New Integrated Modelling with Special Reference to AIM/Ecosystem Model

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From: Y.Matsuoka

- Introduction, the aim and some features of a new integrated assessment model
- Framework of the model
- Some preliminary results of the model calculation

Overview of the new model

1. Integrated Assessment model of Long-term future scenario on global economy, ecological service and environmental protection policy
2. A tool for scenario analysis on
   - Energy policy and climatic change
   - Economic assessment of natural services
   - Macro-economy and land-use changes
   - Economic assessment of global environmental conservation activity
3. Extension of AIM on climate change
4. Starting model to analyze various global issues, that is the model has generic structure, easy to extend, ...
5. ....

Some features of the new model (1)

1. Top-down global model
2. Coupling of 1) sequential quasi-dynamic general equilibrium model for balancing and pricing goods and services and 2) Dynamic accumulation and depreciation process model of man-made and natural capitals
3. Explicit description of GHGs emission, pollution loading and their reduction activity
4. Simplified natural process models of Carbon and Nitrogen Cycling, Hydrology, Erosion and weathering process

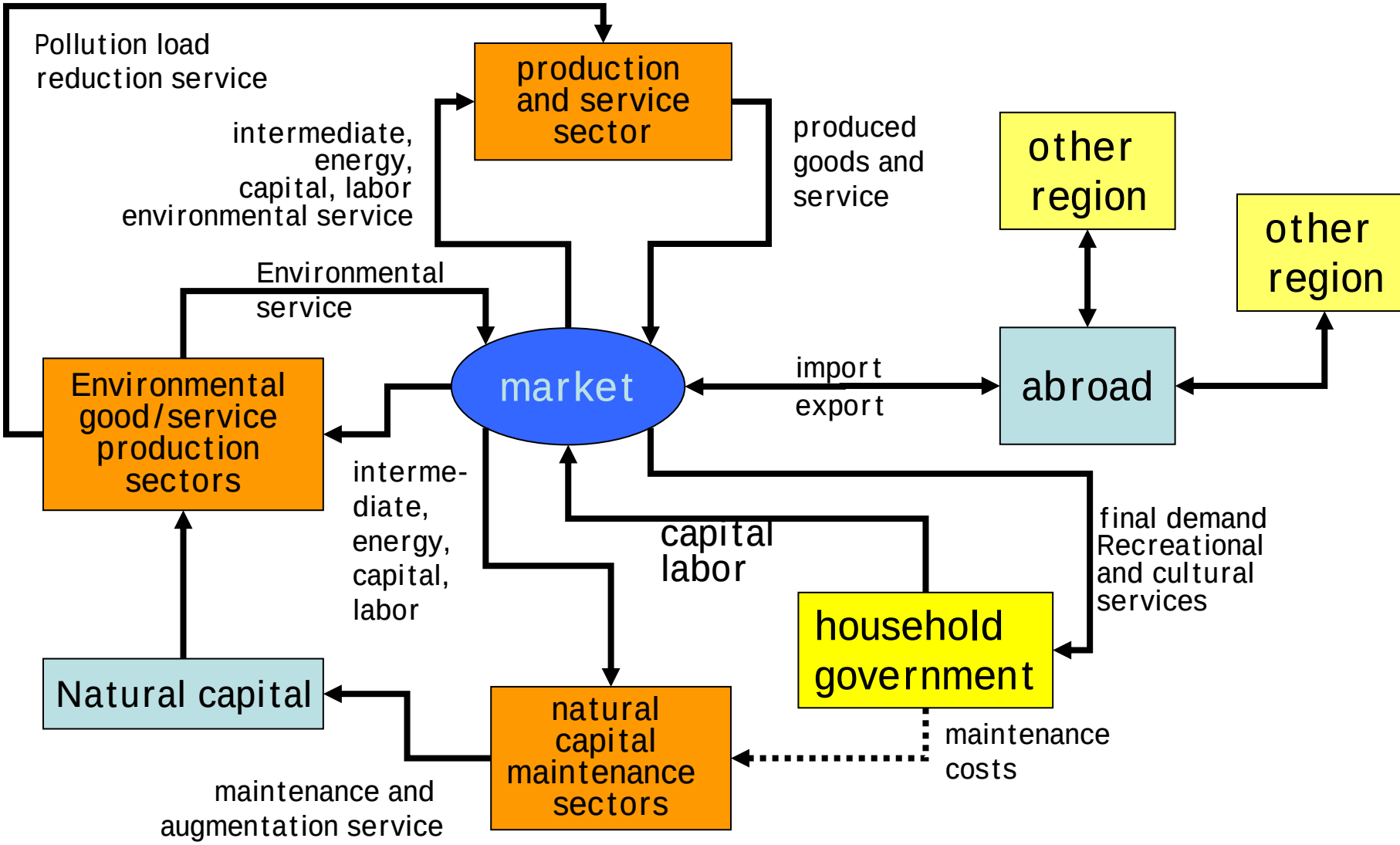
Some features of the new model (2)

5. Consistent description of population, GDP, and land-use change processes
6. Explicit descriptions of

- Interaction among natural/environment management activities and macro-economy
- Natural and environmental services as indispensable inputs of economic production and people living

5. Explicit description of natural services, environmental protection activity and their

Framework of the model



Natural capital

- Natural capital = Renewable resources (stock), having the concepts of depreciation, investment
- Environmental goods/service production sectors : Extension of primary industry. Agriculture, Stock farming, water supply, forestry, fisheries etc..
- Natural capital maintenance sectors : Functional sector, which augments,and invests to natural capital/service.
- Extended concept of investment : Prevention of soil degradation, increase of base water flows. Costs is transferred from government or environmental service production sectors.

Some technical problems on modeling (1)

- Physical volume balancing of goods : Logit share preference function with physical/monetary continuity, i.e.

  Share of input/output goods : Logit equation with variable preference parameters

  Input volume = Output volume (Monetary, Physically)

1) Composition of domestic market goods with domestic products and foreign products
2) Market electricity production by various generation methods

Some technical problems on modeling (2)

2. Systematic and automatic data reconciliation processes among
   1) IO structures and monetary flows (GTAP5)
   2) Financial flows (ISS, Hague)
   3) Energy flows (IEA/OECD), energy resources (fossil, traditional, modern renewables)
   4) Agriculture, forestry and livestock productions (FAOSTAT)
   5) Land-use (FAOSTAT, IGBP 1 km product, GLC2000)
   6) Stocks, man-made capitals, environmental devices, natural resources/capitals, human capitals etc.
3. Automatic sector and regional aggregation program coupled with supporting database with country level resolution

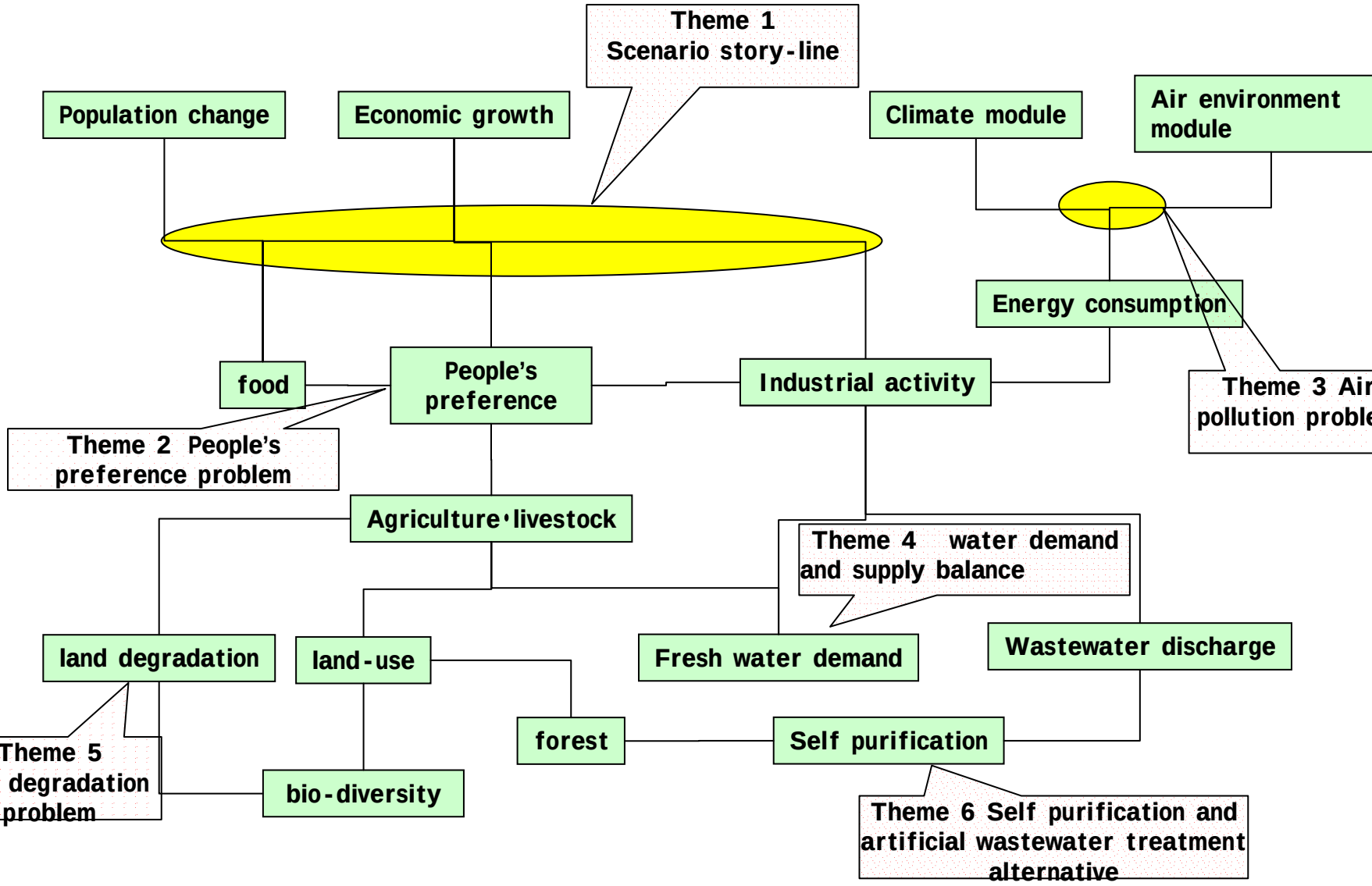
Functions described in the model (1) Production of environmental service, Regulating

Service		Service production sectors	Related Natural Service	Human and Natural capital	Human and Natural augmentation of capital
Regulating : Benefits obtained from regulation of processes					
Climate control	CO2 absorption	CO2 sequestation industry	terestrial absorbtion ocean sink	Forest area	Construction, Maintenance
	CO2 emission reduction	Energy saving Energy mix change		Energy device Power facility	
	Urban climate stabilization	Air conditioning facilities		Forest area	Construction, Maintenance
Air quality control		Emission reduction service Energy mix change Energy saving	natural absorbtion oxidation decompsition	Emission reduction devices, Energy plants	Construction, Maintenance
Flood control	Mitigation factor	disaster prevention industry	water retention Impoundment	Green area, Impoundment Forest area, Crop area, Impoundment	Construction, Maintenance Construction, Maintenance
Water purification	Load reduction	public water supply wastewater industry	self-purifiction	Forest area, Crop area Water works, Well Natural and man-made impoundment	Construction, Maintenance Maintenance

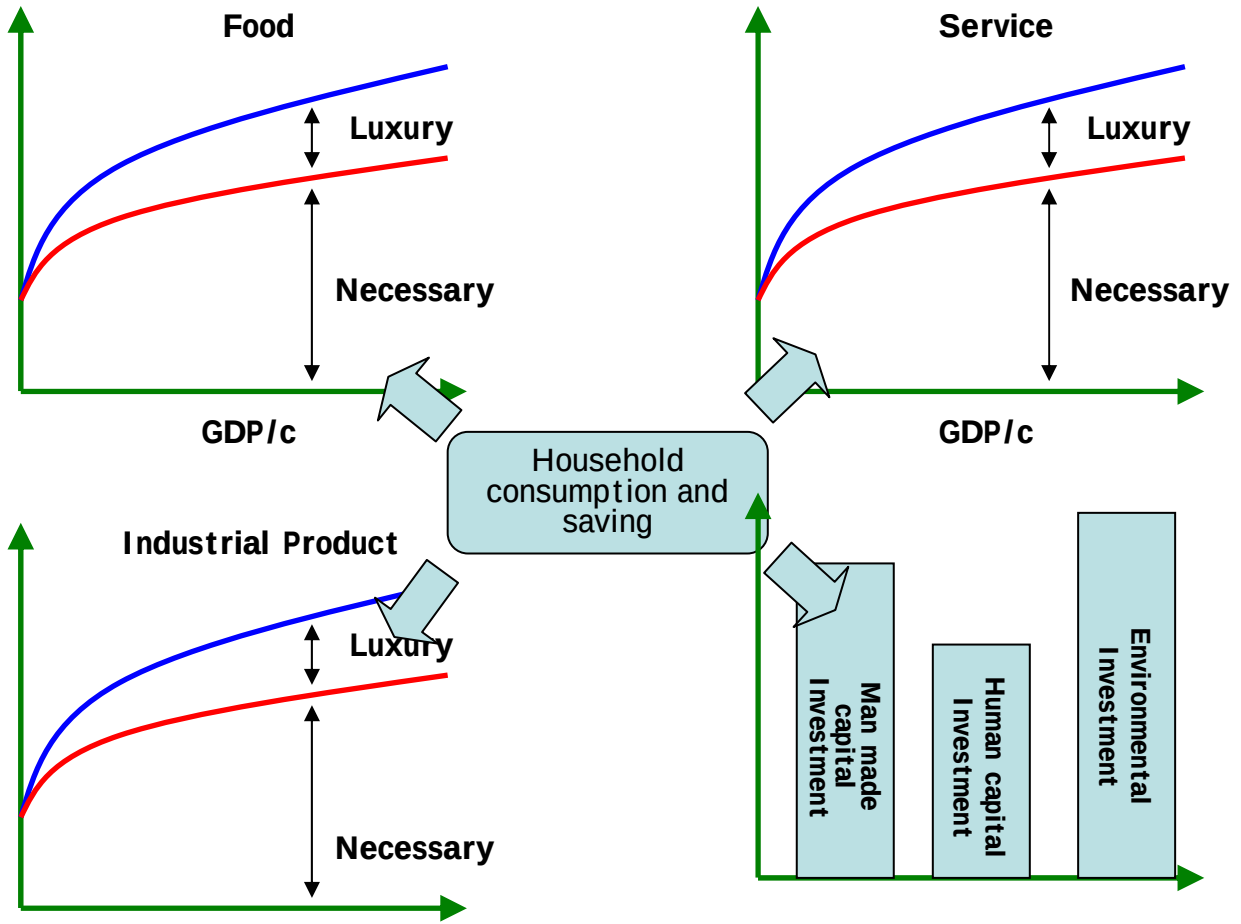
Functions described in the model (2)
Production and enhancement of environmental service

Service		Environmental service production sectors	Related Natural Service	Human and Natural capital	Human and Natural augmentation of capital
Provisioning : Goods produced or provided by systems					
Water supply	Irrigation, Domestic and Industrial water supply	Water industry, Irrigation service sectors	Water hervesting, Surface runoff, Evapotransipiration control Ground water harvesting	Natural base discharge Primary water resource Ground water resource	Forest maintenance, Crop area increase Natural and man-made impoundment
Food supply	Food production	Agriculture (Paddy rice, Wheat, Cereal grains, Vegetables, Fruit, Nuts, Oil seeds, Sugar cane, Fibers)	Soil formation, Green water, Nutrient cycling	Potential crop production	Climate mitigation, Soil adjustment, Fertilizer, Irrigation, Water harvest
Animal product	Livestock	Bovine cattle, Sheep and goats, hourses, Animal products, Milk, Wool, Silk-worm	Soil formation, Green water, Nutrient cycling	Livestock feeding capacity	Climate mitigation, Soil adjustment
Fuelwood supply	Fuel wood production	Fuel wood industry	Forest primary production	Forest primary production (vegetation area)	Forest maintenance, Climate mitigation, Maintenance labor
Biogeochemicals and genetics	-	-	Biogeochemicals and genetics	Forest area, Climate	Maintenance labor

Some confronted issues posed to the model at present



Theme 2 People's preference and its environmental impacts



Theme 3 & 4 Pollutant emission and reduction module

1. Bottom-up estimation of following equations
2. Emissions of SO_2, NO_2, PM, BOD, N and P

$$LO_{s,i,r} = LO_{0,s,i,r} \frac{\left(1 - Rd_{s,i,r}\right)}{\left(1 - Rd_{0,s,i,r}\right)} \cdot y_{i,r}$$

$LO_{s,i,r}$: emission of pollutant s
$LO_{0,s,i,r}$: emission of pollutant s in benchmark year ←WDI (BOD), SO2 and NO2 (EDGAR), PM (WRI)
Rds,i,r : reduction ratio of pollutant s
$Rd_{0,s,i,r}$: reduction ratio of pollutant s in benchmark year
$y_{i,r}$: activity of sector i in region r ←AIM/Ecosystem CGE module

3. Pollutant Reduction service sectors

$$RLO_{s,i,r} = \Sigma\, Ir_{s,i,r} \cdot Vr_{s,i,r}$$

$RLOs,i,r$: Reduced pollutant load, $Rd_{s,i,r} \cdot LO_{s,i,r}/(1\text{-}Rd_{s,i,r})$
$Ir_{s,i,r}$: coefficients of pollutant reduction service function
$Vr_{s,i,r}$: Input of good i to pollution reduction sector

Theme 5 Land degradation module

Estimate crop productivity decrease by land degradation.

•Physical erosion : $E_a = f(T,R,LUT)$

E_a : Degradation degree

T: Terrain erodibility ← Soil texture index, Bulk density index, soil depth index, relief index ←FAO/Soil map of the World

R: Rainfall erodibility ← AIM/Ecosystem climate module

LUT: land cover type ← AIM/Ecosystem land-use module

• Crop production impact: $EI_i = EI_{0,i} \cdot (E_a/E_{a,0})^n$

EI_i : Productivity decrease of crop *i* caused by land degradation

$EI_{0,i}$: Crop productivity decrease in benchmark year, 2% (maize), 1% (wheat) in EU region

$E_{a,0}$: Degradation degree in benchmark year

Soil degradation intensity in 2000, calibration parameter

Regional disaggregation

	Region	Countries
1	Canada	Canada
2	USA	Saint Pierre and Miquelon,United States,United States Minor Outlying Islands
3	Latin America	Anguilla,Bermuda,El Salvador,Jamaica,Panama,Turks and Caicos Islands
		Antigua and Barbuda,Cayman Islands,Grenada,Martinique,Puerto Rico,Virgin Islands, British
		Aruba,Costa Rica,Guadeloupe,Mexico,Saint Kitts and Nevis,Virgin Islands, U.S.
		Bahamas,Cuba,Guatemala,Montserrat,Saint Lucia,
		Barbados,Dominica,Haiti,Netherlands Antilles,Saint Vincent and the Grenadines,
		Belize,Dominican Republic,Honduras,Nicaragua,Trinidad and Tobago,
		Argentina,Brazil,Ecuador,Guyana,South Georgia and the South Sandwich Islands,Venezuela
		Bolivia,Chile,Falklands Islands (Malvinas),Paraguay,Suriname,
		Bouvet Island,Colombia,French Guiana,Peru,Uruguay
4	Africa	Algeria,Egypt,Libyan Arab Jamahiriya,Morocco,Tunisia,Western Sahara
		Benin,Chad,Gabon,Liberia,Saint Helena,Burkina Faso,Congo,Gambia,Mali,Sao Tome and Principe
		Cameroon,Congo, the Democratic Republic of the,Ghana,Mauritania,Senegal,
		Cape Verde,Cote D'ivoire,Guinea,Niger,Sierra Leone,-
		Central African Republic,Equatorial Guinea,Guinea-Bissau,Nigeria,Togo,
		Burundi,Eritrea,Madagascar,Reunion,Somalia
		Comoros,Ethiopia,Mauritius,Rwanda,Sudan
		Djibouti,Kenya,Mayotte,Seychelles,Uganda
		Angola,Lesotho,Mozambique,South Africa,Tanzania, United Republic of,Zimbabwe
		Botswana,Malawi,Namibia,Swaziland,Zambia
5	Oecd Europe	Andorra,Finland,Holy See,Vatican City State,Luxembourg,Portugal,Switzerland,
		Austria,France,Iceland,Malta,San Marino,United Kingdom,
		Belgium,Germany,Ireland,Monaco,Spain,
		Denmark,Gibraltar,Italy,Netherlands,Svalbard and Jan Mayen,
		Faroe Islands,Greece,Liechtenstein,Norway,Sweden,Greenland
6	CIS and Eastern Europe	Albania,Bulgaria,Czech Republic,Macedonia, the Former Yugoslav Republic of,Romania,Slovenia
		Bosnia and Herzegovina,Croatia,Hungary,Poland,Slovakia,Yugoslavia
		Armenia,Estonia,Kyrgyzstan,Moldova, Republic of,Turkmenistan
		Azerbaijan,Georgia,Latvia,Russian Federation,Ukraine
		Belarus,Kazakstan,Lithuania,Tajikistan,Uzbekistan
7	Middle East	Bahrain,Iraq,Kuwait,Qatar,Turkey
		Cyprus,Israel,Lebanon,Saudi Arabia,United Arab Emirates,
		Iran, Islamic Republic of,Jordan,Oman,Syrian Arab Republic,Yemen
8	India	India
9	Other South Asia	Afganistan,Bhutan,Nepal,Sri Lanka,
		Bangladesh,British Indian Ocean Territory,Maldives,Pakistan
10	China	China,Hong Kong
11	East Asia	Korea, Democratic People's Republic of,Macau,Taiwan(Province of China),Korea, Republic of,Mongolia
12	South East Asia and Oceania	Brunei Darussalam,East Timor,Lao People's Democratic Republic,Myanmar,Singapore,Viet Nam
		Cambodia,Indonesia,Malaysia,Philippines,Thailand
		American Samoa,Fiji,Kiribati,Papua New Guinea,Tonga
		French Polynesia,Marshall Islands,Niue,Pitcairn,Tuvalu
		Christmas Island,French Southern Territories,Micronesia, Federated States of,Norfolk Island,Samoa,Vanuatu
		Cocos (Keeling) Islands,Guam,Nauru,Northern Mariana Islands,Solomon Islands,Wallis and Futuna
		Cook Islands,Heard Island and Mcdonald Islands,New Caledonia,Palau,Tokelau
13	Japan	Japan
14	Australia and New Zealand	Australia,New Zealand

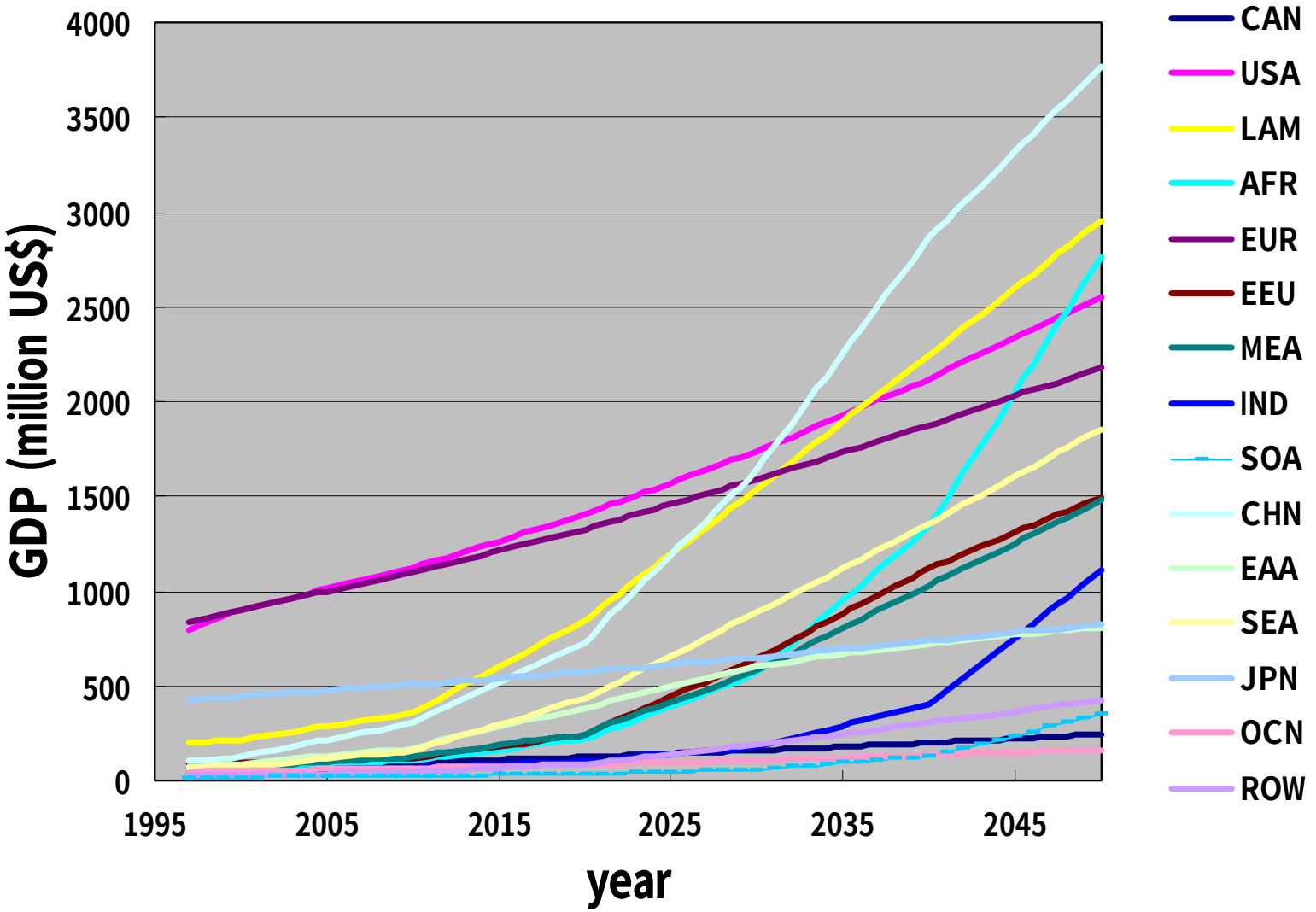
Production sectors

No	CODE	description
	Environmental service industry	
1	AGR	Agriculture
2	LVK	Livestock
3	FRS	Forestry
4	FSH	Fishing
5	COL	Coal
6	OIL	Oil
7	GAS	Gas
8	WTR	Water
9	OMN	Minerals nec
10	DPV	Disaster prevention industry
	Other industry	
11	IDY	Industry
12	P_C	Petroleum, coal products
13	ELY	Electricity
14	SER	Service
15	T_T	Transport

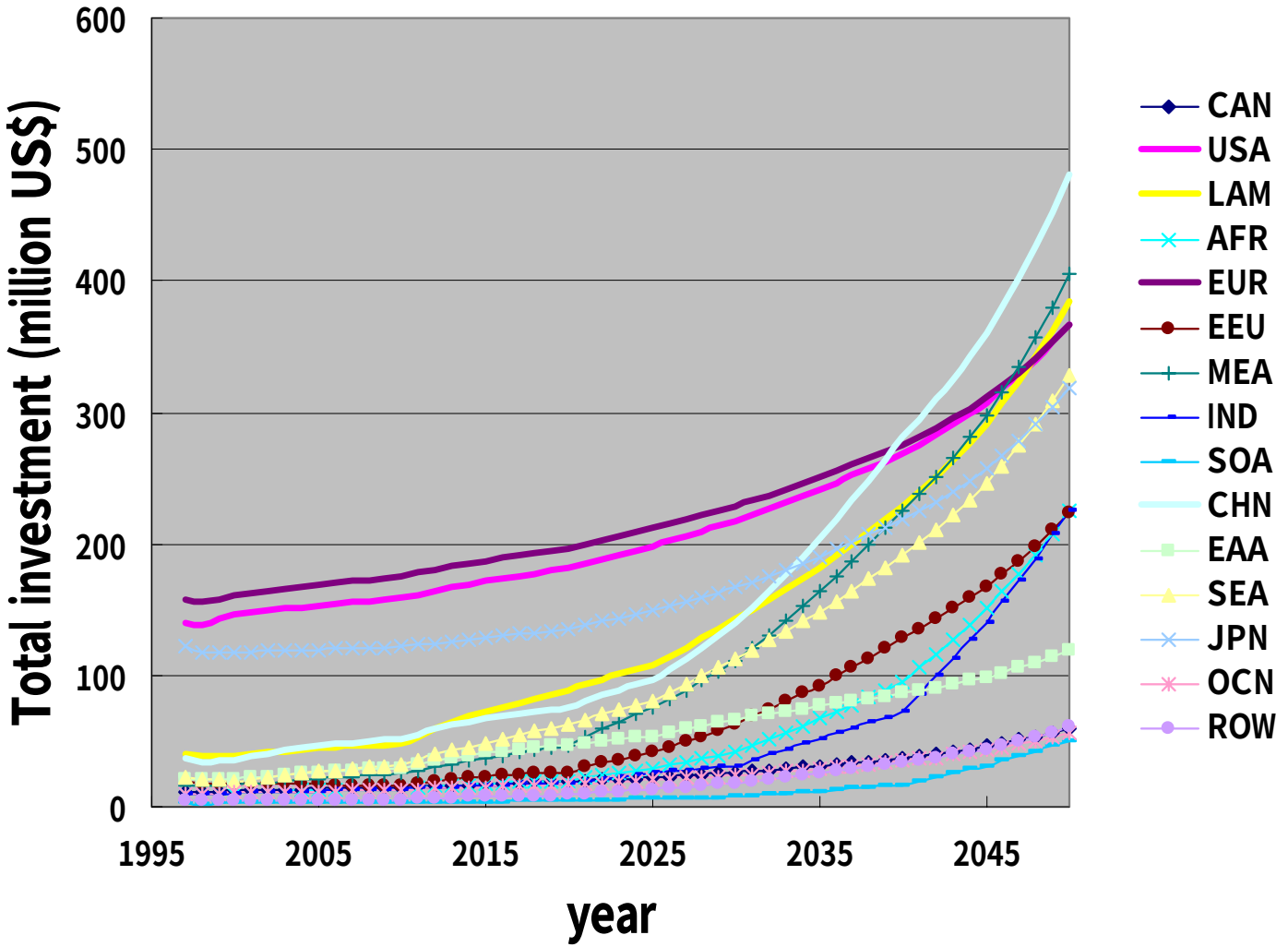
concordance among GTAP5, IEA and this model →

Number	CODE			Description
	CGE_ECO	IEA	GTAP5	
1	AGR	AGR	PDR	Paddy rice
2	AGR	AGR	WHT	Wheat
3	AGR	AGR	GRO	Cereal grains nec
4	AGR	AGR	V_F	Vegetables, fruit, nuts
5	AGR	AGR	OSD	Oil seeds
6	AGR	AGR	C_B	Sugar cane, sugar beet
7	AGR	AGR	PFB	Plant-based fibers
8	AGR	AGR	OCR	Crops nec
9	LVK	AGR	CTL	Bovine cattle, sheep and goats, horses
10	LVK	AGR	OAP	Animal products nec
11	LVK	AGR	RMK	Raw milk
12	LVK	AGR	WOL	Wool, silk-worm cocoons
13	FRS	AGR	FRS	Forestry
14	FSH	AGR	FSH	Fishing
15	COL	COL	COL	Coal
16	OIL	OIL	OIL	Oil
17	GAS	GAS	GAS	Gas
18	OMN	OMN	OMN	Minerals nec
19	LVK	FPR	CMT	Bovine meat products
20	LVK	FPR	OMT	Meat products nec
21	AGR	FPR	VOL	Vegetable oils and fats
22	LVK	FPR	MIL	Dairy products
23	AGR	FPR	PCR	Processed rice
24	AGR	FPR	SGR	Sugar
25	AGR	FPR	OFD	Food products nec
26	AGR	FPR	B_T	Beverages and tobacco products
27	IDY	TWL	TEX	Textiles
28	IDY	TWL	WAP	Wearing apparel
29	IDY	TWL	LEA	Leather products
30	FRS	LUM	LUM	Wood products
31	FRS	PPP	PPP	Paper products, publishing
32	P_C	P_C	P_C	Petroleum, coal products
33	IDY	CRP	CRP	Chemical, rubber, plastic products
34	IDY	NMM	NMM	Mineral products nec
35	IDY	I_S	I_S	Ferrous metals
36	IDY	NFM	NFM	Metals nec
37	IDY	OME	FMP	Metal products
38	IDY	TRN	MVH	Motor vehicles and parts
39	IDY	TRN	OTN	Transport equipment nec
40	IDY	OME	ELE	Electronic equipment
41	IDY	OME	OME	Machinery and equipment nec
42	IDY	OMF	OMF	Manufactures nec
43	ELY	ELY	ELY	Electricity
44	GAS	GAS	GDT	Gas manufacture, distribution
45	WTR	OMF	WTR	Water
46	IDY	CNS	CNS	Construction
X	DPV	CNS	CNS	Disaster prevention industry
47	SER	SER	TRD	Trade
48	T_T	T_T	OTP	Transport nec
49	T_T	T_T	WTP	Water transport
50	T_T	ATP	ATP	Air transport
51	SER	SER	CMN	Communication
52	SER	SER	OFI	Financial services nec
53	SER	SER	ISR	Insurance
54	SER	SER	OBS	Business services nec
55	SER	SER	ROS	Recreational and other services
56	SER	SER	OSG	Public Administration, Defense, Education, Health
57	IDY	DWE	DWE	Dwellings

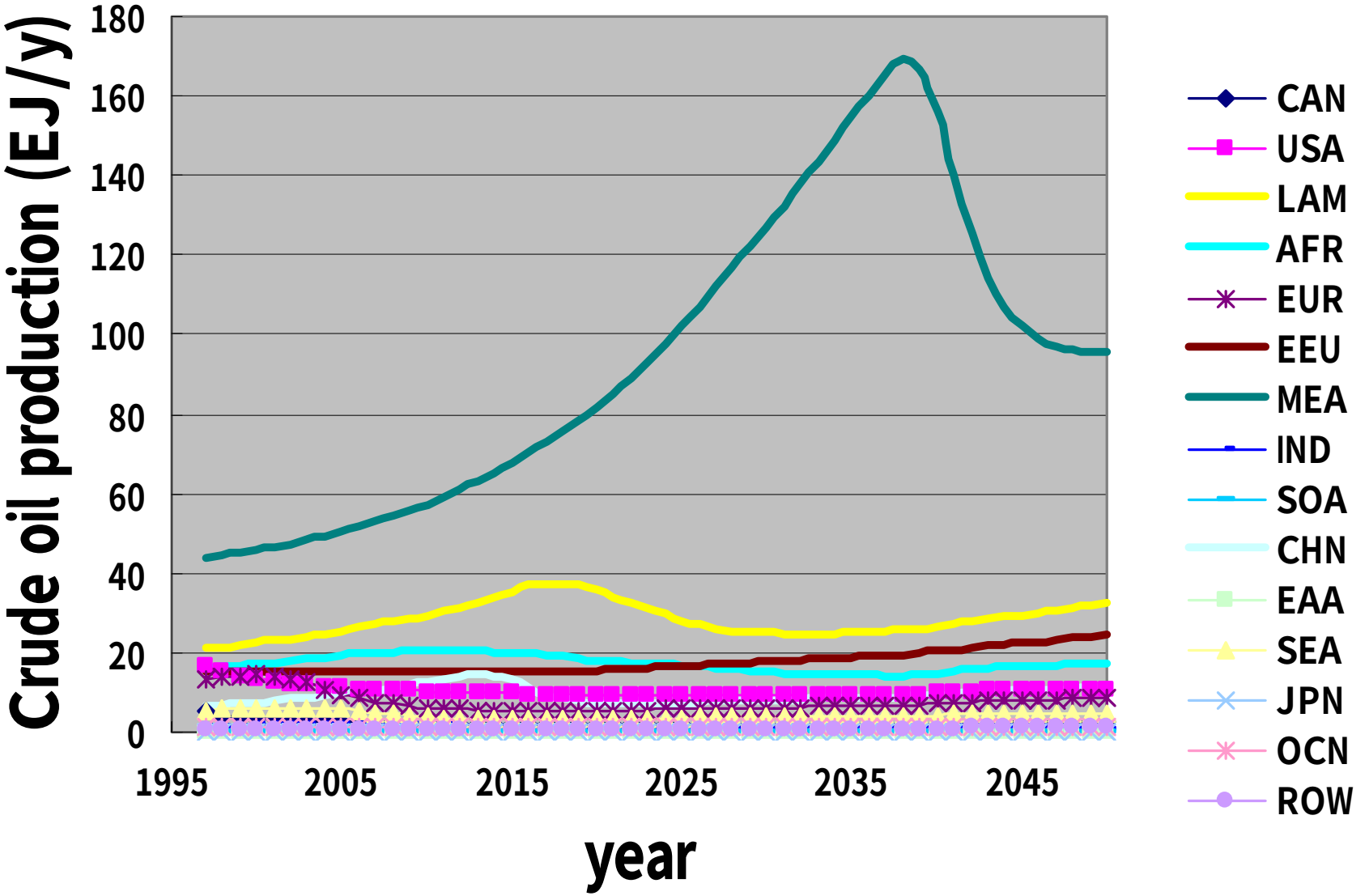
Regional GDP change in the standard case following SRES A1B



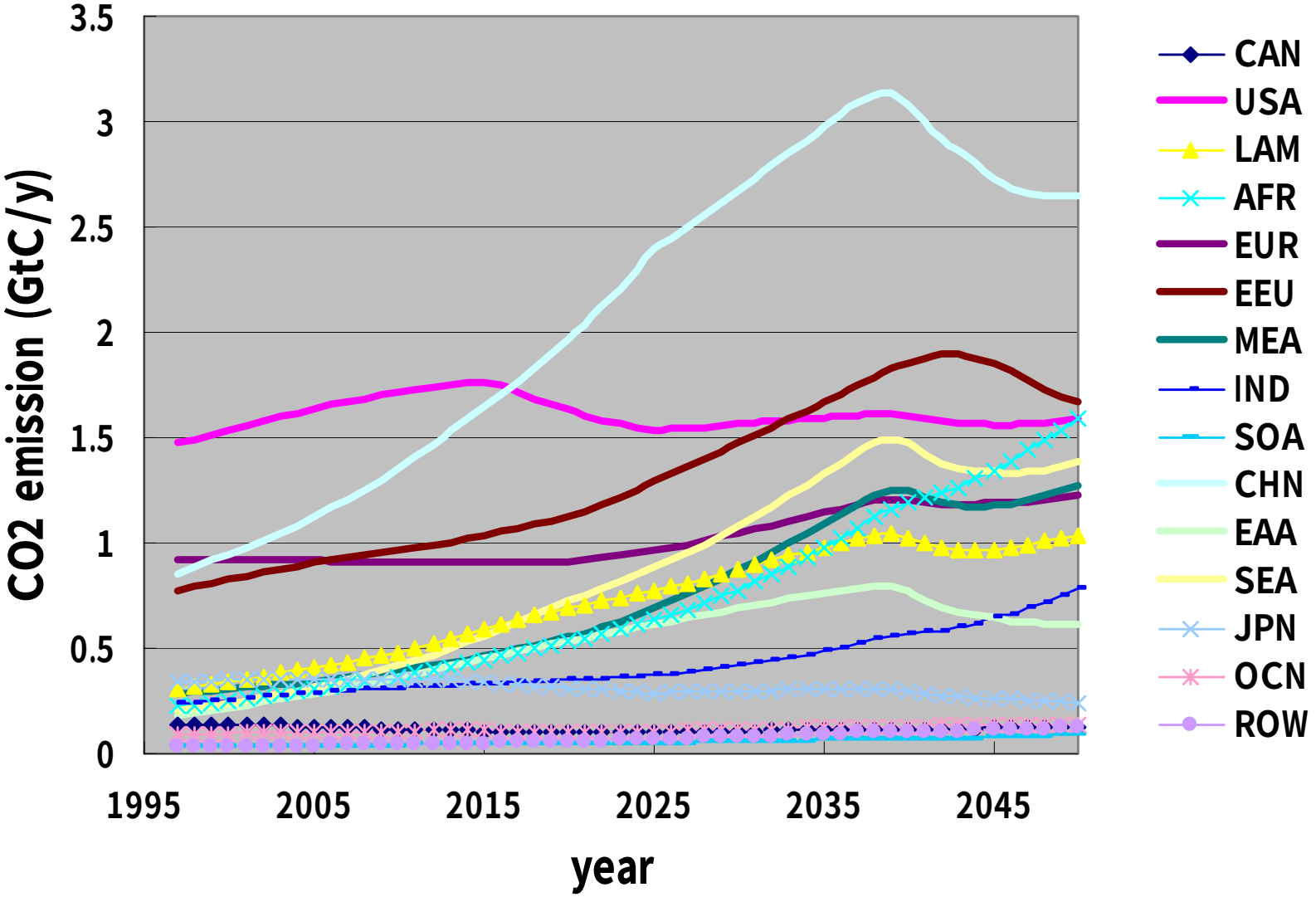
Regional total investment



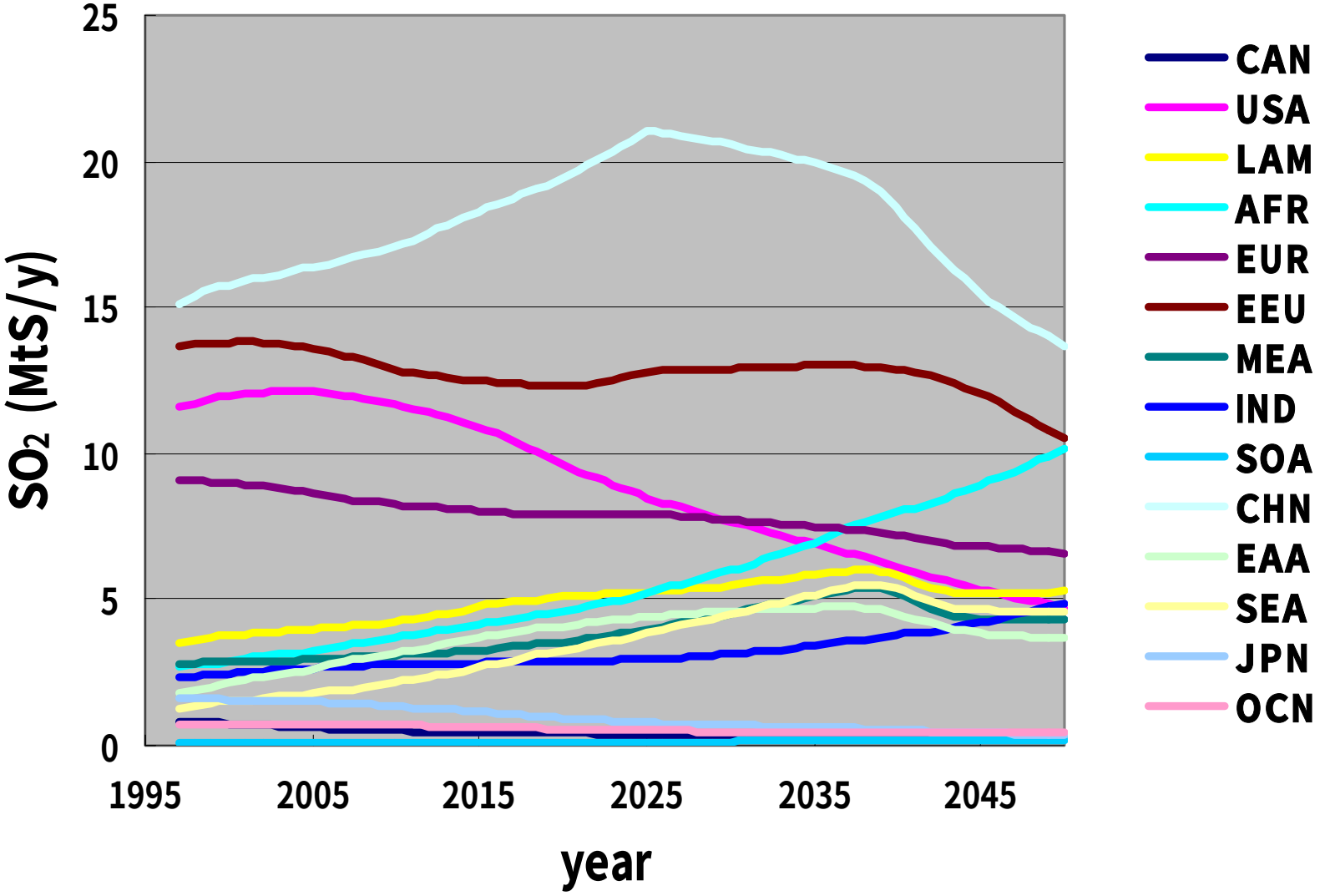
Regional crude oil production



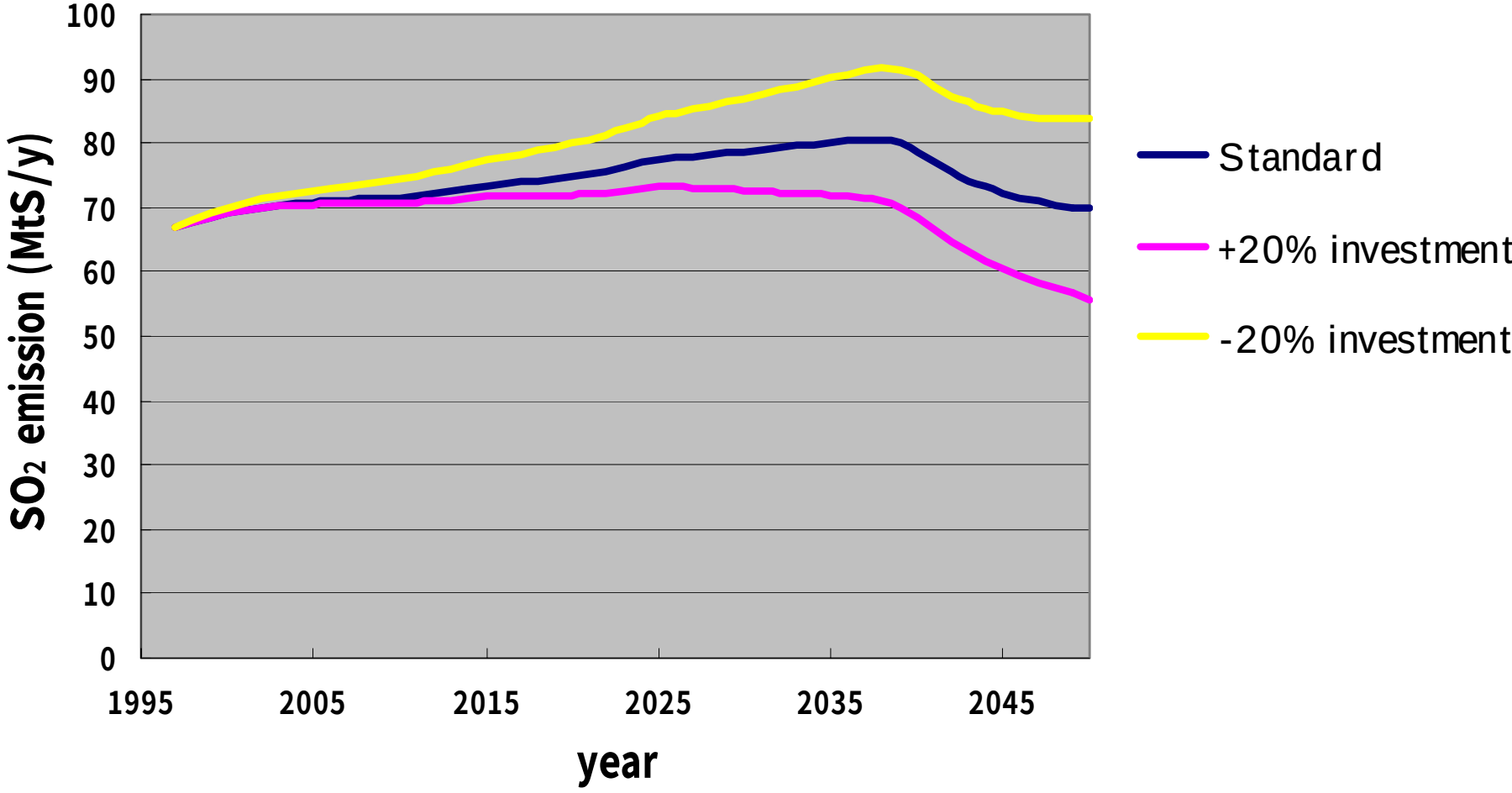
Regional CO_2 emission



Regional SO_2 emission under 0.3% GDP investment

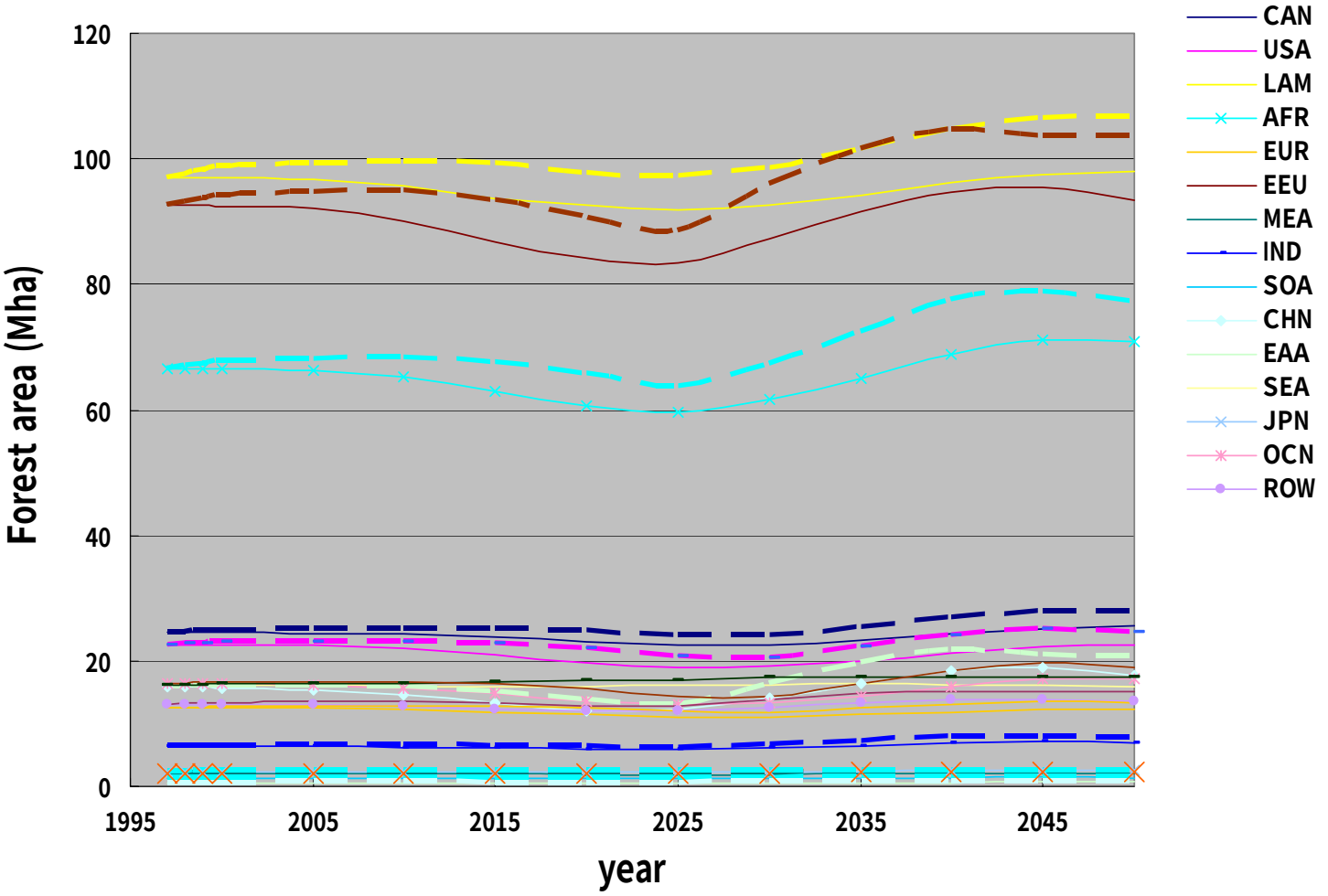


Effect of environmental investment on SO_2 emission

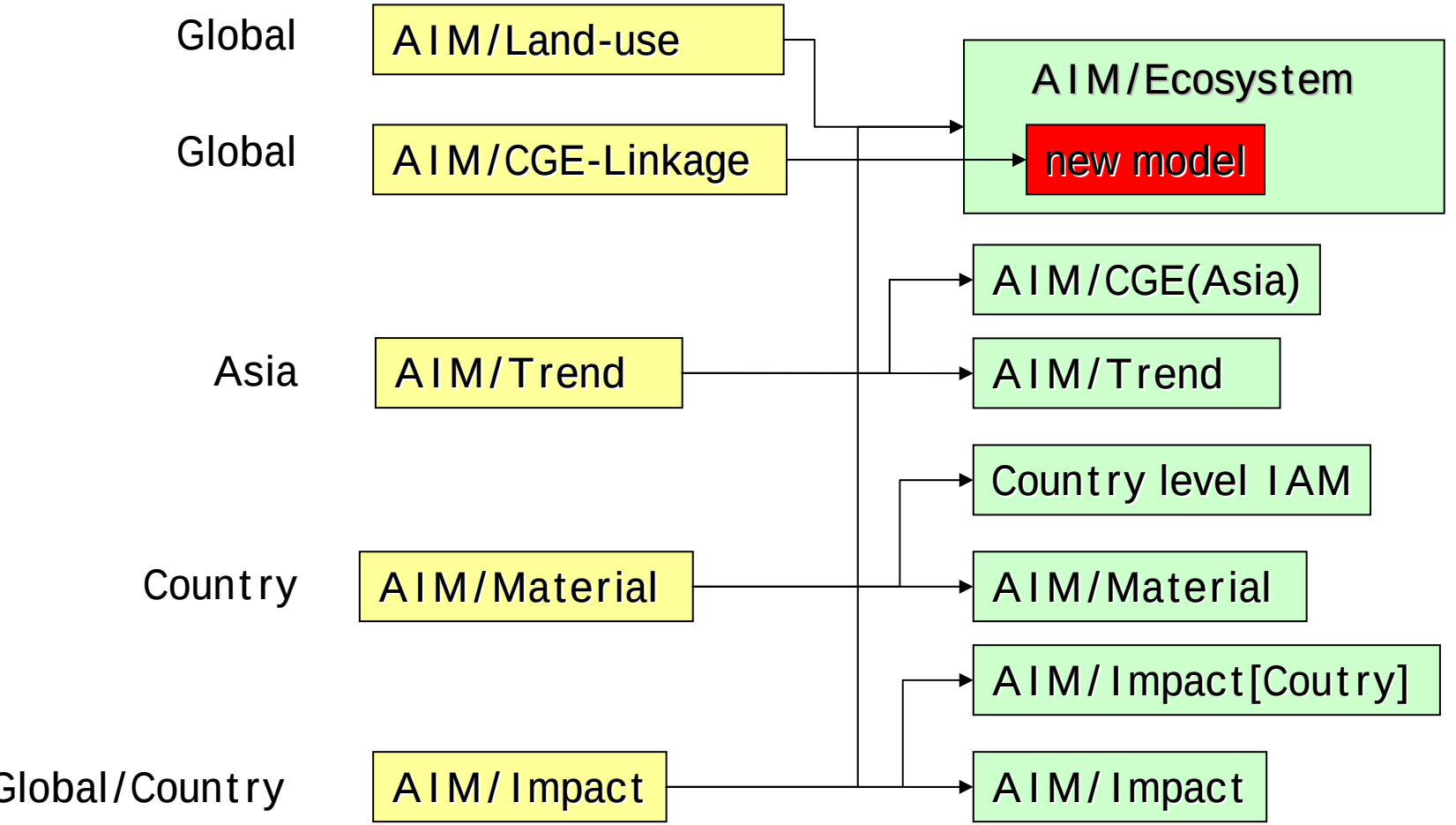


Change of forest area sensitivity to forestry product's premium

(10 % cost equivalent)



AIM family (partly)



Concluding remark

- We started constructing more portable, global comprehensive integrated assessment model for integrating global economic activity, environmental/ecosystem impacts and environmental policies.
- This model is a top-down, CGE type with emphasis's on people and natural environmental activities
- Scenario analysis for the MA assessment is an immediate application of this activity.

Required Information and assumptions

contents

Scenarios

- Population by each region
- Potential Technology Improvement for all inputs by each region and sector, *i.e.* factors, intermediates, water ← GDP growth consistency

Base year statistics

- Food consumption (AGR,LVK,FRS,FSH consumption) by each region
- Land use by each sector and each region
- Water use by each sector and each region
- Biogeochemicals and genetic use by each sector and each region
- Flood damage by each sector and each region

Empirical equations

- Food consumption function by each region
- Flood damage and mitigation cost function by each region
- Draught damage functions (Industry, Domestic, Agriculture) by each region
- Irrigation cost function by each region
- Water production function by each region
- GHG emission and temperature /precipitation change equations by each region