B-052 Integrated Analysis of Mitigation and Adaptation Measures to Global Warming with Asia-Pacific Integrated Model (Abstract of the Final Report)

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[Abstract]
The objective of this research is to assess the countermeasures to solve both the long-term climate change issues and other short-term/middle-term local environmental problems in cooperation with researchers in China, India, Korea and Thailand. For this purpose, two types of models were developed on both the global and national scales. One model, element of environmental model, treats the detailed environmental change and its impacts such as water, air, energy, solid waste and others based on the process based framework. The other model, environment policy assessment model, represents the consistency among the economic activity and the environmental change based on the economic framework. By using the energy demand technology selection model, CO_2 emission reduction potential and the marginal cost were estimated in both global scale and national scale. The other element of environmental models represented the various impact on the local environmental problems. On the other hand, the environmental policy assessment model with various element models assessed the economic impact on the climate change. From the integrated model of economic activity, climate system and agricultural productivity change, it was calculated that the adaptation could reduce the global warming impact, but it could not compensate the damage completely in the case of the severe temperature increase. This result indicates that the integration of mitigation and adaptation is important to solve the climate change problem.

1. Introduction

In order to address the climate change issues, introduction of countermeasures from the long term viewpoint exceeding 100 years is necessary. Although “mitigation” policy has been regarded as the main countermeasure, “adaptation” policy is needed for the areas where the global warming impacts have already been observed. Moreover, the countermeasures in the developing countries will be inevitable to stabilize the temperature and to carry out appropriate adaptation policies.

The Asia-Pacific Integrated Model (AIM), which has been developed in cooperation with the Asian countries such as China, India, Korea and Thailand, has already been utilized to address the climate change issues through the estimation of greenhouse gas emissions and air pollutant emissions from the fuels, and climate change impacts. The international organizations such as IPCC and UNEP are expected to use the information about GHG emissions, water demand and other relevant aspects from AIM simulation results.

On the other hand, as shown in the “Millennium Development Goals (MDGs)” in the United Nations, the important issues to be solved in the developing countries until 2015 are the environmental problems such as water resource, land use, agriculture and forest management, besides the economic development. It is recognized in the developing countries that serious environmental problems affect the economic development. Therefore, in order to realize the goal of sustainable development, it is important to assess the climate policies taking into account both mitigation and adaptation, and the local environmental policy taking into account long-term climate change, short-/medium-term environmental problems and economic development.

2. Research Objective

In order to achieve the goal of sustainable development which addresses various environmental problems including long-term climate change and short-/medium- term local environmental problems, and simultaneously considers economic development, an analysis with multiple scopes is needed. The purposes of this research are stated as follows. The first purpose is the model expansion from the existing AIM model, which mainly focuses on energy system, to include all other environmental problems such as water and air, and economic development. The second purpose is the environmental policy assessment from the viewpoint of the Asian developing countries such as China, India and Thailand as well as the global level to analyze the short-/medium-term environmental protection and economic development issues such as the MDGs and adaptation, and long-term climate policies such as mitigation. The third purpose is the quantification of impacts of climate policies in Japan in cooperation with the developing countries through the clean development mechanism and other cooperation mechanisms. In order to achieve the above purposes, both the country scale and the global scale environment-economy models are developed. At each scale there are two types of models. One model, element of environmental model, treats the detailed environmental change and its impacts such as water, air, energy, solid waste and others based on the process based framework. The other model, environment policy assessment model, represents the consistency among the economic activity and the environmental change based on the economic framework.

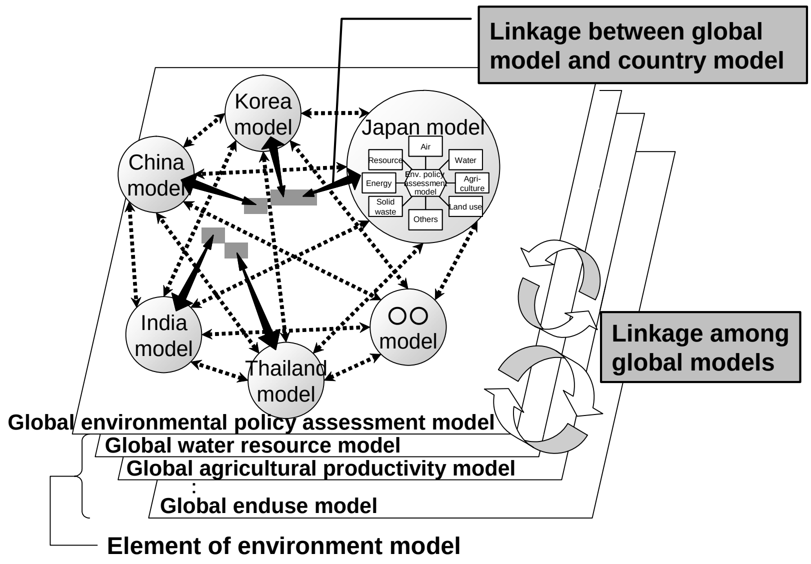


Fig. 1 Developed models and their linkage

3. Activities FY 2005 to FY2007

(1) Development and modification of global models

The AIM/Enduse [Global] model which has 21 regions were developed in order to forecast the future greenhouse gas emissions, their potential reduction by introducing specific technologies, and their marginal abatement costs. Figure 2 represents the greenhouse gas reduction potential less than 100US$/t$CO_2$ in 2020. The total reduction in the world in 2020 is estimated to be 8.8 to 11.3 billion tCO_2, and the developing countries and economic transition countries have larger potential than the developed countries.

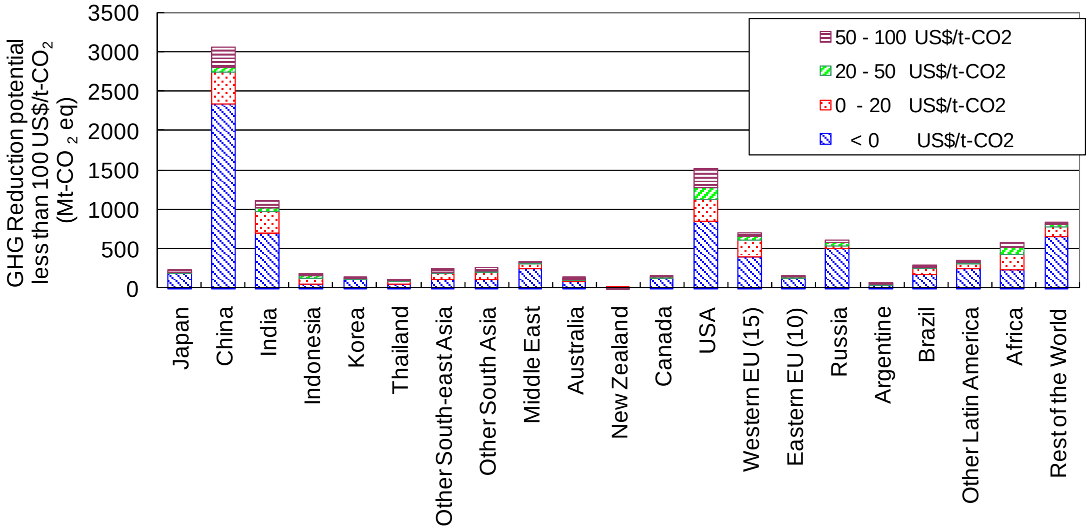


Figure 2 Regional greenhouse gas reduction potential less than 100 US$/t$CO_2$ in 2020

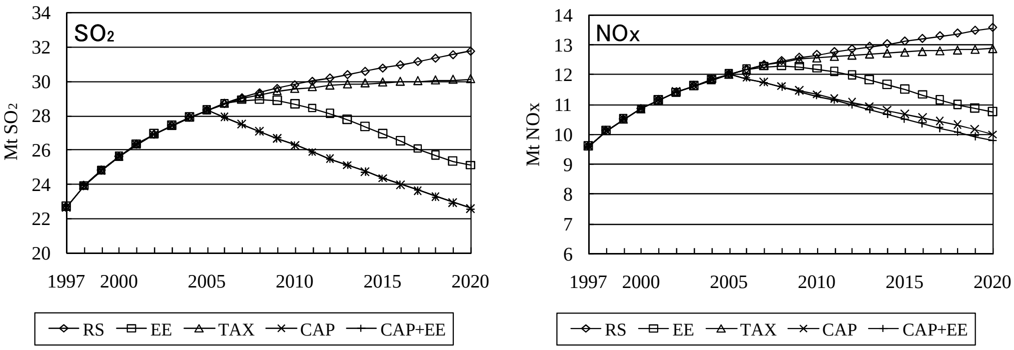
As the global environmental policy assessment model, the global computable general equilibrium model which has 24 regions and 21 sectors were developed. This economic model was used to quantify the greenhouse gas emissions trajectory for the IPCC new scenario.

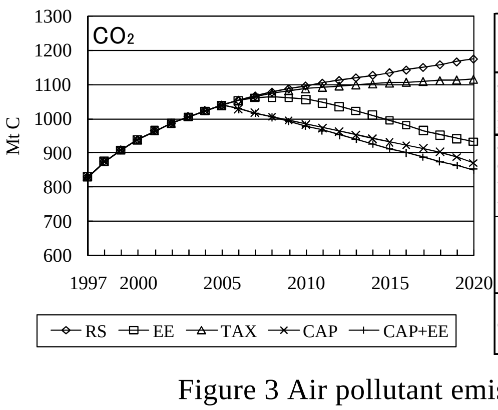
(2) Development of AIM/Enduse [Country]

By cooperating with the Asian countries, the AIM/Enduse [Country] models for China, India, Thailand, and Korea have been developed, and the countermeasures against the global warming were assessed. In China, the model was expanded to the ethylene production, ammonia production and oil refinery sectors, and the CO_2 emission reductions by introducing the carbon tax and energy tax were estimated. Especially, we focused upon the coal use and its reduction by introducing new coal technologies. In India, the model were extended to estimate the multiple greenhouse gas emissions, not only CO_2 but also CH_4 and N_2O, and the future greenhouse gas emission scenarios in India following IPCC SRES were assessed. Moreover, the inventory of power and cement sectors were updated and the reductions of both CO_2 and SO_2 as a ancillary benefit were assessed. For Thailand, the CO_2 emission reduction by introducing bio fuel in transport sector was estimated as well as the air pollutant changes by introducing the CO_2 emission reduction countermeasures. In Korea, the emission reduction potential in transport and household sectors were calculated. The lighting showed the largest reduction potential in household sector in 2030.

(3) Development of AIM/CGE [Country]

Not only the energy technology selection model but also the national computable general equilibrium model as an environmental policy assessment model for each country was developed for China, India and Thailand. In the China model, both CO_2 emission reduction and air pollutants reduction were treated. Figure 3 represents the future scenarios and pollutant emission trajectories.





	Reference scenario (RS)	Energy efficiency improvement scenario (EE)	SO2 tax scenario (TAX)	SO2 constraint scenario (CAP)	Mixed scenario (CAP+EE)
annual labor production growth rate in new investment	1%	1%	1%	1%	1%
annual energy efficiency improvement change in new investment	2.50%	1997-2004:2.5% 2005-2015:5% 2016-2020:3%	1997-2004:2.5% 2005-2020:3%	2.50%	1997-2004:2.5% 2005-2015:5% 2016-2020:3%
SO2 emission tax	no	no	1998-2004: 210Yuan/t-SO2 2005-2020: 630Yuan/t-SO2	SO2 price is endogenous	SO2 price is endogenous
SO2 emission constraint	no	no	no	Annual down 1.5% from the year 2005	Annual down 1.5% from the year 2005

Figure 3 Air pollutant emission estimated from AIM/CGE [China]

(4) Integration of country models

We integrated the existing national environmental policy assessment model, AIM/CGE [Country], and AIM/Enduse [Country] as a element of environment model, and applied it to Japan and China. For Japan, the effectiveness and economic impact of carbon tax policy to achieve the Kyoto Protocol were assessed. For China, the probability to achieve the energy efficiency target from 2005 to 2010 was evaluated. In both analyses, the technology options were selected using the AIM/Enduse models, while the necessary additional costs and energy saving for each sector were introduced to the economic models. Thus the effectiveness of environmental policies was assessed. In an analysis of Japan, the achievement of Kyoto Protocol was found possible, but it was also shown that the shorter the time period left by the end of the 1st commitment period, the more expensive technology options were needed. In an analysis of China, the existing technology options could not achieve the proposed energy efficiency target. In order to achieve the target, the more advanced technologies have to be introduced.

(5) Assessment of safe water and sanitation

The AIM/Water model was developed to assess the investment and operation costs, and reduction of mortality rate caused by diarrhea in each country. The water supply and sewerage systems can reduce the mortality rate drastically, but these measures cost more than other technologies. By using the model we have developed, access to the safe water and sanitation equipment in 2015 is assessed, based on the four scenarios of UNEP/GEO4. In the policy fast scenario, where the positive environmental policies are introduced, the goal 7-target 10 of Millennium Development Goals, which aims to halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015, will be achieved. On the other hand, in the security fast scenario, which represents the world with more severe disparity, the condition of sanitation in some regions becomes worse compared with the present situation.

(6) Air pollution model

The AIM/Air model was expanded in order to calculate the chemical reaction and transport of air pollutants at three levels; entire Asia, country, and region including urban areas. This model was linked to the AIM/Enduse model to assess effects of air pollution reduction as an ancillary benefit of climate policy. This model was applied to China and its surrounding areas in order to show the concentration rates around the emission sources and deposition of long distance transport. The process of chemical reaction and transport of pollutants were analyzed, and the seasonal and regional fluctuation was assessed by comparing the observational data. Moreover, the background concentration was estimated in order to show the impact of transport of pollutants originating inside the urban area and its neighborhood.

(7) Development of global river discharge model and assessment of water scarcity risk inside river basins

The global drainage basin database was developed in order to provide the basic information to construct the global water management model. Then, a new global river discharge model was developed, and we applied this model to the assessment of monthly water scarcity from 1986 to 1995. As shown in Figure 4, the regions judged to have high risk of water scarcity are Sahara desert, Arabian Peninsula, Indus river basin, the northern part of Chile and California Peninsula. Though the regions judged to have high risk of water scarcity were similar to the results of the previous studies, we additionally succeeded in depicting inhomogeneous distribution of water scarcity risk inside the river basins.

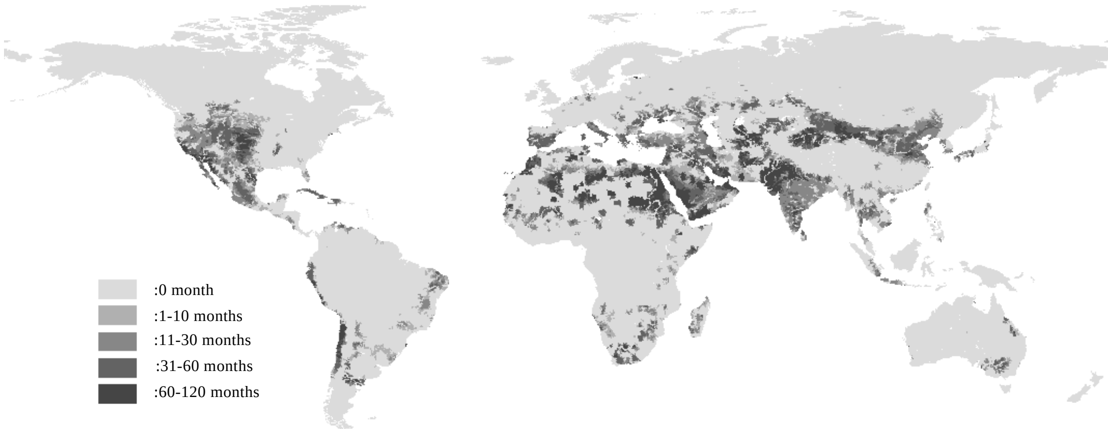


Figure 4 Number of monthly water scarcity (from 1986 to 1995）

(8) Climate change impact and adaptation measures

By integrating the global environmental policy assessment model to simple climate model and agricultural productivity change model, we assessed the macro economic impact of productivity change of rice and wheat due to the global warming, and compensation of that economic impact by introducing adaptation. It is estimated that the higher the global mean temperature increases, the more severe productivity damages and the economic impact become. On the other hand, when the adaptation measures such as changes of the breed and the planting period are introduced, the global GDP loss can be mitigated. Since the GDP loss tends to be larger as the global mean temperature increases, the appropriate mitigation policies will have to be introduced.

Moreover, the multi-region model for China was added to the above model linkage, and simulated. The results showed that the regional economic impacts are different among regions. Similar to the assessment of water scarcity in the previous section, this result indicates the importance of the detailed geographical consideration to assess the climate change impacts.

(9) Other activities

Other new elements of environment model such as a household production model and a stock and flow model for iron were developed to assess the future economic activities. The economic models for Japan and China were linked together, and assessed the CO_2 reduction and impact of technology transfer. The simulation results using the various models were provided to the following international activities; 1) Innovation Modelling Comparison Project which assesses the effectiveness of induced technology changes by introducing the carbon reduction policies, 2) Energy Modeling Forum organized by Stanford University, 3) Scenario consortium for developing the IPCC new scenario, and 4) Assessment of CO_2 emission reduction potential using top-down and bottom-up models organized by ECOFYS.

Using the global economic model we have developed, the greenhouse gas emission reductions by mitigation measures were estimated, and the results were cited in the IPCC 4th assessment report as shown in Figure 5.

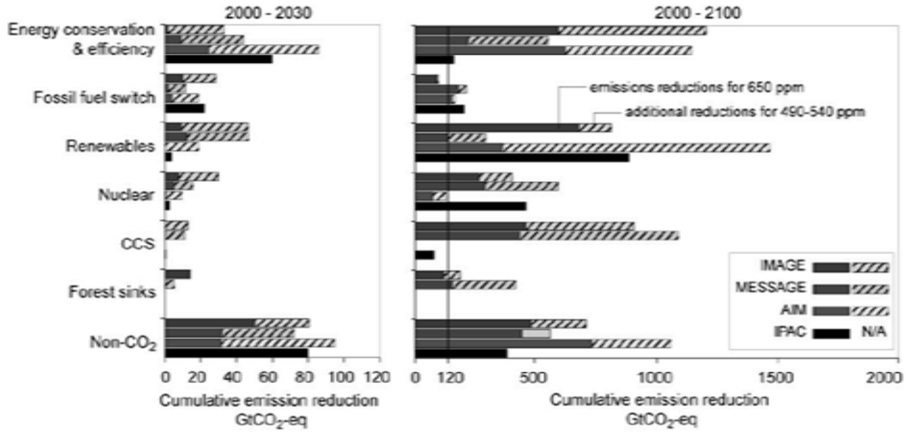
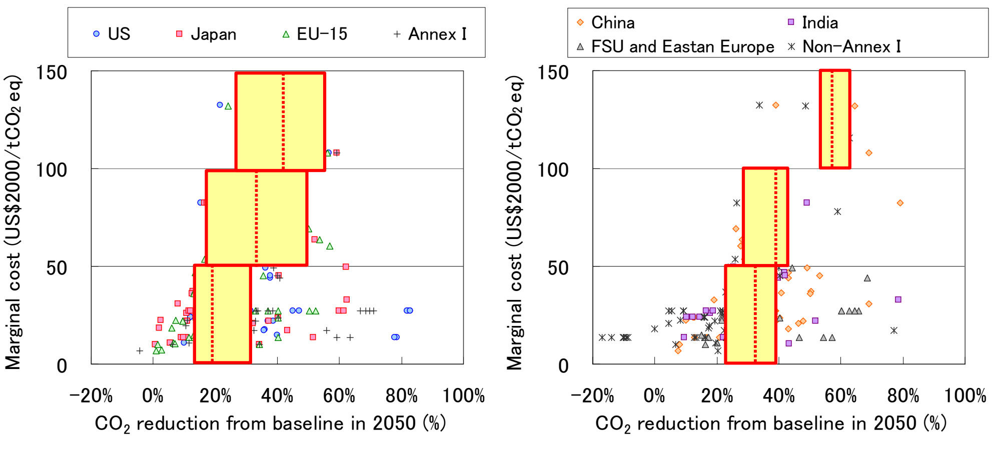


Figure 5 Cumulative emissions reductions for alternative mitigation measures for 2000 to 2030 (left) and for 2000-2100 (right).

The long-term scenarios to stabilize the climate reviewed at the IPCC 4th assessment report were summarized, and the trends of greenhouse gas emission reduction, reduction cost, energy intensity and carbon intensity were assessed. Figure 6 shows the relationship between the CO_2 reduction rate from the baseline emission in 2050 and the marginal reduction cost when the radiative forcing was stabilized at 4.0-4.5 W/m^2.



(a) Developed countries (b) Developing/Transition countries

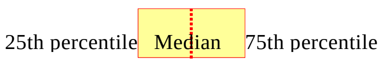


Figure 6 Relationship between the CO_2 reduction from baseline in 2050 and the reduction cost to be stabilized at 4.0-4.5 W/m^2

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none

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