as actual sea level rises, also incorporate into the designs the amount by which sea levels are projected to rise during the lifetime of the structure. In addition to preventing overinvestment and contributing to the facilitation of consensus-building among the parties concerned, this kind of approach can be perceived as being a realistic method that gradually "accommodates coastal structures to climate change" with certainty that the measures will not be too late.

This approach of adopting adaptation measures which utilize observation results and which ensure a certain degree of clearance could also be applied to other sectors besides the protection against disasters sector.

(6) Mainstreaming of adaptation

In the field of development assistance, there is a concept called "mainstreaming adaptation", whereby, rather than drawing up a new policy or program for adaptation, it is incorporated into existing policies and plans as a matter for consideration. Hardly any adaptation measures are implemented only for the purpose of dealing with climate change: they are mostly implemented as part of, for instance, water resources management, coastal protection, disaster prevention plans, and programs for the prevention of infectious diseases. In actual fact, there is already a wealth of experience in these fields related to various measures against natural changes.

Domestically in Japan as well, it is important that the perspective of adaptation to climate change be incorporated into such plans and policies as land-use plans, urban plans, agricultural policies, nature conservation policies and local government environmental policies. In developing countries, although arguments in recent years have tended to question the need for new activities and funding related to adaptation, similarly, in line with the philosophy of mainstreaming, efforts need to be made for the effective use of all resources by implementing additional adaptation measures for existing countermeasures and funds.

In order to realize "mainstreaming", it is vital that persons in Japan responsible for policy areas other than climate change, and persons in developing countries responsible for development assistance hold a view for adaptation and put it into practical use at the working level. It is also important that there be human resources development and public awareness policies to enable this. Furthermore, recipients of assistance need to be prepared so that climate change experts can travel to the development field and put their expertise to best use.

(7) Effective and efficient realization of low-vulnerability "systems with flexible response capacity"

Given both long-term and short-term perspectives, the ultimate objective of "wise adaptation" is not adaptation that just treats the symptoms of climate change; but rather the building of "systems that have flexible response capacity" to climate change, whereby the potential vulnerability of the various systems to the impacts of climate change are mitigated and their character improved.

For example, water resources are used in a variety of areas, including in household and agriculture. By improving the current water utilization system so that water can be arranged flexibly in times of crisis, improvements can be made to the system so that it has a higher adaptive capacity. The review of actual urban structures coupled with heat island countermeasures also has the potential to make a low-vulnerability system architecture. Furthermore, in the natural ecosystems sector, converting artificial forests to natural forests, and securing ecological corridors and refugia will lead to the protection of ecosystems that can withstand the impacts of climate change, and will contribute significantly to the actual preservation of biodiversity.

(8) Promotion of co-benefit-type adaptation

It is preferable that adaptation measures can bring co-benefits for local environment, society, economy or mitigation of climate change as well as realization of its own objective. If co-benefits are expected, the cost for the adaptation measure can be discounted.

For example, tree planting is a beneficial measure for mitigation (sequestration of CO2), prevention of disasters, securing of water resource, conservation of biodiversity, and enhancement of amenity as well as adaptation. If the measures implemented so far originally for other purposes (ex. measures for raising the rate of food self-support, desalinization of sea water in drought-prone areas, establishment of natural sanctuaries, surveillance of infectious diseases etc.) can have benefits of adaptation, they also can be referred to as co-beneficial adaptation measures. It should be noted that on the contrary, the adaptation measures that cause a great amount of greenhouse gas emissions or other environmental and/or socio-economic problems are not recommended.

(9) Improvement of society-wide adaptive capacity by utilizing insurance and other economic systems

Insurance and other economic systems are effective as mechanisms for diversifying and transferring the risks related to the damage caused to buildings and agricultural products by floods and typhoons associated with climate change. These mechanisms need to be institutionalized and their use promoted as a measure for improving the adaptive capacity of

society as a whole, referring to weather derivatives and other systems that are already in use, for their operation..

(10) Development of systems of cooperation and coalition with relevant organizations

As previously mentioned, the impacts of climate change are wide ranging, and they can spread to secondary and tertiary effects in various aspects of people's lives. Accordingly, in implementing adaptation measures, cross-sectoral systems also need to be built. For example, just as with the organization of a committee on heatstroke to liaise between the relevant ministries and agencies, coordination between relevant organizations may be important.

With regard to assistance for developing countries, it is important for there to be coordination between such organizations as the Japan International Cooperation Agency (JICA), which is involved in implementing assistance, and the researchers and environmental administrations that provide knowledge and views on climate change, as well as local government organizations, research institutions, NGOs, local communities, international organizations such as the United Nations, and regional organizations such as the Asian Development Bank (ADB) and the South Pacific Regional Environment Programme (SPREP).

(11) Promotion of voluntary initiatives through entities that allow for a detailed approach at the local site

Since the types and scale of impacts attributable to climate change vary significantly depending on the geographical characteristics of the affected area, with adaptation measures that are to be adopted to counter such effects, independent field investigations and local initiatives are important, even more so than in the case of emissions reductions. Consequently, in addition to just the central government and big businesses, individuals, communities, local governments, primary industry workers and small and medium-sized enterprises need to have a good understanding themselves of the impacts of, and adaptation to, climate change, and they need to voluntarily engage in detailed initiatives at the local level.

(12) Development of human resources

Given that not enough progress has necessarily been made in understanding adaptation measures, going forward: capacity building of experts will need to conduct research on the impacts and adaptation measures in each sector, and who can implement the measures; advisors and facilitators will need to be trained who can communicate to a wide range of entities the significance of adaptation measures and their specific means of implementation

in a way that is easy to understand; and there will need to be effective public awareness policies that stimulate the various bodies into conducting their own initiatives.

Moreover, especially in cases where wide-area vulnerability assessments are to be conducted in different areas, monitoring methods that cover a large area using volunteers and others who have acquired a certain level of knowledge and skills, for instance, may prove effective depending on the sector. There needs to be active promotion of the development of standardized techniques for this type of monitoring, the training of volunteers and others, and the development and utilization of vulnerability assessment techniques that are able to make the best use of those volunteers.

In some cases, it might take time before the development of human resources produces an effect. Even still, effort for these non-structural measures is important for more efficient and effective adaptation.

2.2.3 Perspectives for Assessing Wise Adaptation

In encouraging the implementation of wise adaptation, there will need to be perspectives for assessing which adaptation is "wise adaptation". In view of the specific elements that make up wise adaptation, which were indicated in section 2.2.2, it is also conceivable to assess the appropriateness of adaptation measures by supposing a number of assessment perspectives like those below for instance.

Table 1 Example of assessing wise adaptation

Technology perspective	• Have a diverse range of options been examined and employed? • In instances that involve uncertainty in the projections, have observation results been used in examining the measures? • Has a certain degree of allowance premised on the uncertainty of projections been secured in the adaptation measures? • Have non-structural measures been appropriately incorporated, such as any necessary monitoring and human resources development?
Policy perspective	• Have systems of cooperation and alliance with relevant organizations been developed? • Have measures been considered from both long-term and short-term perspectives? • Have efforts been made for mainstreaming adaptation? (Has adaptation been incorporated into existing programs? …) • Has consideration been given to responses for extreme weather and other unexpected impacts? (Have systems been developed that appropriately predict disasters before they strike? …)
Socio-economic perspective	• Have voluntary initiatives been incorporated, run by entities that allow for a detailed approach at the coalface? • Have the results of regional vulnerability assessments been taken into account? • Have appropriate economic systems been prepared, such as compensation for damage?

One already existing example related to the assessment of adaptation is the Assessment & Design for Adaptation to Climate Change (ADAPT). ADAPT is a tool for assessing and designing adaptation to climate change, and was released as a prototype by the World Bank in 2007. It identifies risks attributable to climate change at the planning and design stage of agricultural and natural resources management projects, and covers sectors in South Asia and Sub-Saharan Africa. ADAPT is an Excel-based system that was designed simply to be used by policymakers and others, and it allows them to select adaptation measures and important points corresponding to the characteristics of the region in question by entering the necessary information in dialogue form. The ADAPT tool refers to weather trends produced by the Japan Meteorological Agency's Earth Simulator.

In this way, it is hoped that various assessment techniques and tools will be developed which reflect the characteristics of regions and sectors, and which are easy for a range of

users to use.

2.2.4 Main Options for Adaptation Measures

On the whole, there are various options for adaptation measures. In some cases, they can be combined to complement measures, and in other cases, selections are required in order to achieve more wise adaptation.

In this section, based on the review findings of each working group, we have categorized the main options for adaptation measures into “technology”, “policy” and “social and economic” options.

[Technology options]

These are options that relate to technology and to information and knowledge.

Options related to technology promote the development and use of individual countermeasure technologies, as well as the development and use of technologies involved in the formulation of comprehensive plans, etc. Options related to information and knowledge promote the building and use of monitoring, early warning systems and databases.

[Policy options]

These are options that relate to legal systems and human resources.

Options related to legal systems improve and review laws, regulations and various kinds of systems, and also contribute to the promotion of all technology options and social and economic options, etc. Options related to human resources promote the nurturing and skills development of experts, and raising the awareness of decision-makers and the general public.

[Social and economic options]

These are options that relate to economic and social systems.

Options related to economic systems make use of techniques that utilize insurance, grants, taxes or other types of economic incentives. Options related to social systems promote initiatives related to customs and culture, and the building and review of other social mechanisms, etc.

The following table shows specific examples of technology, policy and social/economic options for each sector.

This table shows options that could be considered as adaptation measures to counter the effects of climate change. The table is shown for reference, and is necessarily a recommendation that these measures be adopted. When making actual selections, measures need to be examined with consideration given to the various conditions and constraints of

the region in question.

The "Adaptation Measures Menu and Associated System" section in the sector-specific chapters in Part II contains details of the optional adaptation measures for each sector as well as other options that are not listed here. It also covers the philosophy behind selecting and implementing adaptation measures in each sector.

Table 2 Examples of the Options for Adaptation Measures

Option / Sector	Technology options	
	Technology	**Information and knowledge**
Food	• Development and introduction of high-temperature-tolerant varieties • Shift in cultivation areas • Change in cultivation methods • Controlling feedlot environments • Shift in aqua culture areas, and development of aqua culture technologies	• Collection and organization of information from promoters of agricultural improvement
Water Environment and Water Resources	• Introduction of raw water transmission and discharge control systems as a drought measure • Desalination of sea water • Use of treated sewage water and rainwater, etc. • Prevention measures against groundwater salinization • Eutrophication control measures (blue-green algae fences, etc.) • Dissemination of water-saving devices	• Overall evaluation of the characteristics of sources of drinking water, and the selection of suitable water-purification processes
Natural Ecosystems	• Designation and preservation of refugia • Establishing corridors • Conversion of artificial cedar forests to natural forests • Early detection and prevention of pine wilt • Installation of deer fences in alpine regions, etc. • Reduction in nutritive salts and other environmental load substances	• Development of monitoring systems for each ecosystem
Disaster Prevention and Large Coastal Cities	• Alterations in architectural styles, etc. • Maintenance and improvement of coastal protection facilities • Enhancement of drainage systems • Development of super levees with multiple function • Effective utilization of existing facilities and extension of their lifetime • Comprehensive sediment control in rivers and coasts • Reorganization of dam systems	• Production and distribution of hazard maps • Provision of information (utilizing the web, etc.) • Upgrading monitoring systems (long-term monitoring, real-time monitoring)
Health	• Development of vaccines and new medicines for infectious diseases • Removal of suitable condition for emergence of vector mosquitoes, larval control • Suspending the emissions of air pollutants (to counter the climate change effects on air pollution)	• Production and distribution of health care guide manuals for heat stroke, etc. • Thorough surveillance of infectious diseases • Surveys on the incidence and distribution of vectors
Citizen's Life and Urban Life	• Strengthening buildings to mitigate damage caused by disasters • Utilization of heat-blocking and heat-insulating paints and	• Provision and utilization of hazard maps, etc. • Provision and utilization of heat stroke alert information, etc.

	building materials, etc. • Removal of suitable condition for emergence of vector mosquitoes and harmful insects • Promotion of tree-planting	
Developing Countries	• Agriculture: changes in irrigation areas and systems • Water resources: collection of rainwater, prevention of soil erosion • Ecosystems: reduction of habitat fragmentation, establishment of corridors and buffer zones • Disaster prevention and coasts: protection of wetlands, artificial drawdown of glacier lakes • Health: improvement of health facilities, application of technical solution to prevent vector-borne diseases	• Agriculture: Provision of weather forecast information • Water resources: water resource monitoring to readjust national plans. • Ecosystems: monitoring of vulnerable ecosystems • Disaster prevention: and coasts enhancement of early warning systems for weather and hydrology services

Note: With regard to the adaptation measures for citizen's life and urban life sector, since adaptation measures in which citizens and local government can get involved have been extracted from the measures in other sectors, there may be overlaps with adaptation measures given for other sectors.

Table 2 Specific examples of the main options for adaptation measures (continued)

Option / Sector	Policy options		Social and economic options	
	Legal systems	**Human resources**	**Social systems**	**Economic systems**
Food	• Development of mechanisms to support and advise on adaptation measures for elderly farmers • Adjustment of fishing seasons to suit fish migration routes and fishing ground formation	• Provision of information and human resources development to promoters of agricultural improvement and farming advisors.	• Reconsideration of irrigation customs as a result of changes in cropping seasons and delayed drainage seasons	• Utilization of mutual aid systems (quick provision of damage information, and using the information in compensation claims)
Water Environment and Water Resources	• Improvement of water supply (conversion from agricultural water to drinking water based on decrease of arable lands) • Restriction of deep groundwater pumping to control land subsidence	• Raising of water-saving awareness	• Intensification of farmland, and reallocation of water rights • Introduction of mechanisms or regional flexible transfer of water during droughts	• Indirect controls using economic instruments, such as a levy system in regulations for the use of deep groundwater (to control land subsidence)
Natural Ecosystems	• Reconsideration and new designation of nature preserves, national parks etc. • Regulations of artificial transplantation and fish release • Restrictions on tourist activities	• Training of volunteers with knowledge and skills who are able to cooperate in monitoring • Awareness raising regarding treading pressure reduction on alpine flora and in wetlands, and protection of coral reefs	• Consensus-building among relevant entities regarding the identification of and response to climate change impacts	
Disaster Prevention and large Coastal Cities	• Changes and regulation of land use based on disaster prevention (i.e., relocation of housing, prohibitions and restrictions on construction in danger zones) • Integrated coastal zone management	• Implementation of training and education of disaster prevention	• Establishment of voluntary organizations for disaster prevention	• Establishment of a system of inundation insurance for residents • Establishment of funds and subsidies for post-disaster restoration

Health	• Establishment of institutions and regulations for heat stroke prevention. • Care for elderly households (i.e., utilization of care systems, and care provided by neighborhood associations or volunteers, etc)	• Capacity development for prevention planning for the control of vector mosquitoes • Raising of public awareness on health care	• Support for initiatives at workplaces and schools	
Citizen's Life and Urban Life	• Heat-related countermeasures for the elderly, etc. (utilization of neighborhood associations and nursing-care systems) • "Cool Biz" campaigns • Daylight saving time	• Implementation of e training and education of disaster prevention	• Establishment of voluntary organizations for disaster prevention	• Reduction of the extreme weather risk using weather derivatives
Developing Countries	• Agriculture: establishment of grain banks • Water resources: development of water resources; flood, and drought control systems • Ecosystems: enhancement of forest management • Disaster prevention: and coasts: preparation of risk management plans against sea level rise • Health: Public health policies that recognize climate risks	• Agriculture: education and implementation programs on the conservation and management of soil and water • Ecosystems: capacity building for organizations to regulate land-use	• Health: improvement of public education and literacy rates	• Agriculture: crop species insurance; providing preferential tax treatment and subsidies • Water resources: bank loans for the purchase of rainwater storage tanks • Ecosystems: management policies that include socioeconomic factors • Disaster prevention and coasts: review of options such as insurance that deals with climatic damage • Industry: diversification of tourism resources and revenue sources

Note: With regard to the adaptation measures for citizen's life and urban life sector, since adaptation measures in which citizens and local government can get involved have been extracted from the measures in other sectors, there may be overlaps with adaptation measures given for other sectors.

2.2.5 Points of Concern when Promoting Wise Adaptation

(1) Consideration of the relationship between adaptation and mitigation

We must be mindful of the fact that implementing adaptation measures may sometimes lead to increases in the amount of greenhouse gas emissions and may sometimes leads to decreases.

Examples of measures that have the potential to bring about increases in greenhouse gas emissions include the excessive use of air conditioners to accommodate heat waves, and the use of water coolers in the aquaculture industry to address rising ocean temperatures. On the other hand, examples of measures that have the potential to contribute to decreases in greenhouse gas emissions include heat-insulation reforms for buildings, forest management, using rainwater, and the "Cool Biz" campaign.

Adaptation measures that also entail significant mitigation effects should be especially endorsed as a co-benefit type of adaptation, whereas those adaptation measures that involve a considerable increase in emissions need to be curtailed as much as possible. However, given that it is also possible to have adaptation measures which need to be implemented urgently for the sake of securing safety or maintaining life even though they may result in increased emissions, it is important to deal with each measure flexibly on a case-by-case basis and in line with the endemic conditions, etc.

With regard to mitigation and adaptation in vulnerable developing countries, given that: (1) the primary causes of climate change are the previous greenhouse gas emissions resulting from the development of advanced nations and the present and future greenhouse gas emissions from China, India and other developing countries with comparative economic strength; and (2) small island nations and other particularly vulnerable developing countries are one-sided victims, and their own greenhouse gas emissions are relatively insignificant; emphasis should first be put on adaptation.

(2) Sharing of existing examples and policies which can be drawn upon as adaptation measures

There are already a number of specific adaptation measures that are underway in Japan, including: the installation of thermometers in gymnasiums for the prevention of heatstroke, the utilization of heat-blocking materials in facilities improvements, and checks by local residents of pools and waterholes where mosquitoes tend to concentrate with the object of preventing infectious diseases. There are also examples of measures and policies which, although not necessarily designed for adaptation to climate change, turn out to potentially have the same effect. Some examples of policies and measures, including those that boost the resilience of society as a whole (awareness-raising, early warnings, voluntary evacuations, insurance, etc.), could prove to be useful as adaptation measures. Collecting,

accumulating and broadly communicating these kinds of existing cases and policies will be effective in promoting future initiatives.

The section entitled “Examples and Policies that Can be Drawn upon as Adaptation Measures” in the sector-specific chapters in Part II of this Report introduce specific cases and policies in each sector. It is hoped that these examples will also be of reference in reviewing and promoting future initiatives.

(3) Need for further review of the effectiveness of adaptation measures and their appropriateness from a comprehensive perspective

With regard to the effectiveness of individual adaptation measures and their appropriateness when viewed from a comprehensive perspective, there are some cases which still require discussion. As well as addressing these cases as research topics in the future, it appears that there needs to be an exchange of views between a wide range of entities, such as experts, policy makers and citizens.

(Examples)

- Food sector: What are considered as the effects of adaptation? (For example: Is it alright to ignore quality so long as yield increases?) What is considered as effective adaptation? (For example: If apples are introduced into Hokkaido in line with the shift in areas best suited for them, can this be described as good adaptation?)
- Natural ecosystems sector: Can artificially relocating an organism as a measure to counter the impacts of climate change be described as an appropriate adaptation measure? Moreover, is this technologically possible? (For example: Instead of relocating just one certain species, is relocating other related species as well in an integrated fashion realistic?)

2.3 Barriers to Adaptation

Adaptation involves suitable procedures, costs, technical difficulties and various other factors, and implementing adaptation is by no way a simple exercise. As well as sorting out the specific barriers identified to date which hinder adaptation, there needs to be research and studies promoted on the realistic possibility of applying adaptation measures in the field and on effective measures to break through the barriers.

The section entitled “Barriers to Implementing Adaptation Measures” in the sector-specific chapters in Part II describes in greater detail the barriers to adaptation in each sector.

2.3.1 Barriers related to technology

- **Most individual adaptation technologies require ongoing research and development.**

Many of the individual adaptation technologies in each sector are yet to become technologically established, and still require ongoing research and development. The technologies are wide ranging, for example: the development of new varieties and cultivation methods in the food sector; the development of techniques for converting artificial forests into natural forests in the natural ecosystems sector; the development and maintenance of disaster prediction systems in the protection against disasters sector; and the development of new methods for treating infectious diseases, including the development of vaccines, in the health sector. Still more research and development is needed for these adaptation technologies.

- **Using the latest technology based on regional characteristics is essential, especially for assistance to developing countries**

In the support for adaptation measures for developing countries, although the introduction, for instance, of a disaster prediction system in the protection against disasters sector could be regarded as a support measure, in reality, such a system could not be used in regions where information systems have not yet been developed. First, we need to distinguish between cases which can be addressed using Japan’s latest science and technology, and cases which require technology that is better suited to regional characteristics, etc. We also need to promote research and development on how best to select the ideal technologies, and on specific technologies and techniques that are anticipated according to regional characteristics, etc.

2.3.2 Barriers related to information and knowledge

- **There is not enough accumulating and sharing of data, information and research findings.**

Even in developed countries like Japan, it is conceivable that problems might be overlooked due to a lack of knowledge related to the impacts of climate change, for instance, knowledge on infectious diseases, eutrophication, impacts on air pollution and changes in river flows related to snowfalls. More data and information on this type of currently insufficient knowledge needs to be accumulated and studied.

Furthermore, even the data, information and research findings that do exist on the impacts of climate change, vulnerability and adaptation measures may not necessarily have been accumulated systematically, and may not necessarily have been provided in a form that is easy for policymakers to use. Unless data, information and research findings are shared, in the future, this may potentially be a substantial barrier if adaptation measures are needed to be formulated and implemented rapidly. Consequently, it is important that researchers and policymakers cooperate in the accumulation and sharing of data, information and research findings.

- **Progress has not been made enough in the development and utilization of vulnerability assessment tools and early warning systems.**

Tools for assessing regional vulnerability are essential for reviewing the order of priority between program areas and the priority of regions within a single program. However, at present, tools have not yet been developed which enable vulnerability assessments that take into account the natural and social conditions of a region. With regard to hazard maps, heatstroke alerts and other systems that provide early warnings, while there are some examples of such systems being developed and used, in this case as well, it could hardly be argued that their permeation into society has been widespread. Both in Japan and in developing countries, these tools and systems are essential for the formation of social systems which can secure the foundations for people’s everyday lives and which can flexibly respond to climate change. Vulnerability assessment tools and early warning systems need to be developed and their use promoted.

2.3.3 Barriers related to legal systems

- **There are not enough systems and mechanisms for addressing adaptation with a "whole of region" and "whole of industry" approach.**

Adaptation is a challenge that must be tackled with regions working as one and with industries working as one; but at present, not enough systems and mechanisms have been developed which allow this.

An example of an adaptation measure in the health sector is the care for households where only elderly people live. In order to provide the care more efficiently and effectively, it could be effectual to build a mechanism that works hand-in-hand with existing nursing-care systems, or possibly to build a system of care that integrates the entire community by securing the cooperation of neighborhood associations and volunteers. Going forward, consideration needs to be given to these kinds of new systems and mechanisms that can contribute to the implementation of wise adaptation, and for this purpose, research is essential not only in natural science aspects, but in social science aspects as well.

- **Barriers may arise from existing systems not addressing climate change.**

Some kind of barrier may be produced in cases where existing legal systems have not given due consideration to addressing climate change. For example, in the water resources sector, in some instances, conventional water rights and previously established designated water rights may act as barriers to realizing a flexible water supply system that deals with the risk of drought. In the protection against disasters sector as well, in some cases, existing land-use regulations and existing systems related to the restoration of buildings to their original condition after a disaster may also act as barriers to building safe local communities that are resilient to disasters. It is important that a perspective of adaptation to climate change be added to existing systems and that necessary reviews take place.

2.3.4 Barriers related to human resources development

- **An infrastructure has not yet been fully developed for raising the awareness of decision-makers and the general public.**

Examples of barriers to adaptation include: insufficient knowledge related to impacts and adaptation measures; insufficient information for rendering and communicating specialist knowledge in a form that is easy for the public to understand; and the lack of a developed infrastructure for broadly disseminating this knowledge and information. Furthermore, compared to mitigation measures, the public has a lower level of understanding and awareness of the need and substance of adaptation measures, and so further dissemination of knowledge is important.

Moreover, in some least developed countries (LDC) etc., the phenomenon of climate change itself is not well understood even at the policymaker level. Thus, the dissemination of information is the most pressing need for the promotion of adaptation measures. Also, the LDCs may not necessarily fully understand the methods for using sophisticated simulation models, etc. provided under the guidance of developed countries, and the models may not used in the actual policy decisions.

- **There are shortages of experts, advisors and other human resources.**

Insufficient human resources are also a barrier to adaptation: for instance, a shortage of experts to conduct research on the impacts and adaptation measures in each sector, and a shortage of advisors and facilitators to communicate to a wide range of entities the significance of adaptation measures and their specific means of implementation in a way that is easy to understand.

For example, in the health sector, the scarcity of experts in infectious disease vectors has been raised as a problem, and so the development of these experts is a matter requiring immediate attention. Also, in the national lifestyles sector, as with energy saving diagnoses, etc. in mitigation measures, human resources need to be developed who are able to provide advice on adaptation measures (vulnerability diagnosis, proposal of appropriate adaptation measures, etc.) to individuals, communities, businesses and local governments, etc.

2.3.5 Economic barriers

- **There is a lack of fair assessments of the costs involved in adaptation.**

In implementing adaptation measures, by assessing the cumulative costs related to damage that would be caused by climate change if the adaptation measures were not implemented, and by comparing them to the costs of the adaptation measures needed to prevent that damage from occurring, it should be possible to make a rough determination of whether those adaptation measures should be implemented. However, in reality, estimating the costs of damage is difficult, and particularly in cases where values which are difficult to quantify are omitted from the calculations, damages tend to be underestimated, and in the end, the need for the adaptation measures lacks conviction and no progress is made in implementing them. Furthermore, in cases where the damages are enormous, there is often an impression that the funds required for the adaptation measures will also be extensive, but in actual fact, by selecting effective and efficient adaptation measure options, adaptation is sometimes possible without the need for vast funds.

Research needs to be promoted on the fair assessment of costs involved in adaptation (assessment of both the costs of damage and the costs involved in adaptation).

- **Economic instruments and systems related to the arrangement and procurement of funds needed for adaptation have not yet been fully developed.**

With respect to the arrangement and procurement of funds needed for adaptation, some kind of economic instrument or system is important, such as a subsidy system, insurance or other type of preventive mechanism, or income compensation or other such ex-post relief measure. For example, in the agriculture, livestock and fishing industries, businesses tend to be small, and so it is likely that funding the capital expenditure needed for adaptation would be economically difficult. Therefore, subsidy systems and the like need to be provided. In cases such as heat waves, seeing as there is a chance that agricultural produce would sustain large-scale damage, thereby dealing a massive blow to the operation of farms, systems need to be prepared which use insurance and other economic instruments to enable stable farm management. Moreover, if a large-scale disaster caused by extreme weather strikes, developed and developing countries alike need enormous funds for reconstruction, and so consideration needs to be given for income compensation and other measures. Since these kinds of economic instruments and systems have not yet been fully developed, research needs to be promoted on precedents and effective instruments and systems.

- **In most cases, the developing countries that most need the adaptation measures do not have adequate financial resources.**

Usually, the countries that most suffer the impacts of climate change are the highly vulnerable developing countries. However, these developing countries do not have enough financial resources to implement adaptation measures. The problem of financing adaptation in developing countries was also taken up as an important topic at the Conference of the Parties to the United Nations Framework Convention on Climate Change. Research needs to be promoted on international assistance for the shortage of funds in developing countries.

2.3.6 Social barriers

- **There are insufficient consensus-building mechanisms related to understanding and responding to impacts.**

Since the impacts of climate change are closely related to people's livelihoods and to economic activities, we can suppose that there will be differences in thinking and conflicts of interest between regions, generations and sectors regarding how the impacts should be understood and dealt with. No mechanisms have yet been prepared for facilitating social consensus-building on these kinds of impacts of, and adaptations to, climate change. Therefore, in the future, this kind of consensus-building mechanism will also need to be built.

3. Future Challenges

The objectives of this Report are to clarify the latest scientific knowledge in Japan on the impacts of, and adaptation to, climate change, and to present the concept of "wise adaptation" and the direction for future research. The Report presents a summary based on the reviews conducted by the Committee and the working groups comprised of experts from various fields of study.

In view of this Report, the future challenges are outlined below. The "Future Challenges" section in the sector-specific chapters in Part II describes more detailed research topics in each sector.

- **Implementation of adaptation measures based on scientific assessment, and the accumulation and sharing of the relevant data, information and research findings**

In order to mitigate or avoid as much as possible the risks of adverse impacts brought about by climate change, adaptation measures need to be implemented effectively and efficiently, that is, "wise adaptation" is required. Keeping in mind the facts that the sectors and regions subject to adaptation and the substance of the measures are wide ranging, and that the measures will be implemented over a long period of time, in order to maximize the long-term benefits obtained by the nation through adaptation, the sectors and regions to be preferentially adapted need to be clarified, the details of the measures need to be scrutinized, and the valuable financial and human resources need to be allocated optimally.

In order to realize wise adaptation, it is essential to enhance the research and monitoring of the climate change impacts and vulnerability in each sector and in each region. In addition, highly reliable projections are needed for future temperatures, precipitation amounts, precipitation patterns, snowfalls, and extreme events, etc. accompanying the advance of climate change.

In order to preventively mitigate or avoid future damage, it will be necessary to implement adaptation measures based on scientific assessments as mentioned above. However, with regard to projections, the optimal allocation of resources, etc. will need to be taken into account in a comprehensive manner, while standing by the "precautionary principle" and recognizing that projections involve uncertainty.

Furthermore, so that scientific knowledge and assessments can be fully utilized in the planning of adaptation measures, necessary data, information and research findings need to be accumulated systematically, and provided in a form that is easy for policymakers to use. It is hoped that researchers and policymakers will cooperate in the accumulation and sharing of this necessary information.

- **Learning from past examples, and incorporating the adaptation viewpoint into various policies**

When considering future adaptations, it is also useful to learn from corresponding cases that have been implemented in the past for natural disasters, such as damage caused by droughts or high tides, etc. It is often the case that many adaptation measures associated with climate change have been incorporated into existing social systems as courses of action for conventional natural changes. With regard to not only these adaptation measures, but also to new projected impacts and their related adaptation measures, their consistency with existing initiatives needs to be increased by incorporating the viewpoints of the impacts of, and adaptation to, climate change into land-use plans, urban plans, agricultural policies, nature conservation policies, basic environment plans and climate change countermeasure area promotion plans, etc. Doing so enables systematic and integrative measures to be taken, such as implementing necessary adaptation measures, for instance, by flexibly revising the various kinds of standards that are affected by changes in climate, or by making the most of opportunities for city planning, urban renewal or the redevelopment of obsolete infrastructure, etc.

- **Systematic promotion of adaptation measures that should be implemented immediately**

Some impacts of climate change have already become obvious at the present time. For some of these impacts, we now need to urgently promote the implementation of adaptation measures (for example: tangerine farmers, rice growers in Kyushu, etc.).

Although, on this occasion, the Committee has not fully considered specific adaptation measures that ought to be implemented urgently, in terms of the next topic for review, with reference to the opinions presented in this Report, as well as reviews in each sector, general and specific adaptation plans will need to be established at the country/region level, and a system will need to be built to put these plans into effect as required. As a basis for preparing these plans, in addition to monitoring that is related to the changes in climate systems, an urgent issue is to enhance the currently scarce monitoring and surveillance of climate change impacts.

● **Establishment of an ongoing review structure, and periodic communication of review findings**

In this review, by means of the working groups comprised of experts from various fields of study, we organized the existing scientific knowledge on impacts and adaptation, and we reviewed how adaptation should be as well as directions for future research. Research on the impacts of, and adaptation to, climate change is an area of rapid progress. Furthermore, various kinds of large-scale disasters, which are feared to be the impacts of climate change, are occurring all over the world. Although on this occasion, we focused on reviews by experts from scientific perspectives, when conducting future reviews, we can expect that cross-sectoral and more policy-oriented review will be conducted, with a view to securing the participation of relevant ministries and agencies. Furthermore, regularly communicating these review findings both in Japan and abroad is a valuable exercise, and in particular, it is hoped that they will contribute to future reviews by the IPCC.

● **Ongoing reviews related to adaptation support for developing countries**

Given the fact that the majority of greenhouse gases being emitted around the world are emitted from about 20 countries, we could say that for the remaining 160 or so countries, the issue of global warming is nothing but adaptation measures. Furthermore, compared to developed countries, developing countries are more vulnerable; and small islands, the Asian mega-deltas and the African arid areas are particular vulnerable. Accordingly, in the area of adaptation, developed countries are being strongly urged to provide cooperation.

Amid calls for contributions to the international community, Japan also needs to provide active support by making the most of its strengths, such as in environmental research and in science and technology. To this end, Japan launched “Cool Earth Partnership” as a new funding mechanism in its climate change measures for assistance for developing countries. Going forward, Japan needs to continue its reviews on support for adaptation in developing countries so that it can contribute to the implementation of effective and efficient adaptation measures in developing countries. The results of these reviews are also expected to be a positive input for the relevant ministries promoting the Cool Earth Partnership fund.

● **Promotion of further research on the impacts of, and adaptation to, climate change**

In the future, in order to implement effective and efficient wise adaptation for those impacts of climate change that are projected to progressively worsen, as well as striving for further elucidation of such impact mechanisms as the types of weather and natural conditions in which impacts become obvious (threshold) and the types of regions and entities that are easily affected (vulnerability), Japan also needs to improve the spatial and temporal accuracy of simulations that make projections, and to proceed with research that will enable appropriate forecasts. In addition, further research also needs to be promoted on giving shape to wise adaptation, such as: What kinds of barriers and challenges are there in implementing adaptation measures, and how can they be overcome? To which geographical areas and in which sectors is it effective and efficient to direct limited financial, human and temporal resources?

Below are research topics that are envisaged at present.

➢ **Research topics related to understanding impact mechanisms**

At present, impact mechanisms in each sector contain many unexplained parts, and so research is needed to shed light on these. Possible examples include: in the food sector, ascertaining the sensitivity of different species to environmental changes; in the water environment sector, ascertaining the impacts of droughts and floods on the quality of water at water sources; and in the disaster prevention sector, research on the refinement of information related to external forces. Research is also needed not only on natural elements, but on social elements as well: for example, research in the natural ecosystems sector on the interaction of human activity with biodiversity and ecosystem services.

➢ **Research topics related to methods for predicted impacts**

With regard to future projections, as well as continuing to promote research that contributes to the reduction of uncertainty, research is also needed on techniques for down-scaling simulation models from the global level to the regional level so as to contribute to the prediction of regional impacts. It will also be important that there be research on the dangerous levels of the impacts of climate change in each sector (threshold), and on the associated indicators.

➢ **Research topics related to vulnerability assessment methods**

Development is needed for vulnerability assessment methodologies and tools that specify regions and entities as being vulnerable based on various criteria. In particular, at present, there are limited examples of vulnerability assessments that go as far as taking into account the adaptive capacity of society; and so, accumulating data that contributes to the assessment of social adaptive capacity and conducting research on assessment methodologies that use that data will be important.

- **Research topics related to the technology perspective of adaptation measures**

There needs to be research and development on individual countermeasure technologies, monitoring and the building of databases for both natural and social factors, and research on the development of vulnerability assessment methodologies and tools.

A broad range of research and development is envisaged for individual countermeasure technologies, for example: in the food sector, developing varieties that are resistant to high temperatures, appropriately shift cropping seasons and developing aquaculture technology to water temperatures; in the water environment and water resources sector, conducting research on new sources of water supply; in the natural ecosystems sector, developing technologies for converting artificial forests into natural forests; and in the health sector, developing vaccines and new remedies for infectious diseases. Moreover, there needs to be an integrated promotion of monitoring, establishment of databases and development of vulnerability assessment methodologies and tools so that the data obtained through monitoring can be utilized in vulnerability assessments.

- **Research topics related to the policy perspective of adaptation measures**

There needs to be research on how legal systems should be revised and improved, as well as research on methodologies for human resource and capacity development and on awareness-raising and dissemination techniques.

Examples for research on legal systems include: in the water resources sector, conducting methodological research on legal restrictions at times of drought, and on the revision of conventional water rights and designated water rights; and in the protection against disasters sector, conducting research on how adaptation should be implemented based on land-use regulation. Examples for research on techniques for human resources development and awareness-raising include: in the natural ecosystems sector, researching methodologies for the development of volunteers and others employed to conduct monitoring; and in the development assistance sector, researching public awareness policies and human resources development policies on adaptation, which are directed at responsible persons in the sector.

- **Research topics related to the social and economic perspective of adaptation measures**

There needs to be research on economic incentives that encourage adaptation measures and on economic assessments such as the assessment of costs involved in adaptation measures; and there needs to be research on social systems, such as on social mechanisms that incorporate adaptation measures. In a broad sense, these could also be covered in the legal system topics of the preceding paragraph. They will be important topics, especially in striving for efficient and effective wise adaptation.

An example of research on economic incentives is the research into insurance systems as mechanisms for diversifying and transferring risk, such as for damage caused by extreme weather. An example of research on social systems is the research on consensus-building and specific methodologies related to the promotion of adaptation measures.

- **Research topics related to impacts and adaptation measures in the industrial sector**

Although a specific working group for the impacts and adaptation measures in the industrial sector was not established in this review, it is envisaged that the impacts on the industrial sector are large and that the adaptation measures to be adopted are diverse. Looking at an example of other countries, in England, the Department for Environment, Food and Rural Affairs (DEFRA) takes a initiative in promoting efforts such as for the development of Business Areas Climate Impacts Assessment Tool (BACLIAT) (including agriculture, building design and construction, motor manufacturing, financial services, etc.). In Japan as well, it is important that we organize the latest knowledge on the impacts and adaptation measures in the industrial sector.