

# **Environmental Assessments using Environment-Economy Integrated Models for the Asia-Pacific Innovation Strategy Project**

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## **1. Introduction**

The Asia-Pacific region is expected to lead world economy growth in 21st century, and its stable development with half of the world population would become a key to secure global economic activities. However, environmental problems in this region are threatening its economic growth. Moreover, less availability of scientific knowledge on environment obstructs solving the problems. Therefore, the balancing environmental protection and economic growth is an urgent issue in Asia-Pacific region for the next decade, and it is crucial from longer-term viewpoint to design more efficient and effective policies in order to introduce innovative technologies/measures into the integration between environmental conservation and economic development.

The international team of the Asia-Pacific Integrated Model (AIM) Project has been developing environment-economy integrated models to assess the future scenarios of socioeconomic development and environmental change in the Asia-Pacific region as well as at global level. The team is also establishing a new type of database which supplies not only basic socioeconomic and environmental data but also key indicators linked to the data as well as several model to predict these indicators for policy makers' use. The model development and database establishment were adopted as core research works for the Asia-Pacific Environmental Innovation Strategy Project (APIS).

This paper explains the outline of model development and database establishment planned for the APIS project, with special reference to the AIM/trend model.

## **2. Required innovation for Asia-Pacific sustainable development**

Innovations in environmental field have been urgently required in the Asia-Pacific region to bring in something new to break through the tradeoffs between environmental conservation and economic growth as well as other policy goals. These innovations include technological innovations, new products development, new production processes penetration, establishment of new industrial organization, shifting to new consumption

patterns, new market creation, and new integration of innovations. Such innovations are expected to solve the tradeoffs of policy goals not only between environmental field and other policy field such as economic growth, but also among different environmental policies, for example, global environmental policies vs. local environmental policies, environmental policies in developed regions vs. those in developing regions, biomass energy supply for climate policies vs. nature conservation for biodiversity policies, and long-term environmental policies vs. short-term environmental policies.

Major innovation strategies for the Asia-Pacific region can be identified based on the innovation type and the tradeoffs to be broken throw by innovations. Table 1 shows the tentative list of these strategies which was used for determining the direction of model development.

**Table 1 Tentative list of innovation strategies**

	to solve tradeoffs between environmental goal and other goals such as economic growth	to solve tradeoffs among goals of different environmental policies
technological innovations, new products development, new production processes penetration	<b>Strategy of advanced environmental technology development, Environment-IT integration strategy, Strategy of wide-area recycle system introduction, etc.</b>	<b>Region-based zero-emission system introduction strategy, Strategy of supplemental new environmental technology development, etc.</b>
establishment of new industrial organization, shifting to new consumption patterns, new market creation	<b>Strategy for environmental industry development, Strategy of establishing new environmental finance market, Environmental premium raise strategy, Strategy of consumers' participation in production process, etc</b>	<b>Strategy for comprehensive economic incentive introduction, Environmental government bond strategy, etc.</b>
new integration of innovations	<b>Strategy of soft-hard integrated technology transfer, Strategy for expanding international environmental market, etc.</b>	<b>Global-local integration strategy, Kuznets-Footprint integration Strategy, Environmental turnpike strategy, Inter-urban network strategy, etc.</b>

### 3. Applicable AIM modules for the APIS project

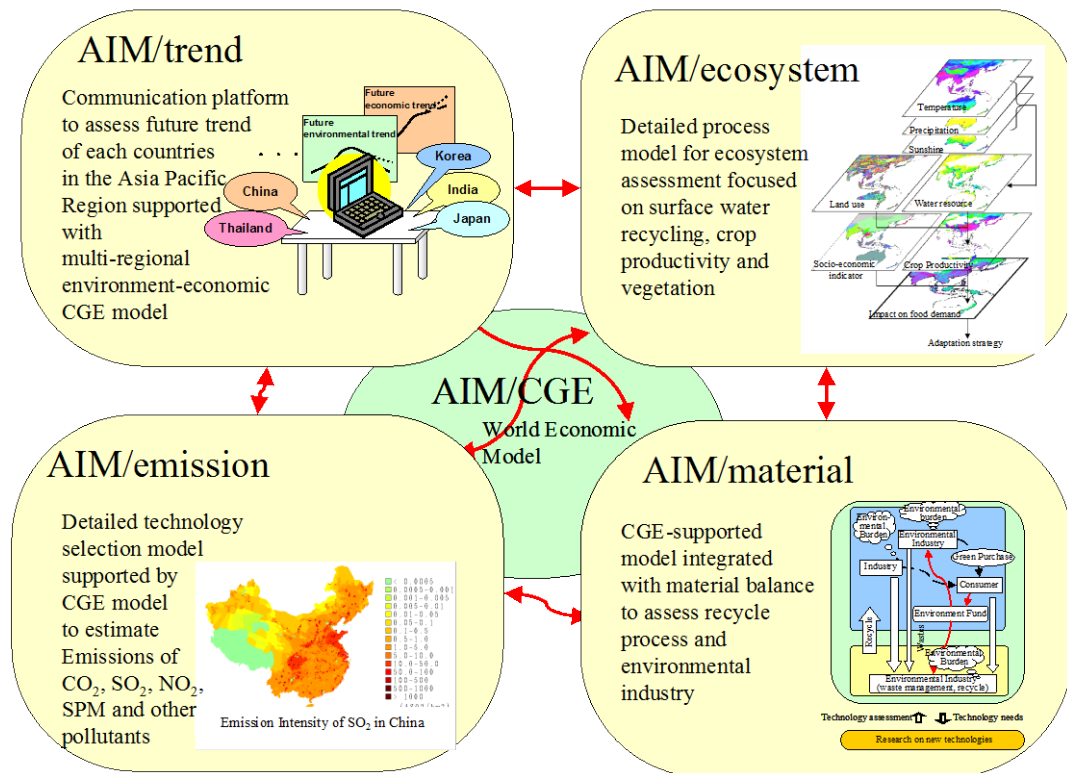
The set of AIM model were developed primarily for assessing effects of climate policies and climate change impacts, but it can be applicable to other environmental fields such as air pollution, water resource, land use change and ecosystem assessment. Among of the AIM modules the following environment-economy modules could be useful for the APIS project:

- AIM/trend: communication platform to assess future trend of each countries in the Asia-Pacific region supported with multi-regional environment-economy CGE

(Computer General Equilibrium) model

- AIM/emission: Detailed technology selection model supported by CGE model to estimate emissions of CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, SPM and other pollutants, bottom-up type
- AIM/material: CGE-supported model integrated with material balance to assess recycle process and environmental industry
- AIM/ecosystem: Detailed process model for ecosystem assessment focused on surface water recycling, crop productivity and vegetation
- AIM/CGE: General equilibrium model to simulate multi-regional global economy with trade of commodities

### Applicable AIM modules for the APIS project



**Fig. 1** Applicable AIM modules for the APIS project

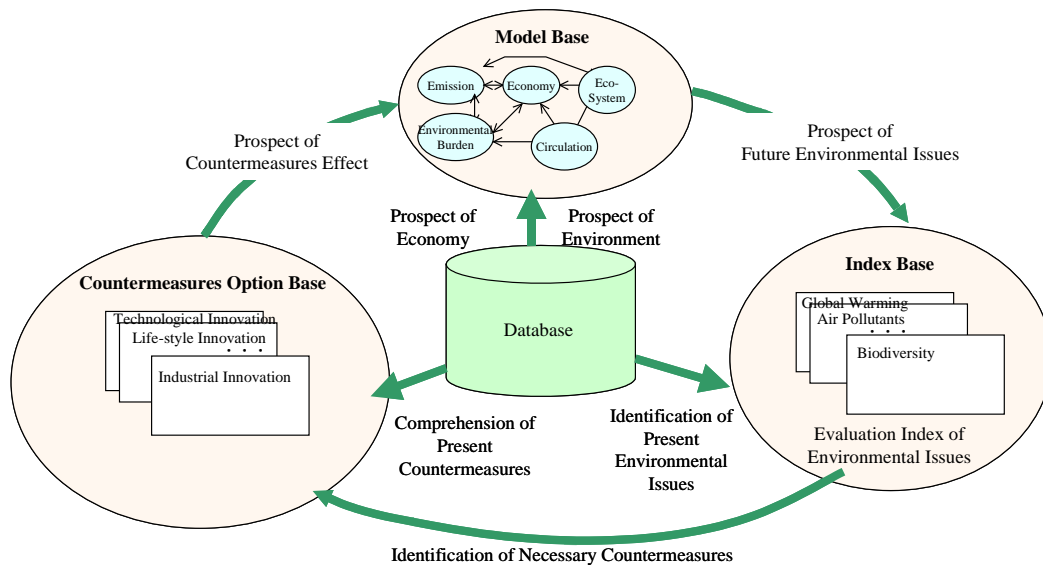
The above five types of modules can cover most of the request to analyze the environmental innovation strategy in the Asia-Pacific region. Table 2 shows the correspondent relationship, which module can be used to assess the effects of which innovation strategy listed in Table 1.

**Table 2 AIM modules and correspondent strategy to be assessed**

AIM module	correspondent innovation strategies to be assessed
AIM/trend	General analyses on the demand of environmental innovations, Strategy of advanced environmental technology development, Strategy for expanding international environmental market,
AIM/emission	Strategy of advanced environmental technology development, Environment-IT integration strategy, Strategy of supplemental new environmental technology development, Strategy of soft-hard integrated technology transfer, Environmental turnpike strategy, Inter-urban network strategy,
AIM/material	Strategy of advanced environmental technology development, Environment-IT integration strategy, Strategy of wide-area recycle system introduction, Region-based zero-emission system introduction strategy, Strategy for environmental industry development, Strategy for comprehensive economic incentive introduction, Environmental premium raise strategy, Environmental turnpike strategy,
AIM/ecosystem	Strategy of advanced environmental technology development, Strategy of supplemental new environmental technology development, Strategy for comprehensive economic incentive introduction, Global-local integration strategy, Kuznets-Footprint integration Strategy
AIM/CGE	Strategy for environmental industry development, Strategy of establishing new environmental finance market, Strategy for comprehensive economic incentive introduction, Environmental government bond strategy, Environmental premium raise strategy, Global-local integration strategy, Kuznets-Footprint integration Strategy Environmental turnpike strategy, Strategy for expanding international environmental market,

### 3. Development of strategic database

In addition to several models as assessment tool, a strategic database links various types of supporting data and environmental indicator data, which will be provided from model base, countermeasures option base, and index base (Fig. 2). This database will be set in a useful form for policy makers and other related parties.



**Fig. 2 Strategic database development**

#### 4. AIM-Trend Model

In order to clarify the demands of innovation introduction in the Asia-Pacific region, we have been developing the model for assessing the future environmental burdens based on the past socio-economic trends and future scenarios. By using this model, the environmental trends until 2032 in the Asia-Pacific countries have been estimated. This “AIM-Trend Model” is a communication tool to enhance discussions and search for countermeasures by envisaging environmental conditions in a consistent way (Fig. 3).

AIM-Trend model is built as a simple econometric model and written in ATPL (AIM Trend Program Language) using VBA in Microsoft Excel. The user can change the model structure and make sensitivity analysis.

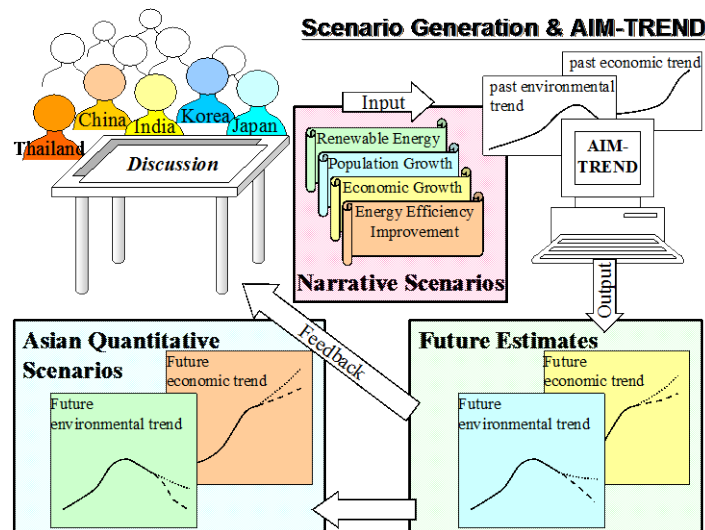
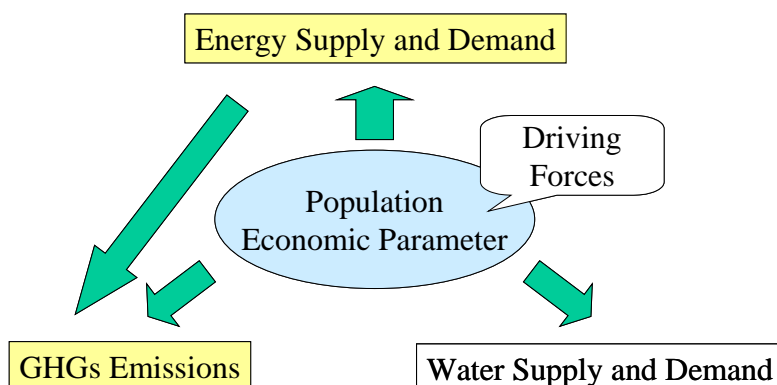


Fig. 3 Concept of AIM-Trend Model

#### 4.1 Structure of AIM-Trend Model

AIM-Trend model is an econometric model to project economy, energy, and environment situation in middle-term future. It calculates the relationships between each parameter by regression method and extrapolates those relationships for the future projection. It makes simulations of energy supply and demand, GHGs emissions and water supply and demand by setting basic data –population GDP, GDP per capita, GDP share and so on– as driving forces (Fig. 4). In this paper the module of energy supply and demand is mainly focused.



**Fig. 4 Model Structure**

**Model Region:**

This model covers 42 countries in Asia-Pacific region. They are divided into two categories: Model A and Model B (Table 3). Model A uses detailed energy data, IEA energy balance data. Model B uses less detailed energy data, UN energy data. The countries are grouped in four categories: OECD (OECD members in 1990), CPA (Centrally Planned Economy Asia), OAP (Other Asia-Pacific), and CA (Centrally Asia)

**Table 3 Tentative Model Countries (left: Model A, right: Model B)**

Code	Country	Group	Code	Country	Group
AUS	Australia	OECD	MNG	Mongolia	CPA
JPN	Japan	OECD	BTN	Bhutan	OAP
NZL	New Zealand	OECD	BRN	Brunei	OAP
CHN	China	CPA	FJI	Fiji	OAP
PRK	Korea, Dem	CPA	KHM	Cambodia	OAP
VNM	Vietnam	CPA	KIR	Kiribati	OAP
BGD	Bangladesh	OAP	LAO	Lao	OAP
IDN	Indonesia	OAP	MDV	Maldives	OAP
IND	India	OAP	NRU	Nauru	OAP
KOR	Korea, Rep	OAP	PLW	Palau	OAP
LKA	Sri Lanka	OAP	PNG	Papua New Guinea	OAP
MMR	Myanmar	OAP	PYF	French Polynesia	OAP
MYS	Malaysia	OAP	TON	Tonga	OAP
NPL	Nepal	OAP	VUT	Vanuatu	OAP
PAK	Pakistan	OAP	WSM	Samoa	OAP
PHL	Philippines	OAP	SLB	Solomon Islands	OAP
SGP	Singapore	OAP	AFG	Afghanistan	CA
THA	Thailand	OAP			
TWN	Taiwan	OAP			
IRN	Iran	CA			
KAZ	Kazakhstan	CA			
KGZ	Kyrgyz Republic	CA			
TJK	Tajikistan	CA			
TKM	Turkmenistan	CA			
UZB	Uzbekistan	CA			

**Simulation Period:**

The “Rio+10” summit will be held in South Africa at 2002. The target year is set as 2032 when is 30years after that summit.

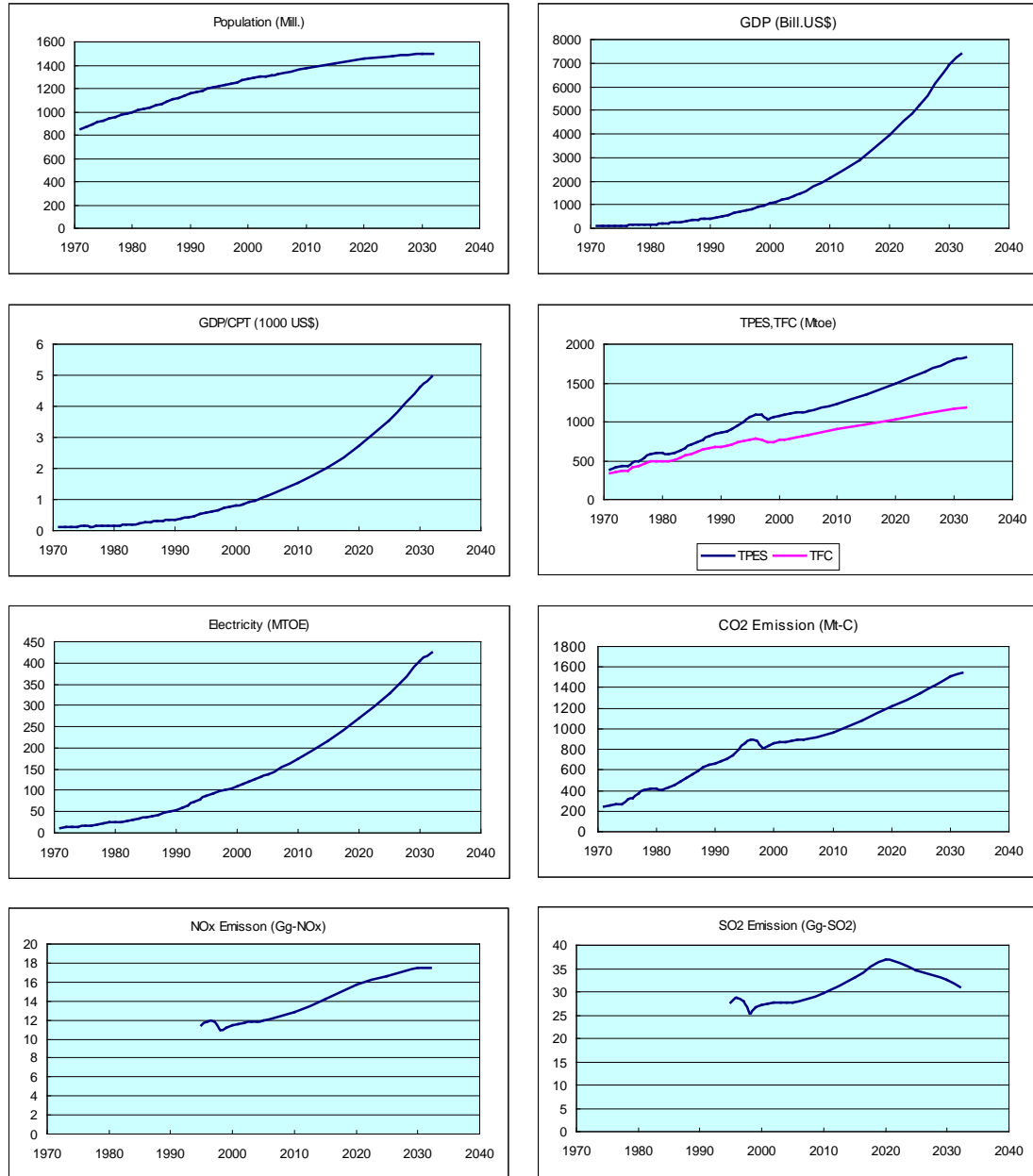
**Index:**

- Population: population, rate of urbanization
- Economy: GDP (growth rate, per capita), GDP share (agriculture, industry, service, PFC (private final consumption), car holders
- Energy: primary energy supply by fuel, final energy demand by fuel and sector, energy plant, economic intensity, carbon intensity
- Environment: GHGs (CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO)
- Water: withdrawal, consumption (agriculture, industry, domestic), population in water stress\*
- Food and Agriculture\*: average daily consumption, vegetable food consumption, animal food consumption, fraction of meat from feedlots, fish production, crop production, feed production, nitrogen fertilizer consumption
- Land use\*: crop land, irrigated cropland, potential cultivable land, mature forest, growing forest, pasture, protected, other land
- Human Health\*: SPM (PM<sub>10</sub>, PM<sub>2.5</sub>)
- Biodiversity\*: species, degree of threat to biological diversity, area of habitat remaining

(Note: sign “\*” means the element under consideration)

## 4.2 Model Run and Results

Through a series of model calculation for each country, following preliminary results are obtained.

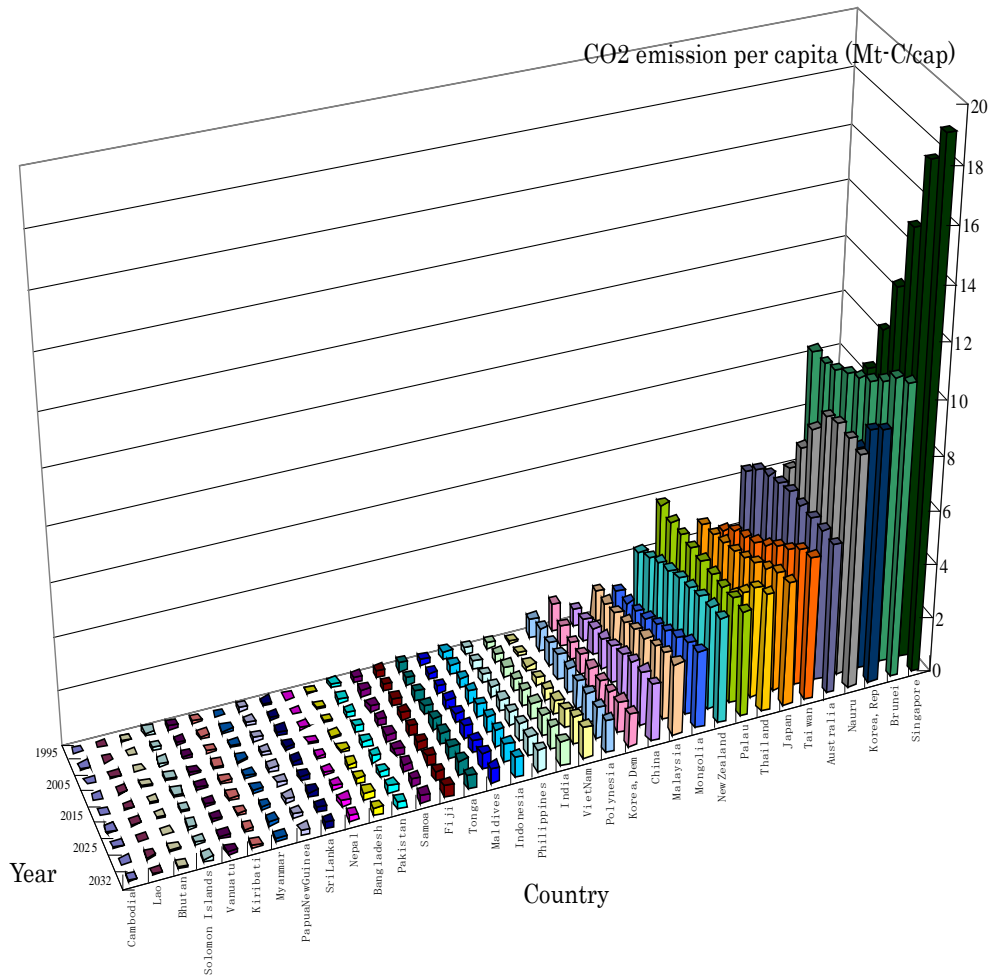


**Fig. 5 Projection of each index for China**

Fig. 5 shows the projection of main indicies for China. These results give an overview of country-level development. A rapid GDP growth drives energy use. According to increase of total final energy consumption and total primary energy supply,

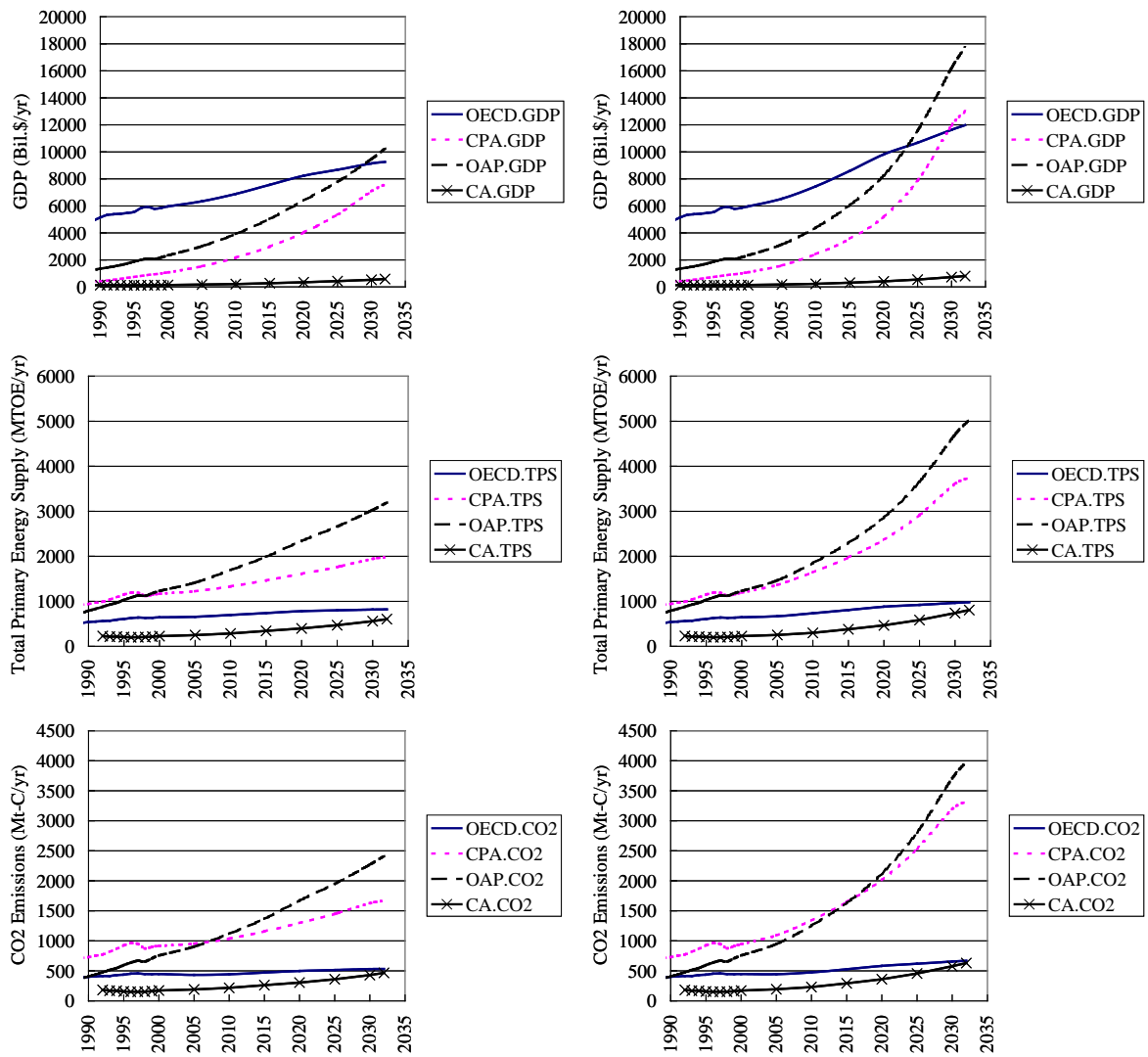


CO2 emission will be about 1.5Gt-C around 2030. On the other hand, SO2 emission will decrease after 2020 because of economic growth, known as Kuznetz curve.



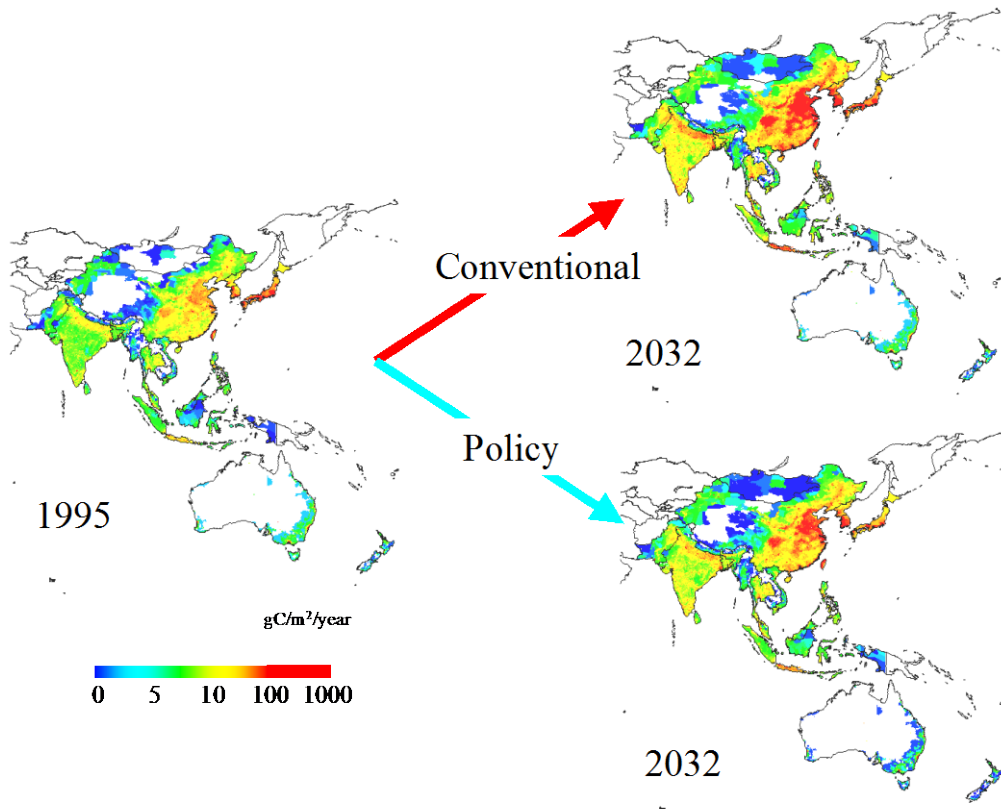
**Fig. 6 Projection of CO2 emission per capita for each country**

Fig. 6 shows the projection of CO2 emission per capita for each country. This figure gives a comparative view of an index by country and by year. This is one of the effective ways to show the results.

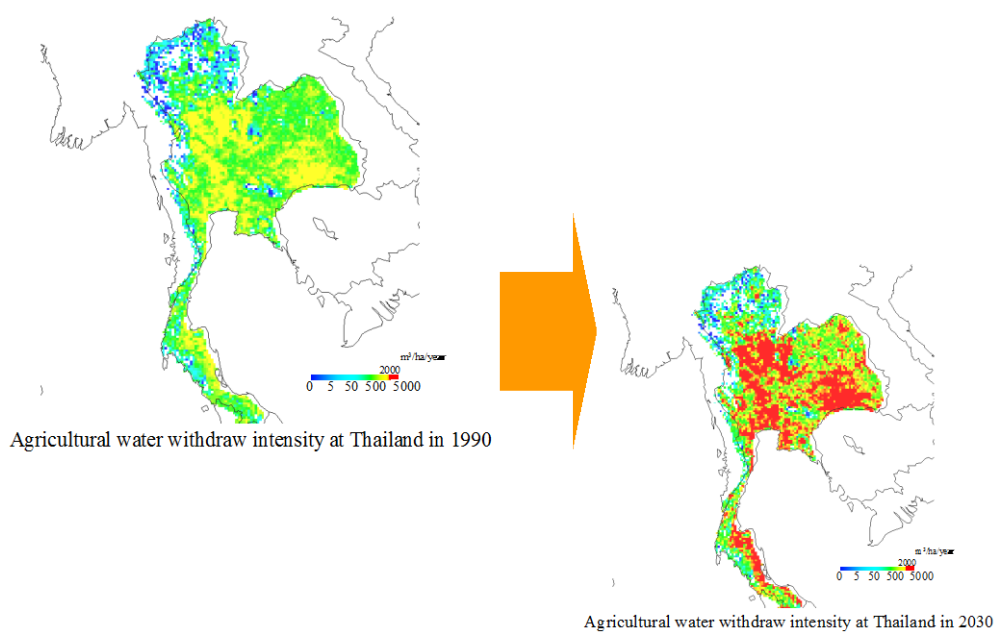


**Fig. 7 Projection of GDP, total primary energy supply, and CO2 emission for Model A regions (left: reference scenario, right: high economic growth scenario)**

Fig. 7 shows the projection of regional aggregated results of GDP, total primary energy supply, and CO2 emission for reference scenario and high economic growth scenario. These results show the trend of regions and make it easy to compare with projections of other studies (e.g. IEA; World Energy Outlook, DOE/EIA; International Energy Outlook, APERC; Supplement to APEC Energy Demand and Supply Outlook, IPCC; SRES, and so on).



**Fig. 8 Trajectory of CO2 emission intensity for each scenario**



**Fig. 9 Trajectory of agricultural water withdraw intensity at Thailand**

Fig. 8 shows the trajectory of CO<sub>2</sub> emission intensity for each scenario. Fig. 9 shows the trajectory of agricultural water withdraw intensity at Thailand. These give geographical views of each index.

### **4.3 Preparation for future work**

“AIM-Trend model” for assessing the future environmental burdens based on the past socio-economic trends and future scenarios, has been built. By using this model, the environmental trends until 2032 in the Asia-Pacific countries can be estimated.

The role of this model is to enhance discussions about country-level projection as a communication platform between policymakers and researchers.

For this purpose, this model was built as a simple econometric model and written in VBA in Microsoft Excel. The user can change the model structure and make sensitivity analysis.

Through a series of model calculation for each country, preliminary results were obtained for economy, energy, and environment for each country.

Further communications with policymakers and researchers are necessary to grasp the situation of each country and collect data. It is also important to develop the CGE type model that explains the relationship between countries comprehensively to support this country-level econometric model.

## **5 Concluding remarks**

Even though our modeling work for the Asia-Pacific Environmental Innovation Strategy Project (APIS) has started in this April, the fundamental module of AIM/trend model has already developed. This module will be distributed to individual countries, and it will be used as major tool for interactive communication with each country to identify urgent demands of innovation introduction for sustainable development. Furthermore, other detailed model such as AIM/emission and AIM/material has already started to be applied to developing countries for policy assessment of innovation strategies. However, communication to develop the AIM/ecosystem has been continuing with experts in the region in order to clarify the interface between innovation introduction and ecosystem conservation. Recent discussion on ecosystem modeling has been focusing on the tradeoffs between pollutant/GHG emission reductions and ecosystem conservation in order to identify innovation strategy to integrate pollution/climate policies and nature conservation policies.