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Hirokazu Kato *Editors*

Climate Change, Energy Use, and Sustainability

Diagnosis and Prescription after the Great East Japan Earthquake

NAGOYA UNIVERSITY

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Preface

This book is a concise record of an international conference: *Climate Change, Resource-Energy Use and Sustainability of the Earth and Human Society—Having Experienced the Disasters Caused by the Great East Japan Earthquake*. The conference was held at Nagoya University on February 29, 2012, one year after the devastation caused by the Great East Japan Earthquake and subsequent nuclear power plant accident, and at a time when people in Japan were very concerned about how to secure energy sources. The conference raised a fundamental question of what viewpoint on climate change issues human society and global community should have, and was aimed at presenting a general road map to solve the issues, rather than trying to seek direct solutions. The conference brought together world-renowned researchers and was hosted by *Nagoya University Global Center of Excellence* (GCOE) Program "From Earth System Science to Basic and Clinical Environmental Studies" and *Chunichi Shimbun*, a daily newspaper publisher. This book is basically an English translation of the Japanese version published by Akashi-shoten in March 2013.

Part I of this book is a collection of presentations delivered by four scholars. The presenter of Chap. 1 is Dr. Syukuro Manabe, a senior scientist at Princeton University. He pioneered the use of computers to simulate and study global climate change and natural climate variation, and was one of the first to be inducted into The Earth Hall of Fame Kyoto along with Dr. Brundtland and Dr. Maathai. He has studied the basic principle of global water circulation and discovered that CO_2, emitted through human economic activities, induces global warming and causes droughts, heavy rains, and floods. To overcome the problem, he explains the importance of collaboration among various academic disciplines which are involved in processes ranging from diagnosis to treatment of the problem.

The presenter of Chap. 2 is Dr. Ernst Ulrich von Weizsäcker, Co-President of the Club of Rome. In the 1992 report of the Club of Rome, The First Global Revolution, he proposed the Factor Four concept to double wealth while halving consumption of resources. He has been a world leader not only in academic research on sustainability but also in its politics and philosophy. He explains that an increase in resource efficiency is required in the manufacture of individual industrial products, and further proposed the Factor Five concept, which features the redesign of whole technological and socioeconomic systems such as transportation systems, tax systems, etc. He argues that fundamental to our well-being is not just efficiency based on market fundamentalism in which only the stronger can survive, but human sufficiency.

The presenter of Chap. 3 is Dr. Hans-Peter Dürr,[1] Director emeritus at the Max Planck Institute for Physics and Astrophysics. He worked with Dr. Heisenberg to study unified field theory and the uncertainty principle, and was a successor to Dr. Heisenberg in nuclear physics. He was also a philosopher who compiled the Potsdam Manifesto 2005, a follow-up to the Russell-Einstein Manifesto of 1955. In Chap. 3 of this book, he explains how the Earth has stored underground resources with the benefit of solar energy, and how humans have made critical mistakes which lead to destabilization of the Earth's system since they, who once co-existed with animals and plants, started using fossil fuels in the Industrial Revolution, and later obtained nuclear energy.

The presenter of Chap. 4 is Mr. Shohei Yonemoto. He is a historian of science as well as a philosopher. He explains how global warming became a political issue after the end of the Cold War, and that the issue is a rare case in which preventative measures have been taken based on scientific knowledge. In addition, he discusses the role Japan should play in this issue, raises Malthusian questions regarding food and population, and argues for the necessity of conversion to a new science called futurology which also takes account of factors such as adverse effects of global warming, international cooperation among Asian and other nations, and threats of natural disasters like earthquakes and tsunami.

Each chapter includes an interview with the presenter entitled "Eco-Lab Talk," which first appeared in Japanese in a series of *Kwan*, a magazine of the Graduate School of Environmental Studies, Nagoya University in Japanese.

Part II of this book relates to a panel discussion which followed these presentations. Mr. Ayumu Iio, an editorial writer for the *Chunichi Shimbun*, and I, acted as moderators, and the following topics were discussed:

(1) Japan, which suffered the Great East Japan Earthquake, is in a position to propagate the idea that huge earthquakes induced by the distortion of the Earth's crust are a threat from Nature, in the same way as climate change caused by CO_2 accumulation in the atmosphere.
(2) We should look for a cascade method of energy usage to sustain civilization and bring happiness to people.
(3) We should rely on solar energy. We should stop relying on unsustainable fossil fuels and nuclear energy: using such energy sources is stealing Earth's resources and making profits by stealing.

[1]Dr. Hans-Peter Dürr passed away on 18 May 2014 at the age of 84 when we were editing this volume.

(4) We should reproduce Japan's success stories in the way that the country once increased energy efficiency and gained the leading edge under the influence of its wonderful culture.
(5) Complete disposal of nuclear waste, requiring a huge energy commitment, is ultimately the only method and it is currently unachievable economically.

The conference's goal was to develop road maps for the creation of a cycle in which our generation, as well as our future generations, can live happily. To achieve this, many ideas were shared, suggesting that humankind should not plunder natural resources from the Earth, but should rather conserve Earth's resources and learn to live with other living creatures by developing technology, raising people's awareness, and restructuring our social, economic, and political systems.

This description may have made the book sound a little arcane, but each chapter is easy to read, with detailed and clear descriptions. I hope that the book's great insights will get across to readers, and be of help in steering Japan and the rest of the world, as well as the planet's biosystem, towards more sustainable society and systems.

I would like to thank the members of the university's GCOE program who organized the conference, and Dr. Masayuki Fukumoto, a member of my research group who gave up a lot of his time and offered his advice to edit this book. I must not forget to mention Mr. Paul Mason and Mr. Kenji Sasaki of SIA Inc. for their excellent translation. To host and organize the conference as well as to publish this book, we were financially supported by the Global COE program of the *Ministry of Education, Culture, Sports, Science and Technology*. The *Chunichi Shimbun* offered us its help in organizing the conference. I would like to extend my gratitude to each of these individuals and organizations.

Nagoya, Japan
September 2015

Yoshitsugu Hayashi
Chairperson of the Conference Executive Committee and Chief Editor
Leader of Nagoya University
Global COE Program "From Earth System Science to Basic and Clinical Environmental Studies"

Contents

Part I
Special Presentations

Chapter 1
Global Warming and Water Resources—From Basic Science to Environmental Studies

Syukuro Manabe

Dr. Manabe has won many prizes for his achievements. He pioneered the use of computers to simulate global climate change and natural climate variation based upon the laws of physics. Dr. Manabe started working for the US Weather Bureau (currently the National Oceanic and Atmospheric Administration) in 1958, and later became a senior scientist there. He has taught at Princeton University for many years. He returned to Japan to take up the position of director of the Global Warming Research Program at the Frontier Research Center for Global Change of the former Science and Technology Agency before resuming teaching at Princeton. Dr. Manabe was one of the first to be inducted into the Earth Hall of Fame Kyoto in 2009, together with Dr. Wangari Maathai from Kenya and Dr. Gro Harlem Brundtland of Norway. This Earth Hall of Fame was founded as a memorial to the Third Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3) held in Kyoto, Japan.

1.1 Global Warming and Water Resources

Today I would like to address the topics of global warming and water resources. I talked about this topic ten years ago, when Nagoya University opened its Graduate School of Environmental Studies. The issue has become more serious over the last ten years, and it is an appropriate theme for the conference. This is the main reason why I decided to talk about this topic today. For further details, see the papers written by Wetherald/Manabe (2002) and Manabe et al. (2004).

You probably associate global warming with a rise in atmospheric temperature. You may not know it, but it also accelerates the global hydrologic cycle. This can be explained based upon the law of thermodynamics expressed by the Clausius-Clapeyron Equation. If temperature increases at the oceanic surface, the saturation vapor pressure also increases, thereby enhancing evaporation from the surface. Since water that has evaporated falls as rain in about a few weeks, the increase in evaporation results in the increase in precipitation, thereby accelerating

Syukuro Manabe, Senior Meteorologist at Princeton University, Inductee to the Earth Hall of Fame Kyoto, and Distinguished Invited Professor at Nagoya University.

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the pace of global water cycle. This explains why global warming increases the rates of both precipitation and evaporation. If both precipitation and evaporation change by the same magnitude everywhere, it does not affect the water available for river discharge, for example. However, water vapor is transported three-dimensionally in the atmosphere. Thus, it is not surprising that precipitation increases in one place but decreases in other places despite the increase in evaporation due to global warming.

For example, in middle latitudes, extratropical cyclones carry warm, humid air poleward on southerly winds, whereas they carry cold, dry air equatorward, transporting water vapor from the subtropics towards middle and high latitudes. On the other hand, trade winds carry water vapor-rich air towards the tropical rain belt, where air converges and moves upward as illustrated in Fig. 1.1, yielding heavy precipitation.

As temperature increases in the atmosphere, the saturation vapor pressure of air increases, thereby increasing the air's moisture-holding capacity. The absolute humidity of air is therefore also expected to increase owing to global warming. The increase in the absolute humidity of air in turn speeds up the export of water vapor from the subtropics, not only to the middle and high latitudes but also to the equator, thereby increasing precipitation in both of these regions. On the other hand, because of the increased export of moisture, precipitation hardly increases in the subtropics despite the increase in evaporation from the oceanic surface. As a matter of fact, it usually decreases over subtropical continents. This is the main reason why river discharge is expected to increase, not only in the tropics but also in high and middle latitudes, whereas soil moisture and river discharge decrease in

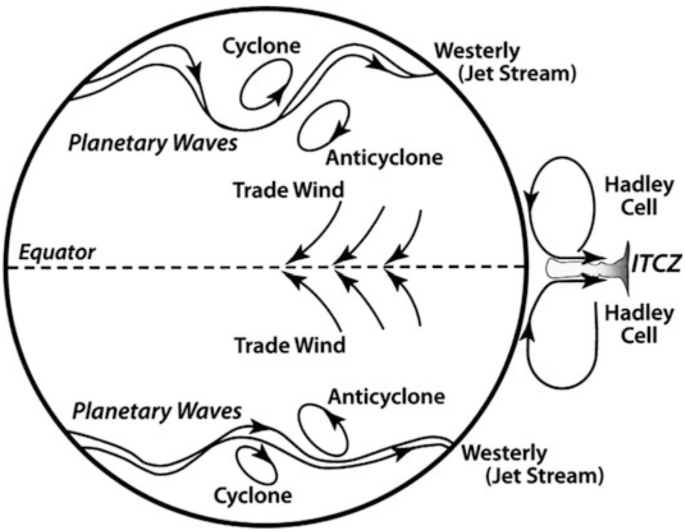

Fig. 1.1 Atmospheric circulation. From McGuffie/Henderson-Sellers (2005) with some modifications

many arid and semi-arid regions in the subtropics and middle latitudes. In this presentation, I would like to show how water availability such as river discharge and soil moisture is going to change owing to global warming, based upon the numerical experiment that we conducted some time ago.

1.2 Is Global Warming Occurring?

Before discussing the issue of water availability, I want to discuss whether global warming is actually happening or not. Because it has been very cold this winter, for example, I am sure that some of you may be skeptical about the existence of global warming. The apparent contradiction may be understood by recognizing that the difference in the average temperature between one winter and the next is far larger than the magnitude of the global warming that has occurred during the last several decades.

Figure 1.2 shows the smoothed time series of Northern Hemisphere mean surface temperature reconstructed by Mann et al. (1988) for the last millennium. For the period prior to the middle of the 19th century, it is obtained based upon the statistical analysis of widely distributed proxy indicators such as dendro-climatic, coral, long-term historical as well as instrumental records. From 1902, it is extended using instrumental records. Their reconstruction clearly indicates that the warmth of the last half century is quite unusual at least during the previous 1,000 years.

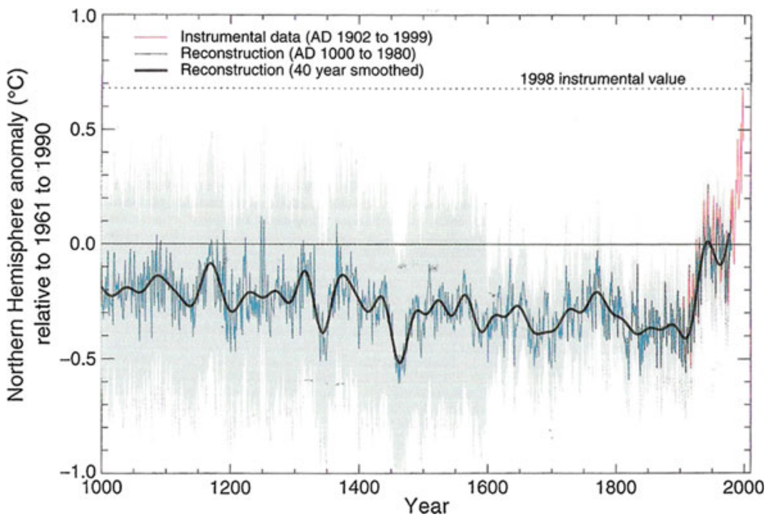

Fig. 1.2 Average temperature anomaly (°C) during the last one thousand years in the Northern Hemisphere. From Fig. 2.20 of IPCC (2001), adapted from Mann et al. (1999), with some modifications

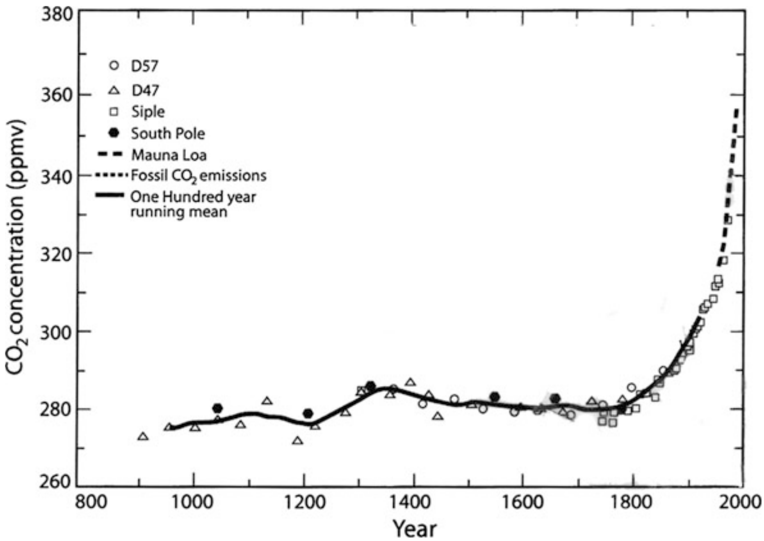

Fig. 1.3 Temporal CO_2 variation. From Fig. 1.5 of Schimel et al. (1994) with some modifications

According to the analysis of air bubbles trapped in the Antarctic ice sheets, the CO_2 concentration of air stayed around 280 ppmv until 1800 but started to increase gradually, as shown in Fig. 1.3. The accelerated increase of CO_2 concentration during the 20th century has been confirmed by accurate instrumental measurement. The recent increase in global surface temperature is attributable in no small part to the recent increase in CO_2 concentration shown here.

1.3 Coupled Atmosphere-Ocean-Land Model

Here, I would like to describe a climate model that has been used for predicting global warming. Figure 1.4 presents a box diagram of a climate model that is based upon the laws of physics as expressed by equations of motion, thermodynamics, radiative transfer, and so-on. The model is often called the coupled atmosphere-ocean-land model. It is constructed by combining a so-called general circulation model of the atmosphere with that of the ocean, along with a heat- and water-budget model of continental surface. Figure 1.5 shows schematically various physical processes that are incorporated in the climate model used here. Aided by rapid advances in computer technology, remarkable progress has been made in the development of climate models that have become indispensable in studying and predicting global warming.

Figure 1.6 shows, as an example, a view of the three-dimensional array of the global grid system used for the computation of the atmospheric component of the coupled model used here. (A similar grid system is also used in the oceanic and land

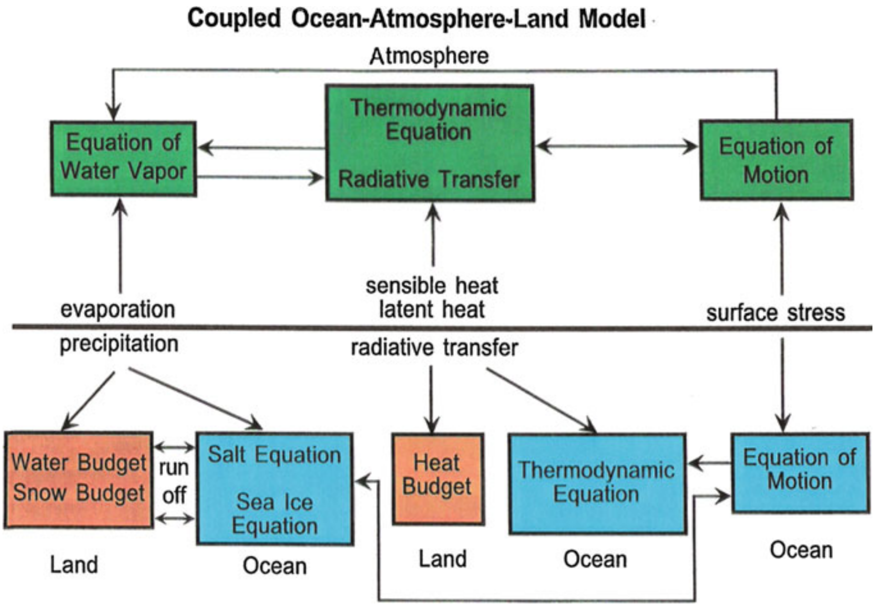

Fig. 1.4 Coupled atmosphere-ocean-land model. *Source* The author

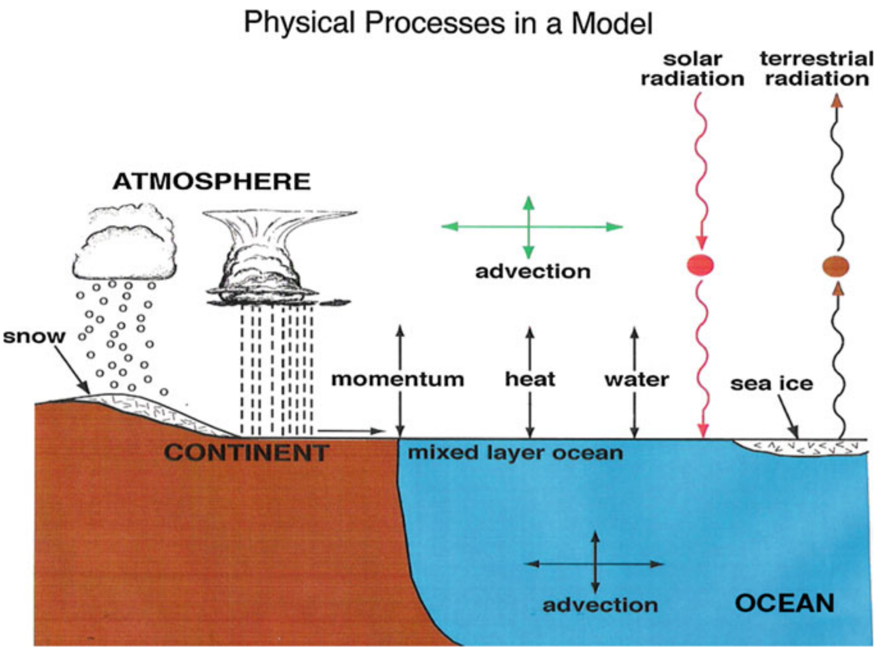

Fig. 1.5 Physical processes in the model. *Source* The author

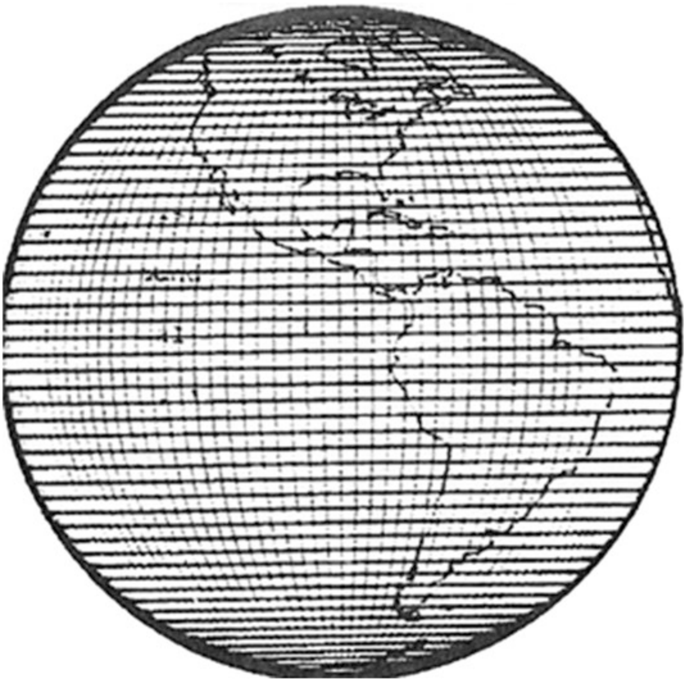

Fig. 1.6 Global grid system. *Source* The author

components of the model.) For each grid box, the model specifies wind, temperature, and specific humidity, and computes, for a small time interval, the temporal variation of these variables.

The initial condition for time integration of the coupled model is an isothermal and dry atmosphere over an isothermal ocean at rest. We start integration, with sunlight cast from above. Because the ocean has high thermal inertia, it takes a very long time for the coupled model to approach the state of equilibrium. Eventually, the climate distribution becomes realistic enough to conduct global warming experiments on the computer.

The distribution of annual mean precipitation thus obtained is shown in the upper frame of Fig. 1.7 and the other, shown in the bottom frame of the figure, comes from observations of actual precipitation. Inspecting the simulated distribution in the top frame, one can identify the almost zonal belt of heavy precipitation along the equator and in middle latitudes, and areas of meagre precipitation in the subtropics. In general, the geographical pattern of simulated precipitation agrees well with that of observed precipitation. Upon close inspection, however, one can identify differences between the simulation and observation. Nevertheless, it is quite encouraging that the model reproduces the observed, large-scale distribution of precipitation well.

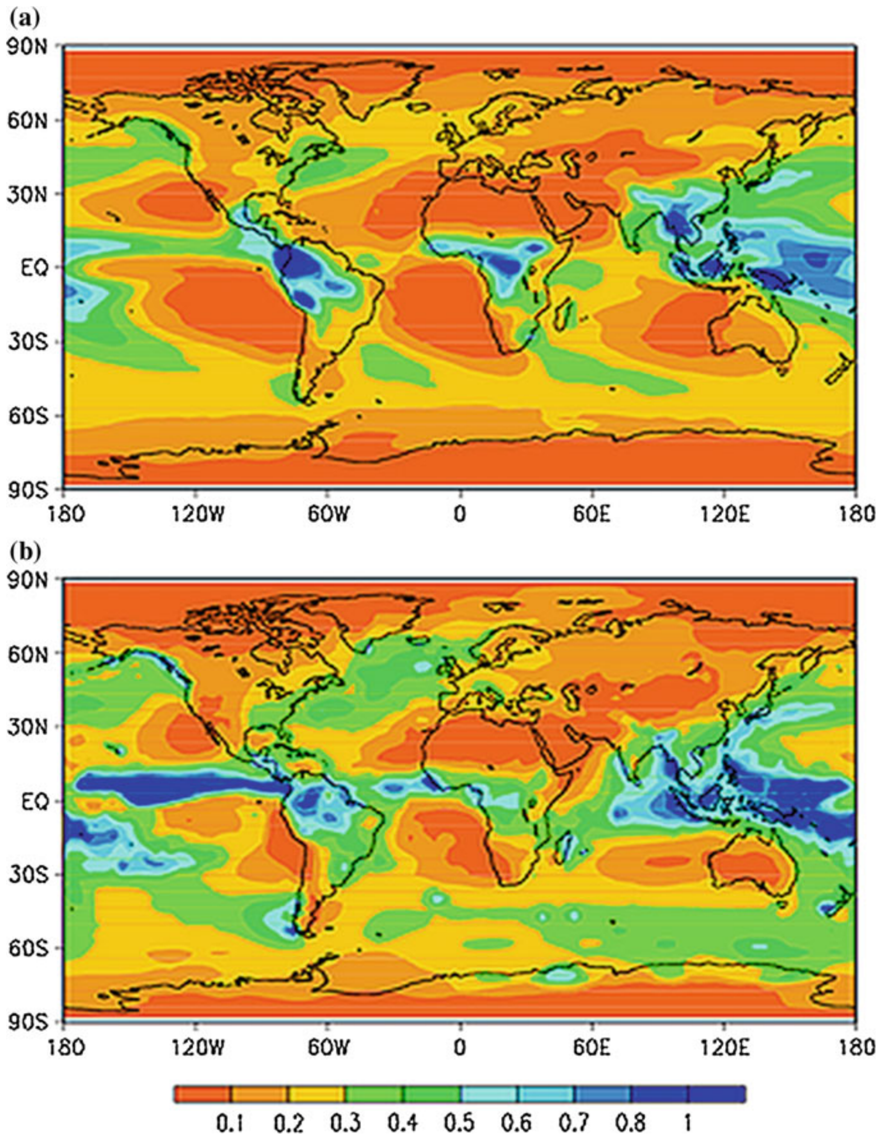

Fig. 1.7 Annual mean precipitation (cm/day). **a** Simulated, **b** observed. From Wetherald/Manabe (2002)

One of the important variables of the model is soil moisture, defined as the difference between the total amount of water and the wilting point in the soil's root zone. A meaningful and direct comparison of modeled soil moisture with observations is not possible, because of difficulties in defining the depth of the root zone and the plant-available water-holding capacity of the soil, and because of the

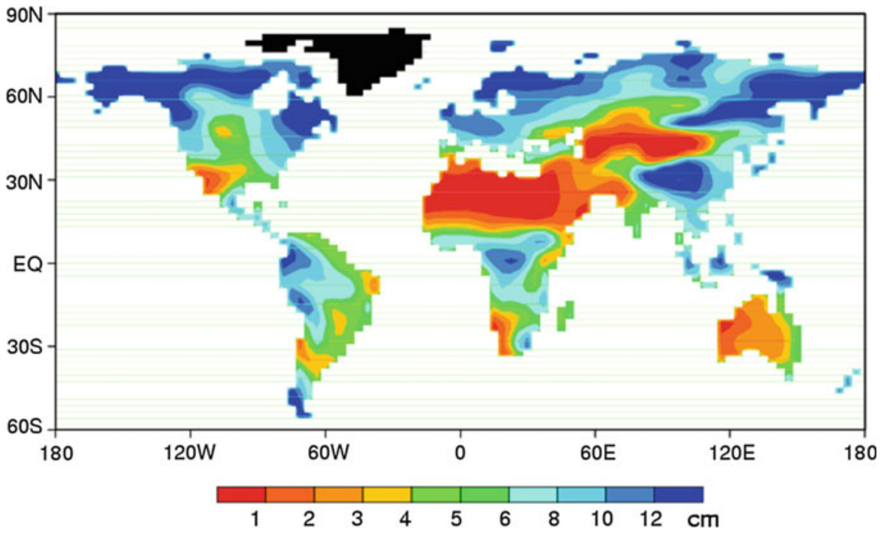

Fig. 1.8 Annual mean, soil moisture (cm) simulated by the model. From Wetherald/Manabe (2002)

extreme heterogeneity of soil moisture, soil properties and vegetation rooting characteristics. Nevertheless, soil moisture in this model is an excellent indicator of soil wetness and associated biome. Figure 1.8 illustrates the distribution of annual mean soil moisture simulated by the model. It shows that the model reproduces reasonably well very broad scale features of soil wetness.

For example, the regions of very low soil moisture simulated by the model correspond well to the major arid regions of the world shown in Fig. 1.9: the Gobi and Great Indian deserts of Eurasia, North American deserts, Australian deserts, the

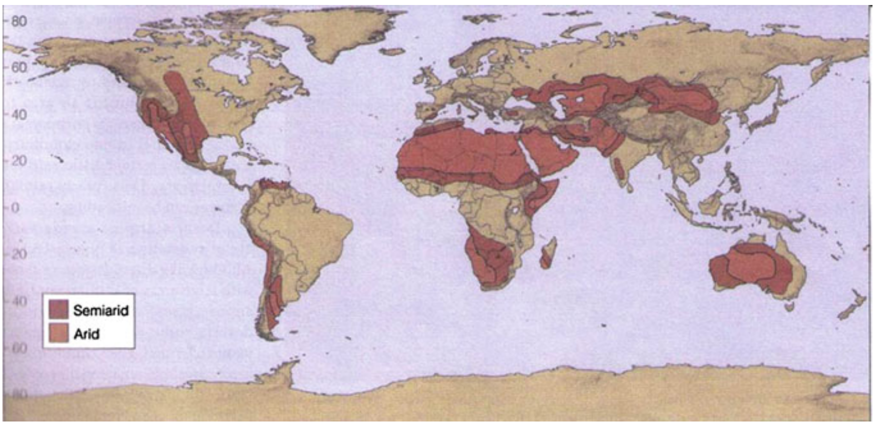

Fig. 1.9 Arid and semi-arid areas. *Source* In the public domain

Patagonian desert of South America, and the Sahara and Kalahari deserts of Africa. Furthermore, the model is reasonably good at placing the semi-arid regions (green in Fig. 1.8) in Africa, Australia, and Eurasia. Although the semi-arid western plain of North America is simulated by the model, it extends too far eastward, particularly in the southern US, where precipitation is substantially underestimated (compare Fig. 1.7a with 1.7b). On the other hand, soil moisture is high in Siberia and Canada, high northern latitudes where precipitation substantially exceeds slow evaporation. As expected, soil moisture is also high in heavily precipitating tropical regions of South America, Southeast Asia, and Africa. In summary, the model is reasonably good at modeling the locations of arid, semi-arid, and wet regions of the world.

1.4 Global Warming Experiment

Encouraged by the successful simulation of climate presented above, we decided to conduct a global warming experiment, in which CO_2-equivalent concentration of greenhouse gas changes by a substantial factor.

Figure 1.10 shows the temporal variation of the CO_2-equivalent concentration of greenhouse gases used in the numerical experiment presented here. As this figure shows, it was increasing at a rate of 1 % per year (compounded) around 1990, when the first phase of this experiment was performed. Assuming that this trend continues, it will have doubled around the middle of the 21st century, and quadrupled in the early 22nd century. As we know, coal has accumulated over the last several hundred million years, and huge coal deposits remain. If we continue to mine coal in a business-as-usual way, the CO_2-equivalent concentration is likely to quadruple during the next few hundred years as suggested, for example, by Walker/Kasting (1992). In this study, we attempt to simulate the climate change that is likely to occur when the CO_2-equivalent concentration doubles in the middle of the 21st century and quadruples sometime in the 22nd century.

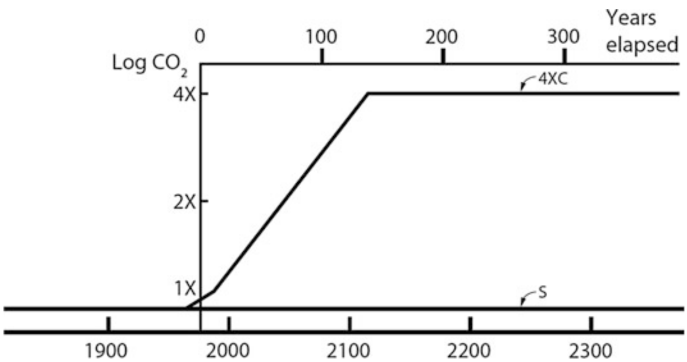

Fig. 1.10 CO_2 concentration over time. *Source* The author

Table 1.1 Global mean changes

	ΔT_s^G (°C)	ΔPrecip. = ΔEvap. (%)
2050	+2.3	+5.3
4 × C	+5.5	+12.7

Source The author

Because the main focus of this talk is water, I am not going to dwell too much on the distribution of temperature change resulting from the change in the CO_2 concentration of the atmosphere. Instead, we focus our attention mainly on the global mean change in surface temperature. According to the results of our numerical experiment, the global mean temperature will increase by 2.3 °C by 2050, when CO_2 concentration doubles, and by about 5 °C sometime during the 22nd century, when CO_2 concentration quadruples in the numerical experiments conducted here (Table 1.1). The latter approaches the temperature of the late Cretaceous period, when dinosaurs roamed the planet.

Averaged globally, the percentage change in both precipitation and evaporation in response to the doubling is 5.3 %, and to the quadrupling is 12.7 %. These do not appear to be overwhelmingly high. Locally, however, the percentage change in precipitation is not so small, substantially changing the rate of river discharge and soil moisture as described below.

1.5 Future Change in Water Availability

Here, I would like to discuss what will happen to river discharge and soil moisture at the continental surface, accompanying global warming.

Figure 1.11 shows how the geographical distribution of the rate of runoff is going to change owing to global warming. The top and bottom frames of the figure show the changes that are expected to occur, when CO_2-equivalent concentration of greenhouse gases doubles and quadruples, respectively. Although the magnitudes of the changes differ substantially from each other, the geographical patterns of the changes are quite similar to each other, underscoring the robustness of the result obtained. As this figure shows, the rate of runoff increases greatly over Siberia and Canada. The magnitude of the increase is particularly large on the western slopes of the Canadian Rockies and Scandinavian mountain ranges. For example, the river discharge from the Mackenzie in Canada and the Ob in Russia increase by 20 % when the CO_2-equivalent concentration of greenhouse gases doubles, and by 40 % when it quadruples. As explained above in Sect. 1.1, the large increase in runoff from these regions is attributable mainly to the increase in precipitation resulting from the increase in the transport of water vapor by extratropical cyclones from the subtropics to high latitudes.

In the tropics, simulated runoff increases in Brazil, the western slopes of the Andes, Northern India, the Tibetan Plateau, Indonesia, the coastal region of Africa near the Gulf of Guinea and so on. For example, runoff from the Amazon River

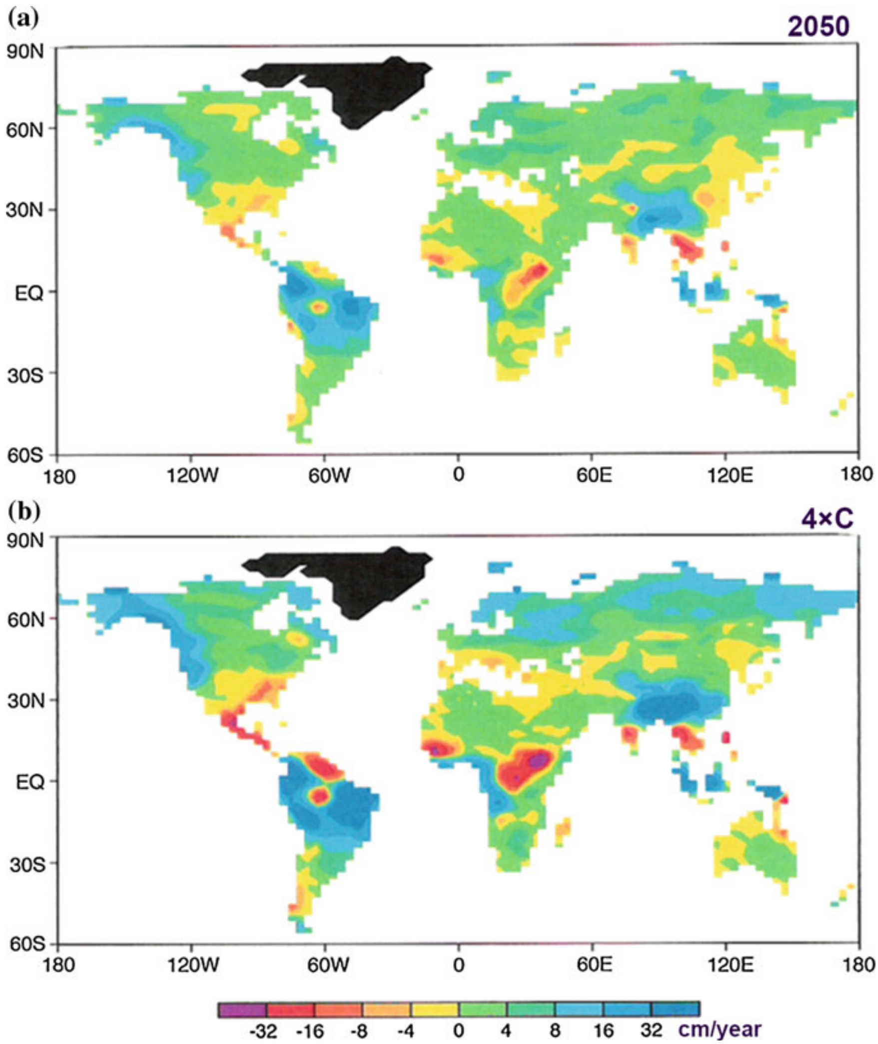

Fig. 1.11 Change in the rate of annual mean runoff (cm/year). From Manabe et al. (2004)

Basin increases by about 11 % when CO_2-equivalent concentration doubles and 23 % when it quadruples. As discussed already, the increase in tropical runoff is attributable mainly to atmospheric moisture transport from the subtropics to the tropics due to the general increase in the absolute humidity of air.

In sharp contrast to the situation in the tropics and high latitudes, runoff hardly increases or even decreases in the subtropics. However, the percentage of reduction is not necessarily small, which has profound implications.

Figure 1.12 shows the geographical distribution of the simulated change in soil moisture as a percentage of its pre-industrial value. (Note here that soil moisture is

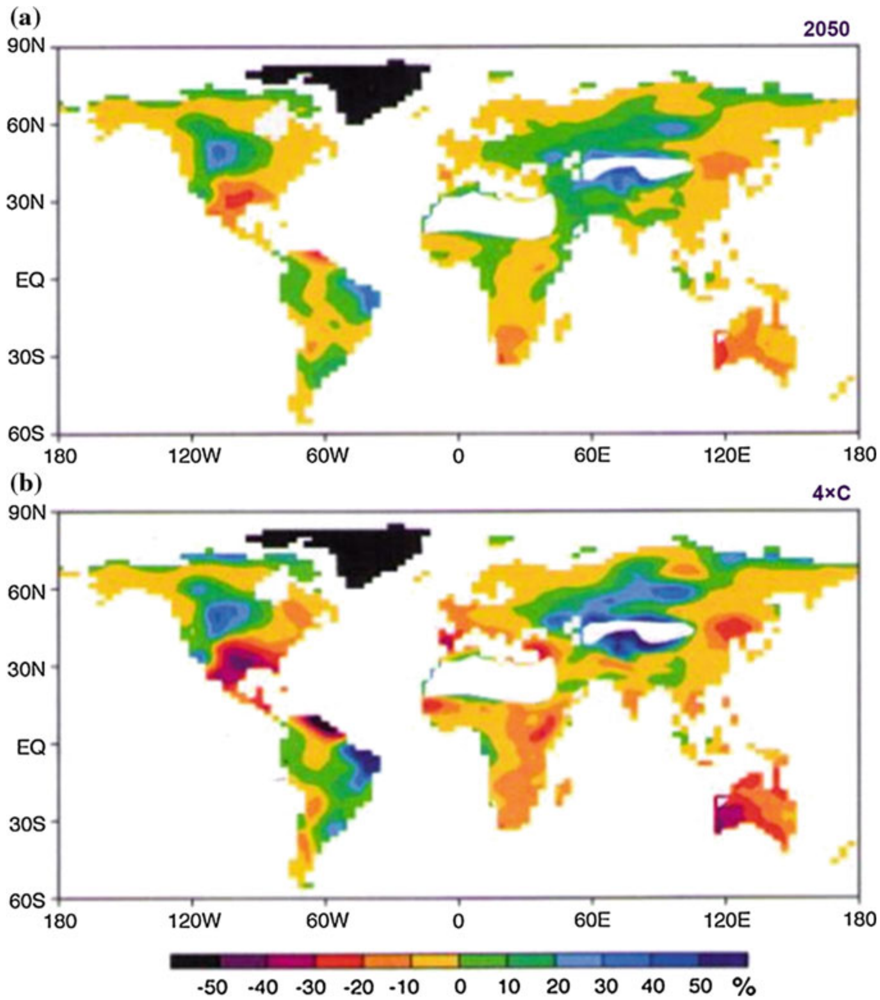

Fig. 1.12 Change in annual mean soil moisture (%). From Manabe et al. (2004)

not shown in the extremely arid regions, e.g., the Sahara and Central Asia, where soil moisture is less than one centimeter and is too small to be meaningful.) The upper and lower frames of the figure show the total change that is going to occur by the middle of the 21st century and sometime in the 22nd century, when the CO_2-equivalent concentration of greenhouse gas doubles and quadruples, respectively, in the numerical experiment conducted here. As this figure shows, soil moisture decreases in many arid and semi-arid regions of the world such as the south-western region of North America, southern Europe, the north-eastern provinces of China, the grasslands of Africa, and the southern and western parts of Australia. Although it is not shown here, the percentage reduction of soil moisture is particularly high during dry seasons. For example, it is particularly high during summer and autumn in southern Europe and the Middle East, whereas it is relatively high in spring to autumn in the north east of China, the south-eastern part of North America, southern Africa, and Australia. As already explained, the reduction in soil moisture described above is mainly attributable to the increase in moisture transport from relatively dry regions to relatively wet regions owing to global warming.

1.6 Worsening Water Shortage

If the concentration of greenhouse gas continues to increase according to a business-as-usual scenario, the reduction in soil moisture in many arid and semi-arid regions of the world is likely to become increasingly noticeable during the 21st century. By the latter half of the 22nd century, the reduction in soil moisture in these regions could become very substantial and will be almost as great as the change yielded by the CO_2-quadrupling experiment described here. To make matters worse, the increase in surface temperature could accelerate evaporation from irrigated crop land, increasing the demand for water. Unfortunately, river discharge in these semi-arid regions is not likely to increase significantly, and may actually decrease, as global warming proceeds. It is therefore likely that the shortage of water in these regions will become very acute during the next few centuries. In contrast, an increasingly excessive quantity of water is likely to be available through river discharge in many water-rich regions in high northern latitudes and in heavily precipitating regions of the tropics. The implied amplification of existing differences in water availability between water-poor and water-rich regions could present a profound challenge to the water-resource managers of the world.

The frequency of drought appears to be increasing in many semi-arid and arid regions of the world such as the grasslands of Australia and Africa, and south-western regions and the Great Plain of North America. On the other hand, because of the rapid increases in population, per-capita consumption of water, and water pollution, many relatively arid regions already suffer from serious water shortages. Unfortunately, it is quite likely that global warming is going to aggravate the situation, posing very challenging questions for mankind.

Given the very serious water shortages that we currently face in many arid and semi-arid regions of the world, it is very urgent that we conduct research on the range of topics listed below:

1. Desalination of sea water
2. Filtering and recycling of water
3. Conservation of water
4. Storage of water
5. Sharing of water, development of laws for fair sharing
6. Construction of dams, artificial lakes, pipelines, and canals

7. Changes in agricultural practice
8. Development of genetically engineered species for reduced water consumption

In order to conduct research on these very important issues, the participation and close collaboration of practically all departments of Nagoya University are needed, in my opinion.

Eco-Lab Talk (1): Encounter of Scientific Curiosity and Social Mission: Curiosity-Driven and Mission-Oriented Research

Syukuro Manabe and Hiroshi Kanzawa

Left: S. Manabe Right: H. Kanzawa

1.7 A Pioneer Who Continues to Research Climate Change

Kanzawa: Dr. Manabe, after you completed a doctoral course at the University of Tokyo, you went to the United States in 1958, invited by Dr. Joseph Smagorinsky. You belonged to the General Circulation Research Section of the US Weather Bureau, which was later organized into the Geophysical Fluid Dynamics Laboratory (GFDL) of the National Oceanic and Atmospheric Administration (NOAA). You took part in innovative research conducted by the Laboratory under Dr. Smagorinsky.

You devised a vertical one-dimensional, globally averaged model of the atmosphere-Earth system, and included the influence of water vapor in the model to calculate how temperature at the Earth's surface changes when CO_2 concentration is doubled in the atmosphere. In 1967, you published the results in a journal of atmospheric sciences. In hindsight, it was the beginning of quantitative prediction of global warming using high speed computers. Later, in collaboration with Kirk Bryan and Ronald Stouffer, you successfully developed a three-dimensional, general circulation model of the coupled atmosphere-ocean-land system. The model was used to study how the geographical distribution of climate would change in response to a gradual increase in the CO_2 concentration of the atmosphere. The study skillfully elucidated the role of the ocean in global warming, and was published in *Nature* in 1989. It attracted worldwide attention, and was extensively referenced by the First Assessment Report of the IPCC, the body which assesses climate change, published in 1990.

The climate models developed and used by Dr. Manabe's group have turned out to be an innovative foundation, enabling scientific understanding of the climate maintenance and change mechanisms, as well as prediction of the climate change which follows an increase in greenhouse gases. I remember, when we talked before, you said, "The research using the vertical one-dimensional radiative-convective equilibrium model was a sort of side-track." You accomplished the great mission Dr. Smagorinsky had given you, with a grand view of where research should go. You developed and applied a general circulation model in order to satisfy your scientific curiosity and which, as a result, responded well to social needs. This is a happy combination of "curiosity-driven" and "mission-oriented" research.

1.8 My Side-Track Led to the Prediction of Global Warming

Manabe: Global warming is a serious problem in current society, but we initially did not take it so seriously. At that time, Dr. Smagorinsky had started an ambitious project to create a computer model of the general circulation of the atmosphere and climate based upon the laws of physics. He invited me to join him in 1958 after some of my publications caught his attention. It was only 13 years after the end of World War II, and it was still hard even for those with doctorates to find good jobs. So the wonderful offer was unexpected but timely: I accepted, and went to America.

As soon as I joined his project group, Dr. Smagorinsky told me to work on the general circulation model of the atmosphere. Compared with contemporary three-dimensional modeling of climate, it was not an easy job at all, as computers at that time had much lower performance and were much slower at calculation than those we have now. When we ran into problems, it took us a long time to solve them. So I decided to construct a one-dimensional, global average model of the atmosphere as a first step towards the construction of a three-dimensional model, incorporating basic physical processes such as solar radiation, long wave radiation, and convective heat transfer. Because I was not very good at computer programming, I had a hard time debugging it. Eventually, I succeeded in constructing my so-called radiative-convective equilibrium model of the atmosphere, which successfully simulated the vertical distribution of temperature in the atmosphere and at the Earth's surface. The successful simulation convinced me that the scheme for computing radiative transfer was good enough to be incorporated into the three-dimensional model that we were constructing. At that point, I decided to follow a side-track from my main job. Using the one-dimensional model of radiative-convective equilibrium thus constructed, I evaluated how the vertical temperature profile in the atmosphere depends upon the concentration of various greenhouse gases (e.g., H_2O, CO_2, and O_3) and cloud cover. I had a very good time performing these numerical experiments and satisfying my curiosity.

Kanzawa: You did it, not because you were concerned about global warming, but simply because you found it interesting, didn't you?

Manabe: Without question it was important to develop understanding of the general circulation of the atmosphere, but this study turned out to be the beginning of my research into global warming. If I had concentrated my attention solely on the development of a general circulation model, my life would be very different. At that time, I was aware that CO_2 concentration was increasing, but I had no idea that it would become so serious. That is why I want to encourage young scientists to do curiosity-driven research.

1.9 "Air Man" and "Sea Man" Cooperated on Coupled Ocean-Atmosphere Model

Kanzawa: While you continued your research using the one-dimensional model for better theoretical understanding, you developed a three-dimensional general circulation model on the basis of Dr. Smagorinsky's grand concept. Then, you went further, cooperating with Dr. Kirk Bryan to combine the atmospheric general circulation model and an oceanic general circulation model to develop a more complex "coupled ocean-atmosphere general circulation model." It was in 1969 that the

first article was published describing a series of studies using a coupled model. At that time the development of a coupled atmosphere-ocean model was an epoch-making work. How was it developed?
Manabe: Since Dr. Smagorinsky regarded an oceanic model as a necessary element of a global climate model, in 1961 he recruited Dr. Kirk Bryan, from Woods Hole Oceanic Institution, to develop an oceanic general circulation model. Our atmospheric general circulation model was in use by the mid-1960s, and Dr. Smagorinsky thought of having the two groups—that is, "atmospheric specialists" and "oceanic specialists"—work together. I learned oceanic physics from Dr. Bryan, and cooperated with him to develop the "coupled atmosphere-ocean model." Because the climate is influenced by interaction between the atmosphere and the ocean, an integration of the two fields opened the door to a big new field.

1.10 Accepting Criticisms as Challenges

Kanzawa: How was the response to your achievements?
Manabe: We were absorbed in simulations using the model we had developed, and published one article after another. We were proud of our work but some critics remarked that only simulating a phenomenon does not necessarily contribute to true understanding of the phenomenon. I accepted the remark as a challenge, so I determined to clarify what mechanism controlled the phenomenon. For this purpose, we conducted many numerical experiments, changing one factor at a time. We found, for example, that if we got rid of the Tibetan Plateau with the Himalayan mountain range, the Indian summer monsoon weakened and the Central Asian Desert would disappear. If the concentration of greenhouse gas such as carbon dioxide changes in the atmosphere, not only temperature but also precipitation changes, profoundly affecting the global distribution of climate, as discussed in my presentation in this chapter. The focus of our research shifted from simulation to analysis of the mechanisms which maintain and change climate. "Simulation does not necessarily mean true understanding of phenomena"—there was a great deal of truth in the criticism which I regarded as a challenge. I did not want to end up showing only simulations, like a picture-story show. Even those who are currently developing climate models should take this criticism seriously.

1.11 Importance of Stepping Between Disciplines

Kanzawa: When you look back, what do you think about your research in the United States, and Dr. Smagorinsky as a manager?
Manabe: I spent most of my time there studying and enjoyed it very much. It was heaven, indeed. Once Dr. Smagorinsky had confidence in a researcher, he just assigned a general research topic and never forced chores on them. He just let his

researchers do their jobs freely. He was not a micromanager at all. It was his philosophy to let his team concentrate on research while he raised funds and created an ideal environment for research. This made us researchers feel embarrassed if we were not able to get interesting results. His leadership has made the GFDL one of the most esteemed laboratories of climate science in the world.

Kanzawa: There were three Japanese researchers in the GDFL at that time, and all of them were impeccable scientists.

Manabe: We worked very hard. All of them quit their jobs in Japan to join the laboratory, and made truly outstanding contributions. I urge more Japanese researchers to go abroad. Even if they cannot succeed in research, by the time they return to Japan they will have improved their English language skills and learned to think differently. Diversity is most important in research. People with different backgrounds come to the United States from various parts of the world, compete and collaborate with each other, and discuss freely. This nurtures superb scientists, yielding subsequent progress.

In future, it is very desirable that increasing numbers of Japanese scientists visit foreign research institutions over extended periods of time. In so-doing, they will expose themselves to different ways of thinking and diversity in scientific approach. It is very desirable that universities and research institutions in Japan increase international collaboration in climate research.

As you know, climate science is a highly interdisciplinary science. However, this does not imply that we should train jacks-of-all-trades, who are masters of none. In my opinion, it is critically important that a climate scientist has expertise in at least one discipline and gradually expands it as he collaborate with other scientists, who are experts in other disciplines.

Kanzawa: Thank you very much for your wonderful talk today.

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References

IPCC, 2001: *Climate Change 2001: The Scientific Basis.* Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Houghton, J.T. et al., Eds., Cambridge University Press, U.K., 881 pp. Available also from http://www.ipcc.ch/

Manabe, S. and K. Bryan, 1969: Climate calculation with a combined ocean-atmosphere model. *Journal of Atmospheric Sciences*, **26(4)**, 786–789.

Manabe, S., P.C.D. Milly, and R.T. Wetherald, 2004: Simulated long-term changes in river discharge and soil moisture due to global warming. *Hydrological Sciences-Journal*, **49**, 625–642.

Mann, M.E., R.S. Bradley, and M.E. Hughes, 1999: Northern Hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations. *Geophysical Research Letters*, **26**, 759–762.

McGuffie, K. and A. Henderson-Sellers, 2005: *A Climate Modeling Primer, 3rd Edition*, John Wiley & Sons, 296 pp.

Schimel, D., I.G. Enting, M. Heimann, T.M.L. Wigley, D. Raynaud, D. Alves, and U. Siegenthaler, 1994: *CO_2 and the carbon cycle*. In: Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios. [Houghton, J.T. et al. (eds)]. Cambridge University Press, Cambridge, U.K., 35–71. Available also from http://www.ipcc.ch/

Walker, J.C.G., and J.F. Kasting, 1992: Effect of fuel and forest conservation on future levels of atmospheric carbon dioxide. *Paleogeography, Paleoclimatology, Paleoecology*, **97**, 151–189.

Wetherald, R.T., and S. Manabe, 2002: Simulation of hydrologic changes associated with global warming. *Journal of Geophysical Research*, **107 (D19)**, 4379–4393.

Chapter 2
Factor 5: Towards an Affluent Society with Least Use of Resources

Ernst Ulrich von Weizsäcker

Dr. Ernst Ulrich von Weizsäcker founded the world's first research institute for studies on the global environment in Wuppertal in the Ruhr, Germany and became the first President of the Wuppertal Institute for Climate, Environment and Energy. After serving as Director of the Institute for European Environmental Policy and President of the University of Kassel, Germany, he became Member of the German Bundestag (parliament). In the late 1990s, he formed the Environment Committee in the Bundestag and served as its first Chair, and has been a key figure in implementing environmental policies in Germany ever since. He was later also invited to the University of California, Santa Barbara. He is currently a co-chair of the United Nations Environment Program International Resource Panel.

Like Dr. Dürr, Dr. Weizsäcker has been a member of the Club of Rome since its foundation. He is particularly known for having advocated the "Factor 4" concept. This was a call for doubling wealth and halving resource use. To achieve this, efficiency must be increased fourfold. He proposed this quite fundamental concept at the United Nations Conference on Environment and Development (UNCED), the so-called Earth Summit, held in Rio de Janeiro, Brazil in 1992. In 2012, the twentieth year since the Earth Summit, Rio + 20 was held. Thus, Dr. Weizsäcker has been a leading proponent of concerning modern environmental thinking.

Incidentally, his wife has also played a leading role in the field of environmental issues. She served as the leader of NGOs at COP10 in Nagoya, having contributed to the establishment of various protocols.

2.1 Countries Satisfying the Conditions for Sustainability

Some people told me that Factor 4 could imply "factor death," as four is a homonym of death in Chinese. They recommended Factor 8 instead, because eight is considered a lucky number as the shape of its Chinese character is a symbol of

Ernst Ulrich von Weizsäcker, Former Co-Chair of UNEP International Resource Panel, Club of Rome Member (Currently Co-President); Visiting Professor at Nagoya University Graduate School of Environmental Studies

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good luck. It is very difficult, however, to increase resource productivity eightfold. Knowing it to be impossible for us, we settled on Factor 5, instead of 4, and not 8.

Today's topic is Climate Change, Resource-Energy Use, and Sustainability of the Earth and Human Society. Before getting into this topic, we should know what we mean by sustainable development.

Figure 2.1 shows clearly what sustainability means. First, ecological footprints (the area of land required by a person to exist) should be small. The ecological footprint per person should be kept at 2 ha or below. I think this is not a very high target but quite a reasonable figure.

In terms of wealth, the Human Development Index, or HDI, has been developed by the UN. HDI is an index that represents the three aspects: economy, medicine/health and education. If HDI is 0.8 or higher, you are making a decent living. If HDI is less than 0.8, you are in poverty. The rectangle in the bottom right represents the sustainable range. How many countries are currently satisfying the conditions for a sustainable human society?

In fact, only one country is currently inside this sustainability rectangle. That is Cuba, as you can see in Fig. 2.2. This means that the most attractive country in the world is Cuba. This fact indicates a challenge facing us.

If 7 billion people had the current US American footprint level, we would need five Planet Earths (see Fig. 2.3). But we have only one Earth. This depends largely on our lifestyle. If, for example, we change our way of living, footprints can be reduced. But many people want the highly luxurious American lifestyle. Thus larger footprints are necessary. More land and more Earths are necessary.

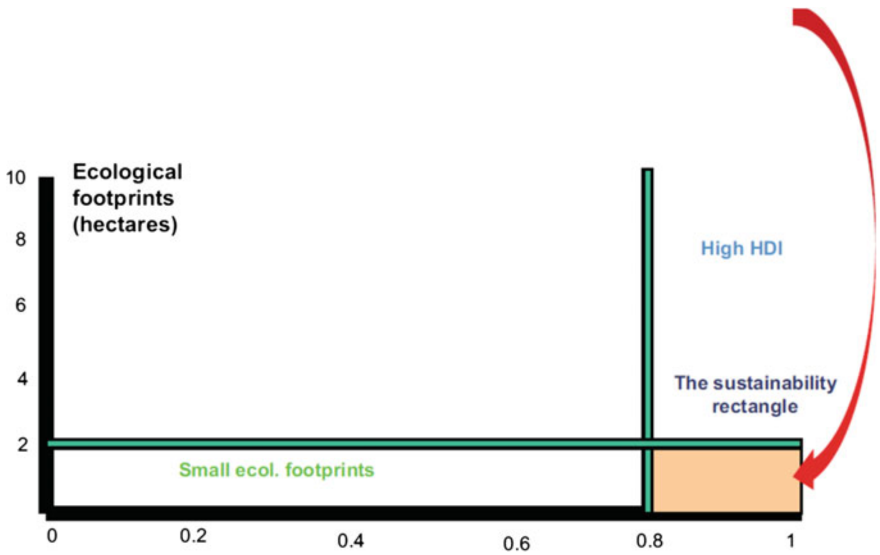


Fig. 2.1 Sustainable development means small ecological footprint and high Human Development Index (HDI)

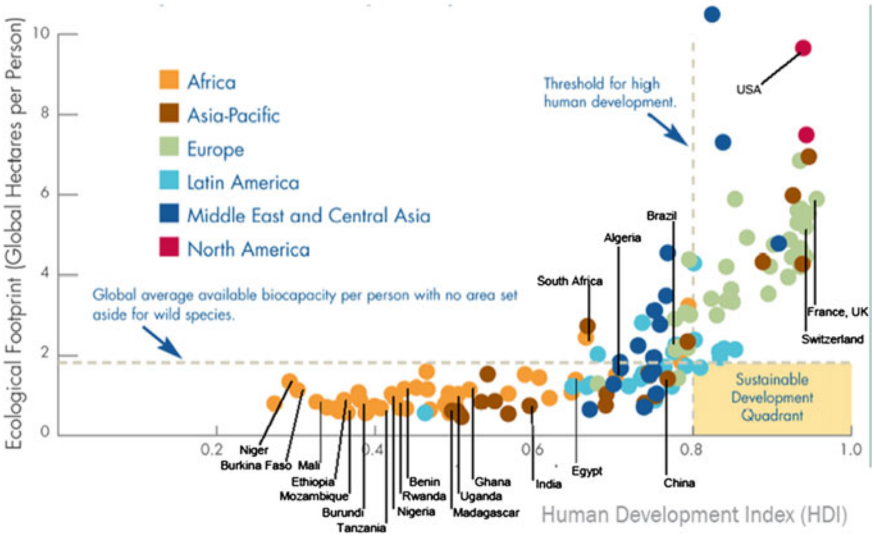
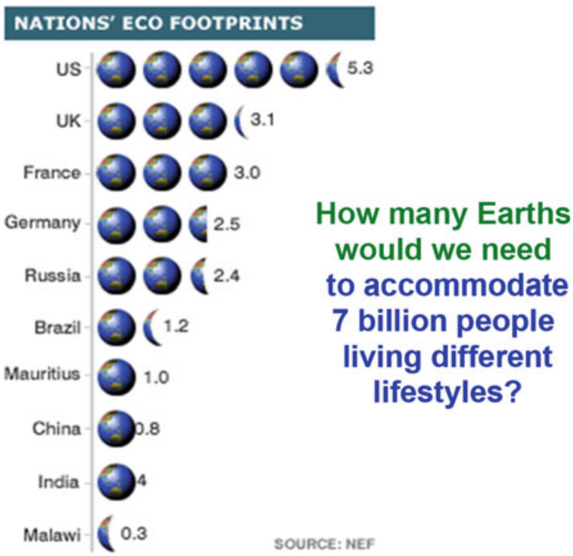


Fig. 2.2 Only one country currently populates the sustainability rectangle. *Source* The author

Fig. 2.3 Nations' ecological footprints. *Source* The author



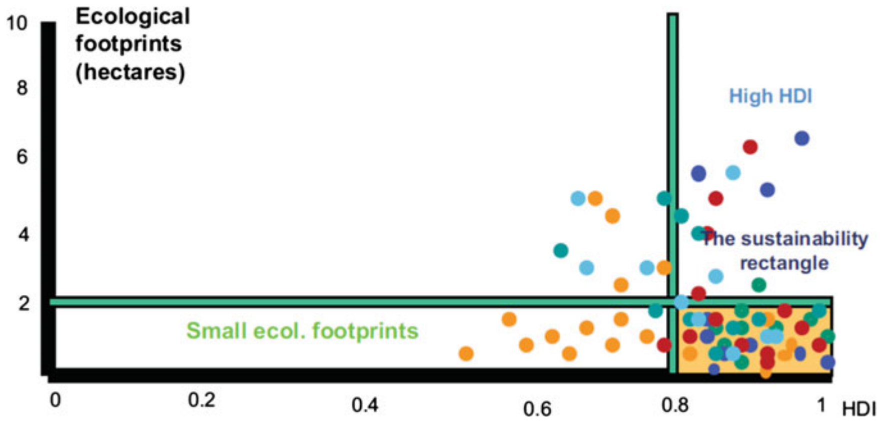


Fig. 2.4 A fivefold increase of resource efficiency could repopulate the sustainability rectangle. *Source* The author

2.2 Increasing Resource Efficiency Fivefold

Thus, from both technological and political viewpoints, we have reached the conclusion that the only way to solve this problem is to increase the efficiency of resource use. In other words, to make 1 kW of electricity, to obtain 1 barrel of water, or to gain 1 kg of iron ore, resource efficiency should be improved.

If resource efficiency can be increased fivefold, poor countries will move from the upper left to the lower right as shown in Figs. 2.2 and 2.4. They will get into the sustainability rectangle without increasing their ecological footprints. And these rich countries can also enter the sustainability rectangle without sacrificing HDI, or wealth.

Then, a single Earth would be enough. This is, however, a big challenge. And we have to tackle this challenge. This is the major philosophy that lies behind the Factor 5 concept.

We are required to maintain wealth while reducing footprints. I do not think this is just a dream only in the mind of crazy engineers. It is actually a sheer necessity if we want to maintain our current rich lifestyles. In Germany, Japan, Cameroon or Ecuador, no one wants poverty. Without exception, we all want to live a civilized life.

2.3 What Is Going on in Greenland?

Dr. Manabe gave a wonderful presentation on climate change and water. I want to add a little bit about climate. I want to discuss the situation of Greenland, where the areas that are covered with water in summer increased in a relatively short period of ten years. Figure 2.5 shows a comparison of Greenland in 1992 and 2002. The

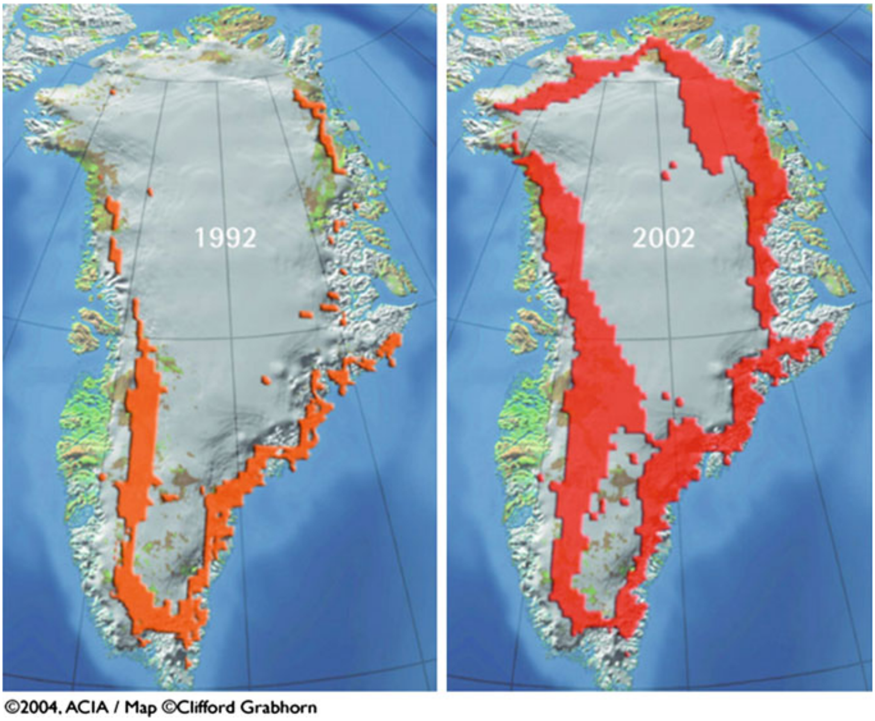


Fig. 2.5 Ice coverage of Greenland in summer 1992 and 2002. *Source* Clifford Grabhorn in: ACIA (2004)

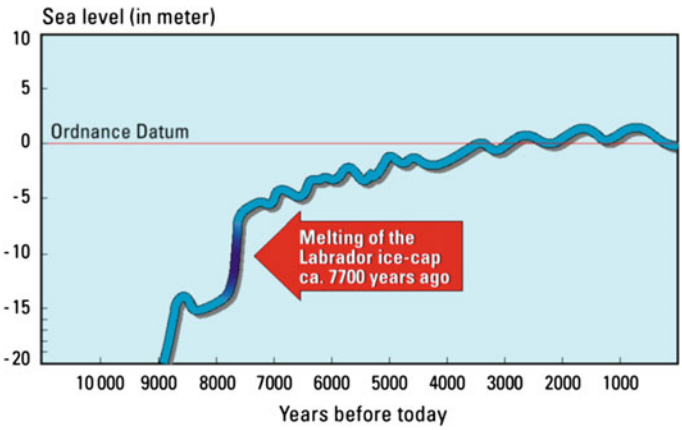


Fig. 2.6 Rise in sea level can be catastrophically fast!

situation is even more severe in Greenland today. Flows of melted ice running on the ground surface have been increasing, which is very dangerous.

In fact, the same thing happened on Labrador in Hudson Bay, in eastern Canada. Just as the ice coverage decreased in Greenland, ice melted in Labrador. Let's look at the sea level (Fig. 2.6). The sea level rose by 7 m in Labrador at that time. Although it did not have a big impact because no humans lived in Labrador 7,700 years ago, it caused a large rise in sea level. This is what is going on in Greenland today.

2.4 We Now Need a Kuznets Curve of Decarbonization

Figure 2.7 shows growth centers in Asia. Asia's vibrant growth centers are mostly located in coastal areas. So is Nagoya.

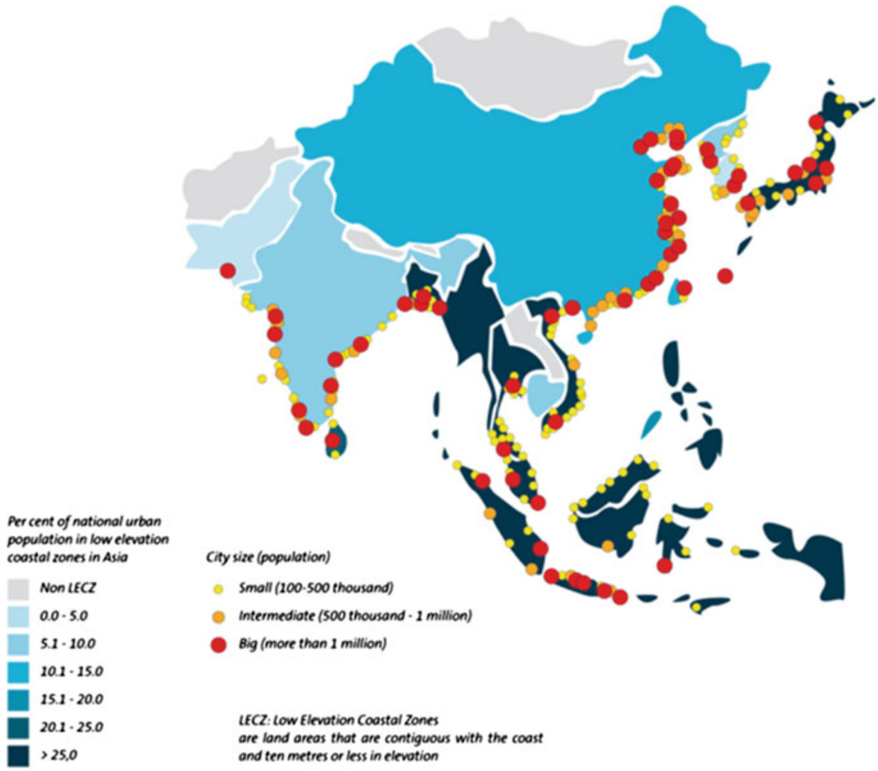


Fig. 2.7 Asia's vibrant growth centers are mostly at the coast! *Source* The author

Is this promising a brilliant future for you? I do not think so. The situation is different from in Europe. Why is climate policy making little progress despite the current critical situation?

Conferences of the United Nations Framework Convention on Climate Change (UNFCCC) over the past three years ended up with terrible results, with no concrete actions or achievements.

I think the reason for this is very simple; the higher the CO_2 emission intensity, the higher the degree of economic development. We must change this correlation. In other words, we must create a Kuznets Curve of decarbonization.

Japan once suffered pollution. Japan in the Edo period was a poor, but clean country. There was no pollution. But as it passed through the course of industrialization, the country became rich but dirty. Pollution occurred and made Japan dirty. Today, having overcome the pollution of those days, Nagoya, and Japan as a whole, has become rich but clean. This is what a Kuznets Curve represents. CO_2 emissions increased once and then decreased to the level in Japan today.

Meanwhile, the populations of China and India are nearly 2 billion and 1.3 billion, respectively. These developing countries are rapidly increasing their CO_2 emission intensity. And Greenland is showing a consequence of this.

We therefore have to help developing countries bypass the curve of increasing CO_2 emissions once and decreasing it later, and go along a better road (Fig. 2.8). We must make them reduce CO_2 emissions while allowing them to pursue economic development. This is our highly important task.

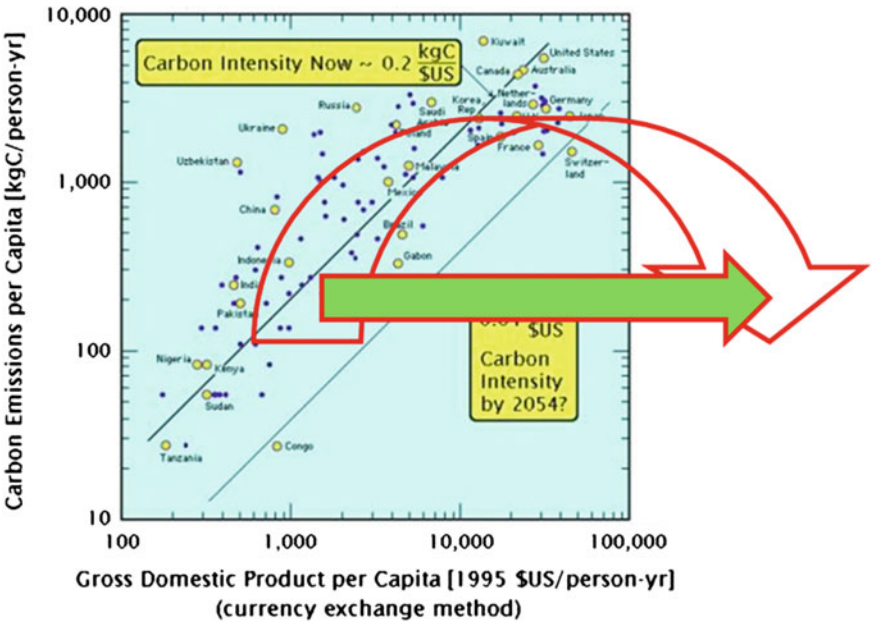


Fig. 2.8 It is necessary to help developing countries reduce CO_2 emissions

2.5 Three Methods of Decarbonization

I think there are three methods of decarbonization. Although there may be other methods, let us consider these three here. The first is to obtain energy without emitting CO_2. The second is to become wealthy without using energy. And the third option is not to seek wealth.

Which one would you choose? The first option "to obtain energy without emitting CO_2" probably seems to be the most realistic methodology. Examples of this choice include wind power, solar light and nuclear power. Some may choose "to become wealthy without using energy," in short, to increase efficiency, or even "not to seek wealth," but I think they are in a minority. This is why I said earlier that it is a big challenge. In fact, these options are not enough. Before explaining this in detail, let me show you what happened in Japan.

In 2011, Japan was hit by a big earthquake and tsunami, which were followed by a very serious nuclear accident. As a result, a radioactive cloud moved as shown in Fig. 2.9, which is even said to have reached California. This was really a big tragedy.

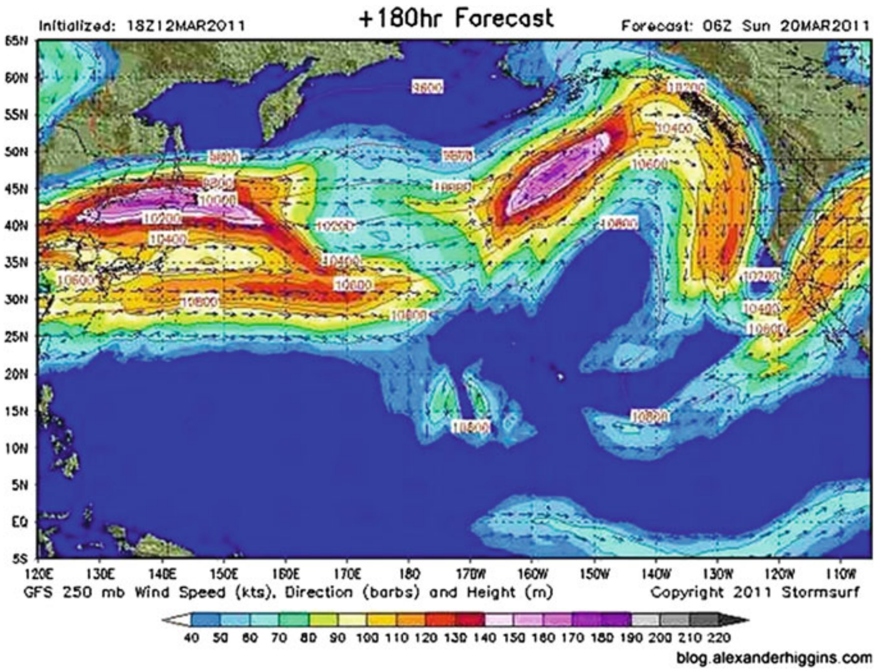


Fig. 2.9 The radioactive cloud 7 days after the Fukushima Daiichi Nuclear Power Station accident. *Source* The author

We should not resort to the option of obtaining energy without emitting CO_2. If we want to gain the same level of wealth without using nuclear power or burning highly dangerous methane hydrate, this option becomes extremely difficult.

How about CO_2 capture and storage (CCS)? It is of course possible to capture and store CO_2. But as shown in Fig. 2.10, it requires enormous cost to dig sufficiently deep into the Earth, and to store CO_2. We must call it a crazy idea.

How about bio-fuels? In Germany, we can see many large maize fields extending as shown in the left photo of Fig. 2.11. But from the viewpoint of biodiversity, this is wrong. Also, huge palm oil plantations seen in Indonesia, Malaysia, etc., as shown in the right photo, are just an ecological nightmare.

In Germany, photovoltaic power generation has also been increasingly promoted. As shown in the upper left photo of Fig. 2.12, even a photovoltaic power plant as large as an airport has been built. This is wrong. The situation is the same for wind power. Look at the rows of wind turbines in the upper right photo of Fig. 2.12. Is this what we want Germany to be like in the future?

When I was a parliament member, I was involved in establishing the Feed-in Tariff law. But today, complaints are arising about wind turbines.

There are also huge hydroelectric dams. The lower left photo of Fig. 2.12 is a dam in Austria. Mountain climbers complain that the scenery of the Alps has been

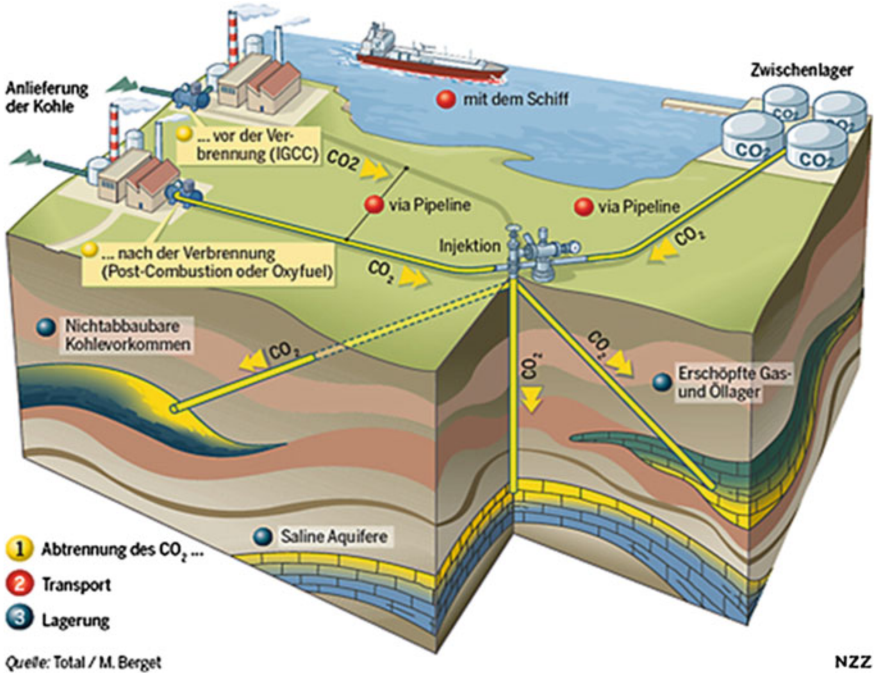


Fig. 2.10 CO_2 capture and storage (CCS) requires a lot of money. *Source* Total/M. Berger. NZZ

Fig. 2.11 Bio-fuels are an ecological nightmare! *Source* The author's archives

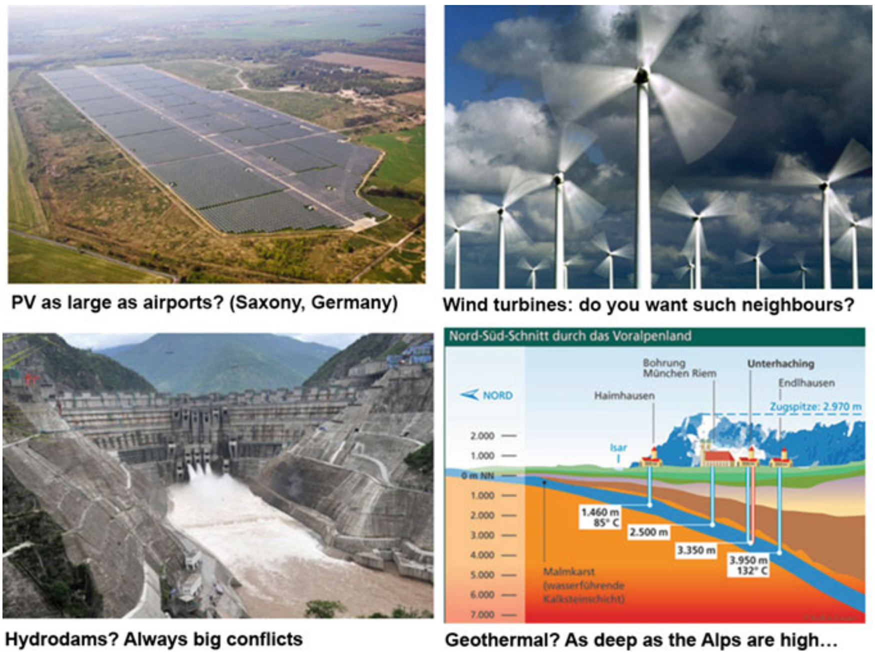


Fig. 2.12 Solar, wind, hydro and geothermal are fine on a small scale but can be nasty on a large scale. *Source* The author's archives

spoiled by power plants. They want no more hydroelectric plants or dams to be built, as they already have enough of them.

How about geothermal power? It may sound good. But we have to dig as deep as the height of the Alps to make effective use of geothermal power. It is unrealistic. It is a program that cannot be achieved without spending tens of billions of money.

2.6 What Can Renewable Energies Achieve?

Of course some renewable energies are easy to use and are actually being used effectively. Some of my friends are playing a leading role in exploring alternative energy sources. Another friend of mine received the Nobel Prize for research on renewable energy. This Nobel laureate, who pioneered photovoltaic power generation, has made wonderful achievements.

Photovoltaic power generation and offshore wind power generation seem to be good options. Or there is another option of encouraging the use of composting of biomass resources, which requires no electricity (Fig. 2.13).

In calculation, this seems to be a realistic option. It would be a big challenge for 1 billion people living in rich countries to make 20 % of their energy sources renewable ones. This means, however, only 1/35 of energy necessary for 7 billion people on the Earth.

While 1 billion people are living in rich countries, the total population of the Earth is 7 billion. To support all 7 billion people, efforts by 1 billion people are not enough.

If we have to increase 35-fold the examples I mentioned earlier—palm oil plantations, wind power, hydro power, or photovoltaic power—they will destroy ecosystems, which is an ecological nightmare.

What should we do to avoid this nightmare? Let's change the figure and assume that the target we have to achieve is 100 %. How about achieving 30 % of it by finding ways to obtain energy without emitting CO_2, 65 % by taking the option of becoming wealthy without using energy, and the remaining 5 % by quitting seeking wealth.

Then, a 5 to 10-fold increase of renewable energies would be enough. Let me remind you here that I am not an opponent of renewable energies. What I am pointing out is that excessive use of renewable energies may cause trouble to ecosystems.

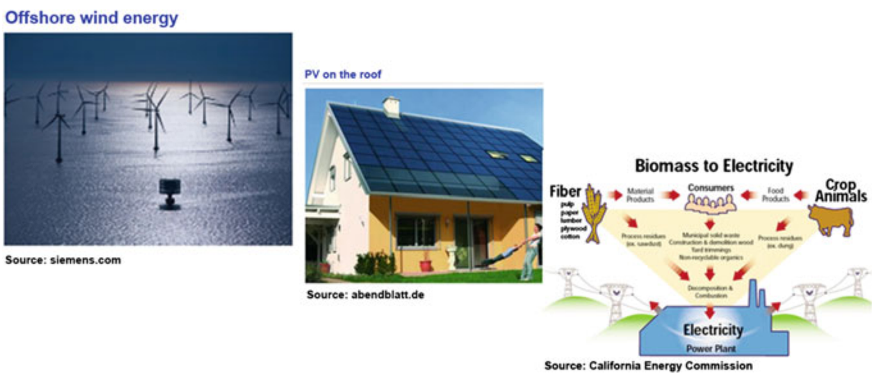


Fig. 2.13 We need a lot more renewable energies—where they are ecologically benign! *Source* The author's archives

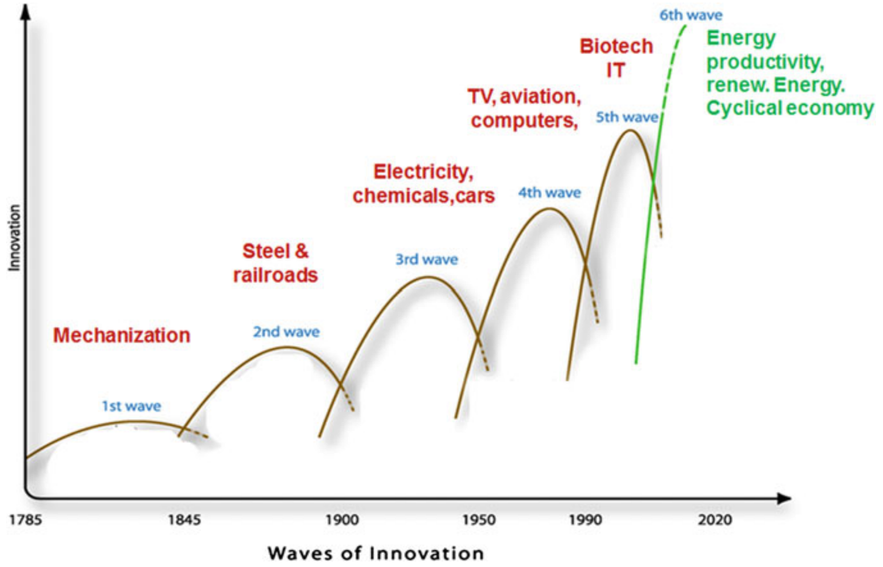


Fig. 2.14 Green Kondratiev Cycle, after five brown Cycles. *Source* The author

Therefore, a technological revolution is strongly needed. We have developed various technologies. Let's take a look at these technologies with reference to the so-called Kondratieff long waves (Fig. 2.14).

The past five cycles were all bad for the environment. We have already experienced five dirty cycles that have harmed the environment. Greenland shows an obvious result of those cycles.

2.7 Idea of Making Per-Capita Emissions Rights Equal

What is required now is a new green Kondratiev Cycle, which is friendly to the environment. In other words, we must find a way to help developing countries become rich without increasing their CO_2 emissions. As an answer to this, Indian Prime Minister Manmohan Singh proposed a wonderful idea of equal per capita emission rights. Germans, Americans or Japanese do not have more rights to emissions. People in India, Bangladesh, or the Philippines, or even in Nigeria, should have equal rights of CO_2 emissions, because they are all the same human beings. The concept of equal per capita emission rights is to make per-capita emission rights equal, so that the developed countries in the North should purchase emission rights from developing countries. By introducing this idea, CO_2 emissions in developing countries in the South such as India, in particular, will be reduced, as I describe the details later.

German Chancellor Angela Merkel expressed her agreement to Singh's idea on August 30, 2007 at the Nikkei Symposium in Tokyo, while the United States seems to dislike this idea and is opposing it.

With such an incentive, developing countries will make efforts to improve their energy efficiency, and then move to renewable energies. The market mechanism will automatically work, enabling renewable energy technologies to spread to developing countries in the South. No additional investment is necessary to achieve this, as developed countries will purchase CO_2 emission rights from developing countries. This incentive may also lead to the scrapping of ongoing plans to build many new coal power plants.

2.8 Task of Decoupling Prosperity from CO_2 Emissions

To this end, we must take a bold challenge in the real sense. In short, we must decouple prosperity from CO_2 emissions. Here, I want you to do a simple physics calculation.

How many kWh do you need to lift a bucket of water weighing 10 kg from sea level to the top of Mount Everest? Some may say 1,000 kWh and others may say 100 kWh. You are probably imagining a figure around them. But the truth is that it can be done with only 1 kWh.

Although it is probably hard to believe, it is true that only 1 kWh is enough. But we tend to think more and more power is required. It is ridiculous, in the first place, to lift a bucket of water up to the top of Mount Everest. However, this is what we are doing in seeking more and more energy and wealth.

Bob Lutz, former vice chairman of GM, who is called a US automobile guru, published a book titled *Car Guys versus Bean Counters* in 2011. In this book he points out how many MBA holders, or business school graduates, have been sent out into the US economy, and they are still increasing, while at the same time the power of American industry has been weakening.

In short, this book indicates that a greater number of MBAs from business schools cannot make the world better. Lutz says that we should let engineers run the show, not MBAs. I am sure that engineers are already playing major roles in Japan and probably in Germany.

An ordinary car runs 100 km with 6 to 12 L of gasoline. But a super-efficient car can run 100 km with 1.5 L of gasoline. And we should remind ourselves that we have the technology to bring that about.

The photo in Fig. 2.15 shows Mayor Boris Palmer of Tübingen, a university town in southern Germany. An electric bicycle is a better form of urban transportation than a car. You can get where you want to go faster by riding a pedelec than a Mercedes or Toyota.

Figure 2.16 shows passive houses, houses that require almost no energy. Most energy is generated by a heat exchanger, equipment ensuring high heat recovery efficiency, and the remaining energy requirements can be adequately covered by the

Fig. 2.15 Pedelecs are better for urban transport (as shown by Tübingen's Mayor Palmer). *Source* The author

Fig. 2.16 Passive houses: more heat efficient by a factor of ten. *Source* The author

solar panels installed on the roof. It is also possible to refurbish existing buildings into passive houses.

Look at the thermographs of Fig. 2.17. The left is before refurbishment. The house warmed up the atmosphere. But this situation dramatically changed after refurbishment. Replacing incandescent bulbs with LED lights increased energy efficiency ten-fold. This is widely known in Japan.

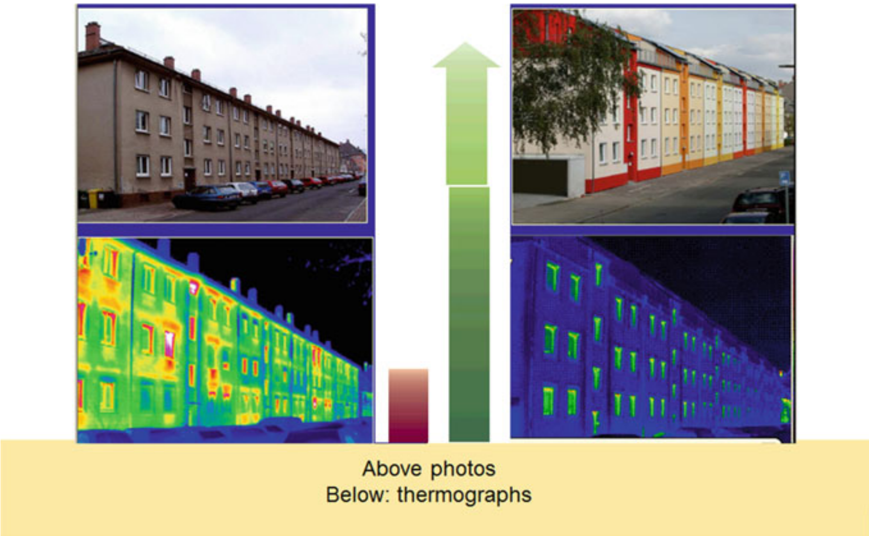


Fig. 2.17 Change in thermography as a result of refurbishing existing buildings. *Source* The author

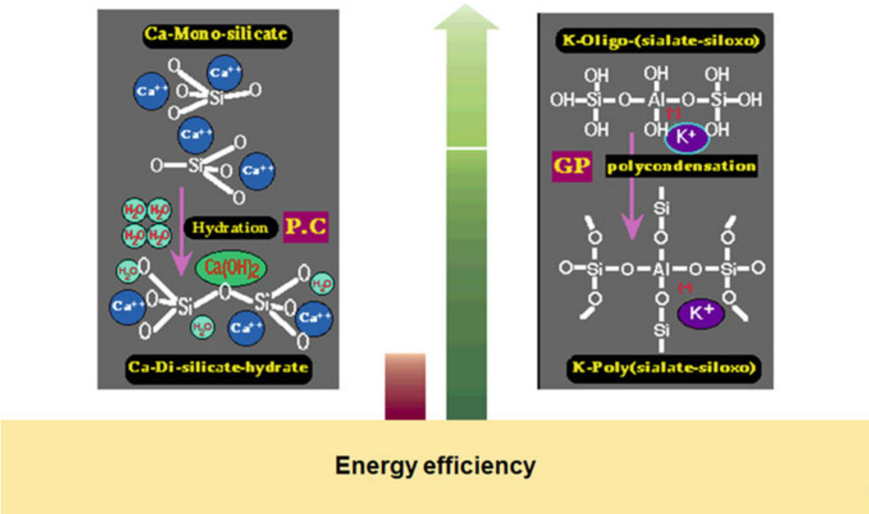


Fig. 2.18 Portland cement to geopolymer cement. (e.g. fly ash from coal power plants). *Source* The author

Figure 2.18 shows a comparison between Portland cement and geopolymer. Conventional cement consumes a large amount of energy. Portland cement is the type of cement currently in use. If cement can be produced using slag from

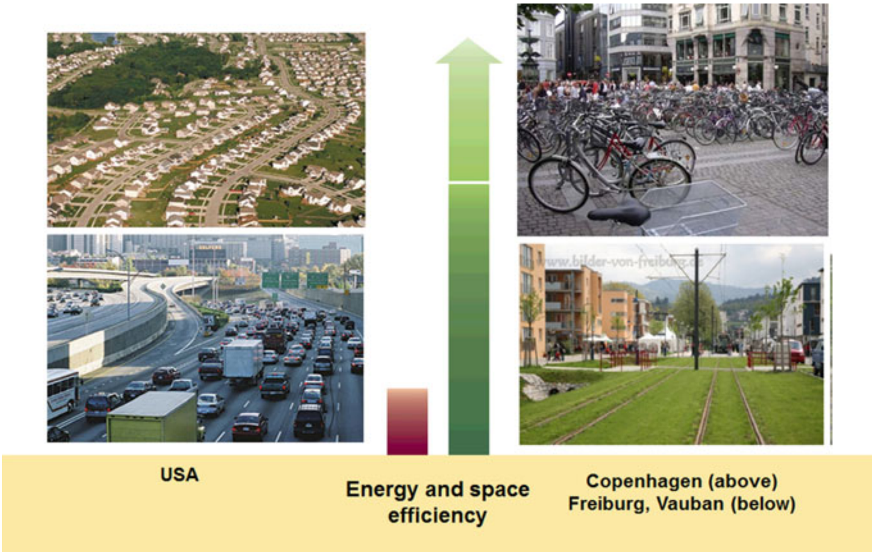


Fig. 2.19 City structure and energy efficiency. *Source* The author

ironworks or fly ash from coal power plants, for example, energy efficiency will be increased fivefold.

I once lived in the United States for six years. During that time I was frustrated that I was not able to go anywhere without a car. I now live in the neighborhood of Vauban, Freiburg. In Vauban, nine out of ten households have no cars. But the town is designed to enable residents to go wherever they want without a car. Figure 2.19 shows Vauban in the lower right, Copenhagen in the upper right and Atlanta, US, in the left.

Atlanta is 25 times as large as Barcelona, Spain. But Barcelona has a larger population. Nagoya is close to Barcelona; about the twice the size of Barcelona while the population is smaller (Fig. 2.20).

A shift from business trips to teleconferences is also effective. Or reducing consumption of cattle is another option (Fig. 2.21).

Logistics is another area with potential. Figure 2.22 shows the logistics of yogurt. A researcher named Balda studied the paths yogurt follows in becoming a product. Look at the chart on the left. It shows the terrible situation where trucks are running all over Europe. A total of 8,000 km routes have to be followed to produce strawberry yogurt. This is just crazy.

If aluminum is recycled instead of being produced from bauxite, resource efficiency will increase and the volume of mining can be reduced. I think having the principle of 3R, or Reduce, Reuse and Recycle, to eliminate waste is a wonderful culture.

The United Nations Environmental Programme (UNEP) set up the International Resource Panel in 2007, and since then the Panel has held annual meetings. We studied the recycling rates of metals, with support from Dr. Yuichi Moriguchi of the University of Tokyo (Fig. 2.23).

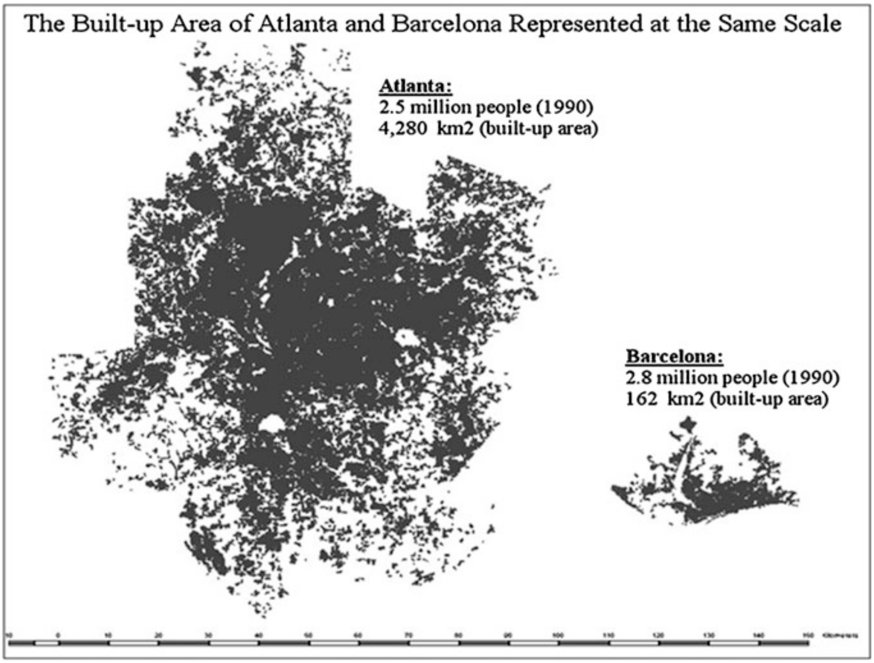


Fig. 2.20 Atlanta is 25 times larger than Barcelona, but has a smaller population. *Source* The author

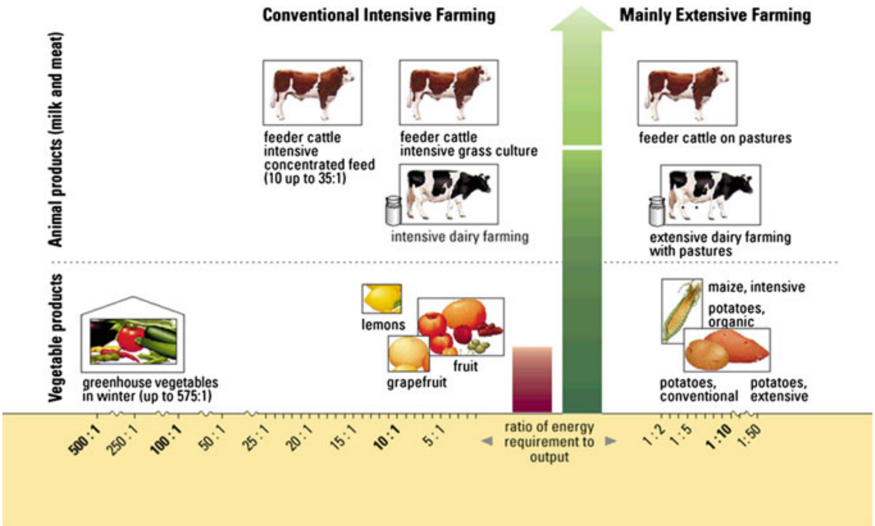


Fig. 2.21 Seasonal diets, organic farming, less beef consumption. *Source* The author

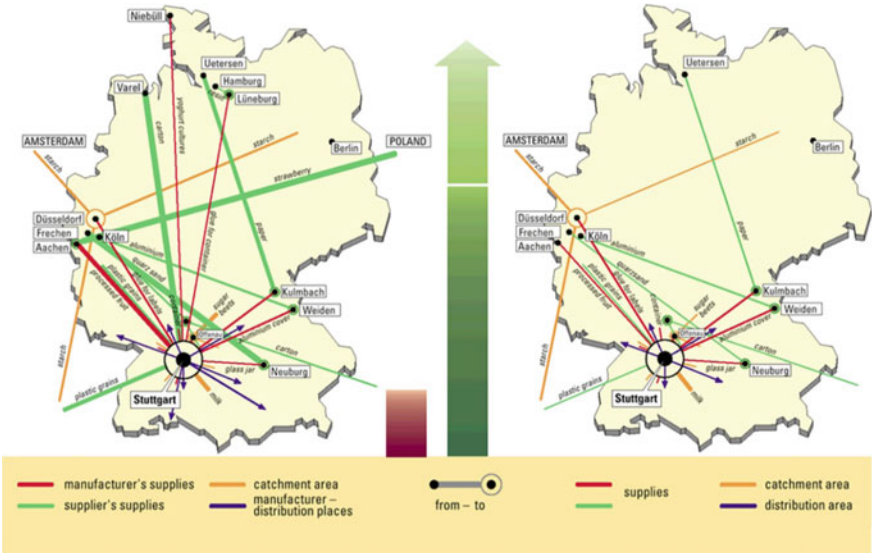


Fig. 2.22 Overcome crazy logistics (e.g. for strawberry yogurt). *Source* The author

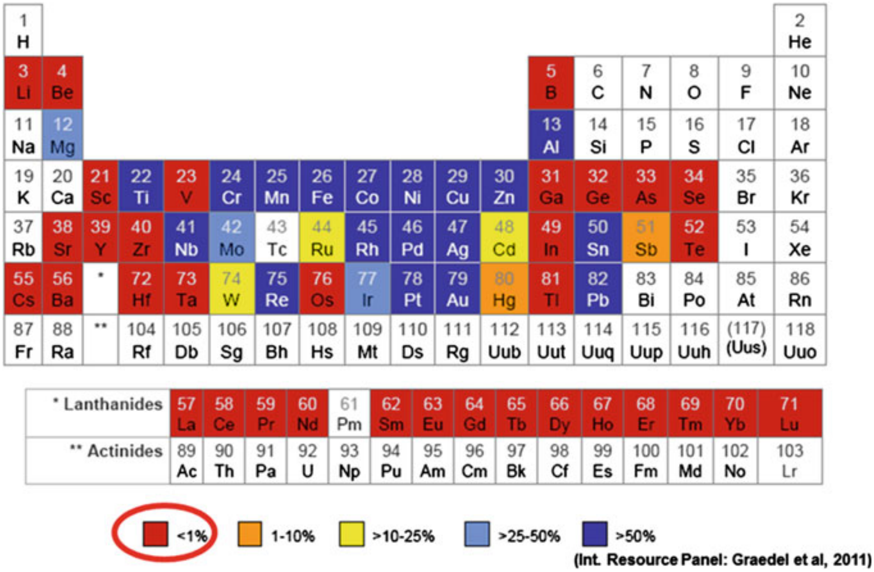


Fig. 2.23 Specialty metals recycling rates are below 1 %! *Source* Graedel et al. (2011). International Resources Panel of UNEP

Figure 2.23 shows the result of research on rare earths, in particular, the metals used for high technology. Their recycling rates were below 1 %. In other words, over 99 % of them are burned in incinerators or buried in the ground. Or they are somewhere in the environment and polluting the environment, which is a terrible situation.

I know it is very difficult but it should be possible to recover rare earths since we have excellent technology.

2.9 Higher Energy Prices Are Necessary

Now, will the efficiency revolution occur naturally? I don't think so. I think our intervention is needed. Look at the reality. Look carefully at what is happening in this society. Then you will find the world is going in the wrong direction, because everything is left to the markets. Of course I do not think a controlling approach is good. It may be appropriate to leave prices to natural forces. But look at Fig. 2.24, which describes air traffic. Prices have declined while the volume of traffic has increased.

Figure 2.25 shows the price elasticity of fuel consumption. Japan and Italy are in the bottom right, meaning that their fuel costs have been very high over the past ten years, though this information is rather old. On the other hand, oil is always very cheap in the United States, meaning that gasoline is cheap. This explains the situation of Atlanta. Cheap fuel makes people feel that it's easy to use cars.

But Japan tries hard to minimize the use of cars and to reduce fuel consumption by making bullet trains, etc. Germany has introduced the so-called eco-tax. Surprisingly enough, they achieved favorable economic growth rate while decreasing CO_2 emissions.

Look at the US and Canada in Fig. 2.26. Their gasoline use is increasing. In Germany, the introduction of an eco-tax has not meant a heavy tax burden. Because the rates of other taxes were lowered after the introduction of the eco-tax, the overall tax burden decreased.

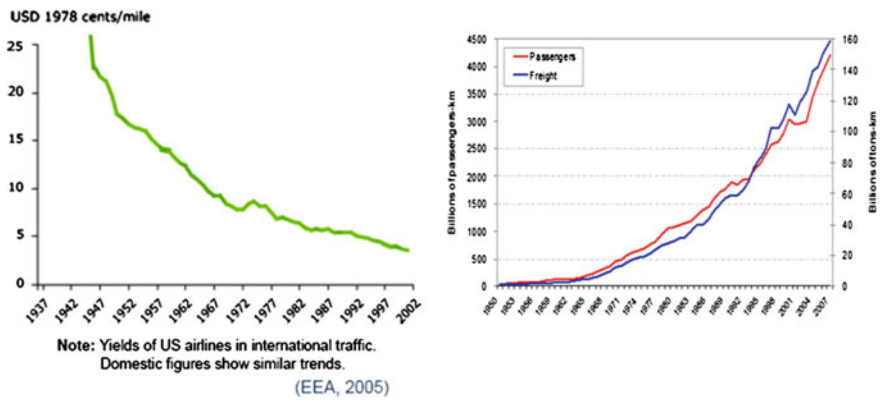


Fig. 2.24 Collapsing prices and corresponding explosion of air traffic). *Source* EEA (2005)

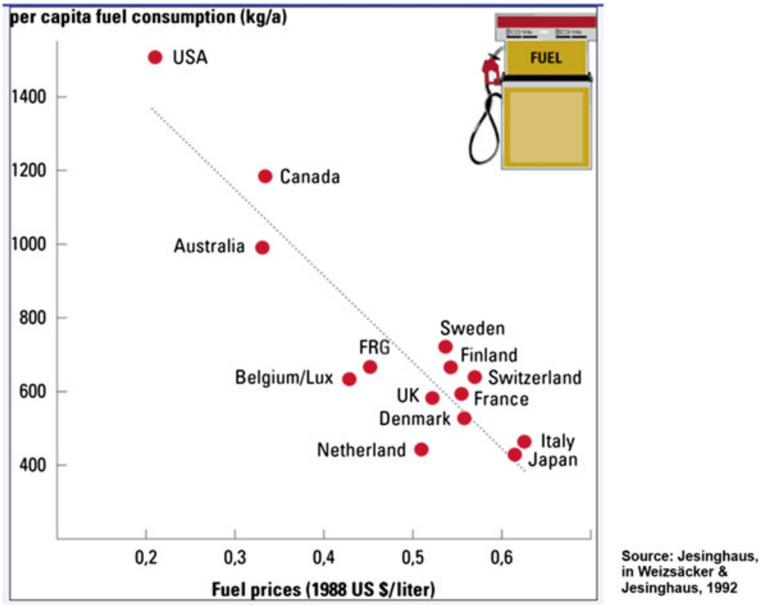


Fig. 2.25 The price elasticity of fuel consumption is very high! *Source* Jesinghaus/von Weizsäcker (1992)

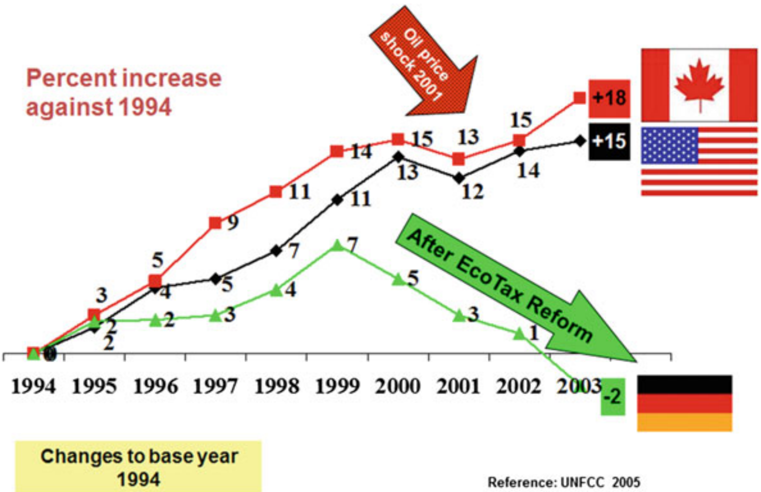


Fig. 2.26 Eco-taxes can reverse the trend in transport emissions. *Source* UNFCC (2005)

The Industrial Revolution increased labor productivity 20-fold. But in parallel with labor productivity, wages also rose. This is like a ping-pong game.

A rise in labor productivity causes a call for higher wages, resulting in an increase in wages. Then efforts for rationalization are made, leading to further improvement in labor productivity. Then wage negotiations start again. This process was repeated 200 or 300 times, until labor productivity was increased to 20 times higher.

This resulted in the accumulation of a large amount of wealth, which is a great success. On the other hand, however, the prices of resources have been falling. This means that resources are used wastefully (Fig. 2.27).

We therefore have to change this trend. Although this trend has actually been changing since around 2000, we must stabilize this ascending current. If we intentionally raise energy prices while improving energy efficiency, even by a small percentage, expenses for energy services will remain stable.

And then we will not need to raise the prices of what we call lifelines for poor people. Since what we really need is always necessary anyway, prices for such things should not be raised.

High fuel costs will probably not hurt the economy. Why not? For example, for 15 years after the oil crisis, although Japan refrained from importing energy, resulting in higher energy prices, the country showed a good economic performance. This was probably partly due to the contribution of nuclear power generation. But during the period from 1975 to 1990, Japan boasted unrivaled competitiveness. Japan's high economic growth was called a miracle. This boosted real estate prices and became a risk factor. Then the bubble economy collapsed, and Japan subsequently entered the stagnant economy stage.

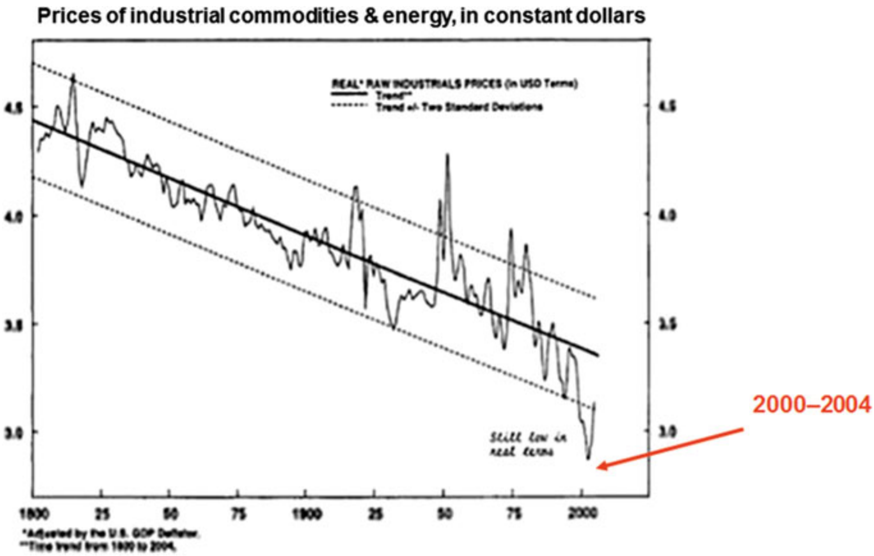


Fig. 2.27 Prices of industrial commodities and energy. *Source* The Bank Credit Analyst (year)

But we are pioneers. Pioneers need not decelerate nor wait for slower people to come. And who will win this game? I think high technology, engineers, culture, high quality or railroads, etc. will be the winners. This is truly the paradigm of Japan. So what kind of people are the losers?

2.10 Who Will Be the Winners?

The winners will be the countries in Europe and East Asia, as well as the developing countries with no resources, which account for 90 % of the total population (Fig. 2.28). So who will lose? It will be the people who ignore the idea of improving energy efficiency and not wasting raw materials.

The alliance of winners is those who take really effective climate policies, ecology policies, and ensure a good balance between government and the market. This means that we must relieve ourselves of the current Anglo-American cultural dominance. We should not follow the principle of Harvard Business School, which is that the government should leave everything to the control of the market. We must get rid of this almost religious belief in markets.

Let me review a little bit of history and introduce some Anglo-American heroes. Thomas Hobbes says that humans are selfish beasts. And therefore an authoritarian (Leviathan) must tame such beasts. 100 years later, Adam Smith appeared. He says that although humans may be beasts, markets can do the taming and therefore the Leviathan is not needed. Another 100 years later came Herbert Spencer, a friend of Darwin. He is an advocate of so-called Social Darwinism. He says that the state is not needed because the theory of evolution works and the strong will attack the weak so as to make everyone strong. He once went to New York and saw many immigrants, who were suffering from hunger. He proudly told his friends that they were seeing "evolution in action." What inhumane words they are! This historic trend

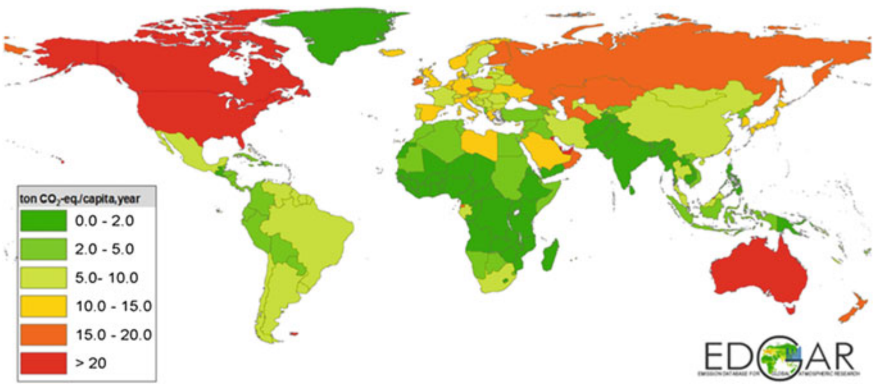


Fig. 2.28 Per-capita CO_2 emissions. *Source* RV-JRC/PBL. EDGAR version 4.0.; at: http://edgar.jri.eu/.20009

gave rise to the idea that dominates Wall Street Journal, which is the idea of Milton Friedman. He says that the state should withdraw and markets should take control. The ideas of their Chicago School stood behind the whole wave of deregulation.

My conclusion is: Factor 5 is needed, and available to us. The North-South issue, or so-called "carbon justice" is highly important. Prices should make the transition profitable. We must create an alliance of the winners while keeping a good balance between the government and markets. This is my message.

Eco-Lab Talk (2): Technology × Society = Transformation

Ernst Ulrich von Weizsäcker and Hidefumi Imura

Left: E.U. von Weizsäcker Right: H. Imura

2.11 Toward a Society that Coexists with the Environment, as Beautiful as a Butterfly

Imura: Professor von Weizsäcker, you have been active in various fields of environmental studies and environmental policies. Please tell me about your first encounter with environmental issues.
Weizsäcker: I have loved butterflies since I was a child.
Imura: Butterflies? That reminds me that you were wearing a tie with butterflies on it at our meeting yesterday.
Weizsäcker: Yes. I love to see a caterpillar growing and transforming itself into a beautiful butterfly. I think I am strongly attracted by their splendid molting, or transformation.
Imura: The idea of transformation is deeply related to environmental issues. If the conventional industrialized society is a caterpillar, a society that coexists in harmony with the environment is a butterfly that has undergone its final molting.
Weizsäcker: Absolutely. A society that has undergone sufficient dynamic changes and achieved sophistication is as beautiful as a butterfly.

2.12 Halving Resource Use, Doubling Wealth

Imura: One of your books is the world-famous *Factor Four*. Factor Four was a call for doubling wealth and halving resource use, and initiated a flood of discussions on the environment, resources and energy from the global viewpoint.
Weizsäcker: Over the past 200 years, labor productivity has increased 20-fold. This means that the same production volume (economic prosperity) can be maintained with less labor input.

How about applying this to energy resources? First, technological improvement itself can surely increase environmental efficiency. Meanwhile, the prices of energy and resources such as oil are rising. The price rise provokes technological/political efforts, which result in further increases in energy resource efficiency. In 2007, for example, although the oil price rose by 3 %, the fuel efficiency of automobiles also increased by 3 %, which absorbed the oil price rise.

If we can make an effective mechanism like this, efficiency in energy resource use will increase, enabling resource use to be halved and wealth to be doubled.
Imura: It is difficult to build such a mechanism by leaving everything to technology or market competition.
Weizsäcker: That's right. You mentioned this point in your book *Environmental Policy in Japan*, citing Japan's experience. Things will not move in a good direction through the efforts of industry alone. The government should take appropriate initiatives through such measures as introducing environmental taxes or emissions trading to control prices for energy use. It is important to ensure a good relationship between industry and the government.

Imura: Japan has addressed environmental issues based on negotiations between industry and the government. But now that politics and the economy are globalized, limitations to this conventional system have been pointed out.
Weizsäcker: As the economy is globalized, international financial systems may undermine the state, which is an unfavorable trend from the viewpoint of the environment and social fairness. During the Cold War years, on the other hand, not only pursuit of market profit but democracy, social fairness and commitment to environmental issues were also considered important in the US-Soviet confrontation. But in the post-Cold War globalized world, the highest priority is placed on markets.

2.13 Factor 5 Suggests the Form of Society We Should Have

Imura: I hear you are currently writing *Factor Five*. What made you advance from Factor 4 to '5'?
Weizsäcker: In the first place, the figure '4' was not good. My Chinese friend told me that '4' has the same pronunciation as 'death' in Chinese and therefore it is believed to bring bad luck. (Laughter) Anyway, I thought it was about time to move a step forward from Factor Four.

During the 12 years since *Factor Four* was published, the world has undergone substantial changes. One of them is technological advancement. *Factor Four* presented high-efficiency fluorescent lighting as an example of highly energy-efficient technologies. But today, LED technology is already spreading. Shuji Nakamura, well-known inventor of LED lighting, is at my university. Various other environmental technologies have been developed over the past ten years. If we make good use of these technologies, it is possible to make wealth × environmental efficiency '5'.
Imura: While technologies have been developed, government and policy should play a major role in making effective use of them.
Weizsäcker: Yes. Technology itself is not almighty. The government's role is to help establish mechanisms for promoting the spread of, or demand for, new technologies. Discussions in *Factor Four* focused mostly on technology. In *Factor Five*, I will get to the core of the significance of policies and systems. In other words, I will discuss the form of society we should have by presenting mechanisms that create multi-layered cycles of energy efficiency.
Imura: What you said now is certainly connected to 'transformation,' as you mentioned at the beginning of this talk. Technological advancement alone cannot improve the global environment unless the social foundations and systems to make use of it have been developed. Even if social awareness has increased, on the other hand, without technology practical action will bear no fruit. In short, it is very important that both technology and society undergo qualitative transformation and

harmonize well with each other. By ensuring this, we can achieve Factor 5, or go even further ahead.
Weizsäcker: Absolutely. If both technological efficiency and social systems work effectively like two wheels, we can aim at a goal higher than Factor 5.
Imura: You have promoted eco-tax reform[1] as a researcher and also as a politician. Do you think eco-tax reform is effective as a means to develop a framework to achieve Factor 5?
Weizsäcker: As a means to gradually raise the prices for stable energy use, eco-tax reform is effective. In the EU, a carbon emissions trading market was established, where the trading price fluctuates drastically on a daily basis. Unlike the stock exchange, such a game element is not needed in emissions trading, which may inhibit us from taking a consistent approach to address global warming. Eco-tax reform, on the other hand, will enable the industry to forecast long-term price fluctuations and take proper action.

2.14 Entering, and Emerging from, the Era of Global Warming

Imura: How do you see the actions taken by various countries in addressing global warming and climate change?
Weizsäcker: Among the EU nations, Germany has been making a particularly large commitment to global environment-related policies, strengthening its international presence. Japan is in danger of failing to achieve the reduction target of the Kyoto Protocol. But considering the substantial quantity of greenhouse gas emissions that Japan had already reduced before the standard year (1990), I am quite sympathetic to Japan.

In the United States, despite its constantly reluctant attitude, even the current president is beginning to take action, which makes us expect substantial progress when the next President takes office.[2] Before that, the G8 Summit in 2008 (held at Toyako, Hokkaido) has made climate change and energy efficiency central subjects of international forums, dramatically changing world trends.
Imura: Do you have any specific ideas about policies or systems to help solve the global warming issue?
Weizsäcker: I would like to suggest "per-capita equal emission rights for carbon." While making efforts to reduce their own carbon emissions, developed countries must also promote the establishment of a framework by which they will purchase emission rights from developing countries and make joint efforts with developing countries for climate stabilization. Developing countries, on the other hand, must

[1]The idea of raising energy tax in stages while at the same time lowering pension premiums.
[2]George W. Bush was the then President.

increase energy efficiency to five times what it is now, which is technically possible for sure.

Imura: Although the population increase in developing countries may be a problem, this seems to be a good idea if emissions rights quotas are set based on the population at a certain time.

What do you think about the situation in Asia, where rapid industrialization is taking place with environmental policies left behind?

Weizsäcker: I believe in the potential of Asian countries. We will soon see an era which can be called the Century of Green Asia. If they can avoid the paths that advanced countries once followed, they will be able to achieve economic growth in harmony with the environment. It is important to build collaboration and unity on a global scale to tackle global environmental issues, and to establish a fair system, led by the United Nations, not dependent on a single country.

Enlightenment and education are also important. I was impressed to hear that the Indian Supreme Court had made a decision to provide the people with environmental education. Such movement makes us believe that we still have a chance of recovery.

2.15 What Universities Should Do in Collaboration

Imura: In leading such pioneering approaches, I think universities should play an important role.

Weizsäcker: The Bren School (University of California, Santa Barbara) offers the Group Project, a unique program for student education. Students in groups study and research actual environment-related issues for a year, in response to requests from private firms or municipalities. I like this project very much because it helps to dramatically improve students' autonomy, initiative and analysis/research abilities.

Imura: The Graduate School of Environmental Studies, Nagoya University and the Bren School entered into an exchange agreement, which enabled us to invite you.

Weizsäcker: Let us start by actively promoting mutual visits between students or young researchers. I have already come up with some ideas for matching researchers of the two universities on several specific research themes.

Imura: That sounds great. Thank you very much.

This interview is a modified form of that first appearing in Japanese in *Kwan,* vol.14, spring 2008.

Chapter 3
Energy and the Use of Nuclear Power

Hans-Peter Dürr

Dr. Dürr, a successor to Dr. Heisenberg, entered the Max Planck Institute for Physics as the first assistant when the institute was established in Germany by Dr. Heisenberg. His career is wide and varied. Though he was born German, he received his doctorate from the University of California, Berkeley. Around that time, there was a big party at Berkeley's Physics Institute. When he asked why people were so excited and happy, he was told that: "The child is born." It turned out they were celebrating the development of the Hydrogen Bomb by Dr. Edward Teller, who was Dr. Dürr's supervisor. You may recall that a Japanese fishing vessel was exposed to radiation at that time at Bikini Atoll. Dr. Dürr was shocked and returned to Germany. His return was around the time when Dr. Heisenberg, a successor to Dr. Einstein, established the institute, and Dr. Heisenberg employed him as an assistant.

Like Dr. Weizsäcker, Dr. Dürr is a member of the Club of Rome, and has been awarded numerous awards including the prestigious "Right Livelihood Award" which is known as the "Alternative Nobel Prize." He is also an honorary citizen of Munich. Dr. Dürr is one of the key authors who drafted the 2005 update of the well-known Russell Einstein Manifesto, known as the Potsdam Manifesto. He passed away on 18 May 2014 at the age of 84.[1]

3.1 Earth's Matter and Energy Are Limited

Since I am a nuclear physicist, you may be expecting to hear from me that nuclear energy or atomic science and physics are important. But I am 100 % against the use of nuclear energy, despite the difficulty of inventing a new thing or making a new statement.

Hans-Peter Dürr, Director Emeritus of the Max Planck Institute for Physics and Astrophysics, Member of Club of Rome, Visiting Professor at Nagoya University Graduate School of Environmental Studies.

[1]For an obituary by Prof. Götz Neuneck, Hamburg University; see: http://alt.vdw-ev.de/images/stories/vdwdokumente/aktuelles/In%20Memoriam%20HPD_Neuneck.pdf.

Y. Hayashi et al. (eds.), *Climate Change, Energy Use, and Sustainability*,
Sustainable Development and Sustainability Transition Studies 25,
DOI 10.1007/978-3-319-40590-2_3

And I am also well aware that as a physicist I have to meet certain conditions. We all have an impression that the Earth is limitless, and tend to think that whatever it offers can be used. Unfortunately, however, it is very hard to raise awareness that Planet Earth is actually limited.

I have talked with a lot of people in the business world. They often respond, "You scientists say that the Earth is limited, but business knows no boundaries." Their point is that the human imagination is limitless. Having heard from them, we also know that if something does not work we should make an effort to solve it. We physicists are well aware that the planet called Earth is limited.

It is impossible for the Earth to suddenly become twice as large tomorrow. Matter and energy do not increase, as they follow the law of the conservation of energy. They do not increase, but circulate. Energy is matter, or we could say a form of material quality. And matter is another form of energy. These constitute the Earth as a whole. From now, we should realize that we do not live on a limitless Earth.

The very thin layer that can be used on the Earth is the soil or 'earth', and we live on it. We have to face the reality of what condition that part is now in. Namely, the resources on the Earth's surface have not increased.

So, planet Earth's matter and energy are constant. The Earth is an independent and isolated system, and we have to continue using its resources in our future, too. We cannot increase them even if we want to. Based on the fact and realization that they are limited, we should set our own boundary conditions within which to utilize them.

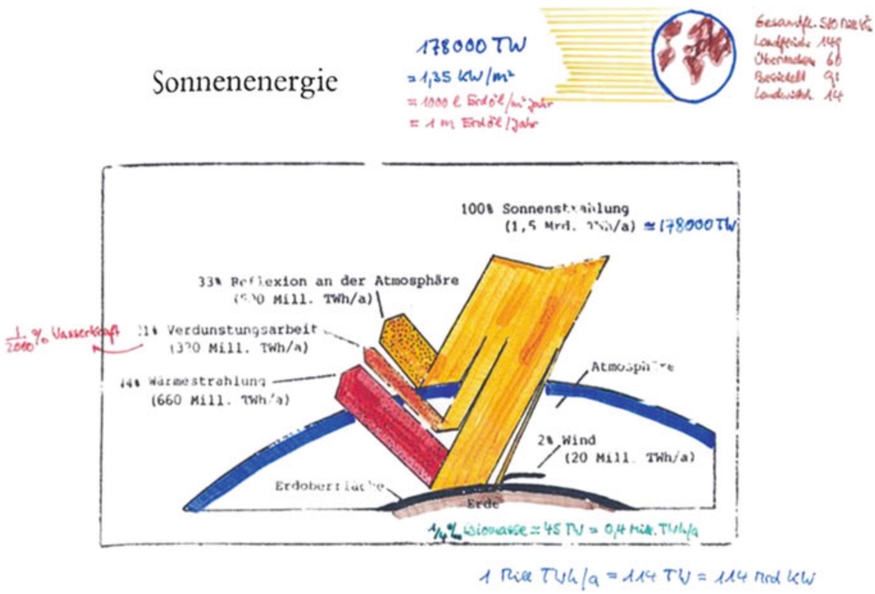


Fig. 3.1 Solar energy reaching the Earth. *Source* The author

Some people may think that the Earth's matter may not increase, but that it does not decrease. The fact is that there is a loss. By throwing away what you have, the materials that we use are being lost endlessly. Therefore, we have to make every effort to establish various methods to recycle materials without losing them.

Energy is the same. It must be conserved. Surprisingly, energy supports the entire Earth. The reason is that light from the sun reaches the Earth's surface and provides the Earth with all the energy it needs (Fig. 3.1).

Figure 3.2 shows how it works. All the solar energy that the Earth receives actually goes back to space. Otherwise, the Earth would melt away and disappear as gas. What is important is not the energy, but part of the energy, which is called exergy. Energy is heat, and heat is radiated by the Earth and absorbed by space. Therefore, the total energy does not increase.

What is strange is that if you observe various forms of energy on the surface of the Earth you will notice that the solar radiation spectrum is divided into various wavelengths, as shown in Fig. 3.3. The wavelengths vary from violet to red, and are distributed in this way. The light we see is only a part of this distribution.

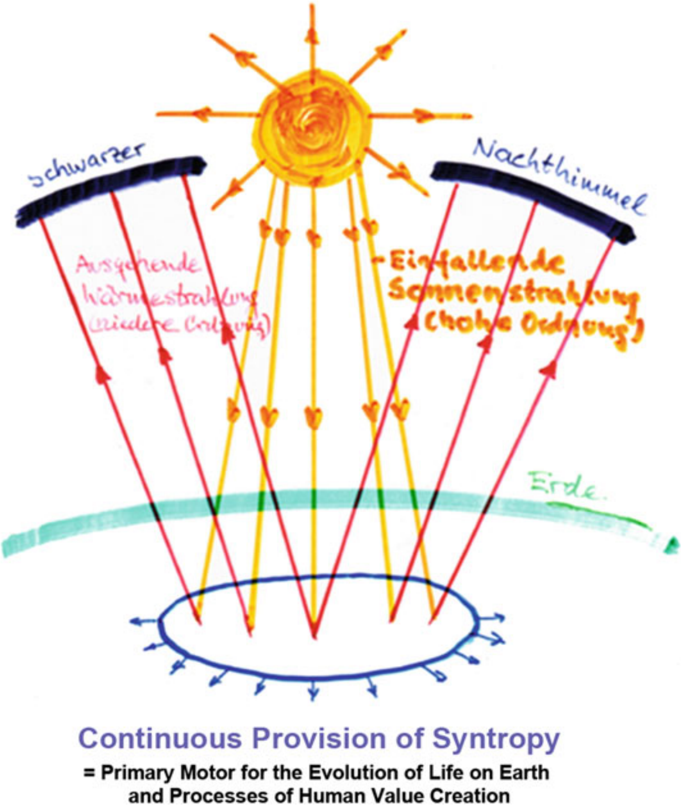


Fig. 3.2 The sun as a source of syntrophy. *Source* The author

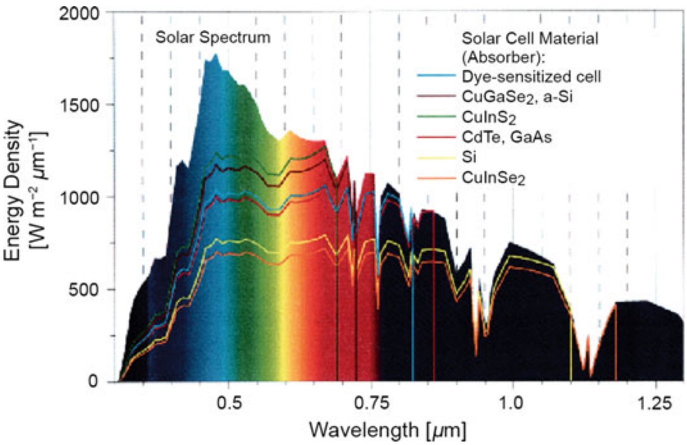


Fig. 3.3 Solar radiation spectrum. *Source* The author

3.2 Fossil Fuels Are the Accumulation of Energy Provided by the Sun

We have a question here. "Where does this sunlight go?" Part goes into the clouds in the sky, and again changes into heat, and the heat goes back to space as radiation. Part penetrates the ground. Considering the rule that what comes in goes out, we have a discovery. Part of the energy goes into the soil, and it is caught there.

As you know, there are various types of energy that we use. Figure 3.4 shows the energy provided by the sun. Man cultivates land, using horses. This is also energy. Using the energy provided by the sun, man grows plants and crops, and takes in the energy by eating them. This is the circulation of energy. Part of the energy gets caught, and is used by being absorbed on the Earth's surface.

This is a very important point. *Fossil fuels* are the accumulated energy from the sun, and we have been using them by taking them out. I would like to emphasize this point. "How are these fossil fuels made?" The sunlight has been absorbed through several hundred million years and been accumulated underground. This is *accumulated energy.*

If we do not give the Earth some energy or 'food' in some way or other—in other words, if we just dig and use what the sun provides without any compensation, fossil fuels will be lost. They are the accumulation of energy that has been provided by the sun over several hundred million years. Coal and oil are the same. They have been accumulated underground. We even turned underground resources such as uranium into atomic bombs.

There are various ways and means to use the accumulated energy. Fossil fuels are the accumulation of the energy that we have found. There are also other fuels that are the same as fossil fuels, but are in other forms. Since the amount is limited, they will be gone if we use them up.

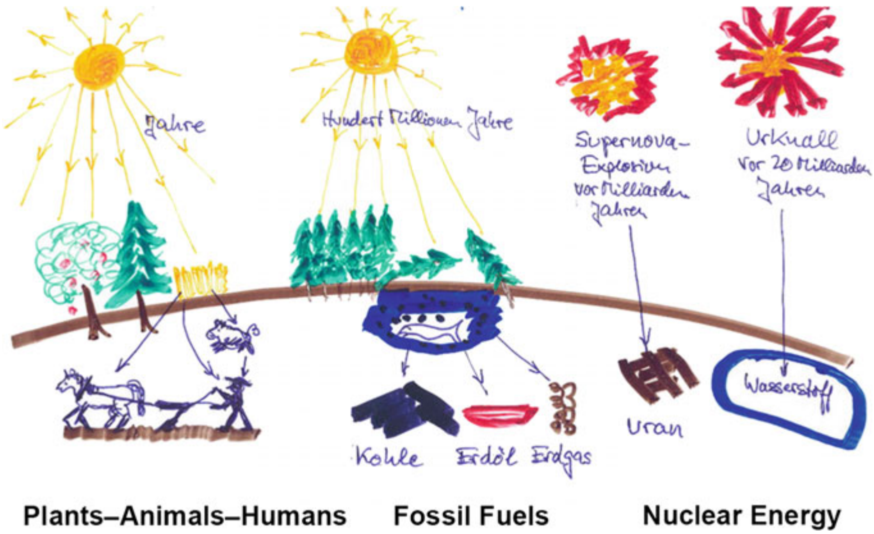
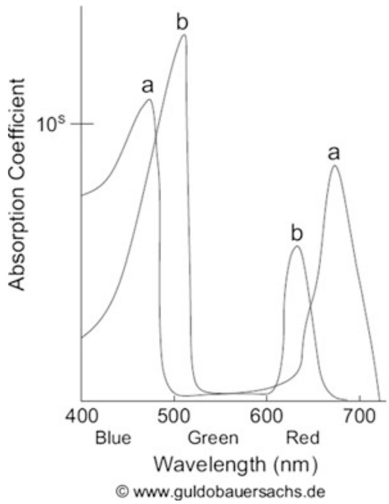


Fig. 3.4 Syntrophic sources on the Earth. *Source* The author

Fossil fuels will not be used up in several years. People used to think that there were no problems in continuing to use them. But the current generation has noticed that they are limited natural resources, and has come to realize that they may be gone in about 50 or 60 years, if not sooner. What is left is only the sunlight. Only the sunlight will be the source of energy.

Figure 3.3 shows the solar radiation spectrum, but only the wavelengths ranging from 0.5 to 0.7 μm are absorbed and used by plants (Fig. 3.5). They can also be a source of fossil fuels.

Fig. 3.5 High sources of syntrophy on the Earth. *Source* Guido Bauer Sachs



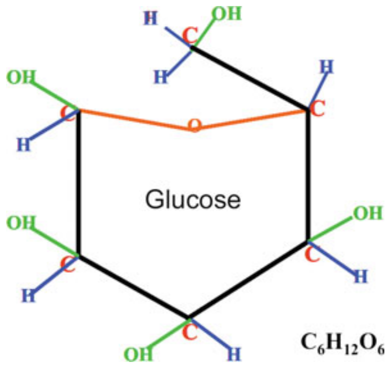


Fig. 3.6 Glucose. *Source* The author

This process is called *photosynthesis.* Plants absorb CO_2 and react with water by using the blue-green wavelengths. This chemical reaction will produce in the end a chemical compound, which is the glucose produced by sunlight, CO_2 and water. It is the origin of all life on Earth (Fig. 3.6).

Any biosystem is based on glucose. Glucose may be considered to be something like the basic currency or money. What is important is not how many dollars we have. It may be better to consider how much glucose we have and how much glucose we are entitled to use. We need to know how much glucose the sun provides and how much of it we will be allowed to have.

3.3 Life and Matter Are Unstable

What is happening now is this: what allows life on Earth to continue? Life is composed of atoms. Life exists in an unstable condition rather than in a stable condition. It exists because it is unstable. It may be said that there is a process called life. Each atom is cooperating with each other in order to make something like a tower made of playing cards.

The evolution of life is a process which makes the tower of cards higher and higher. As shown in Fig. 3.7, man is dancing on the tower of cards. But he has to be very careful because the tower is not stable. To live and lead a life is essentially unstable.

In order to dance on the tower of cards without destroying the tower he has to keep a good balance. Sunlight reaches the Earth without destroying the tower. Man has to be very careful not to destroy all the towers of life by losing his balance.

In physics, we use technical terms for this kind of structure. Materials and energy do not exist unless they have this kind of structure. We tend to misunderstand this point. It is not that we cannot trust anything because we are standing on the tower of cards. If we are careful in keeping a good balance, we can keep on dancing. And the sun is the source of the towers of life. This tower, for example, which is made of

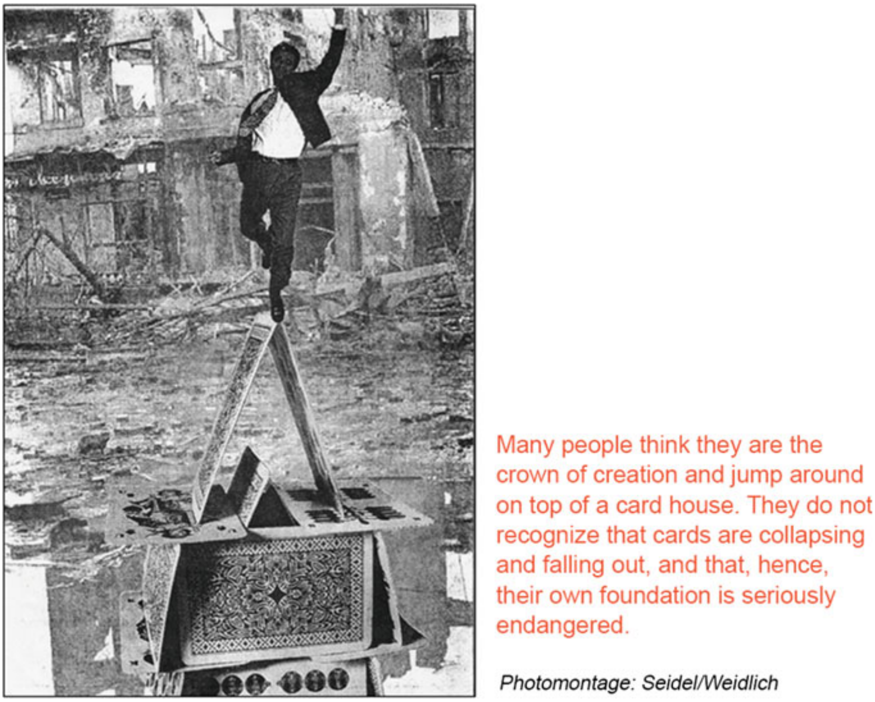


Fig. 3.7 Vulnerable biosystem. *Source* Photo editing by Seidel and Weidlich

playing cards as shown in Fig. 3.7 (you may call it a building) builds other towers by supporting each other. This is exactly an analogy of the evolution of life. This interdependence is very important.

3.4 What Is Sustainability?

Now, I would like to discuss sustainability. In my lectures to young students, I often say that the most important thing is sustainability. Sustainability means the ability to sustain, but this term is not such an exciting one. Do you think it is so simple? If you lie in bed and die as you are in that condition, you may call it sustainability. But is this really sustainability? I don't think so.

What we should sustain is life. Life includes vitality, productivity, creativity, recuperation, hardiness and others. To achieve all these at the same time is to sustain. Sustainability is to make all living things more full of life. Just lying in bed and keeping that condition is not sustainability at all. I think sustainability is to make all living things more lively and energetic.

What is required for sustainability is not quantity but quality. A growth of quality is required. Or, it may be said that an improvement in quality is required.

It is now 3.5 billion years since the birth of life. Something like a chemical soup, which existed from the beginning of this Earth, formed the planet, and our life was born. Looking back at those earliest days, we find the actions and interactions of a variety of materials. We need to be fully aware of those actions and interactions.

These actions stimulated creativity and diversity during the initial stages of life on Earth. Each material is different, having its own creativity, yet all are interdependent. With creativity and diversity, each material gradually reached a higher stage as a whole. All living things are now parts of the whole. The essential creativity is buried in each of us, and in each atom of matter. We are not living separately.

I am now standing here, and you are sitting and listening to my lecture there. Because we are separate as individuals or sitting separately, you may think that we are different creatures. This is not true. We are connected to each other through the basic nature of the materials that make us up.

I am speaking as a physicist. We are connected to each other in some way or other. We cannot be disconnected and separated. We are connected by some basis or some background. Under these circumstances, sustainability is a life that wishes "I want to live". It is a life that exists in each life that wishes to live. This is my understanding of sustainability.

3.5 Our Reality and the Problems We Face

The world is a reality. What does this reality mean? Each material can be separated and isolated. It may look that way, but we are all a part of a greater existence called life.

Our existence seems to be separated, but if we trace back the layers of existence to their depths, we are connected to each other at the very bottom. The creativity that I mentioned earlier is that we try to find our way in different directions, not that we make it. Space has not only the three dimensions which we know, but also alternate dimensions. In order to make something new, the important thing is how far we can move forward. To move forward, all materials that constitute the universe must be connected to each other.

It is said that the universe was created by the Big Bang. Various materials have been made since. We are at the end of this process of creation and see what is left now. However, the Big Bang may happen again.

Somewhere in space, Big Bangs are always happening. Therefore, creation has been occurring. Creation has continued to occur while life exists. Therefore, we see much greater vitality in a living creature than in a dead creature.

Where are we heading? If the direction we go in the morning and the direction we go at night are opposite, the entire world will be in total confusion. Energy plays a very important part, but what we want to discuss is how energy works.

Fig. 3.8 The "bank robber". *Source* The author

Earlier, I discussed the uses of fossil fuels. They are used in various ways. Using fossil fuels from the ground can be compared to the bank robber who steals some money from a safe, as shown in Fig. 3.8. We are stealing fossil fuels like a bank robber.

Our problem is that we are stealing and using assets from the sun that have been absorbed and accumulated by the Earth.

And the changes so far have been happening at a faster pace than the speed at which the solar energy is absorbed. This has caused a lot of problems for human activities. For example, if the changes that happen very rapidly in a certain century lead to a great emission of CO_2, then we notice the problems all of a sudden. Only then, we realize that what we stole from the safe was not free, and we have been seriously affected by stealing too much.

What can we do to escape from these problems? Before considering how we should use fossil fuels, the point I want to make is that we should consider how many people the Earth can support.

3.6 Energy Slaves and CO_2 Emissions

There are about 7 billion people on the Earth. However, I would say that the actual population is not that important. What kind of activities are people engaged in? I would add that even if there were 20 billion people on the Earth, it could support those people depending on the way energy is used.

Considering the energy usage and amount, maybe I can explain it like this. Although there are now 7 billion people on the Earth, there are about 130 billion energy slaves in the background. These are energy equivalents to human power. This is the concept used when we calculate how many people's energy we use in terms of fossil fuels. Based on this concept, there are more than 10 billion people on the Earth, or there are about 130 billion energy slaves. This causes an imbalance.

Table 3.1 Per capita consumption of primary energy (2003)

Region	Power of primary energy (kW)	Number of energy-slaves
World	2,200	22
UAE	21,610	216
Canada	12,252	123
USA	10,460	105
The Americas	5,071	51
Europe	4,407	44
Australia	7,672	77
New Zealand	6,345	63
China	1,035	10
Asia	982	10
India	677	7
Indonesia	624	6
Africa	372	4

Table 3.1 shows the calculation of 130 billion energy slaves in terms of energy equivalents. The energy is not evenly distributed.

In the United States, there are 105 energy slaves per person. In Europe, 44 energy slaves per person, In China, 10 energy slaves per person. While there are 105 energy slaves in the United States, there are only 12 energy slaves on the average in the countries apart from the United States. This is quite an imbalance. The viewpoint of energy slaves makes it clear who is causing a great quantity of CO_2 emission, and who is not.

And we can conclude that the Earth can support up to only 15 energy slaves per person, and that it allows only 2 energy slaves in terms of CO_2 emission.

3.7 Why I Am Against the Use of Nuclear Energy

Now, I would like to discuss nuclear energy. At present, there is much discussion about nuclear energy, and I am sure you are greatly interested. I have been involved with this problem for a long time.

Table 3.2 shows a brief history of the development of nuclear energy in Germany. Since I was a student in 1953, I have been personally involved, and I am very familiar with nuclear energy.

As an individual, I am against the use of nuclear power. I am even against the peaceful use of nuclear energy. It may make logical sense to use such energy for peaceful purposes, but there is no guarantee that peaceful use won't be diverted to military use. It may be used for wars.

As a matter of fact, it led to the invention of atomic bombs. Nuclear reactors should not be used. We allowed the development of such technology and it led to

Table 3.2 Brief history of the development of nuclear energy in Germany

1953: Atoms for Peace
1966: Grundremmingen (237 MW)
1974: Biblis (1.3 MW)
Nov. 1975: Open letter from the presidents of MPI, DFG, GFI to Chancellor Helmut Schmidt
Dec. 1975: Major Bundestag inquiry into nuclear energy
1976/1977: Intensive public debate on nuclear reactors
1976–1980: Commission of inquiry of the German Bundestag: future energy policy
1977–1988: Ohu Isar I and II
Sept. 1977: HPD article: For or Against—Critical thoughts on the nuclear energy debate

the atomic bombs being dropped on Nagasaki and Hiroshima. As a result, a great number of human lives have been lost. In Germany there are many movements opposing nuclear power plants. Voices against the peaceful use of nuclear energy have been raised. I believe I must oppose any use of nuclear energy.

This is a very important point. As a general statement, there is one thing that should be considered. Even if it is a very well thought-through system, the system should not be adopted if there is even a slight possibility of very serious accidents in the worst case scenario. When the result that an accident may bring is unacceptable, we have to say ‘No.’ We have to judge correctly whether the damage is acceptable or not.

What is an unacceptable level? If there is a chance that a great number of human lives will be lost, we have to raise the voice of opposition. The risk we have to consider is that the results of accidents may affect not only our generation but also future generations. If the effects extend to our children’s and grandchildren’s generations, we have to raise our voices, saying that this is a level of accidents that cannot be acceptable. That is why we have to say ‘No’ to nuclear energy.

When we make something in the future, there is no guarantee that it will not be at all dangerous. We have to consider whether it may lead to an accident in the worst case scenario. In other words, an accident may happen even if the probability is low. In this case, it is meaningless to calculate the probability. Since there is no zero percent, we have to realize that it is impossible that the possibility that some accident may happen is zero.

At present, nuclear reactors are being developed. I am totally against their development. What we have to do is to reduce the number of nuclear reactors to zero. As for plutonium, we have to realize that it is a very, very dangerous substance. Plutonium has been spreading to many countries in the world, so it will be very difficult to control it. Plutonium’s half-life is very, very long and it will continue to exist for more than 100,000 years.

3.8 Solar Energy to Depend On

The important thing is how we should deal with the energy problem in the future. If fossil fuels are gone, what should we do? Should we start to use nuclear energy? If such a situation arises in 100 or 200 years, what should we do? It may be very difficult for us to imagine a far-away future, such as several billion years hence, but there is always a problem as to how the younger generations should respond in the future.

We have the sun. When fossil fuels are gone and nuclear energy is not available, we still can depend on the sun. We can receive an unlimited amount of energy from the sun. But at the same time, we should not take solar energy away from plants. Plants use only 1/4000th of the solar energy that reaches Earth. Only part of the remaining energy is used, and the rest goes back to space. Therefore, my suggestion is that we should make use of the huge quantity of solar energy that goes back to space. As I explained earlier, we can obtain a great amount of energy from the sun.

Ten terawatts (TW), which is equal to 10 billion energy slaves, will have a great influence on the biosystem.

Therefore, we have to reconsider our lifestyle. Since the quantity of energy we can use is limited, we have to think and control carefully in order to avoid an energy problem. Out of the great quantity of energy, an important part is distributed to plants. The energy goes to plants to make glucose, as I mentioned earlier. I have already explained that all living things on the Earth are based on glucose.

How should we use solar energy, for example, in a good combination of wind power, the biosystem and other renewable energies? As we saw in Fig. 3.3, solar energy is strongest in the blue, red and green wavelengths. Plants are green because they use only the blue and red wavelengths of solar energy. For the purpose of photosynthesis, plants use only the necessary parts of the sunlight. We need to consider how to use the other parts of the sunlight.

We can convert some of the solar energy to electricity. We can generate electricity using solar photovoltaic cells. We should be able to obtain sufficient electricity from solar energy. Of course, as time passes, we may find that the proportion we can use becomes more or less. But we need to exert control effectively and cut the unnecessary part.

Power generation, including solar energy, has been conducted on a collective basis. But a collective type of power generation is not always needed. We should set up a separate type of power generation system. We should take sunlight and use efficiently only the part that can be used. Here, we can see a great possibility in the future.

However, we are using even the part that we don't need. We should take only the part that we can use from solar energy, but we are trying to take what cannot be used. Why are people so intent on wasting energy? How can we stop this huge waste?

It may also be necessary to change our lifestyles. Why don't we acknowledge the necessity of changing our lifestyle in order to make our lives happier?

Democracy cannot be set up and achieved just with documents. We must achieve true democracy through the participation of all people in order to solve our future problems. There is still a great possibility of creating a system for us to directly enjoy such democracy. We should generate energy not by the collective type of power generation but by small-unit and separate power generation. I think we should try to find such methods in the future.

Eco-Lab Talk (3): Diversity × Cooperation = Sustainability

Hans-Peter Dürr and Yoshitsugu Hayashi

Left: Y. Hayashi Right: H.-P. Dürr

3.9 How Should We Design the Future of all Humanity?

Hayashi: The Graduate School of Environmental Studies was established in Nagoya University in 2001. Scholars from the fields of science, engineering and social studies gathered at that time, aiming to hand over to future generations Nature and humanity, and also the artificial environment produced by humanity in a well-balanced manner. With that intention, the graduate school was started with a mission to make a systematic study of two fields. One is the study of safety and security, in order to have a good balance of natural environment and artificial environment, and the other is the study of sustainability, to continue to keep a good balance through many generations.
Dürr: When we are facing a crisis for all humanity, it is very important for us to think how we should design the future of all humanity. We have to remember that we are a part of all the living things of the Earth, and to share the diversity in order to coexist with other living things.

Nature can continue to exist without humanity, but humanity cannot exist without Nature. Environment in German is *Umwelt*, which means the world around us, but I think we should understand the environment as *Mitwelt*, which means the world we live with.

3.10 Humanity Continues to Destroy Gaia's Autonomous System of Life

Hayashi: Dr. Dürr, from the viewpoint of physics, you are proposing that energy is the key to sustainability.
Dürr: We live only on the surface of the Earth, not on the whole Earth. From the 10 km atmosphere above us to 1 km underground: this is the zone we inhabit. And the sun sends us energy every day. The sun's energy is the only resource that we can use. Probably for the coming 5–6 billion years, we will be able to use solar energy. The other sources such as oil and metal are limited resources that we are stealing from the Earth.

Most of the solar energy is reflected by the Earth's surface, and emitted back to space. Only 1/10000th of the solar energy is conserved by biosystems and plants. The Earth's life—Gaia—is sustained as a dynamic system in which the blessings of the sun are stored for all humanity to take out and use them slowly. However, since the Industrial Revolution humanity has been stealing like a bank robber the deposits that Gaia has been saving for our future. In other words, we have kept on opening the safes of Nature one after another and using the resources without realizing that Gaia is a dynamic autonomous system.

3.11 Static and Dynamic Power to Sustain Fragile Biosystems

Hayashi: As an important concept for the environment, the idea “Spaceship Earth” came to be used in the 1960s. After experiencing continuous air and water pollution, we have come to share the understanding that the Earth’s capacity to clean itself up is limited. But the situation is worse at present. We now live, as it were, on a small flat space at the top of a mountain, and are facing the process that the slopes around us are slipping away. To cope with this problem, we have no other alternatives but to stop the landslides, or to maintain our living environment by increasing the efficiency of our use of resources even if the flat space becomes smaller.

Dürr: I often compare such a situation to a fragile house of cards. The house of cards is somehow supported by friction in order to maintain its stability. It is the solar energy radiating to the Earth that stabilizes the house of cards.

I would like to emphasize not only that resources are limited but also that biosystems are very fragile. Each biosystem is an unstable house of cards, and its stability is maintained by homeostasis. Moreover, the whole pyramid of life is maintained by solar energy.

In German, *Nachhaltigkeit* has a rather static meaning of maintaining something. However, a biosystem has the vitality to produce things. Therefore, I think what is required of ‘Sustainability’ is not only the power to maintain, but also the power to produce. The definition of your graduate school’s philosophy is quite to the point: on one hand there is “the study of safety and security”—a static balance, and on the other, “the study of sustainability”—a dynamic progression in time.

3.12 The Earth and Humanity’s Diversity and Cooperation

Hayashi: What are the problems for sustainability now?

Dürr: Sustainability is not only a problem of ecology. It is also a problem of how humanity can coexist with each other. The problems are on three levels. They are the ecological level, the social level and the third level, which is wise men’s level in a true sense of the word.

Gaia is very sensitive and will die if it loses its balance. Under these circumstances, we have to consider that sustainability is being broken in many fields.

Nobody knows what to do with nuclear waste and CO_2. CO_2 comprises only 0.04 % of the atmosphere. It is like seasoning, but it keeps the balance for Gaia. It is a dramatic change for CO_2 to have been increasing every year by 1 %. As a result, biosystems are becoming unstable in various ways.

Hayashi: Before the Industrial Revolution, human activity and the natural environment were in a so-called “Primitive environmental balance”. But, now, that balance has changed and is falling apart. If this situation continues, a crisis will arise for all humanity. What should we do to stop this crisis? We have to look for a new balance. What standards should we use? For this reason, I think our way of looking at Nature or our ethics will become very important.

Dürr: I think we should consider diversity, cooperation, and sufficiency. We should not forget that Gaia is maintained by diversity and cooperation. If you want to monopolize a lot of food, you have only to kill others. But if you do so, you will cut off the dynamics of Gaia, and after all, endanger your own existence. You can obtain sufficiency together with diversity and cooperation.

This is the sustainability we aim to have. Even without quantitative sufficiency, you can lead a happy life. And, if you have creativity you can find a clue to the solution of problems. As long as we seed a field, our next generation should be able to harvest it.

Hayashi: The philosophy of sustainability on the basis of your thinking can be applied to Gaia, which is the life of the Earth, and also to a globalizing human society. It is universal, isn't it? Thank you very much for giving up your time for this interview.

This interview is a modified form of that first appearing in Japanese in *Kwan,* vol.13, autumn 2007.

Chapter 4
Politics in Global Change: A Threat Called Global Warming

Shohei Yonemoto

Professor Shohei Yonemoto worked for Mitsubishi Kagaku Institute of Life Science for many years. He became the director of the institute and later took up the post of President of the Center of Life Science and Society. He has presented his unique ideas about life, medical practice and relationships between the global environment, politics and society. He taught at the University of Tokyo as a Project Professor of its Research Center of Advanced Science and Technology, and currently teaches as a visiting professor at Nagoya University. He is also a member of various councils and committees such as the Science Council of Japan.

He has authored many books. His books written in Japanese, *Chiseigaku no susume* (*Introduction to Geopolitics*) and *Iden kanri shakai* (*Society Controlling Gene*), won him prizes, the Chuokoron-Shinsha's Yoshino Sakuzo Prize and Mainichi Shuppan Bunka Prize. His *Biopolitics* led to the award of the JASTJ Prize (of the Japanese Associations of Science and Technology Journalists) in 2007.

4.1 End of Idealism After the Cold War, and the Global Warming Issue

I have studied the interactive relationship between natural science research and politics, and I today want to discuss my study of global warming. I believe some of you may feel instinctively that the nature of the global warming issue has changed, so I have analyzed this from the perspective of international politics, and I would like to focus on three points to explain why the issue has changed.

The first point is the reason why global warming became part of the agenda of international politics. This was because the threat of nuclear war suddenly diminished with the end of the Cold War, and global warming was raised instead as a new problem, a 'new' threat to fill the void created in international politics.

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Sustainable Development and Sustainability Transition Studies 25,
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The second point is how global environmental problems became a diplomatic issue. This movement was led by the European Union. During the Cold War period, the EU had negotiations among its member countries about the transborder acid rain problem, and that experience remains a significant legacy.

Thirdly, Germany was reunited immediately after the end of the Cold War, but this was opposed by Mrs Thatcher, the British Premier at that time. Both World Wars I and II were caused by the German quest for mastery over Europe. She argued against its reunification because she was afraid that the relative position of the UK might become weaker if two German nations came together when the Cold War stopped, and the hostility between East and West ceased. Germany opposed her argument, saying that the country would not consider such self-interested behavior. Instead, the country announced work on matters important to the history of mankind, and raised global warming as one such challenge. Another challenge on which Germany worked was the creation of the single European currency. That is, the country gave up its unrivalled Deutschmark to show that the new Germany would not do anything to menace its neighboring countries. This means that Germany declared that it would address issues which relate more to the philosophy of civilization.

In such circumstances, a sort of post-Cold War idealism took actual form in the Kyoto Protocol. This sort of view may offend environmentalists, but an analysis from the perspective of international politics reveals the protocol's genesis as such.

The United Nations Framework Convention on Climate Change (UNFCCC) is a unique environmental convention in that it is based on the precautionary principle. The reunited Germany made the effort to host the first Conference of the Parties in Berlin. Because of the Berlin Mandate established at this conference in Berlin, the Kyoto Protocol was decided. The Protocol, however, is very unusual, deviating from norms of international agreement.

It is possible to say that post-Cold War idealism, which more or less constituted the context of international politics or diplomacy for nearly 20 years, broke down or ceased at the conference held in Copenhagen in 2009. Understanding these circumstances, we have to think, in the first instance, about threats from Nature in order for us to continue our life in Japan after the 3.11 Earthquake. With the end of the Post-Cold War idealism and emergence of rapidly growing China and India, the scheme in which only developed countries should reduce greenhouse gas emissions broke down.

Countries have moved towards regional cooperation since the end of idealism. Europe has its own sense of values, political framework and comprehensive energy supply system, which are all common in the region. However, East Asia is such an unusual region that it is not very easy for the nations in the region to take measures against global warming on a cooperative basis. On one hand there is China, which emits the largest quantity of CO_2 and behaves as a representative of developing nations. On the other, located just across the East China Sea from China, there is Japan, a representative of developed nations which has almost completed its energy-saving investment in the country. It is essential that these two very different countries cooperate. Countries which contrast so sharply with each other usually lead to international conflict, but there can be much room for political maneuver when the two involved countries contrast so greatly. This implies that such different countries may be able to work together well in a cooperative manner.

What is necessary, then? It is necessary to raise the accuracy of predictions, released by the Intergovernmental Panel on Climate Change (IPCC), of how global warming will progress, and how much damage will be caused. To achieve this, we need new futurology.

Futurology caught people's attention from the end of the 1960s to the beginning of 1970s, and in this period it chiefly discussed population growth and the exhaustion of resources. Futurology in our time needs to take account of global warming and resources, without doubt. In addition, since we suffered a huge earthquake which only occurs once in 600–1000 years, induced by the movement of tectonic plates, Japan should regard earthquakes as threats from the Earth, or Nature, and include them in factors to be considered by futurology. These are the points I would like to explain.

4.2 Global Warming Takes the Place of Nuclear Threats

The United Nations Framework Convention on Climate Change was signed in June 1992. In this convention, countries agreed that global warming was a threat, but they did not know at that time how serious the threat was. In 1995, the IPCC Second Assessment Report was released. The report states that global warming has been accelerated by anthropogenic CO_2 emissions, as suggested by the balance of evidence, and recognizes the threat of global warming in a very ambiguous, or very careful, manner.

This convention for the prevention of global warming was formed, modeled on its predecessor treaties for the protection of the ozone layer: the Vienna Convention for the Protection of the Ozone Layer, and the Montreal Protocol on Substances that Deplete the Ozone Layer. Immediately after the Vienna Convention was agreed, ozone holes were found and harm done by them was clarified. The Montreal Protocol therefore was established ultimately to prohibit totally production of fluorocarbon, and the convention and protocol are often referred to together. This indicates that the UNFCCC was potentially an idealistic treaty.

The UNFCC describes its objective in a very convincing manner (see the excerpt, below). Its ultimate objective is to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Convention also says that such a level should be achieved within a period in which economic development can continue in a sustainable manner.

UNFCCC Article 2 Objective

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at

> a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow biosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Before and after this UNFCCC was signed in 1992, did we have any scientific data which supported the contention that global warming was a danger? No, we did not. Unlike the Vienna Convention and Montreal Protocol, the UNFCCC was formed not because we needed to take immediate action to deal with obvious damage to the Earth. In other words, the Convention was not necessary for a scientific reason.

Except for predictive science, nothing but the end of the Cold War brought about a significant change in international politics before and after the Earth Summit in June 1992. To put this in a very simple context, we cannot but interpret it this way: because the threat of nuclear war diminished so suddenly, international politics looked for a new threat as if to fill the void created by the reduced threat (Fig. 4.1).

Reflecting upon the threats of nuclear war and global warming, they are similar in the following ways. Firstly, they are global-scale threats. Secondly, they are interconnected with each country's economic policy. Thirdly, it is very difficult to discern what the threats are really like. There are differences, of course. Nuclear

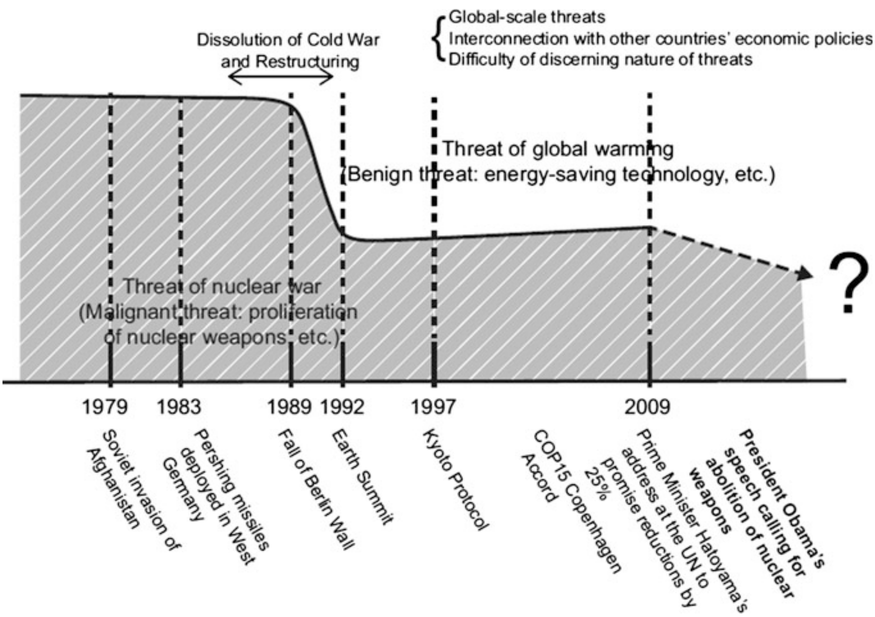

Fig. 4.1 Law of threat conservation in international politics. *Source* Figure 2 of Yonemoto (2011) in Japanese has been translated to English. See the References added in this version

war, if compared to a tumor, would be malignant. The greater the estimated threat of nuclear war, the more nuclear warheads or tanks are made. The former Soviet Union made more than it could afford, and finally broke up.

On the other hand, if the prediction of global warming is a little delayed or the threat is over-emphasized, our society will invest money to develop technologies to save energy and prevent environmental pollution. Threats of global warming are therefore benign and non-malignant.

I'm afraid it is human nature that we start to rack our brains only after we recognize an immeasurable menace. It is more appropriate, in this sense, to say now, "Global warming will occur someday," than "threats of global warming are false."

As I have explained, through a significant political change which followed the end of the Cold War, when the UNFCCC came into existence we barely recognized it as a very ambitious treaty. In this context, countries came to a consensus, a product of idealistic international politics, that developed countries should lead CO_2 reduction, and they then concluded the Kyoto Protocol. After 20 years or so, in 2007–2008, the tacit consensus collapsed, however.

4.3 What Japan Should Do After the 3.11 Earthquake

Although I cannot discuss in detail today how the consensus collapsed, let me explain briefly. The United States, the number one superpower in the 20th century, spent the second half of the century at war.

America was suddenly involved in the Second World War when Pearl Harbor was attacked in December 1941. Immediately after World War II ended, the Cold War started, and the United State was at war for half a century, until the fall of the Berlin Wall in 1989 or the collapse of the Soviet Union in December 1992.

The prime objective for America's scientific research was to develop and deploy nuclear weapons as well as to make them compact. To achieve this, the country mobilized its scientific technology to the full. My understanding is that natural science research topics have continued to change since the 1990s, to mobilize scientific technology towards different objectives in the post-Cold War period (Table 4.1).

I believe that Japan's critical weak point is that the country debates the post-Cold War period without having basic understanding of security, and military affairs in particular. This must not be overlooked.

Hydrogen bomb testing began around the end of the 1950s, and adversely affected the environment. For this reason, the Limited Test Ban Treaty was formed in 1963 to stop nuclear tests in the atmosphere. Only underground nuclear testing was therefore continued, and consequently the US Department of Defense offered a huge amount of money to seismologists in the world in the 1960s. This significantly raised the accuracy of observation. Figure 4.2 shows a total of 29,000 earthquakes

Table 4.1 American ideologies of technological development

<table>
<tr><td colspan="6">Pragmatism + self-help = ideology to improve contemporary society with technologies</td></tr>
<tr><td>1800</td><td>1900</td><td>1940</td><td>1990</td><td></td><td>2000</td></tr>
<tr><td colspan="2">Agriculture</td><td colspan="2" rowspan="5">World War II + Cold War (50 Years War)</td><td colspan="2">Conversion of military industry to civilian industry</td></tr>
<tr><td colspan="2">Skills to manage large-scale plantations which continued expanding towards the west</td><td colspan="2" rowspan="2">Reinvestment in civilian industry</td></tr>
<tr><td colspan="2">Mass consumption society</td></tr>
<tr><td colspan="2" rowspan="2">Ford Model T first released in October 1908</td><td colspan="2">Global environmental problems</td></tr>
<tr><td colspan="2">Information society
→ Age of life science</td></tr>
<tr><td colspan="2">Scientific research</td><td colspan="2" rowspan="2">Science mobilized by the government</td><td colspan="2" rowspan="3"></td></tr>
<tr><td colspan="2">Agricultural research by state universities</td></tr>
<tr><td colspan="2">Basic research by foundations</td><td colspan="2">Military-industrial complex (nuclear-weapon complex)
→ Emergence of research universities
→ Spin-off effects</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">National security</td><td colspan="2">National interests</td></tr>
<tr><td colspan="2">Military sector (nuclear weapon system) as a superstructure over mass consumption society</td><td colspan="2">Application of scheme to control nuclear power (other than weapons) in civilian use</td></tr>
</table>

in eight years between 1961 and 1968, which are all plotted on the figure. This figure substantiates plate tectonics. Plate tectonics was a barely convincing scientific theory in the early 1960s, but the possibility increased suddenly at the end of 1960s to scientifically verify the theory. This result of seismological research was motivated by the Cold War. Looking at the capital cities of the developed nations, we find that only Japan has its entire territory on tectonic plates.

The 3.11 earthquake claimed nearly 20,000 lives in Japan. No developed country has had a battlefield on its own territory since World War II, but Japan suffered serious damage, as if it were directly involved in a war. This is the reason why Japan should take the initiative to develop futurology, considering huge earthquakes and tsunamis to be threats from Nature. I believe that Japan is in a position to take the leadership.

4.4 Environmental Diplomacy: Integration of Science and Diplomacy

Global environmental issues have the unusual feature that they are global-scale international issues. They come onto the agenda only when they involve two very different sectors of human activity: one is the quest of natural science research for truth, and the other is international politics, which ostensibly speaks up for idealism, but actually maneuvers in the interests of countries.

To begin international negotiations, it is necessary to have a scientific assessment body which is funded by an official organization. Such a body makes international negotiations open to the public, and in the case of global warming issues it is the IPCC.

European countries agreed to the Convention on Long-range Transboundary Air Pollution (CLRTAP) at the end of the 1970s, and very special scientific research programs were initiated in the name of this convention, for the sake of diplomacy (Table 4.2).

In the Cold War period, the Helsinki Protocol was a very artificial agreement for all signatory countries to reduce SO_x emissions by 30 %. However, after the Cold

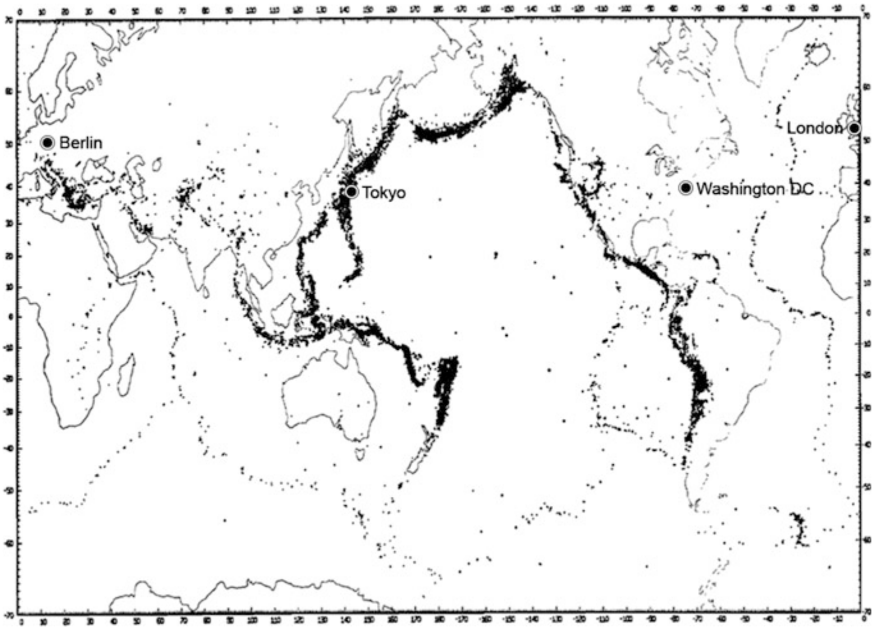

Fig. 4.2 Earthquakes in the world between 1961 and 1968, and location of national capitals. *Source* Figure 17 of Yonemoto (2011) in Japanese has been translated to English with addition of some locations of national capitals. The original is from the following website: http://www.mantleplumes.org/WebDocuments/Isacks1968.pdf

Table 4.2 Merger of earth science and international politics

	Acid rain	Ozone layer	Climate change
Initial warning	Late 1960s	1974	1970s
Scientific assessment body	EMEP 1978–	CCOL 1977–	IPCC 1988–
Session for negotiation of treaties	UN-ECE 1978–	United Nations Environment Programme 1981–	Intergovernmental Negotiation Committee (INC) 1990
Framework convention	LRTAP	Vienna Convention	UNFCCC
Year of signature	1979	1985	1992
Year of entry into force	1983	1988	1994
Protocol	SO_x NO_x	Montreal	Kyoto
Year of signature	1985–1988	1987	1998
Year of entry into force	1987–1991	1989	2005
Amended protocol	Oslo		
Year of signature	1994		
Year of entry into force	1998		

Source Table 1 of Yonemoto (2011) in Japanese has been translated to English

War, the protocol was entirely converted into the Oslo Protocol, and scientific data began to be used as the basis of diplomacy.

It was in the 1980s that transboundary air pollution, informally known as the acid rain problem, triggered international negotiations, and regulations were put into effect. At that time, the Eastern Bloc denounced environmental pollution as one of the evils of capitalism, but after the Cold War it was found that the East paid hardly any attention to energy-saving policies or environmental pollution.

As I mentioned earlier, Japan started in the early 1970s to invest its limited resources to develop energy-saving technology and prevent environmental pollution. Figure 4.3 shows data on SO_x emissions, which the CLRTAP was responsible for collecting, and indicates that emissions began to reduce in the 1980s.

The reasons for the reduction are the two oil price shocks that Japan experienced in 1973 and 1978. Until then, Japan had been able to rebuild itself after World War II by obtaining cheap petroleum from the Middle East, but the crude oil price suddenly quadrupled in the space of a few months. The country regarded this situation as a national crisis, invested its limited capital to develop energy-saving technologies and prevent environmental pollution, made such technology available for practical use, and continued investment. Japan was the only country to do this (Fig. 4.3).

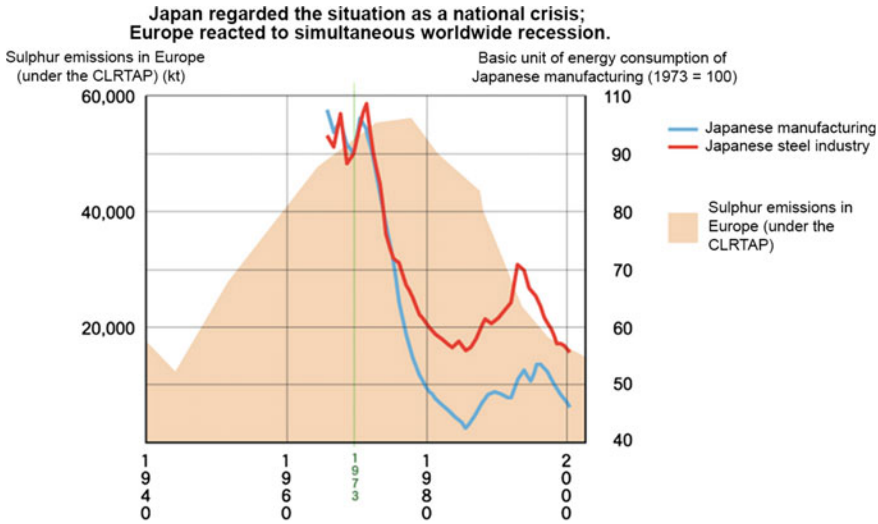

Fig. 4.3 Difference of air pollution policies between Japan and Europe after the oil shock. *Source* Figure 4 of Yonemoto (2011) in Japanese has been translated to English

Oil price shocks induced the first simultaneous worldwide depression. Business leaders outside Japan responded to it by stopping all investment. Of course, they also stopped investment in the development of energy-saving technology and the prevention of environmental pollution, which did not contribute to production. In reality, the relationships between developed countries deteriorated in the 1980s, and Europe introduced a regulatory policy in the same period.

The 1985 Helsinki Protocol obliged all signatory countries to reduce SOx by 30 %, which is a very artificial figure. Why did European countries agree to it? Because shortly before the protocol was drawn up, the tension had increased to an extent in the region that a limited nuclear war could have broken out. East and West therefore agreed to cooperate in the field of the environment to ease the tension.

If you read only the contents of the Helsinki Protocol, you might imagine it to be a success story, with the ratification of the convention and the protocol it entailed, but in fact it is not. Environmental diplomacy in the Cold-War period produced treaties as a result of cooperation between East and West when tension eased, and drew up protocols to ease tension when it increased. This is how it was.

It took about 20 years after the end of the Cold War before all the science research programs which had been initiated in Europe began to function, and in the case of SO_x, the Helsinki Protocol was entirely revised into the Oslo Protocol. Figure 4.4 is Annex I to the Oslo Protocol.

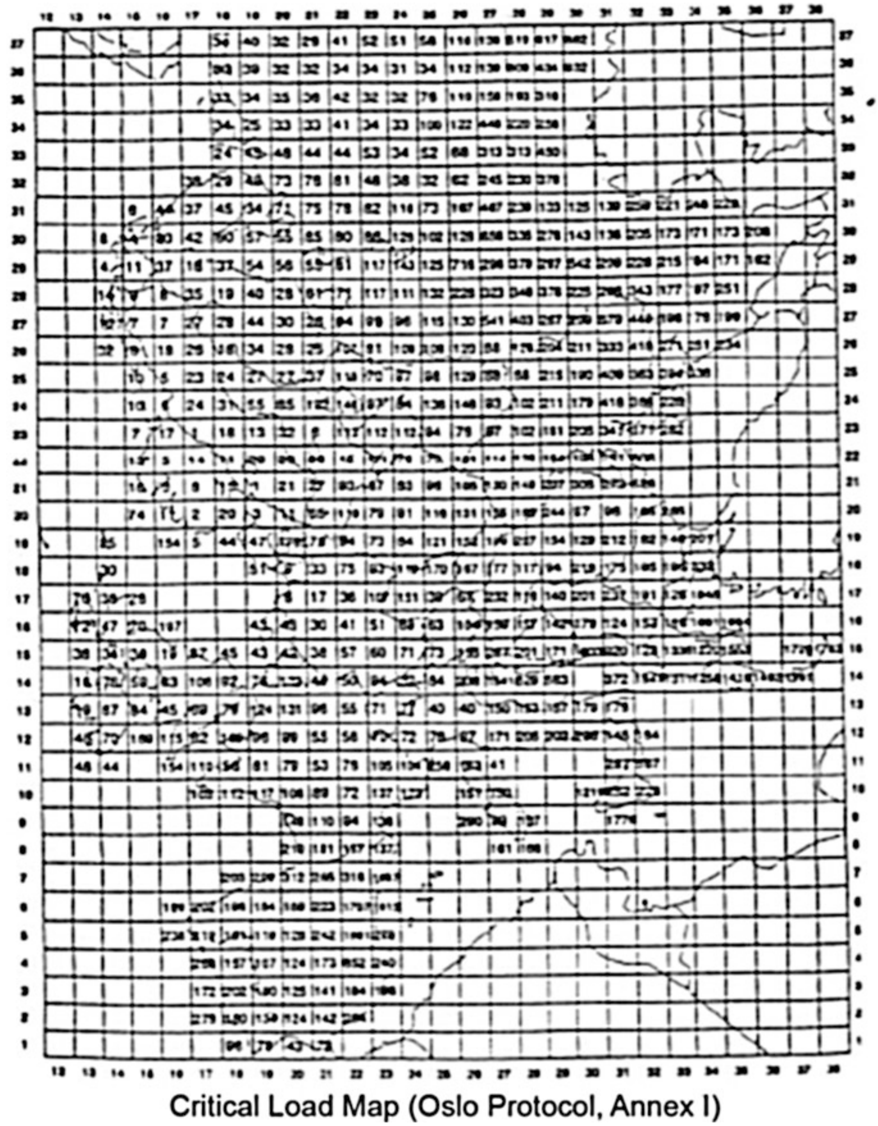

Fig. 4.4 Annex I to Oslo Protocol. *Source* Figure 5 of Yonemoto (2011) in Japanese cited this Figure. The original is from the 1994 Oslo Protocol website. See the References added in this version

This divides the area from the Iberian Peninsula to Scandinavia using a grid pattern. If more SOx is emitted than the value indicated in the Annex, it will have an ecologically critical impact. The Protocol was therefore revised to reduce SOx emission across all Europe to less than this level as an ultimate goal.

Since it was not possible to revise the Protocol immediately, a scientific assessment program called ENOS prepared a computer program for diplomatic use, and all data were entered. The emission reductions, calculated by computer so that they would be the optimum figures as well as the minimum burden on each country's economy, were incorporated as Annex II to the Oslo Protocol, requesting each country to reduce SOx emissions in 2000, 2005 and 2010, that is, every five years for 16 years from 1994 (Table 4.3). The protocol was ratified as a diplomatic treaty, which thus eliminated the necessity for diplomatic negotiations. "You should cut SOx by this amount because we are affected this much by the emissions from your country." Such negotiations based on each country's interests completely gave way to reduction calculations rationally worked out by computer.

This is a combination of scientific research and diplomacy. CLRTAP negotiations in Europe have developed to this stage. Following this experience, the EU

Table 4.3 Annex II to Oslo Protocol (excerpt)

	SO_x emission (kt per year)		SO_x emission ceilings (kt per year)			SO_x emission reduction ratio (%, base year 1980)		
	1980	1990	2000	2005	2010	2000	2005	2010
Austria	397	90	78			80		
Belgium	828	443	248	232	215	70	72	74
Bulgaria	2050	2020	1374	1230	1127	33	40	45
Czechoslovakia/Czech Republic	2257	1876	1128	902	632	50	60	72
Denmark	451	180	90			80		
France	3348	1202	868	707	737	74	77	78
Germany	7494	5803	1300	990		83	87	
Greece	400	510	595	580	570	0	3	4
Hungary	1632	1010	898	816	653	45	50	60
Italy	3800		1330	1042		65	73	
Netherlands	466	207	106			77		
Norway	142	54	34			76		
Poland	4100	3210	2583	2173	1397	37	47	66
Portugal	266	284	304	294		0	3	
Russian Federation	7161	4460	4440	4297	4297	38	40	40
Spain	3319	2316	2143			35		
Sweden	507	130	100			80		
Switzerland	126	62	60			52		
Ukraine	3850		2310			40		
United Kingdom	4898	3780	2449	1470	980	50	70	80
EU	25513		9598			62		

Source Table 8 of Yonemoto (2011) in Japanese has been translated to English. The original data were taken from the 1994 Oslo Protocol website. See the References added in this version

Table 4.4 Science and politics in global warming

1992	United Nations Framework Convention on Climate Change signed (Rio de Janeiro)
1995	IPCC Second Assessment Report First Conference of the Parties (Berlin)
1997	Third Conference of the Parties (Kyoto) Kyoto Protocol adopted Reductions from the 1990 level to be achieved in the first commitment period: EU 8 %, (USA 7 %), Japan 6 %
2001	IPCC Third Assessment Report
2007	IPCC Fourth Assessment Report
2008–2012	Kyoto Protocol's first commitment period
Dec. 2009	Copenhagen Accord

Source Table 2 of Yonemoto (2011) in Japanese has been translated to English with some modifications

entered into negotiations on global warming issues and made a commitment to cut greenhouse gases by 8 % in the Kyoto Protocol (Table 4.4).

Japan, feeling outflanked, sometimes says that it was disadvantaged by the EU in negotiations on global warming issues, but this is not true. The EU has taken very firm steps in diplomacy and has taken advantage of that diplomatic scheme in negotiations on global warming issues.

4.5 Necessity of International Joint Research by East Asian Nations

In contrast, the Kyoto Protocol of 1997 is dissimilar because most CO_2 is emitted by economic activity. In fact, the governments of sovereign states don't make promises, in diplomatic negotiations, regarding their country's future economic activity. I suppose that Japan, in particular, does not like this sort of promise because it once promised the United States in economic negotiations that it would import a certain ratio of goods, and this was a bitter experience for Japan. Basically, in economic negotiations, sovereign states never speak about figures but discuss conditions. Europe naturally did not put forward numerical targets for reduction.

Europe did not outmaneuver other countries. Rather, it took the position, based on European values that developed countries should be working on reduction. The world at the time was rather idealistic, and so countries signed up to the protocol. The United States, however, revoked its signing of the Protocol because there was no likelihood that its Senate would ratify it. This is what actually happened.

As mentioned earlier, Germany in particular has been working on global warming issues since the earliest days. The West Germany Bundestag had regarded global warming issues as challenges common to humanity before East and West Germany were reunited in October 1990.

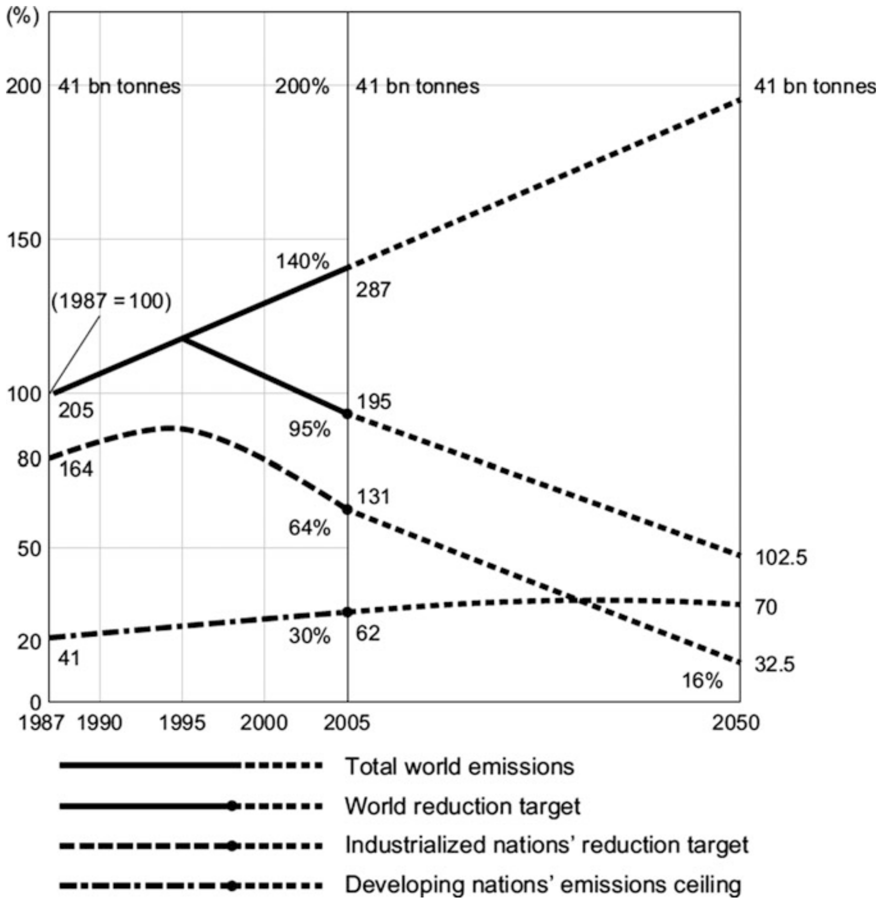

Fig. 4.5 Global scale CO_2 reduction planned by West German parliament in 1990. *Source* Figure 26 of Yonemoto (2011) in Japanese has been translated to English. The original is from a report of West German Bundestag (1990) "Protecting the Earth". The report was prepared and proposed for the then West German Bundestag as early as 1990, on the grounds of 1987 statistics

The report prepared for the then West German Bundestag proposed as early as 1990, on the grounds of 1987 statistics, that the world should start reducing CO_2 emissions by 2005 (Fig. 4.5).

Thus Germany was the first nation in the world to resolve to put global warming on the global agenda.

From a balanced perspective, a sensible analysis, from the viewpoint of international politics, also suggests the possibility that Germany took this action partly because it wanted to ease its neighboring countries' concerns about the emergence of a powerful reunited Germany.

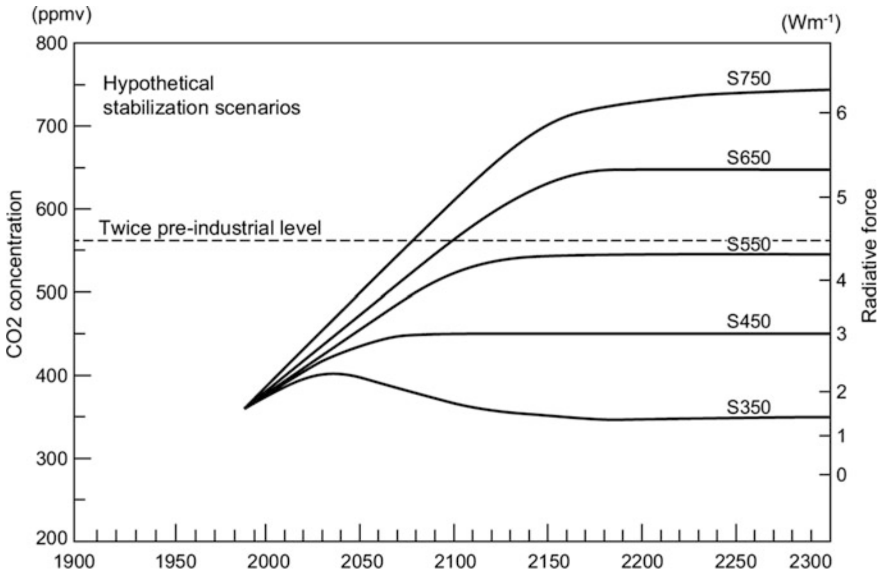

Fig. 4.6 Scenarios in IPCC Second Assessment Report to stabilize CO_2 concentration. *Source* A part of Fig. 9 of Yonemoto (2011) in Japanese has been translated to English. This figure is a modified version of Fig. 6 of IPCC (1995). See the References added in this version

Among the greenhouse gases CO_2 alone is increasing by about 2 ppm every year. The IPCC released its Second Assessment Report, which simulates how much CO_2 can be emitted to achieve the CO_2 concentration which will ultimately lead to stabilization, an ultimate objective of the protocol (Figs. 4.6 and 4.7).

'S' in the figures represents a scenario. Each scenario takes 300 years to stabilize the CO_2 concentration, and how much CO_2 humans would be allowed to emit to stabilize the concentration according to the scenarios is simulated.

Supposing that CO_2 concentration is increased solely by excessive consumption through human activity, we must cut emissions to 50 % of the 1990 level. If emissions are reduced to this level, anthropogenic emissions of approximately 2 ppm will be halved. The calculation is very simple. Yet the IPCC published the scenarios in order to achieve the ultimate objective of the UNFCCC.

While those who agreed to the Copenhagen Accord recognized the idealism of trying to reduce emissions within two years, they left the reduction of CO_2 emissions to each country so that each country's national interest would be protected. The details of the Accord degenerated into the double-talk of international politics, advocating the ideal while at the same time protecting each country's national interest. Medium- and long-term targets for 2010 and 2050 were included in the Accord, but China adamantly opposed these targets. Why? Because in 2007 China overtook the United States and became the world's largest CO_2 emitter (Fig. 4.8).

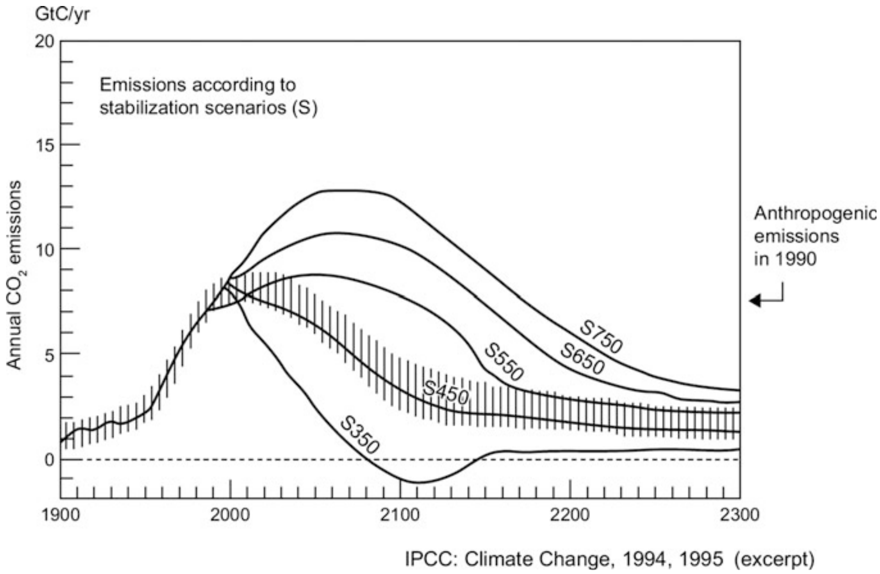

Fig. 4.7 Emissions to bring about scenarios in IPCC Second Assessment Report to stabilize CO_2 concentration. *Source* A part of Fig. 9 of Yonemoto (2011) in Japanese has been translated to English. This figure is a modified version of Fig. 7 of IPCC (1995). See the References added in this version

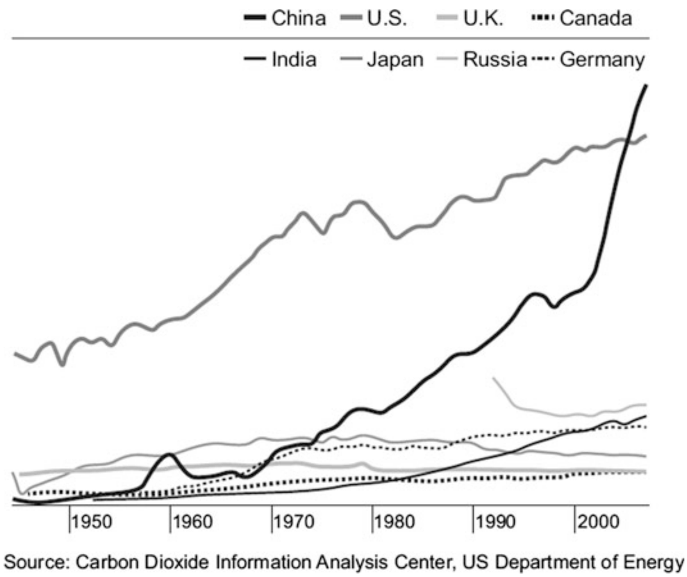

Fig. 4.8 CO_2 emissions in the world. *Source* Figure 21 of Yonemoto (2011) in Japanese has been translated to English. The original is from Carbon Dioxide Information Analysis Center (CDIAC) website. See the References added in this version

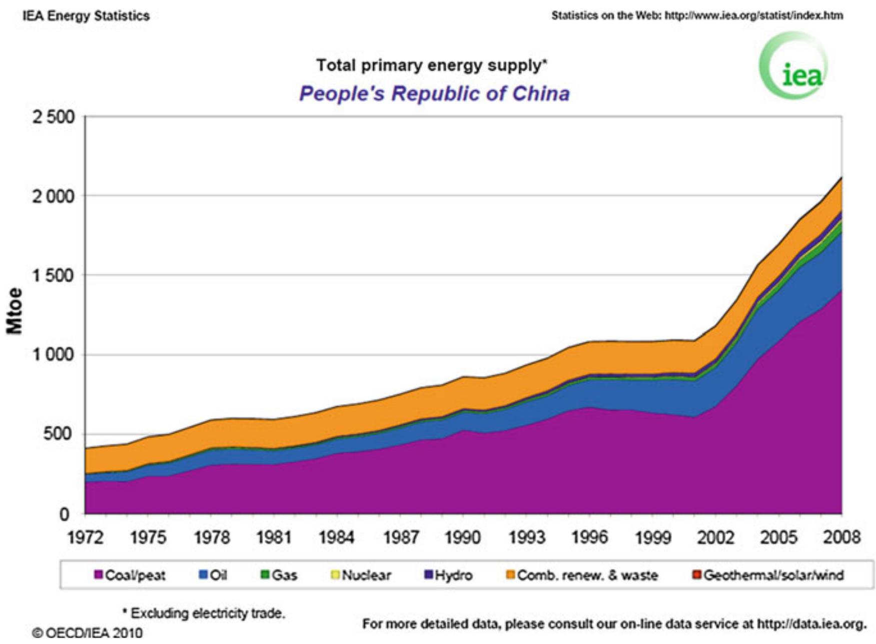

Fig. 4.9 Change of primary energy production in China. *Source* Figure 22 of Yonemoto (2011) in Japanese has been translated to English with a modification from monochrome to color. The original data are from IEA (International Energy Agency) website

It does not make sense to criticize China one-sidedly. China formerly put emissions under the control of its central socialist government, but its energy demands went up sharply after the country shifted more towards a market economy. China had no other way but to turn to the available coal in the country to satisfy the increased demand for energy (Fig. 4.9).

As I mentioned at the beginning, if regional cooperation is required in East Asia, one of the possibilities is a combination of Japan and China, which are very dissimilar to each other. Or we should consider how Japan can offer its support to China (Table 4.5).

Dr. Weizsäcker pointed out that we should not follow a Kuznets curve any longer. The curve represents how as economy starts to develop, it damages the atmosphere and environment, but that when the economy develops to a certain level, capital starts to be invested in environmental measures. The challenge is how to guide the curve downwards as early as possible. The curve, however, reflects a philosophy of an autonomous economy, and we would need to wield a substantial influence over the energy and economic policies of target developing countries in order to achieve the goal. It means that the goal can be achieved only if we interfere in other countries' internal affairs.

Table 4.5 Case of East Asia: diversified types of countries

	Developed nations (Sense of values as found in developed nations)	Semi-developed nations or regions	Developing nations different sense of values (e.g. handling of scientific data, scope of state sovereignty)
Market economy countries	Japan, Korea	Taiwan, Hong Kong	Philippines, Indonesia
Countries/regions in transition to market economy		Far East Russia	Mongolia
Socialist countries		China (Socialist market economy)	North Korea

Source The author

I believe that one way to avoid such interference, or one step before actually implementing the plan, is to carry out international joint research to first share the same philosophy of the environment with researchers, through whom the governments and people of each country will later share research achievements and the same philosophy. Moreover, Japan should lead such scientific research, and be a chief contributor to the research activity.

Conducting international joint research itself contributes to regional stability. If we allotted 10 % of Grants-in-Aid for Scientific Research (of the Japan Society for the Promotion of Science) to researchers in other Asian countries, these researchers would make various proposals, from which a variety of information would accrue in Japan. This country should have already considered this sort of plan.

I want to introduce a model program in Bhutan. When I was a student, I joined a team led by Dr. Minoru Matsuo, former president of Nagoya University, which visited the country. After 20 years, I visited the country again, and what I saw there made me think that Japan would have to cooperate with other Asian countries even if we did not take the same path as Bhutan.

In conclusion, we must establish a new futurology. For this purpose, while we acknowledge the idealism that continues to this day, we need to analyze again how politics has developed in order to consider how to turn idealism into reality. In the 1960s, the Cold War was established so firmly that futurology at this time studied long-term factors such as population growth and food resources through computer calculation. From an ideological point of view, futurology of that time discussed Malthusian questions. However, we are in a different situation now. To address global warming, we need to improve the IPCC's functions and predictive capabilities, and clarify damage as well as cooperative relationships at a regional level. Japan should consider futurology that takes account of the country's cooperative relationships with Asian nations and threats from Nature, such as huge earthquakes and enormous tsunami. I believe that Japan is in such a position.

Eco-Lab Talk (4): Think about Environmental Issues: Remove Boundaries and Link Different Regions

Shohei Yonemoto and Tetsuzo Yasunari

Left: T. Yasunari Right: S. Yonemoto

4.6 Getting to Grips with Environmental Issues: An Origin in Mountaineering

Yasunari: Both Professor Yonemoto and I were in Kyoto University's Alpine Club at the same time: it's our common background. Mountaineering was our starting point. Though I left the club to join another called the Explorers Club, climbing mountains turned my attention to Nature, people living in Nature, and the relationship between humans and Nature. We visited Bhutan, Mongolia, Patagonia and various other places at home and abroad. Walking gives us the chance to feel at first hand something we have not experienced before. No matter which discipline we specialize in, we start to sense something before we understand it logically. I believe therefore that in a broad sense this is the first step to getting to grips with environmental issues, and in my opinion, it is still most important to go out in the field and walk about.

It is quite common for researchers to visit field sites to study specific themes. Nagoya University's Global COE program, From Earth System Science to Basic and Clinical Environmental Studies, led by the Graduate School of Environmental Studies, aims to inspire young students to go out into the field and find something that interests them instinctively. For On-site Research Training (ORT), part of the global CEO program, we have established several fields, in Japan and other countries, which are used in environmental education to study how to identify problems and work out plans to solve them.

Yonemoto: I remember that senior members of the Alpine Club often talked about "pioneer work." The ultimate goal is to reach the summit of mountains that no one in the world has ever climbed, and finding new climbing routes is the second. We discussed various ideas and put them together to make a plan. We had to explain to all the club members why we had made the plan to climb a particular mountain. Without their agreement and approval, we were not able to go up the mountain. Once we returned from mountaineering, we had the plan reviewed, again by everyone. We did this throughout the year.

Yasunari: When we were students, the club had many members who did not graduate in four years and hardly attended lectures, and they had a lot of experiences climbing mountains in foreign countries. That was how it was.

Yonemoto: Professor Yasunari, you remark that it is important to go out in the field. No matter what their ultimate goals, mountain climbing and expeditions are projects of a sort, aren't they? That is why mountaineering plans are presented to recruit participants and raise funds. Similarly, in society, we present appealing proposals, raise funds, carry out assignments, and show results. It means that I undertook the on-the-job training called mountaineering, and the training meant a great deal to me.

4.7 What I Learned from Research While Working at a Company

Yonemoto: I aspired to study at Kyoto University. When I started to study there, I encountered student activism in a dispute with the university. I was a naïve high school graduate and regarded the university as a stronghold which opposed power, authority and bureaucracy. As soon as I realized that it was not, my image of the university completely collapsed. I made up my mind to criticize universities for the rest of my life. So I chose to work for a company as most people did, but was also determined to do research as well as university researchers', so that I could criticize those researchers. Giving up postgraduate study more or less closes the door on one's career as a researcher in Japan. I wanted to be an exception, to break such a convention.

So I decided to work for a securities company in Nagoya, my home town, in order to burn my boats so that I would not be tempted to return to university. To rival university researchers, I subscribed to Japanese science magazines, and bought various books of biology, history of science, philosophy of science, etc., whether they were for general or academic readers. All my bonuses were spent on those books, and eventually I wrote a treatise on the history of science. A little before I was 30 years old, I was unexpectedly offered the position of researcher in the Department of History of Social and Life Science at Mitsubishi Kasei Institute of Life Science (later Mitsubishi Kagaku Institute of Life Science). Dr. Keiko Nakamura, a researcher of life science as well as the manager of the department, offered me the place.

The department at this time was analyzing the controversy over genetic modification. As a researcher of the history of science, I first studied the history of eugenics in Germany, and did comparative research, such as of regulations on recombinant DNA experiments, and policies for the regulation of organ transplantation, reproductive organ transplantation, and human genome research. I started to study global environment issues in the latter half of the 1980s, since they involved natural science and politics, as in the case of bioethics. I also secretly hoped that I would be able to meet my old friends if I kept studying policies on global environmental issues.

This is my personal history. From my own experience, I consider that carefully reading original texts of literature is as important as going out into the field. I am now working for the University of Tokyo's Research Center for Advanced Science and Technology. I am responsible for the development of the environmental education program, and teach at the university's College of Arts and Science. The first half of my 14-class course comprises lectures, while in the latter half, I have my students take turns reading, interpreting and discussing foreign documents. I encourage the first- and second-year students to make the effort to read original texts, checking meanings in a dictionary. When I have my students read original texts which are well-known through the media, they find out for the first time what the texts actually say.

For example, former Japanese Prime Minister Yukio Hatoyama delivered a speech at the UN Climate Change Summit, and promised to cut Japan's CO_2 emissions by 25 %. The original text in English was composed so elaborately that it gives us a quite different impression from the one we get from newspaper reports. Students thus get to sense the way information is communicated in Japan. For whatever reasons, I encourage students to read original texts, and show them how to access them on the Internet. While I teach students how to do it, I suspect that people in Japan are debating or making policies without reading original source documents.

Yasunari: Many interpretations are given, particularly to global environmental issues, and there are many books which discuss global warming. Students should read such books, but you suggest that students also read the source documents which originally raised issues, and that they give some thought to those issues. It is also very important to go out ourselves and experience the situation in which a phenomenon actually occurs.
Yonemoto: In my first year as a lecturer, I had students in my class who insisted on going to COP15. Then, as I gave travel expenses in exchange for a translation job, one of the students went to Copenhagen. Students who have definite objectives to do something or find something out, find a way eventually, as we did.

4.8 Global Environmental Issues: Between Natural Science and Modern Society

Yasunari: Nagoya University opened its Graduate School of Environmental Studies in 2001, trying to integrate the humanities and science. Nowadays people recognize that human activity, living things, agriculture and engineering are all closely intertwined in the debate about the global environment. In fact, it seems to me that more students are interested in studying Earth's environment. This subject, in my opinion, relates to one's approach to Nature and one's own humanity. Students should not study this subject if they regard it as a conventional academic discipline; if they are interested in it because they consider it useful to get a job, or think it is popular. I tell my students that to study the global environment is to always ask yourself what the Earth means to you.
Yonemoto: Global environmental issues are a huge domain which lies between natural science and modern society. One characteristic is that the issues are very political. Through global environmental issues, the achievements of research in natural science provide the basis for international negotiations. It can also be suggested that natural science itself has begun to carry political significance. This means that although scientists used to insist that they had nothing to do with politics, economics or international negotiations, and distanced themselves from such matters, they now unwillingly take up an important role in building the basic frameworks of environmental policies which are applied in diplomacy and domestic politics.

I argue that Japan's academia should stop commenting that problems in politics and policymaking are 'difficult,' as it often does when such problems arise. The academic community retreated to its ivory towers, insisting on being politically neutral and distancing itself from policymaking and diplomacy: dangerous activities full of messy negotiations. However, times have changed. Society should consider how to organize and apply the scientific research which is at the core of environmental issues, and how to make it the basis of shared understanding. Academia is responsible for research which helps people to recognize issues in a balanced and stable manner.

More research programs for global environmental issues are being organized, and more of policy proposals are being presented in the world. Japanese researchers should be involved in a more problem-oriented manner, using their research achievements in policymaking and future political decisions.

4.9 Looking for Ambitious Talents to Cross Disciplinary Boundaries and Address Issues

Yasunari: Contemporary academic studies have been segmented in response to the needs of the development of industrialized or information societies. A single discipline alone, however, cannot deal with environmental issues, which arise through interaction between humanity and Nature. An important process for those working in environmental studies is to get rid of the boundaries, in their minds, between various disciplines. Since I have been in academia for a long time, I recognize the importance of academic studies, but at the same time, I have the feeling that they will go through dynamic changes.

What is important is a problem-oriented approach. That is, one should study whatever disciplines one thinks relate to issues. In this sense, I work in a problem-oriented manner, or rather in a non-professional manner.

Yonemoto: I agree. We should start without any bias, and come as close to important issues as possible. Regarding key documents or articles, we should not take other people's interpretations for granted but read the original texts of such documents and articles, and make an effort to gather information ourselves. I have followed this method to examine the policymaking which has been left to the bureaucrats of central government ministries. Only after you really do it, do you realize how useful it is to read documents from different areas with a cross-disciplinary viewpoint.

The United Nations Framework Convention on Climate Change was adopted at the 1992 Earth Summit. As an observer, I attended the convention, as well as the preceding negotiations. Then, at a conference in Geneva, I said to a member of a US NGO, “I am not yet a specialist in this field.” I received the response, “You are wrong. Global warming is a new issue. Everyone here is a newcomer.” I was very impressed by the fresh view.

I believe that young researchers who venture to work in a new field and do something new will achieve the most in the end. If more researchers, following their conscience and responsibility, can analyze various government statements to find their true intentions, they will surely make debates more interesting.

This interview is a modified form of that first appearing in Japanese in *Kwan,* vol.18, spring 2010.

References

Carbon Dioxide Information Analysis Center (CDIAC), U.S. Department of Energy (DOE). DOE's Oak Ridge National Laboratory (ORNL). http://cdiac.ornl.gov/

IEA (International Energy Agency): http://www.iea.org/statistics/

IPCC, 1995: *Climate Change 1994: Radiative Forcing of Climate Change and An Evaluation of the IPCC IS92 Emission Scenarios.* J.T. Houghton, L.G. Meira Filho, J. Bruce, Hoesung Lee, B.A. Callander, E. Haites, N. Harris and K. Maskell (Eds.), Cambridge University Press, U.K., 339 pp. Available also from http://www.ipcc.ch/

The 1994 Oslo Protocol on Further Reduction of Sulphur Emissions, The United Nations Economic Commission for Europe (UNECE). http://www.unece.org/env/lrtap/fsulf_h1.html

West German Bundestag, 1990: *Protecting the Earth.*

Yonemoto, S., 2011: *Chikyu hendo no politics - Ondanka to iu kyoui [Politics in Global Change: A Threat Called Global Warming]*. Kobundo Publishers, Tokyo, Japan, 261 pp. (in Japanese).

Part II
Panel Discussion

Moderators:
Ayumi Iio (Editorial writer, Chunichi Shimbun)
Yoshitsugu Hayashi (Professor and Director of International Research Center for Sustainable Transport and Cities of the Graduate School of Environmental Studies, Nagoya University)

Panellists:
Syukuro Manabe
Ernst von Weizsäcker
Hans-Peter Dürr
Shohei Yonemoto

Chapter 5
Considering Sustainable Society After the Great East Japan Earthquake

5.1 Points of Discussion for a Sustainable Post-3.11 Society

Iio: The panelists for this discussion are a selection of notable world experts, and I am greatly looking forward to the upcoming discussion. In the special presentations (Part 1 of this book), these panelists raised various issues, such as the science of global warming, efficient use of resources, abandonment of nuclear energy, society relying on small but many, distributed energy sources, changes of lifestyles, and global warming and politics.

In my opinion, the most fundamental elements of these problems are connected, as Dr. Dürr explained: small individual lives, which are part of a greater existence called life. As Mr. Yonemoto said, we must rack our brains in the face of immeasurable threats. We do feel the necessity of the futurology for which Mr. Yonemoto argued when we see first-hand the places hit by the Great East Japan Earthquake.

The four presenters all discussed "a challenge to unified field theory." If all of them work together well and can propose solutions for the future, this discussion will turn out to be very fruitful.

Please think back to Part 1, which put forward four themes, presentations, or keys to the future, so to speak, and relate them to make a bridgehead for further discussion.

Hayashi: To begin with, I will explain, as one of this conference's organizers, why we arranged this panel discussion.

Based upon the results of a climate model, Dr. Manabe showed that drought is likely to become increasingly frequent and serious due to global warming. He then discussed how to deal with this very serious issue.

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According to Dr. Weizsäcker, humans, who are causing global warming, use various resources. The ways in which resources are used can be referred to as lifestyles, which have been changed by changes in production methods. Dr. Weizsäcker questions whether such a trend should continue, considering the current capacity of the Earth. He suggests that something be done in order to become "rich and carbon-free." He presented a good guide to important concepts, such as "Factor 4," "Factor 5" as a system to achieve Factor 4, a right to equal CO_2 emissions per capita, and "carbon justice."

Dr. Dürr explained his approach to energy, which he has formed based on his own experiences, or responsibilities that he has assumed. Certainly, he has directed our attention to our lifestyles. We notice that we need to consider how to use energy, and then realize that we have to change the way we use it, referring to Dr. Weizsäcker's suggestion in particular. Dr. Dürr teaches us that the vast universe, made up of atoms, has a balance of life and death, and that if the balance between them is lost, the universe inclines towards death. Keeping this aspect in mind, he suggested pondering first how to keep an energy balance and how to approach the use of nuclear energy, and then developing ideas from there.

Mr. Yonemoto argued that Japanese academia, who tend to be particularly allergic to politics, should understand various backgrounds, primarily the social background of international society, to do their duty in international society. In contrast to Dr. Dürr's suggestion of developing ideas that are based on a broad background such as materials and life, Mr. Yonemoto suggested looking into the social background, which is the base of society and politics as well as economics. I expect him to propose what we should do now, considering these factors.

I am sure this panel discussion will take account of the unprecedented tragedy of the huge 3.11 earthquake and tsunami, as well as the subsequent nuclear power plant accident, which all occurred around this time last year.

Many people are racking their brains and having discussions all over Japan, and I hope to take advantage of this opportunity to hear wide-ranging, generally-applicable ideas about our future from these wonderful experts.

I hope that the comments from the panelists will not only address how to revive the damaged areas, but also become the basis of a discussion on what sort of balance we should strike in Japan and the world, and on how we should reach agreement.

5.2 Calling for an International Cooperation Framework for Huge Earthquakes

Iio: To begin with, I would ask for more comments from Mr. Yonemoto. In the final part of your presentation, you suggested that politics should take enormous earthquakes into consideration. Can you explain that in a little more detail?

Yonemoto: When we make plans for the future, we must consider that a tsunami as high as 10–20 m could hit once in 600 or 1000 years. We barely took such a possibility into account when making plans in the past.

To put this more radically, we are resolved to carry out manipulation of the composition of the atmosphere, which humans have never imagined. The Pacific Plate moves beneath Japan at a rate of 8–10 cm a year, and measured values at least indicate that the Plate is going down faster than any other plate in the world. The greatest stress applies there. In other words, the risk of earthquakes is getting higher and higher. Considering this kind of risk, with regard to the atmosphere, Japan has decided that humans should control chemical substances on a global scale. Therefore, Japan should simulate how the plate will behave, on the assumption that enormous earthquakes will occur, and should take the initiative in organizing an international cooperation framework.

There is an official United Nations framework called the Hyogo Framework for Action 2005–2015, which was started on the 10th anniversary of the Great Hanshin Earthquake which hit Hyogo Prefecture in western Japan in 1995, and Japan should develop and promote it further.

If I were requested to give a reason for doing so, I would say that as a representative of the developed countries, Japan should explain the necessity of considering the causes of huge earthquakes which build up in the Earth's crust as threats from Nature, in the same way that atmospheric change is regarded, and the necessity of considering how to deal with them. Whatever its powers of persuasion, Japan is in the position, and has the obligation, of continuing to assert it.

Iio: I see. The Great East Japan Earthquake certainly reminded us that Japan is such a country. Japan should plan a new lifestyle, considering the circulation of water, atmosphere and tectonic plates: that's what you are saying, isn't it, Mr. Yonemoto? What do you think, Dr. Manabe?

Manabe: As I summarized earlier, I still think that the central theme is energy. Burning coal causes global warming, for example. After this earthquake happened, it occurred to me that such an enormous earthquake called for a reconsideration of energy policy. Some people had suggested going nuclear, but since the earthquake quite a few people now have grave doubts about nuclear energy.

One more thing has happened. Once the operation of the nuclear power plant in Fukushima was stopped after the accident, other nuclear power plants were also suddenly stopped. This disrupted the energy supply.

As a result, Japan is now forced to reconsider energy issues. Nuclear energy is regarded somewhat doubtfully. Apart from the problem of earthquakes, Japan imports coal and oil, most of them from the politically unstable Middle East. This is another headache. These circumstances lead me to conclude that Japan should pursue a diversity of energy sources.

If a country depends on a few energy sources, and something were to happen to them, it would be a disaster. The country should therefore depend on a variety of resources—geothermal power, for example, as suggested earlier by Dr. Weizsäcker. Since Japan is a country of earthquakes and there is underground heat near the surface, we should think about using geothermal power for the generation of electricity. Besides, we should think thoroughly about the possibilities of all energy sources, including solar energy and wind.

Japan does not have resources but it does have some advantages. As Japan is a narrow island country, stretching toward the north and south, I suggest installing a smart grid, feeding solar-generated electricity for example, and connecting all areas of Japan through the smart grid. If the whole country, from Hokkaido to the southern area, is connected, energy availability would be greatly improved.

In short, it is critically important to develop as many energy sources as possible and connect them with a smart grid system. In so-doing, Japan will be able to cope with disruption of energy supply such as the Fukushima nuclear accident. It is also important that Japan develops a long-term energy policy on this very special occasion.

5.3 Energy Source Diversity and Nuclear Power

Iio: Dr. Manabe, do you think that nuclear power should still be considered a potential source?

Manabe: Certainly. Many people are very skeptical of nuclear energy, and that's inevitable. However, I oppose the idea of the immediate shutdown of nuclear power plants. Now is not the time to decide whether to continue or discontinue nuclear power generation. Now is the time to have it thoroughly assessed by experts of not only nuclear energy, but also many other relevant disciplines. It is therefore highly desirable to have committees consisting of scholars, engineers and economists to conduct comprehensive, in-depth diagnosis of the issue and give advice to the government.

It seems to me that, compared to the United States, advice from committees has not worked well. Specifically, the Science Council of Japan should play a more active role. Now is the time to thoroughly reconsider nuclear energy. We may indeed conclude that we should stop using nuclear energy, but it is important to have a thorough discussion now. This is an important opportunity.

Iio: You mean that we should perform genuine scientific verification first. I'm afraid to say that the tide is not in favor of scientists now. As exemplified by the term "nuclear village," (referring to the group of opinion-formers and scientists who tightly control information about Japan's nuclear industry) there is skepticism among Japanese people in general about assessments by scientists. I feel that there is a parallel between this problem and the point, raised by Mr. Yonemoto, that it was necessary to first increase the accuracy of the IPCC's prediction before discussing global warming.

Now I would like to ask Dr. Dürr. My understanding of your remarks in your presentation is that you totally reject nuclear power. What do you think about "energy source diversity"?

Dürr: I clearly said that there was only one source of energy available and it was the sun. I also said that it was important to store solar energy.

I am not worried about depending only on the sun because the sun has more power than the Earth does. Is there any sufficient source other than the sun? Is there anything other than the sun on which we can depend for 10 years, 20 years or the long term? I do not understand why we need to rely on nuclear energy. Rather we should consider how to use solar power.

If we all cooperate, we will be able to obtain all the energy that we actually need, and we will be able to use the energy without destroying the biosystem. So I am not worried about it.

We need the sun. If the sun became unavailable to us, we would need another sun, but that's hardly a problem that worries me now.

Iio: Dr. Weizsäcker, what do you think about Dr. Dürr's opinion that we should rely on the sun, and about Dr. Manabe's opinion that we should choose sources while scientifically studying a variety of energy sources?

Dr. Weizsäcker: Diversifying the sources is a good thing, of course, but it does not solve the problem in the long term. As Dr. Dürr says, uranium is a limited resource. Uranium-rich areas are geographically limited and deposits are not very large. So sustainable use of nuclear energy is a complete illusion, and is geological nonsense.

The other question is what Japan can and should do in the next 10 years. This is a totally different question to address from a different viewpoint. I propose initiating strategies, making us in Japan, Germany, Brazil and China, progressively less dependent on coal and nuclear energy year by year. I believe that this is important. It is ridiculous to use a huge amount of energy to "bring a bucket of water up to the top of the Everest," as I said.

We actually need less energy; using less energy more elegantly to maintain civilization and obtain people's happiness. I suggest making cascade use of energy.

Germany has already decided to phase out nuclear power. Natural gas and coal have been chosen as substitute sources of energy. In addition, more and more wind power will be used in future. I believe that wind power generation will be more and more efficient, and will replace nuclear power generation. I am therefore optimistic about it.

5.4 Impact of the Nuclear Accident on Germany

Iio: I have got the impression that all the panelists are calling for strategic energy policies. Dr. Weizsäcker, Germany once decided not to rely on nuclear energy but Chancellor Merkel later reinstated it. Then, she decided again immediately after the Fukushima accident—even before Japan, which had suffered the accident, made a decision—to phase out nuclear energy as quickly as possible. Why was Germany able to do that?

Dr. Weizsäcker: The trigger was purely political. The CDU (Christian Democratic Union of Germany), which is a conservative party, lost local elections against the Green Party three weeks after the Great East Japan Earthquake and, later, against the Social Democratic Party. In the State of Baden-Württemberg, a member of the

Green Party was elected Minister-President. This was utterly unforeseen and inconceivable for the political elite in Germany. A few hours after the election, the elite said that they could not believe it. It was a shock to them.

It was also a shock for Chancellor Angela Merkel. She said that her conservative camp had to get votes again, by being greener than the Greens. This was the motive and trigger.

The question is, of course, whether this is economically realistic, and it is a totally different question. My personal assessment is that her sudden decision to phase out nuclear energy is a little too ambitious. The energy policy will not work unless the country imports energy from France by 2022. This plan is too ambitious.

It will take us three to five years to think it through. I do not know what will become of this policy if we do not increase the energy price to improve energy efficiency. I suppose that it will take three to five years.

Iio: Dr. Dürr, after the earthquake, I visited Germany and talked to ordinary people there. I believe that there must be a reason for political reactions. Let me ask you the same question. It seems to me that there is greater fear of nuclear energy among German people than Japanese people, and that such fear is a strong motivation for German people to change lifestyles. What changed the policy? I think that this question will relate to the question, “Why was Germany able to change?”

Dürr: I don’t think the public had ever been convinced that they should have nuclear energy. I said four years ago that we must be prepared for the time when there would be no fossil fuels available, and that we must study the possibilities of solar energy in more detail. We are not using even one-ten thousandth of available solar energy. I said that we need only one-ten thousandths of the available solar energy to replace the fossil fuels we are currently using. However, the public did not like this idea.

I realized that the ideal was for energy production to be localized and decentralized. It could be aimed at obtaining energy from Nature without much investment.

Getting something without paying for it is attractive. To do it, we have to be dependent on somebody else or something else through decentralization of power generation. However, people did not want to be dependent on others in the first instance. They wanted to be independent in terms of energy. They wanted to live without relying on somebody outside or somebody with power, and wanted to generate energy on a small scale for their own purposes. That is the consensus of the public, in my opinion.

So, why do I not support this idea? Because I know as a scientist how dangerous it is to use nuclear power for military purposes. This is the reason why I have long been against the idea. It takes only a few weeks to make nuclear weapons. If they are not used in wars, they can be used for deterrence or intimidation. This is not a correct way of thinking.

If fossil fuels were used up, even nuclear energy would not be able to make up for it. This issue reminds me of alcoholism. It has nothing to do with the essence of the problem to say that breweries are the source of the problem or that it is not possible to live without alcohol. There is a parallel with energy problems. Some people may laugh at what I say, but alcoholics just have to learn to drink less. We can approach the energy problem in the same way. We need innovation in our lifestyle so that we consume less energy or use it more efficiently. The Earth has been dependent on solar energy for the last four billion years, and so have living things. It is not a question of whether there is a possibility or not.

I do not like the way that some people make a lot of money by stealing resources from the Earth. I disagree with the way that some people mine minerals in large quantities and ask others to pay for them. By this logic we should have to pay for the oxygen we breathe because we do not own it. If you asked people to pay for the oxygen that is being produced, nobody would pay. However, this is what we are doing now.

We obtain necessary things from the Earth to continue our lives, and our behavior influences future generations. What we need now is something that they will also need in future. In my view, life on Earth will be fantastic by passing things on in this way.

5.5 What Choice Should Japan Make?

Iio: Mr. Yonemoto, Dr. Manabe told us that we must improve our systems for scientific assessment as well as our ability to forecast and prepare for the future. I feel that this must be a prerequisite. Japan suffered a terrible natural disaster and nuclear accident, and so a drastic change in energy policy and lifestyle has been called for, but it doesn't seem to be developing into a great wave. The reactions of both politics and society seem to be very sluggish. On the other hand, there has been a big change in Germany for the reasons which have been just explained. Whichever direction Japan goes, we must have change. What external factor could cause the change? What can get things moving?

Yonemoto: I have long observed Japan's power structure, which can be described as a centralized power structure, characterized by "structural paternalism." In short, our political behavior is that when we face political problems, we always turn to the elite bureaucrats of the central ministries and agencies, and ask them for the solutions. So it is universities that should change first and most, in my opinion. They should put forward their own visions and proposals.

Because universities insist on their neutrality, society does not change at all. Universities should publicize their stances on very hot political issues, taking advantage of academia's neutrality, and leave the judgment to society, which decides which stance to take. I argue that universities themselves should set up behind-the-scenes think-tank projects to address various important issues.

Iio: Thank you very much. Please go ahead, Dr. Manabe.

Manabe: Dr. Weizsäcker has made two points. The first point is that electricity in Japan is very expensive, and I suspect that it is more expensive than any other country. The second point is that energy prices should be raised to develop substitute energy sources. If energy were expensive, clean energy would become more competitive and everyone would make an effort to develop it.

Let me summarize his two points as I understand them. Electricity is very expensive in Japan. It means that Japan has the strongest incentive to develop alternative sources of energy. Therefore, Japan should work hard to develop substitute energy sources. Another point, which I elaborated earlier, is to connect all parts of Japan with a smart grid that optimizes the use of electricity. Japan is an archipelago that stretches over wide range of latitudes. It is therefore very desirable to connect the entire country with a smart grid so that electricity may be shared by means of the smart grid.

Iio: Only Dr. Manabe, who has seen Japan from both inside and outside, could have this kind of opinion. I would like to invite comments from Dr. Weizsäcker and Dr. Dürr. The discussion that we have had today could have as significant an impact as "Factor 8." Can Japan really change its lifestyle? Most people would say that it is easier said than done. After suffering the earthquake in Tohoku and the nuclear accident in Fukushima, what lifestyle should Japanese people choose? Can we have brief comments from Dr. Weizsäcker and Dr. Dürr respectively?

Weizsäcker: As a foreigner, I will not ask Japanese people to follow a particular lifestyle; I will not tell them how they should live. Japan has an admirable culture and civilization. I would advise that people learn from Japan's successes.

In the 1970s and up to the end of the 1980s, Japan was a pioneer, playing a leading role in improving energy efficiency while other countries were still sound asleep. This catapulted Japan to the top of international competitiveness and high technology. So I believe that Japan should make a political decision to repeat that success story, not by raising the price of energy abruptly, but in a more gentle, step-by-step manner to improve quality of life and energy technology to change lifestyles. In the end, you will be able to get rid of nuclear energy completely.

Dürr: What people are not thinking about is the waste of nuclear energy. Nobody considered initially how to dispose of nuclear waste. Whatever future innovation develops, no solution has yet been found to dispose of it. The only way to fully dispose of nuclear waste is a method called transmutation, which changes it completely by bombarding it with neutrons in an accelerator.

The problem, however, is that we need a lot of energy to make such an accelerator, and the accelerator will be enormous. In other words, in order to completely dispose of nuclear waste we need high energy and large facilities which are unlikely to be practically achievable. As my final point, I would suspect that nobody has ever thought about it or considered that the cost of, as well as the energy required for, complete disposal were so enormous. It is irrational to use more energy to get rid of the waste completely than was obtained.

In Japan in the 1970s, I had discussions about how to dispose of the waste completely, and people said that there was no other way to make up for the shortage of fossil fuel. I still remember that I said at that time, "Let's stop it!" I have a feeling that nobody thought enough at the time about how to dispose of nuclear waste.

5.6 Agreement, and Towards Diagnosis and Treatment

Iio: The difficulty of complete disposal is one of two facts which Fukushima's accident has revealed. Today's discussion has been very fruitful as there has been agreement that accurate science, including its calculations, should steer politics in the right direction.

This is a very rare occasion on which renowned panelists have come together and talked about their opinions so enthusiastically. I am sure that the audience have been greatly stimulated.

From the audience (Dr. Keiji Higuchi, Professor Emeritus of Nagoya University): There was some discussion of how lifestyles should be changed. Dr. Weizsäcker has suggested that we have a high standard of civilized life. Dr. Dürr has said that it is important to change the quality of our lifestyles. There is one more important thing. This is what I felt after the 3.11 earthquake and tsunami. My wife comes from Rikuzentakata City, Iwate Prefecture, which is the city devastated by the giant tsunami. So I cannot see the disaster as other people's affair. Feeling this way, I listened to Dr. Weizsäcker and Dr. Dürr, and I thought, "What is happiness?" Their remarks made me think that we should think again about what happy life is. Then, Mr. Yonemoto referred to Bhutan. While we have discussed GNP, Gross National Product, the people of Bhutan have discussed GNH, Gross National Happiness. The country has worked on Gross National Happiness for a long time. This is about to be picked up by the United Nations. In this sense, now is the time to shift from GNP to GNH. I consider it also important to include such an intention.

Hayashi: Dr. Higuchi summarized today's discussion very well. Listening to today's presentations and the panel discussion has given me tremendous food for thought. One of the discussions was about the difference between Germany and Japan. This may have confused you a little. It was pointed out in the discussion that two things were mixed up: one is the goals to set, and the other is preparation of road maps or step-by-step benchmarks to achieve the goals.

Whether nuclear energy is good or not depends on the long-term goal to be set, and we must agree to the goal.

Whether the goal is feasible depends on technological development on one hand, and Dr. Weizsäcker particularly introduced various tools for this purpose. However, it cannot be attained by technological development alone. On the other hand, it is considered important to change the taxation and other systems and raise prices gradually so that we can alter our own behavior naturally. There are parallels between the discussions of this issue and consumption tax. Discussion could not develop if it sought an all-or-nothing conclusion. Using a method recently called "backcasting," which sets future goals first and works out necessary steps backward from the goals, it is necessary to design what to change at what rate.

At the time of design, we should raise public awareness, calling for debate. For the last 50 years or so, we Japanese people have become very good at following a path paved by somebody and being engaged in production which is assured to achieve something, but have become poor at pondering individual issues. Individuals are required to think about whether to raise the consumption tax and what to do with nuclear energy, for example. General agreement should be reached about how to make preparations against big risks, such as enormous earthquakes, that could cause such nuclear accidents, based on individuals' thoughts.

There is no absolutely correct solution to this problem. Therefore, we need to set up our own mechanism again to reach agreement. In my opinion, the previous generations who are no longer with us were probably very good at devising such mechanisms because Nature was something so big for them that they did not dare to control it at all. We should keep this point in mind. There is a vast universe, as referred to by Dr. Dürr, which humans should carefully take into consideration.

Humans tend to think that it is only they who change, but we learned today that the Earth changes much more than humans do. We should think, taking account of that, and then we could avoid situations that are 'unimaginable,' a rather bizarre term.

No matter what may happen, we should make the effort to think about how to respond and how to adapt to Nature's law. I think it is important to set goals and take firm steps toward them.

Today's conference started with Dr. Manabe's presentation about the interaction between our behavior and Nature, and we learned from Mr. Yonemoto's talk that in politics, there are many issues that Japan should not just consider from its own, insular perspective, in order to work carefully for our future.

We would like to hold this conference again with the same irreplaceable panelists.

What is more, we are participating in the Global COE program, led by Prof Yasunari, with "Diagnosis to Treatment" as its research theme. This program provides classes taught by researchers in science, engineering, and social science. It is said in general that the disciplines of science work hard to clarify truths, which is the diagnosis process, but no more, while those of engineering and social science are only concerned about the treatment process. The Global COE program is an attempt to build up a scheme aiming at diagnosing not only contemporary society but also Nature, considering what to do, and setting targets, in the way that competent doctors would behave. Although it started as a small project, I believe that we are responsible for developing it into a big movement. The program currently involves our students in both research and education.

I would like to keep holding this conference in future since we have asked today's panelists to keep watching the program's development.

Iio: Thank you very much. I feel that today's conference has put forward critical and very detailed questions to be considered by those in science, politics, and economics, as well as ordinary individuals and journalists. As we intend to work hard to answer the questions, I hope that we will have another opportunity in the near future, preferably in the next year, so that all the panelists and others can come together to evaluate our progress. I would like to close the conference, calling for a huge ovation for the four panelists, Dr. Hayashi, and Dr. Higuchi.

Graduate School of Environmental Studies, Nagoya University Message from the Dean

Creating and Developing a New Discipline Called "Environmental Studies"

Our graduate school, the Nagoya University Graduate School of Environmental Studies, consists of three departments; Earth and Environmental Sciences, Environmental Engineering and Architecture, and Social and Human Environment. Our faculty members cover fields in natural sciences, engineering, and humanities in order to exercise our most basic principles—to thoroughly examine existing disciplines, and create an Environmental Studies program founded upon the two main pillars of Sustainability Studies and Safety and Security Science.

There may be many paths to creating a new discipline, but I believe that collaborative research is the cornerstone of our Environmental Studies program. When academics in natural sciences, engineering, and humanities profoundly explore their respective disciplines, they will reach a kind of common knowledge and wisdom. Academic experts with such valuable knowledge are able to understand the essences of disciplines outside of their own. When a need for collaboration is triggered by social demands or students' ambitions, these academic experts from differing fields can come together to pioneer a new discipline integrating fields in natural sciences, engineering, and humanities. It all begins with collaborative research, and this is how we created a new type of Environmental Studies at our graduate school.

Our school has experienced tremendous growth since its establishment in 2001. Our faculty has undergone generational changes and seen an increase in a new breed of member who is more relevant and better equipped to respond to the challenges presented by our students and this new discipline. The Integrated Environmental Studies Course was established under the theme "From Earth

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System Science to Basic and Clinical Environmental Studies" with support from the Global Center of Excellence (GCOE) program by the Ministry of Education, Culture, Sports, Science and Technology (MEXT). The Nagoya University Global Environmental Leaders Program (NUGELP) was also established with support from MEXT. These efforts have been undertaken with the collaboration of interdisciplinary teams from our school as well as the Graduate School of Bioagricultural Sciences, the Graduate School of Engineering, and the Graduate School of International Development.

People in pursuit of in-depth knowledge in existing disciplines, people integrating existing disciplines to pioneer a new discipline, and people bringing those people together. This broad spectrum of faculty members and students are, and always will be, the driving force of our school.

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About the Speakers

Syukuro Manabe (Japan) was Senior Meteorologist for the Program in Atmospheric and Oceanic Sciences of Princeton University, and Distinguished Invited Professor of Nagoya University. Born in Ehime Prefecture, Japan in 1931, Dr. Manabe completed the doctoral course at the University of Tokyo, becoming Doctor of Science in 1958, and went to the United States in the same year. In 1968, he became Senior Research Meteorologist at the Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration, and served as an Adjunct Professor at Princeton University. He pioneered the use of computers to simulate global climate change and natural climate variation, and has been a leader in this field of research.

He returned to Japan in 1997 to take up the position of Director of the Global Warming Research Program at the Frontier Research Center for Global Change of the former Science and Technology Agency. He went to the United States again in 2001 to assume his current position. He won the Carl-Gustaf Rossby Research Medal of the American Meteorological Society as well as the Blue Planet Prize of the Asahi Glass Foundation in 1992, the Roger Revelle Medal and the Bowie Medal of the American Geophysical Union in 1993 and 2010, respectively, the Asahi Prize of the Asahi Shimbun Foundation in 1995, Milutin Milankovic Medal of the European Geophysical Society in 1998, and many others. He is also a member of the US National Academy of Science and an honorary member of the Japan Academy.

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Ernst Ulrich von Weizsäcker (Germany) is Co-President of the Club of Rome, and Visiting Professor of the Graduate School of Environmental Studies, Nagoya University. He was awarded Honorary Doctor of Nagoya University in 2015. Born in Zürich, Switzerland in 1939, Dr. Weizsäcker worked as President of the University of Kassel, Director of the United Nations Center for Science and Technology for Development, before founding the Wuppertal Institute for Climate, Environment and Energy (becoming its first president). In the same period, he was a member of the Bundestag (German Parliament) and contributed much to the promulgation of environmentalism. In the 1992 Rio de Janeiro Earth Summit, he put forward the "Factor Four" concept, of doubling wealth while reducing resource consumption.

He is a leading figure in the global environmental field. His works include *Earth Politics*, *Factor Four*, *Factor Five* and many others, and he has been awarded the WWF's Duke of Edinburgh Conservation Medal, the Order of Merit of the Federal Republic of Germany, and other honors. On the occasion of his 75th birthday he published: Ernst Ulrich von Weizsäcker (Ed.): *Ernst Ulrich von Weizsäcker: A Pioneer on Environmental, Climate and Energy Policy*—Presented by Uwe Schneidewind (Cham–Heidelberg–New York–Dordrecht–London: Springer, 2014). See also this book website: http://www.afes-press-books.de/html/SpringerBriefs_PSP_E.U.v._Weizsaecker.htm.

Photo Credit: Ernst Ulrich von Weizsäcker as a member of the German Parliament in the Bundestag. Reprint is permitted for purposes of political education.

Hans-Peter Dürr (Germany) was Director Emeritus of the Max Planck Institute for Physics and Astrophysics, Professor Emeritus of Ludwig-Maximilians-University Munich, and Visiting Professor of the Graduate School of Environmental Studies, Nagoya University. Dr. Dürr was born in Stuttgart, Germany in 1929, and is an honorary citizen of Munich, Germany, and a successor to Dr. Heisenberg. He worked at the Max Planck Institute as a young co-researcher of Dr. Heisenberg, and contributed to the establishment of quantum mechanics and unified field theory. He is one of those who issued the 2005 Potsdam Manifesto, a follow-up to the 1955 Russell-Einstein Manifesto, and he has explained the nuclear crisis and Gaia's sustainability in a unified manner, appealing to the public.

He has authored *Unified Theories of Elementary Particles* (Springer), *Gott, der Mensch und die Wissenschaft* (Pattloch) and many others. He has won the Right Livelihood Award (often referred to as "Alternative Nobel Prize"), the Order of Merit of the Federal Republic of Germany, and other awards.

Photo Credit: Vereinigung Deutscher Wissenschaftler (VDW)—Federation of German Scientists (FGS).
Dr. Hans-Peter Dürr passed away on 18 May 2014 at the age of 84.

Shohei Yonemoto (Japan) is Professor of the Graduate University for Advanced Studies, and Visiting Professor of the Graduate School of Environmental Studies, Nagoya University. Born in Aichi Prefecture, Japan, in 1946, Mr. Yonemoto graduated from Kyoto University in 1972 and joined Maruman Securities, then Mitsubishi Kasei Institute of Life Science in 1976. In April 2002, he became President of the Center of Life Science and Society, a think-tank which studied bioethics and science technology policy. From 2007 after leaving the Center, he worked as Professor of the Research Center for Advanced Science and Technology, the University of Tokyo. He has held his current position since 2009. He studies the history as well as the philosophy of science, and has authored *Bioethics* (in Japanese; Kodansha Gendai Shinsho), *Heredity Management Society* (in Japanese; Kobundo), *What are Global Environment Problems?* (in Japanese; Iwanami Shinsho), *Eugenics and Human Society* (in Japanese; co-authored, Kodansha Gendai Shinsho), and others.

About the Moderators

Hidefumi Imura (Japan) is Senior Project Manager at Yokohama City University, Contract Professor of the Global Cooperation Institute of Sustainable Cities, and Professor Emeritus of Nagoya University. Born in Ishikawa Prefecture, Japan in 1947, Dr. Imura graduated from the Faculty of Engineering, the University of Tokyo, in 1969, and completed his postgraduate study at the Department of Applied Physics, Graduate School of Engineering, the University of Tokyo in 1974, which awarded him a doctorate in engineering. In the same year, he started to work for Japan's former Environmental Agency.

He also worked for the Ministry of Foreign Affairs and Yokohama City. He was Associate Professor and later Professor of Kyushu University, and Professor of the Graduate School of Engineering, Nagoya University, before becoming Professor of Nagoya University's Graduate School of Environmental Studies in 2001. He specializes in environmental systems analysis. He has authored *Environmental Systems Studies: A Macroscope for Understanding* and *Operating Spaceship Earth* (Springer) *and Environmental Issues in China Today: A View from Japan* (Springer), among others.

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Ayumi Iio (Japan) is Editorial Writer for the Nagoya Head Office of the Chunichi Shimbun. Born in Aichi Prefecture, Japan in 1960, Mr. Iio joined the Chunichi Shimbun in 1985, working at the Gifu Office before moving to the Nagoya Head Office. He belonged to the Community and Economic Affairs Team of the Community Department, and mainly reported waste disposal issues. He was a member of the team which published the report, *How we can solve the problem of waste disposal?* (in Japanese), as part of a campaign to debate the problems of industrial waste. He has held his current position since 2002, chiefly responsible for environmental and agricultural issues.

About the Editors

Yoshitsugu Hayashi (Japan) is Professor and Director of the International Research Center for Sustainable Transport and Cities of the Graduate School of Environmental Studies, Nagoya University. Born in Mie Prefecture, Japan in 1951, Dr. Hayashi was awarded Dr. Eng degree at the University of Tokyo in 1979. He worked as Lecturer at the University of Tokyo, and Associate Professor and Professor at Nagoya University's School of Engineering, before taking up his current position in 2001. He served as the Leader of the Nagoya University Global COE Program "From Earth System Science to Basic and Clinical Environmental Studies" from April 2013 to March 2014.

He serves as Director of the Education and Research Center for Sustainable Co-Development of the Graduate School of Environmental Studies from April 2014. He was an Assistant (for international affairs) to Nagoya University's President, and worked as Dean of the Graduate School of Environmental Studies. He has worked as Vice-President of the Japan Society of Civil Engineers, and Chair of World Conference on Transport Research Society (WCTRS) special interest group on transport—land use interactions since 1989. He currently serves as President of WCTRS. He has authored various books including *Land Use, Transport and the Environment* (Kluwer), *Urban Transport and the Environment: An International Perspective* (Elsevier), *Transport Moving to Climate Change Intelligence: New Chances for Controlling Impacts of Transport after the Economic Crisis* (Springer). Among other honors, he was awarded the Best Paper Prize by the Japan Society of Civil Engineers, the Orange Prize by WCTRS. He became a member of the Club of Rome in July 2015 (He is currently Professor Emeritus of Nagoya University, and Professor of Chubu University).

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Tetsuzo Yasunari (Japan) is Director-General of the Research Institute for Humanity and Nature. Born in Yamaguchi Prefecture, Japan in 1947, Dr. Yasunari graduated from the Faculty of Science, Kyoto University in 1971, and continued his research at the same university's Graduate School of Science to obtain his master's and doctoral degrees. He started teaching at Kyoto University's Center for Southeast Asian Studies in 1977, and moved to the University of Tsukuba in 1982 where he has taught as Lecturer, Associate Professor, and Professor. From 2002 to 2013, he was Professor of the Hydrospheric Atmospheric Research Center (and the Graduate School of Environmental Studies) of Nagoya University.

He served as Director of the university's Study Consortium for Earth-Life Interactive Systems, as well as the Leader of the Nagoya University Global COE Program "From Earth System Science to Basic and Clinical Environmental Studies" from July 2009 to March 2013. He has held his current position since April 2013. He specializes in meteorology, climatology, and earth environmental studies. He has authored *Climate and Glaciers in Himalaya* (in Japanese; co-authored, Tokyodoshuppan), *Global Environment and Asia* (in Japanese; co-authored, Iwanami Shoten), and others.

Hiroshi Kanzawa (Japan) is Professor of the Graduate School of Environmental Studies, Nagoya University. He has served as Dean of the Graduate School since April 2015. Born in Gunma Prefecture, Japan in 1953, Dr. Kanzawa graduated from the Faculty of Science, Kyoto University in 1976, and completed a doctoral course at Kyoto University in 1984, which awarded him Doctor of Science. He started to work as Assistant Professor at the National Institute of Polar Research in 1981. He became Research Program Manager of the Center for Global Environmental Research of the National Institute for Environmental Studies in 1993, and Head of the institute's Atmospheric Physics Section in 1998.

He has held his current position since 2003. In the meantime, he went to the Antarctic as a participant in the Japanese Antarctic Research Expedition, and worked at the Department of Atmospheric Sciences, University of Washington (USA) as a visiting scholar in 1987. In 1997 he led a campaign to launch giant balloons in Sweden to verify sensors installed on a satellite to observe the ozone layer over the polar region. He is currently working on atmospheric science issues concerning ozone depletion, global warming, etc. He won the Horiuchi Award of the Meteorological Society of Japan in 1997. He has authored *Book of the Atmosphere* (in Japanese; Poplar-sha), and others.

Hirokazu Kato (Japan) is Associate Professor of the Graduate School of Environmental Studies, Nagoya University. Born in Gifu Prefecture, Japan in 1970, Dr. Kato graduated from the Faculty of Engineering, Nagoya University in 1992, and continued his post-graduate study at the university's Graduate School of Engineering to obtain a doctoral degree in 1997. He became Assistant Professor at Nagoya University's Faculty of Engineering in 1997 and he has held his current position since 2001. He has won the Encouragement Award of the Society of Environmental Science, Japan, and the Eco-efficiency Award of the Life-Cycle Assessment Society of Japan, as well as others.

He has co-authored *Urban Transport and the Environment: An International Perspective* (Elsevier), *Transport Moving to Climate Intelligence: New Chances for Controlling Climate Impacts of Transport after the Economic Crisis* (Springer), and others.

About this Book

This book is an outcome of the symposium "*Climate Change, Resource-Energy Use and Sustainability of the Earth and Human Society*," organized by the Nagoya University Center of Excellence Program "From Earth System Science to Basic and Clinical Environmental Studies" and held at Nagoya University in February 2012, and presents papers by four eminent researchers. (1) Syukro Manabe, who was honored in 2008 by the Earth Hall of Fame Kyoto, together with Ms. Maathai and Ms. Brundtland, describes the mechanisms of extreme weather, drought, and flood that were caused by climate change due to CO_2 emissions. (2) Ernst Ulrich von Weizsaecker, co-chair of the Club of Rome, describes "Factor 4 and 5" concepts such as technological progress and redesigning socio-economic systems, e.g. taxation and stresses the importance of humanity. (3) Hans-Peter Dürr, ex-president of the Max Plank Physics Institute as a successor of Heisenberg, explains the mechanism of a living Earth sustained by accumulated energy resources provided by the sun. He clarifies a point on preserving the dynamic stability of minerals and life on Earth. (4) Shohei Yonemoto, a well-known political scientist focusing on sustainability, explains environmental politics and why the IPCC and UNFCCC framework were established on the basis of precaution principles. He puts forward a new concept called Futurology which considers population and food problems from a Malthusian standpoint and incorporates them into issues as climate change and natural disasters.

Each paper is followed by an interview with the eminent researcher, which illustrates the circumstances where he has been involved with his disciplines, a concise sketch of his work, a way of his thinking, and so on. The record of a panel discussion on the topics is also given to extract the ideas of the eminent researchers which were not well expressed in their papers.

This book is written and based on a very simple but concrete idea and provides the readers with a chance to consider the shape of Future Earth.

See also the website on this book at: http://www.afes-press-books.de/html/SpringerBriefs_ESDP_25.htm.

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