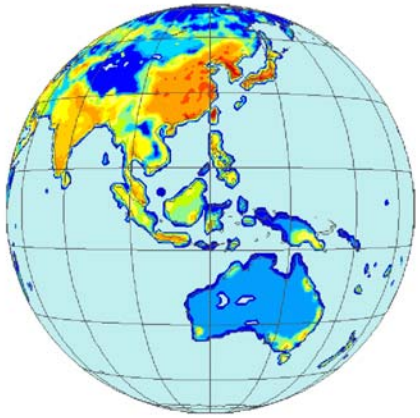


Future AIM modeling

~Focused on global and regional assessment tools~

Yuzuru Matsuoka

The 13th AIM International Workshop

17, February 2008

At Conference Room in Climate Change Research Hall
(Not Ohyama Memorial Hall)
National Institute for Environmental Studies, 305-8506,Tsukuba, Japan

Focused points

More realistic and comprehensive modeling

1. Impact[Policy]

   Climate feedback and economic uncertainties :Implication on 50% reduction of world GHG emission

2. Enduse[global]

   Inclusion of urbanization effects, household energy transition, and spatial emission distribution

   Relative health impacts of environmental factors

3. Developing more consistent database for global economy and environmental modeling

4. More comprehensive modeling for LCS study

   Linkage of ESS,BCM, and Element models

   Extension of ESS for long-term regional environment study

AIM/Impact[Policy]

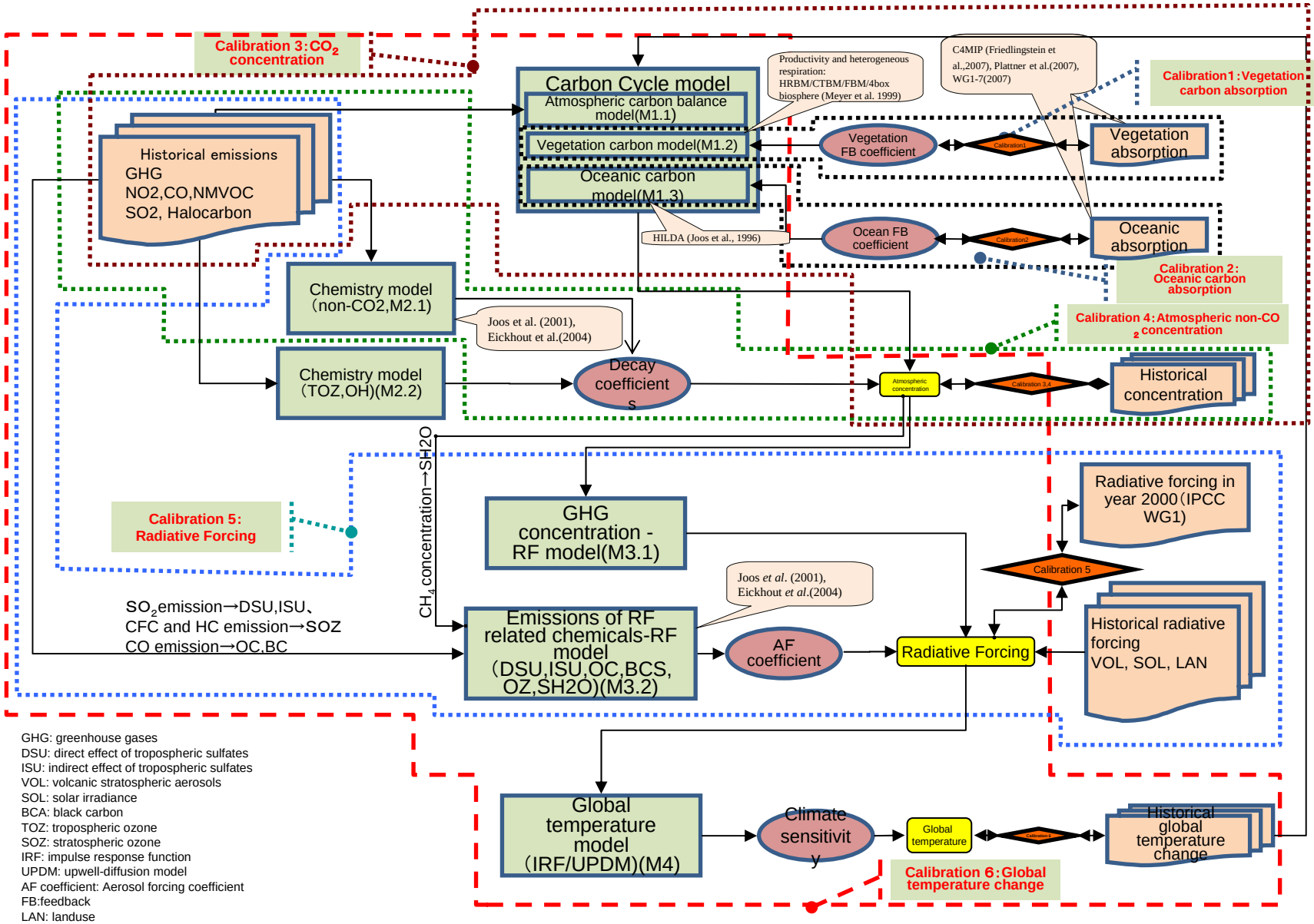
- Global and Long-term climate-economic-energy integrated model
  multi-regions (< 10), year 2000 to year 2200

- Dynamic global model consisted with;
  Dynamic economic CGE module maximizing social utility
  + Simplified climate module (global surface energy balance model)
  + Carbon cycle module with feedback mechanism
  + Simplified chemical reaction module
  + Climate impact module

- Gases : CO_2, CH_4, N_2O, BC, SO_2, and F gases

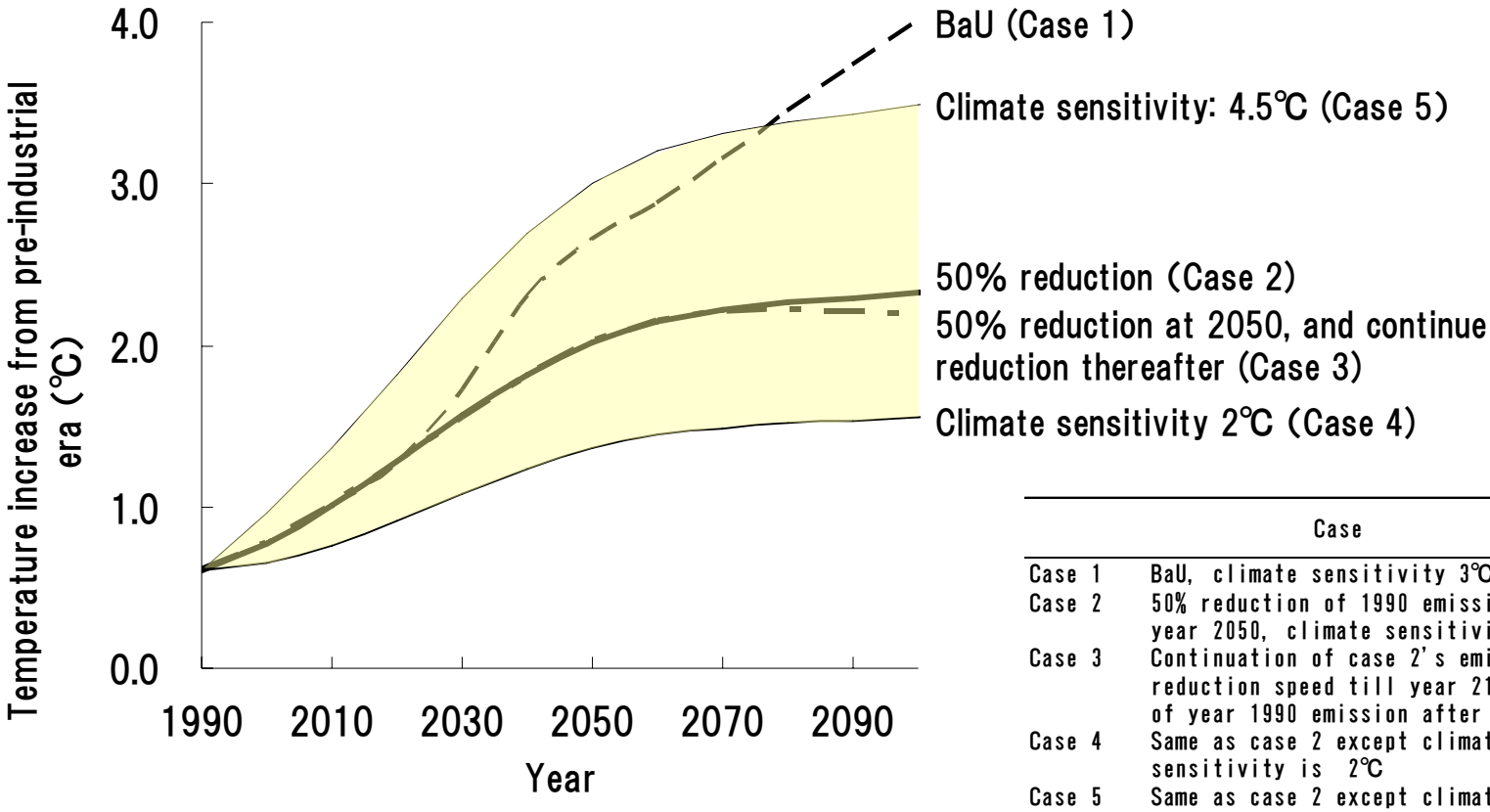
- Now refining: 1)to multi-regional, 2) inclusion of climate feedback mechanism, 3) systematic and organized methodology of impact assessment.

Including climate feedbacks



GHG: greenhouse gases
DSU: direct effect of tropospheric sulfates
ISU: indirect effect of tropospheric sulfates
VOL: volcanic stratospheric aerosols
SOL: solar irradiance
BCA: black carbon
TOZ: tropospheric ozone
SOZ: stratospheric ozone
IRF: impulse response function
UPDM: upwell-diffusion model
AF coefficient: Aerosol forcing coefficient
FB:feedback
LAN: landuse

Effects of 50% GHG emission reduction in year 2050 on long-term temperature change

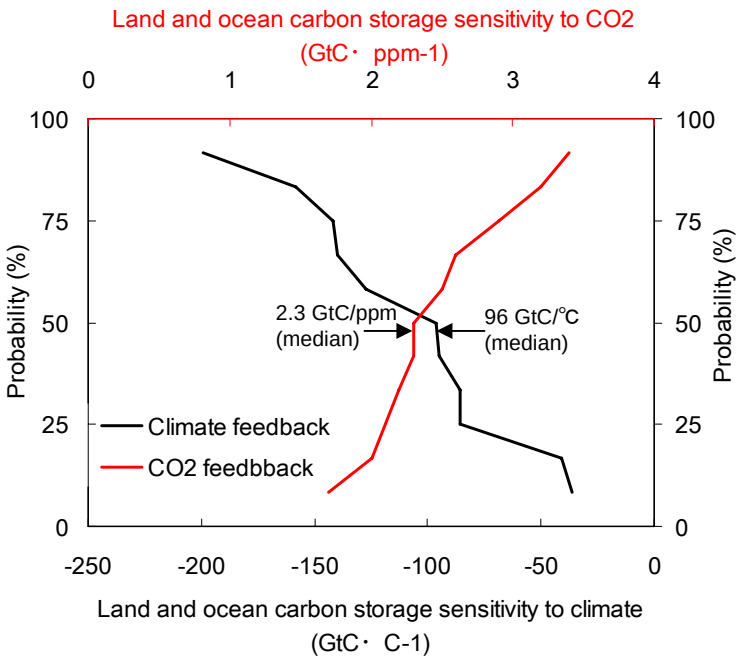


Case		Temperature change [1]
Case 1	BaU, climate sensitivity 3℃	5.7
Case 2	50% reduction of 1990 emission after year 2050, climate sensitivity 3℃	2.8
Case 3	Continuation of case 2's emission reduction speed till year 2100, keep 25% of year 1990 emission after then	2.0
Case 4	Same as case 2 except climate sensitivity is 2℃	1.9
Case 5	Same as case 2 except climate sensitivity is 4.5℃	4.2

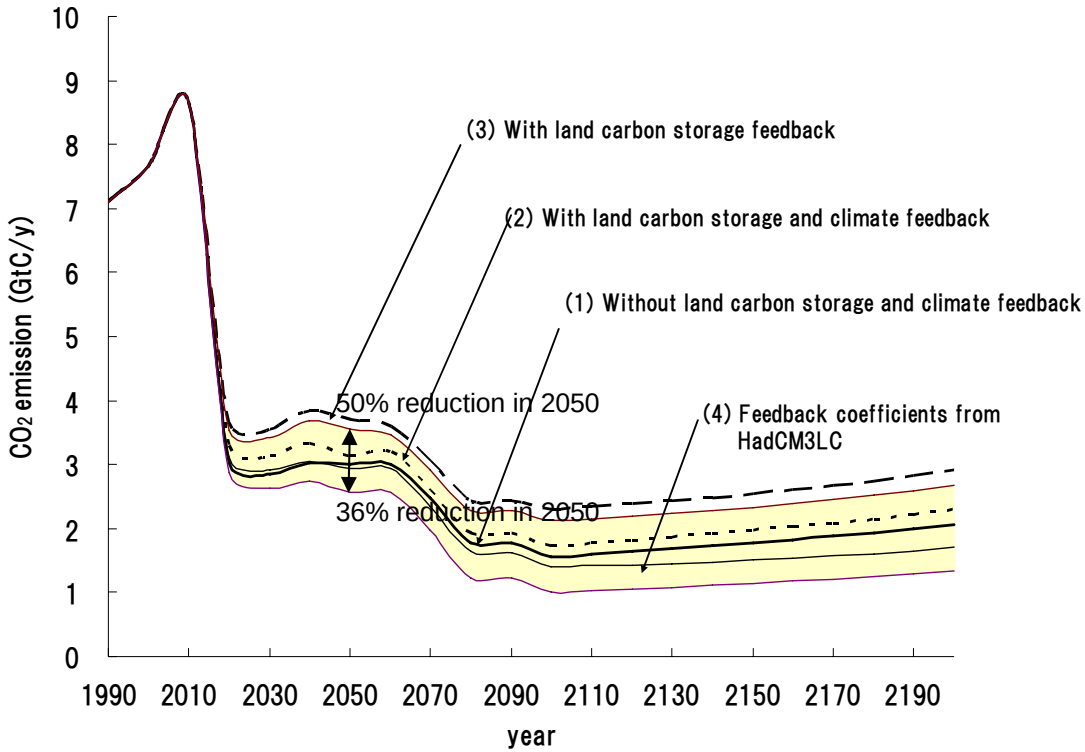
[1] Temperature increase in year 2200 above pre-industrial period

[2] Using same socio-economic assumptions as SRES B2. Compliance with Kyoto target in year 2010 is assumed, and reduction will start after year 2010. Controlled gases are those denoted in Kyoto Protocol.

Impacts of carbon cycle feedbacks on CO_2 emission paths



Sensitivities of carbon cycle in the C4MIP models



Target temperature = 2℃, Climate sensitivity =3℃, Discount rate = 1%/y
Land carbon storage sensitivity = 0.6 GtC・GtC^{-1}(=1.3 GtC/ppm) in (2), (3) and (4)
Carbon storage sensitivity to climate = -96 GtC/℃ in (2), -199 GtC/℃ in (4)

Probability of temperature target compliance and emission reduction rate in year 2050

Temperature target	Probability of compliance				
	10%	33%	50%	66%	90%
2.0℃	0	40	60	78	86
	-4	43	64	87	97
2.6℃	-56	10	32	53	85
	-64	8	34	56	95
3.6℃	-85	-54	-13	16	55
	-79	-63	-21	15	59

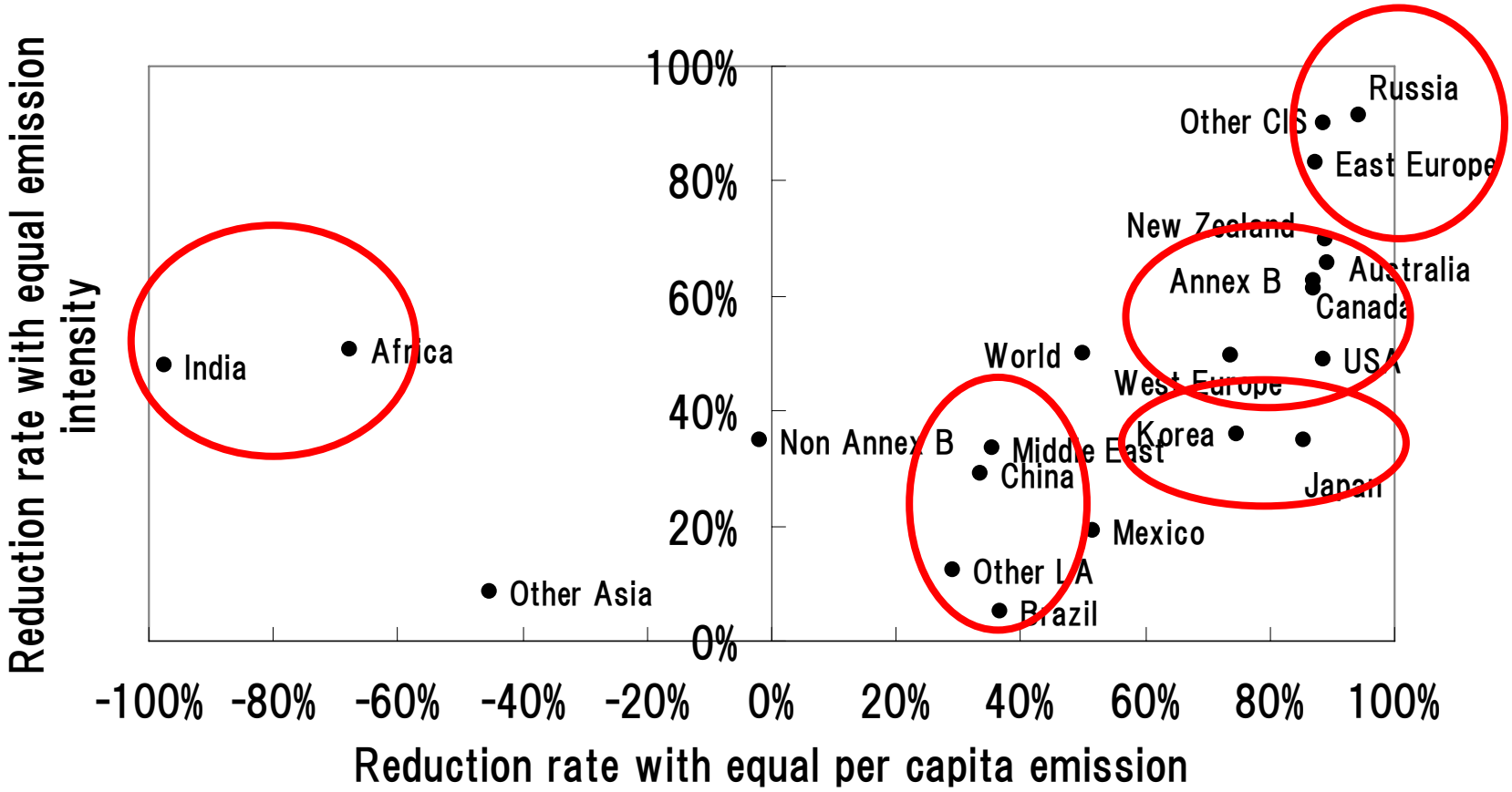
Upper row is of six gases in Kyoto Protocol, lower row is of CO_2.
Temperature targets are increases above pre-industrial period and reduction rates are based on 1990 emissions.

Countries' reduction rates for world 50% emission reduction in year 2050

Country/Region	Equal per capita		Equal emission intensity	Equal velocity of intensity reduction
	emission Mil.tC/y	reduction ratio based on 1990	reduction ratio based on 1990	reduction ratio based on 1990
United States	207	89%	49% (2%～63%)	85% (75%～88%)
Canada	22	87%	61% (33%～65%)	87% (77%～89%)
Japan	53	85%	35% (-23%～44%)	91% (87%～93%)
Australia	14	89%	66% (44%～73%)	80% (65%～83%)
New Zealand	3	89%	70% (51%～75%)	83% (70%～87%)
Western Europe	343	74%	50% (37%～62%)	88% (87%～92%)
Eastern Europe	49	87%	83% (75%～92%)	72% (64%～82%)
Russia	55	94%	91% (75%～94%)	69% (60%～77%)
Other CIS	72	89%	90% (87%～93%)	59% (49%～67%)
South Korea	22	75%	36% (-104%～75%)	68% (62%～78%)
China	728	34%	29% (-69%～46%)	-1% (-46%～12%)
India	852	-97%	48% (-168%～66%)	-36% (-57%～2%)
Other Asia	644	-45%	8% (-27%～49%)	-8% (-15%～22%)
Mexico	68	52%	19% (-13%～59%)	57% (44%～60%)
Brazil	130	37%	5% (-23%～80%)	40% (33%～49%)
Other Latin America	197	29%	12% (-12%～71%)	40% (38%～44%)
Middle East	232	35%	34% (20%～84%)	26% (22%～48%)
Africa	1028	-68%	51% (17%～92%)	-18% (-49%～37%)
World	4719	50%	50% (50%～50%)	50% (50%～50%)
Annex B	705	87%	63% (37%～67%)	82% (78%～84%)
Non-annex B	4014	-2%	35% (29%～66%)	12% (9%～16%)

Projections of GDP in 2050. We used 6 SRES scenarios of AIM (IPCC, 2001), A2r scenario (Grubler et al., 2006), Wilson and Purushothaman (2003), and Poncet (2006).

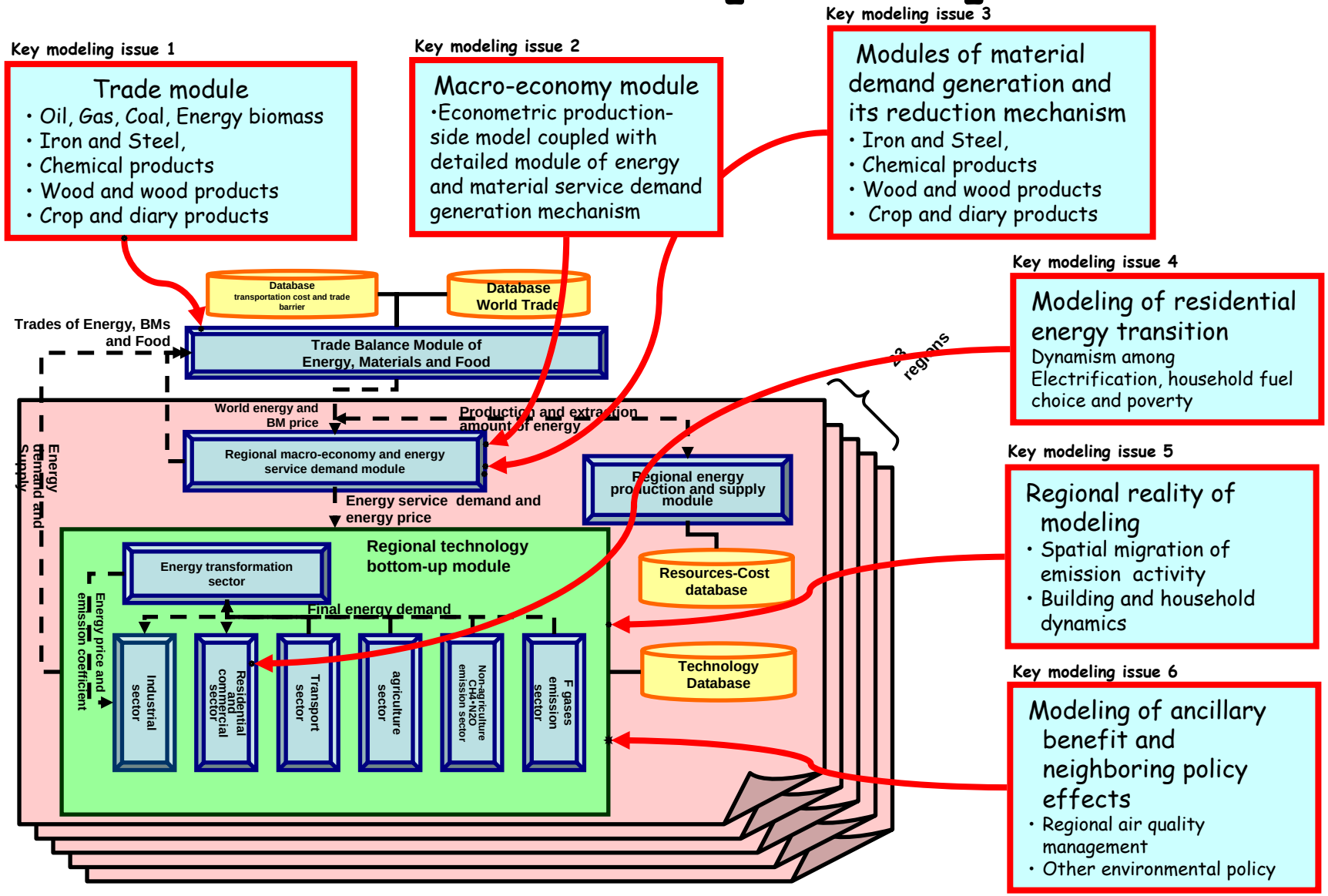
Relation of reduction rates between different sharing schemes



AIM/Enduse[Global]

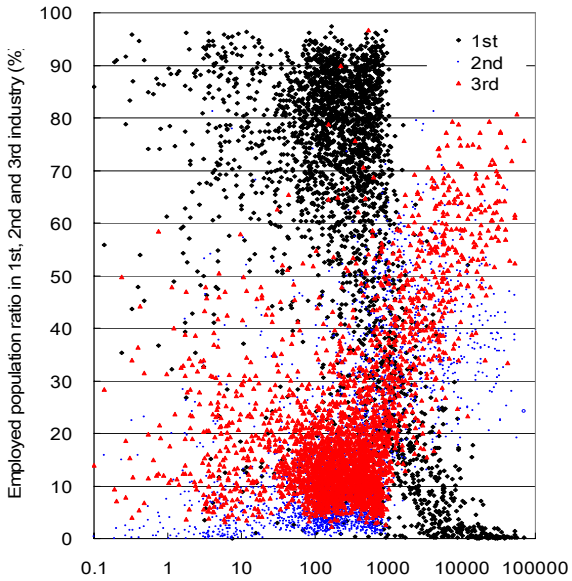
- Regional bottom-up type model
  23 regions (same as AIM/Global[CGE]), year 2000 to year 2050
- Regional energy enduse module coupled with
  Regional energy resource module
  International energy, basic materials balance module
  Regional macro-economy and energy service demand module
- Emission sectors (activities)
  Industrial, residential and commercial, transport, agriculture,
  non-agricultural non CO_2 emission sectors, F gases
- Systematic reconciliation of base year information among
  stocks of energy devices, energy efficiency, energy services, and
  energy consumption
- Gases: CO_2, CH_4, N_2O, BC, OC, SO_2, and F gases
- Compatibility with national AIM enduse modeling activity
  using same methodology and classification of
  energy/device/service

AIM/Enduse[Global]



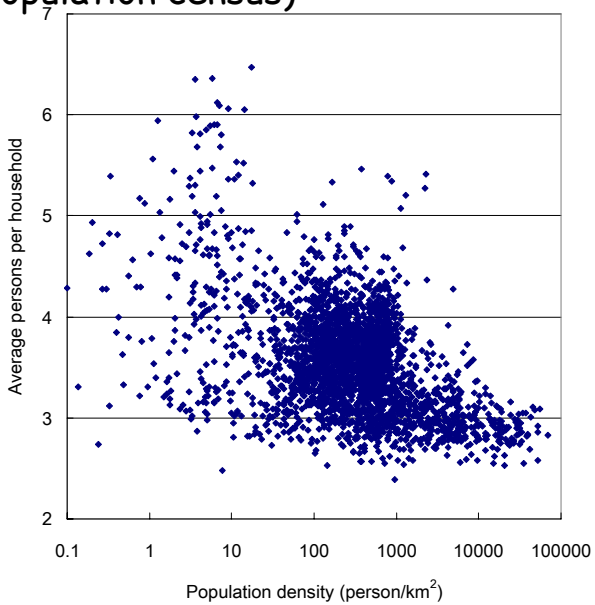
Regional reality of Modeling: Population distribution and its relationship with CO_2 emission activity

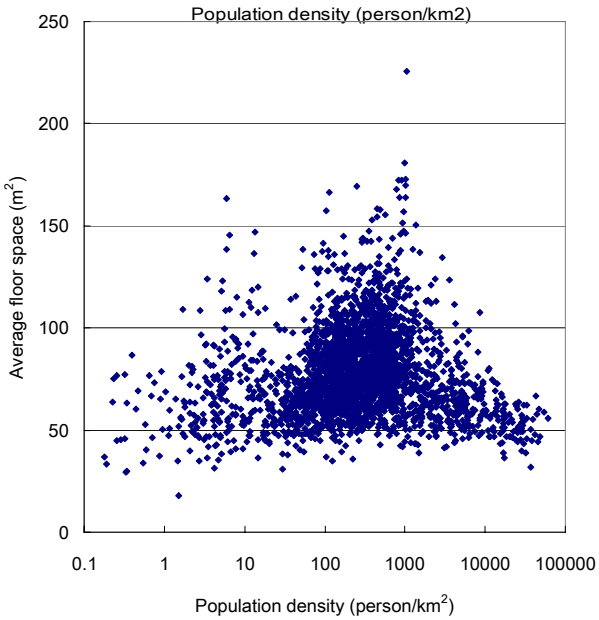
(from county level information of year 2000 China population census)



Types of industrial activities are strongly correlated with population distribution

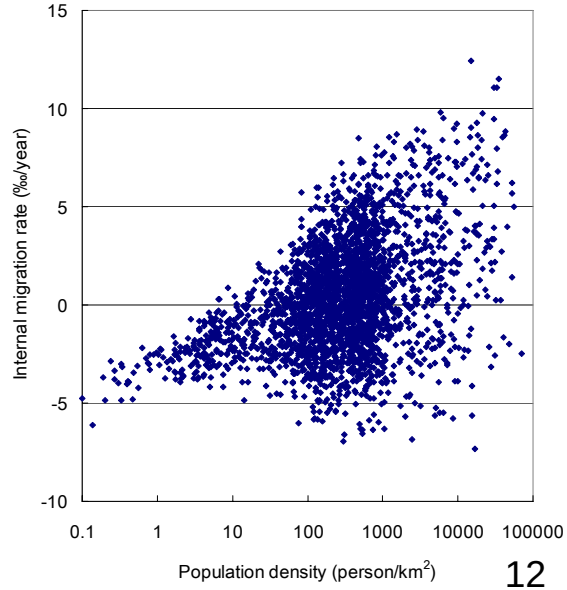
Household size is strongly correlated with population distribution





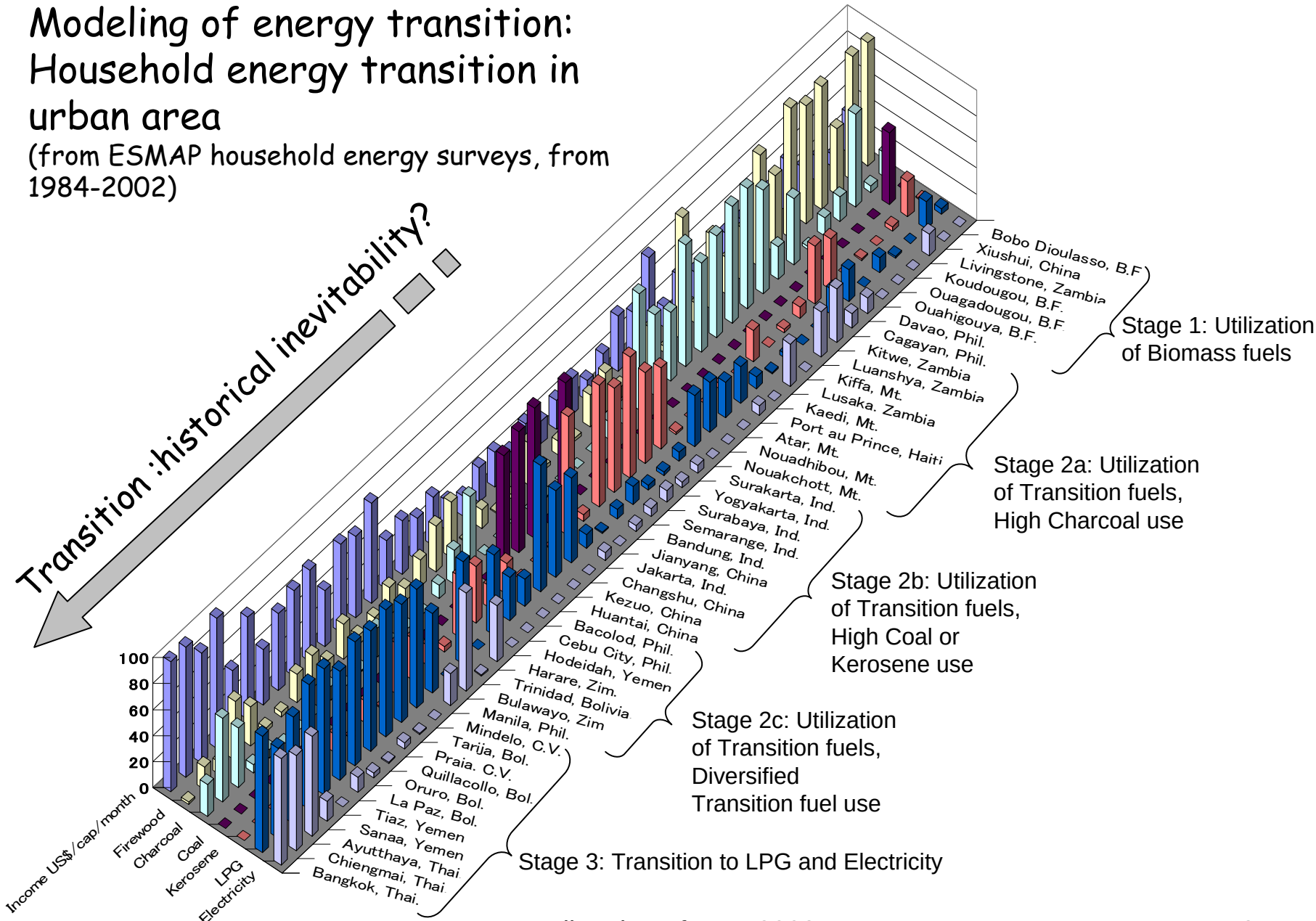
House size is also strongly correlated with population distribution

People migrates toward more dense populated region



Modeling of energy transition: Household energy transition in urban area

(from ESMAP household energy surveys, from 1984-2002)



Stage 1: Utilization of Biomass fuels

Stage 2a: Utilization of Transition fuels, High Charcoal use

Stage 2b: Utilization of Transition fuels, High Coal or Kerosene use

Stage 2c: Utilization of Transition fuels, Diversified Transition fuel use

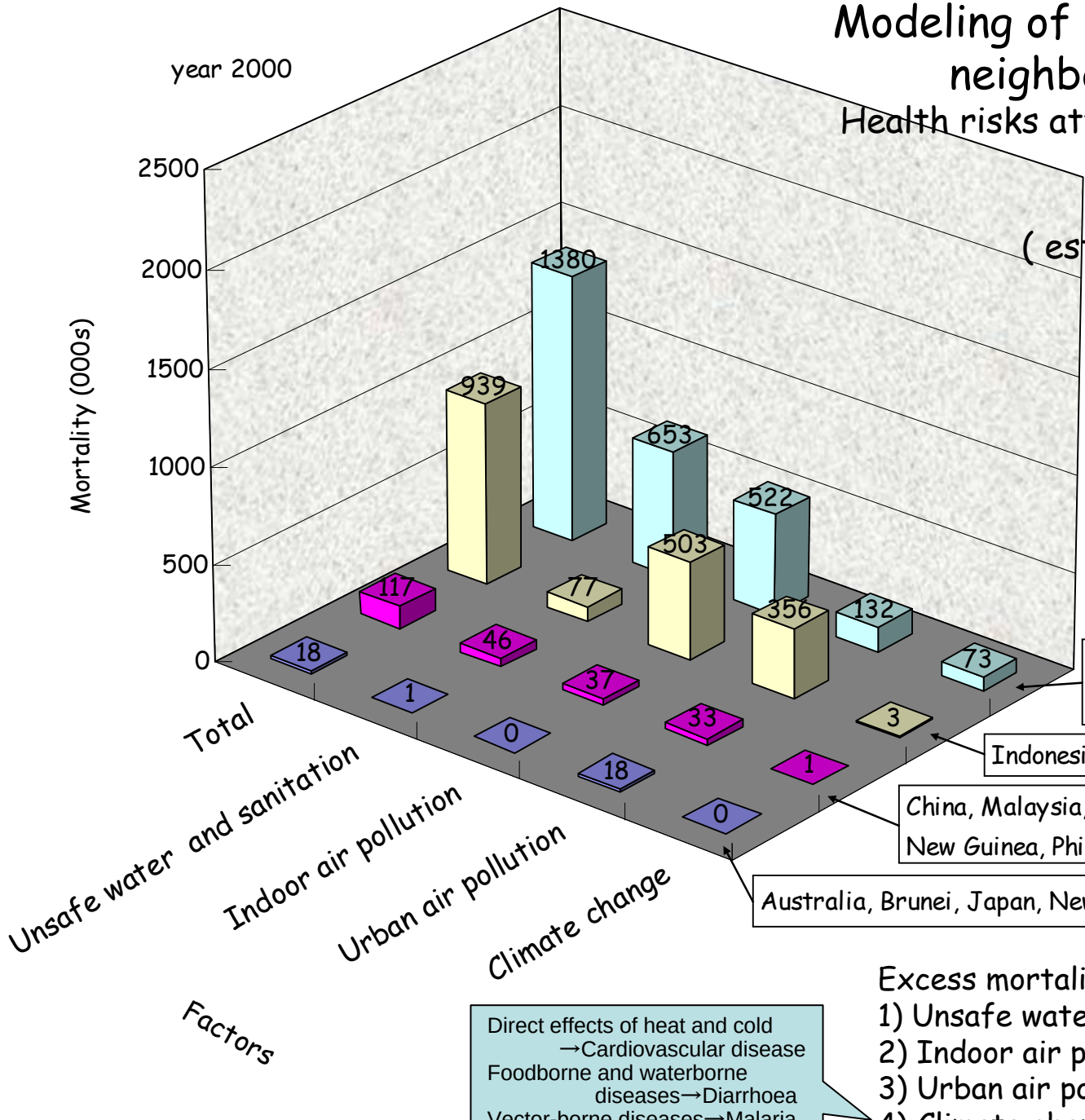
Stage 3: Transition to LPG and Electricity

Modeling of ancillary benefit and neighboring policy effects :

Health risks attributed to environmental factors

year 2000 situation

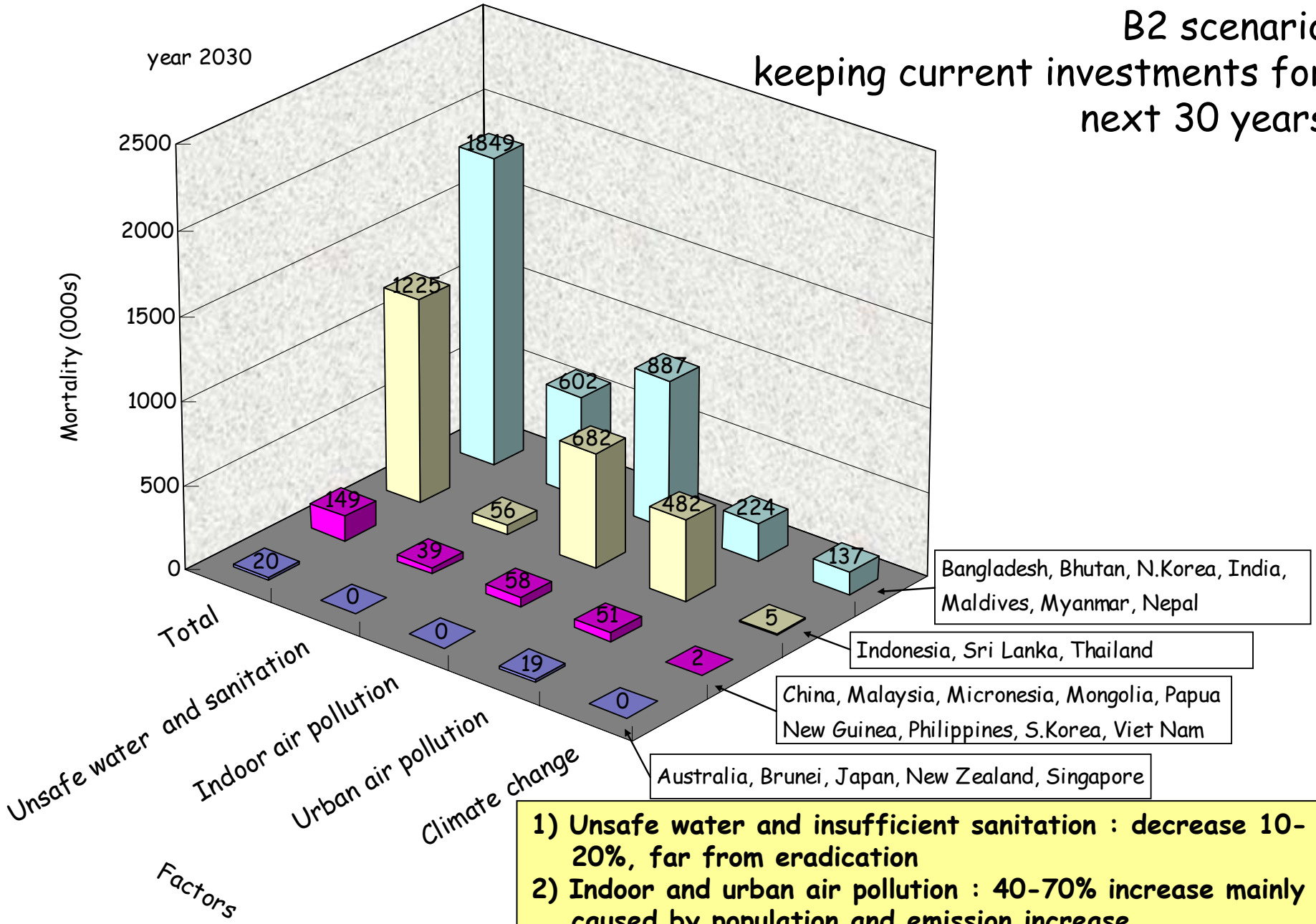
(estimated by WHO method)



Direct effects of heat and cold
→Cardiovascular disease
Foodborne and waterborne diseases→Diarrhoea
Vector-borne diseases→Malaria

Excess mortality attributed to
1) Unsafe water and insufficient sanitation
2) Indoor air pollution
3) Urban air pollution, and
4) Climate change

B2 scenario keeping current investments for next 30 years

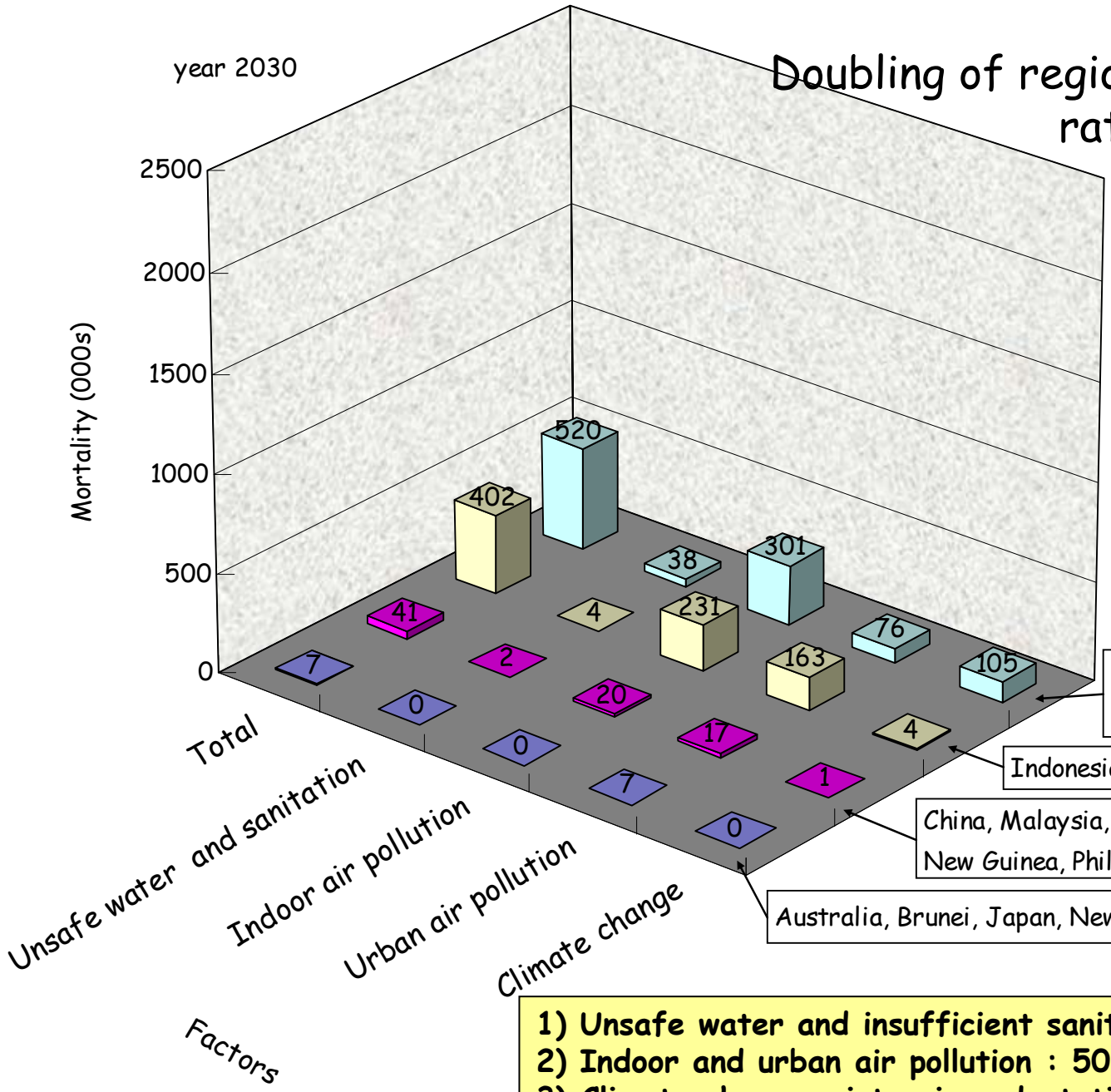


1) Unsafe water and insufficient sanitation : decrease 10-20%, far from eradication

2) Indoor and urban air pollution : 40-70% increase mainly caused by population and emission increase

3) Climate change : 50-90% increase caused by the escalation of climate change

B2+550ppm Scenario
Doubling of regional Investment/GDP ratio for next 30 years



Excess mortality attributed to
1) Unsafe water and insufficient sanitation
2) Indoor air pollution
3) Urban air pollution, and
4) Climate change

Bangladesh, Bhutan, N.Korea, India, Maldives, Myanmar, Nepal

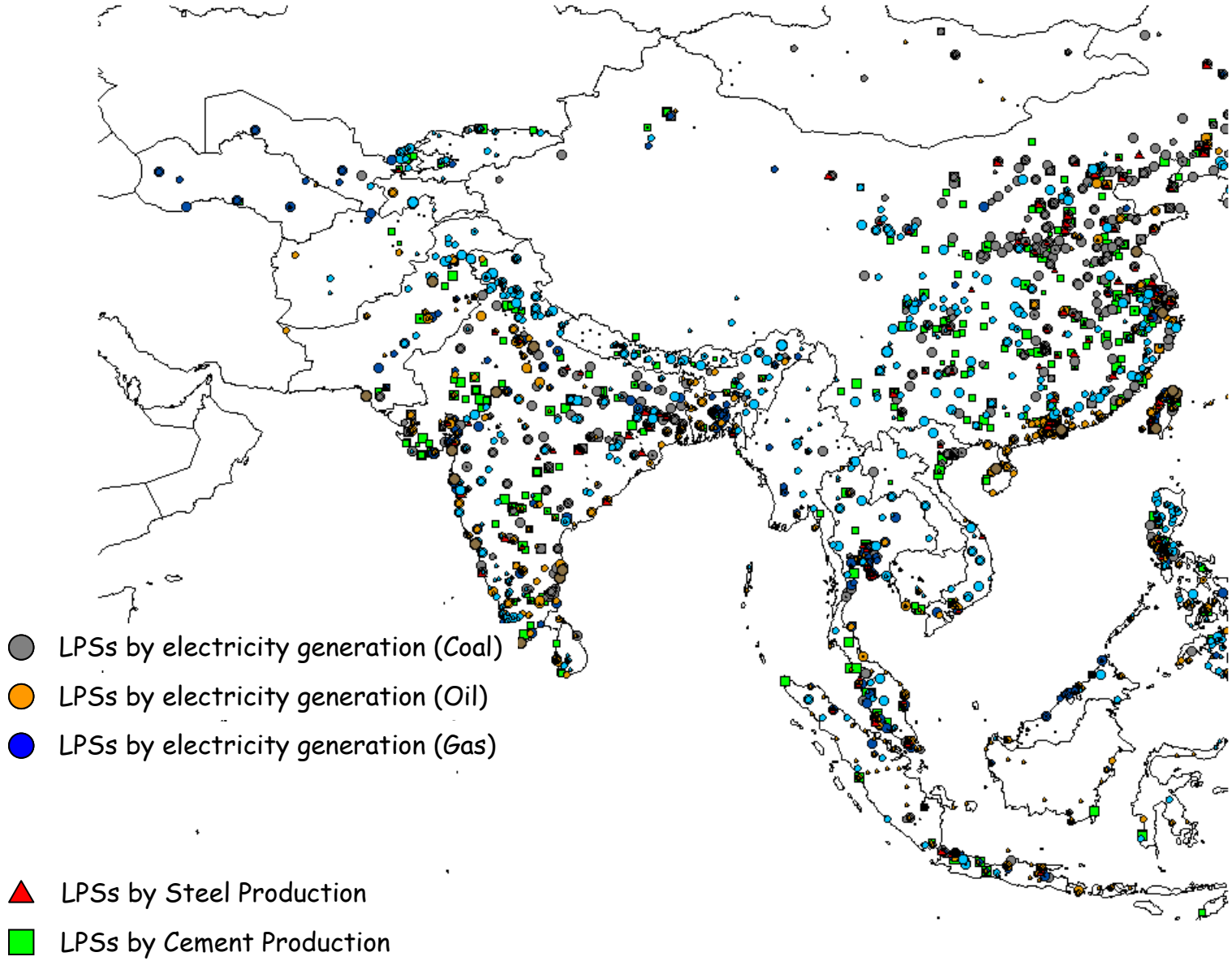
Indonesia, Sri Lanka, Thailand

China, Malaysia, Micronesia, Mongolia, Papua New Guinea, Philippines, S.Korea, Viet Nam

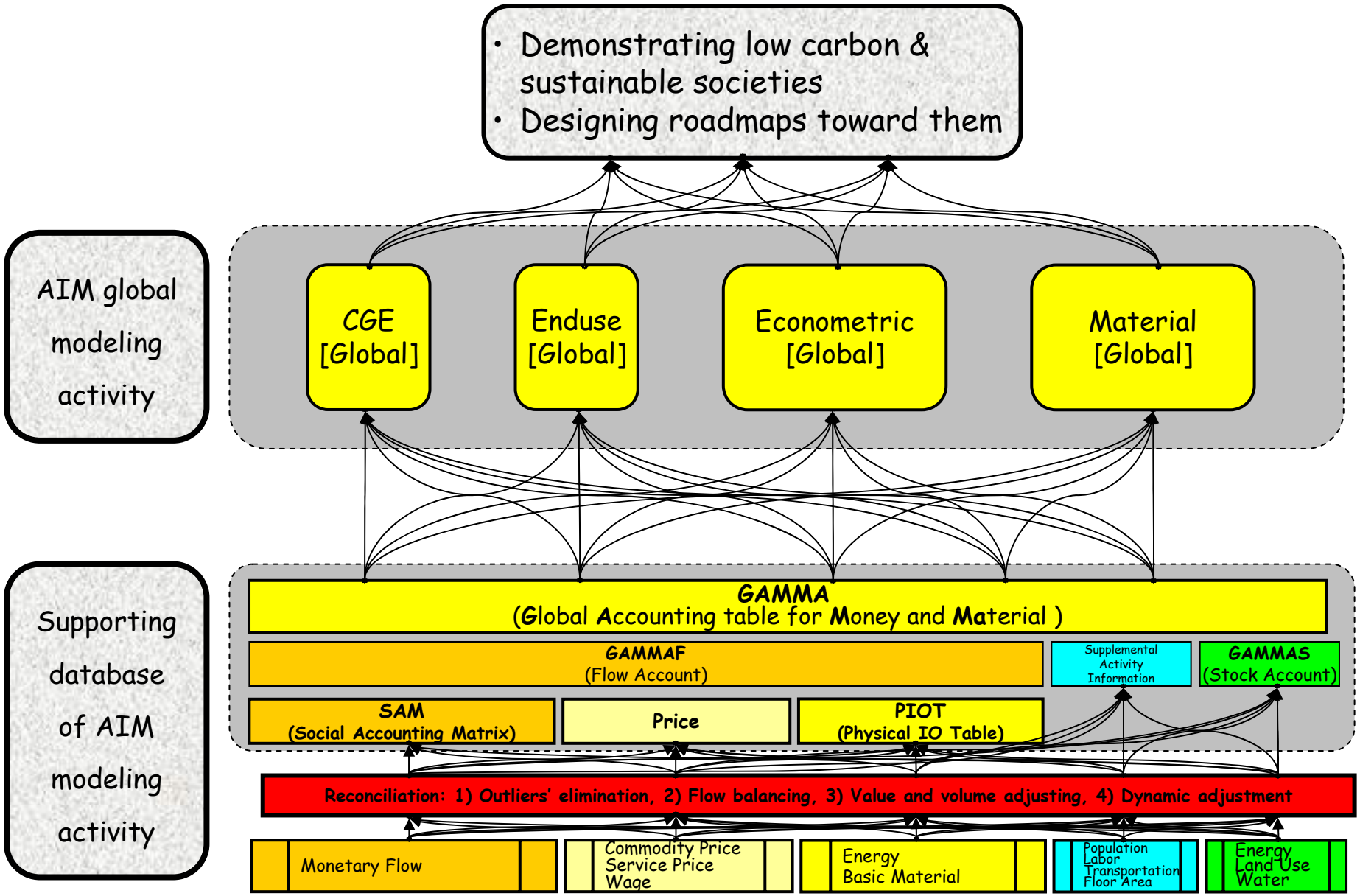
Australia, Brunei, Japan, New Zealand, Singapore

1) Unsafe water and insufficient sanitation : nearly eradicated
2) Indoor and urban air pollution : 50% decrease
3) Climate change : intensive adaptation suppresses increase by 10-40%

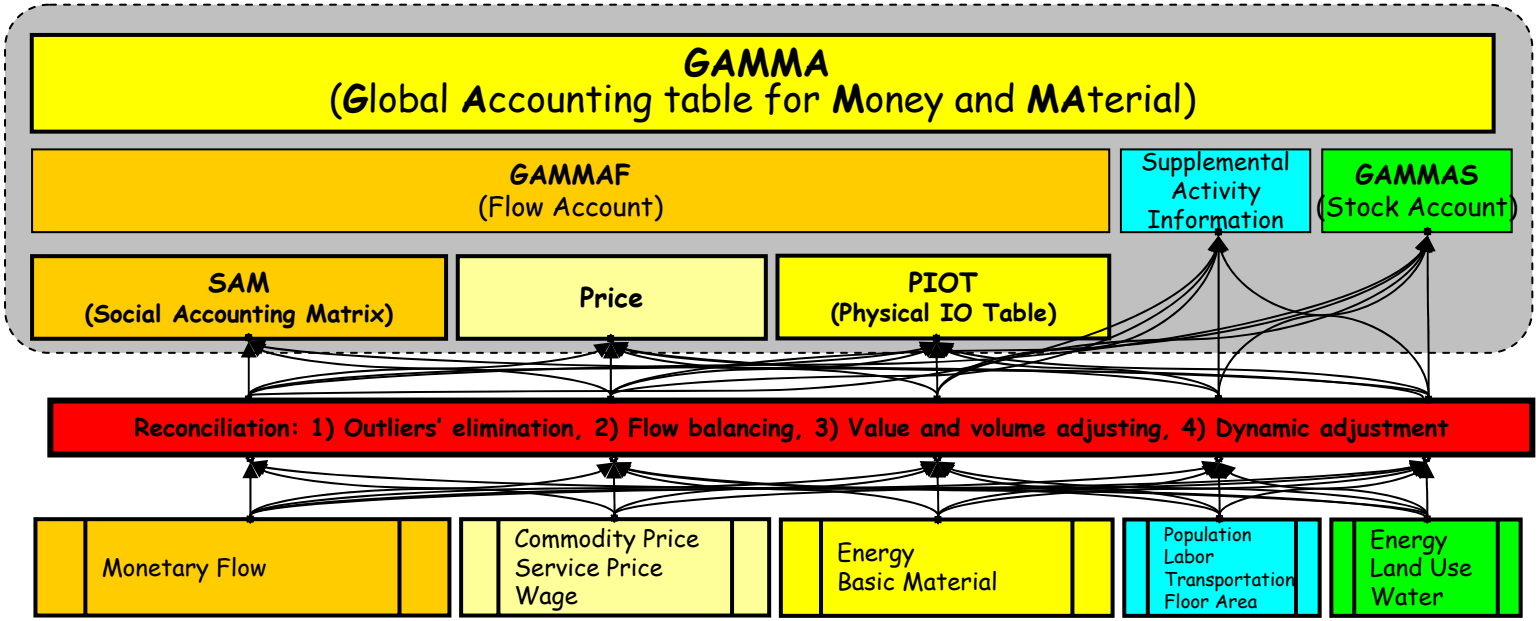
Regional reality of modeling :Large point sources of CO_2 SO_2 and NO_x emission in 2000



More consistent database for global economy and environmental modeling



Supporting database of AIM modeling activity



Statistics Name	Compiler
National Accounts Database	UN
World Development Indicators	World Bank
International Historical Statistics	(Mitchell, 2003)
GTAP Databse	GTAP
OECD Input-Output Tables	OECD
Asian International Input-Output Table	IDE
Asean International Input-Output Table	IDE
Balance of Payments	IMF
Commodity Trade Statistics Database	UN
International Trade by Commodity statistics	OECD
OECD Statistics on International Trade in Services	OECD
General Industrial Statistics Database	UN
Industrial Demand-Supply Balance Database at the 4-digit level of ISIC code	UNIDO
Industrial Statistics Database at the 4-digit level of ISIC code	UNIDO
Asian Long-term Statistics -Industrial Development-	Takushoku University
FAOSTAT	FAO
Structural Statistics for Industry and Services	OECD
The OECD STAN database for Industrial Analysis	OECD

Statistics Name	Compiler
Commodity Trade Statistics Database	UN
FAOSTAT	FAO
Energy Price and Tax	IEA
Eenerdata	Eenerdata
LABORSTA	ILO
International Financial Statistics	IMF

Statistics Name	Compiler
International Historical Statistics	(Mitchell, 2003)
Industrial Commodity Production Statistics Databse	UN
Commodity Trade Statistics Database	UN
FAOSTAT	FAO
Energy Price and Tax	IEA
Eenerdata	Eenerdata
Energy Infromation	EIA
Iron and Steel Statistiscs	IISI

Statistics Name	Compiler
International Historical Statistics	(Mitchell, 2003)
LABORSTA	ILO
UN Population Prospects	UN

- Period: 1970 – latest
- Regionalization: 153 countries and regions (covers more than 99% of global GDP)
- Reconciliation methodology: Flow balancing, cross-sectional and temporal aggregation constrains

More comprehensive modeling for LCS study: Two stages and three model groups of LCS's study:

Stage 1: Design of a Low Carbon Society

1. Creation of narrative storylines of future Low Carbon Societies
2. Description of sector-wise details of the future LCSs.
3. Quantification of the Macro economic and social aspects of the LCSs.
4. Identification of effective policy measures and packaging them

Stage two : Putting them together and making it happen

1. Design of policy roadmaps toward the Low Carbon Society
2. Feasibility analysis of the roadmaps considering uncertainties involved in each policy option
3. Analysis of robustness of the roadmap caused by societal, economical and institutional acceptability and uncertainties

Group 1: Element models;

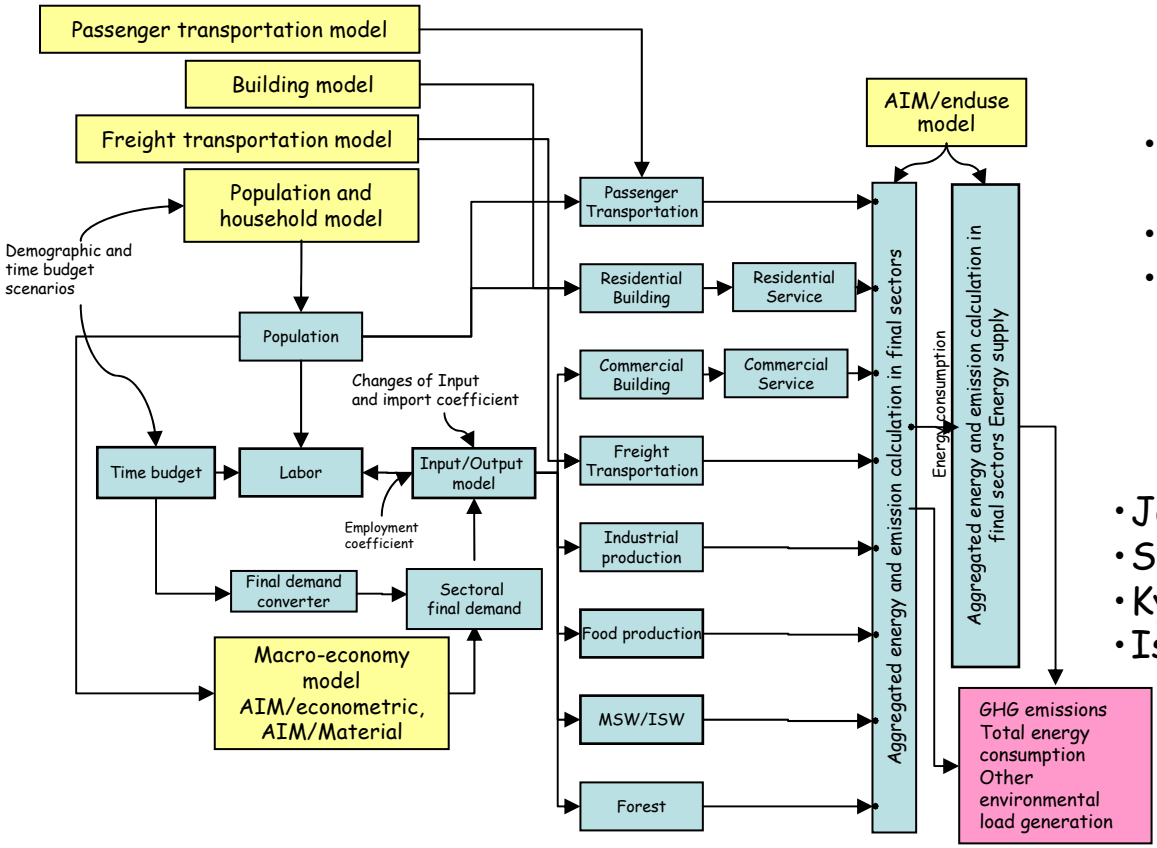
1) Snapshot models;
- Quasi steady Computable General Equilibrium (CGE) model
- Energy technology bottom-up models
  - Energy supply model
- Household production/lifestyle model
- Transportation demand model

2) Transition models;
- Population and household model
- Building dynamics model
- Econometric type macro-economy model

Group 2: Extended Snapshot Tool (ESS)

Group 3: Backcasting Model for transient control (BCM)

Extended SnapShot (ESS)



SITUATION

- Excel and GAMS versions were prepared
- Developing multi-regional version
- Linking with element models

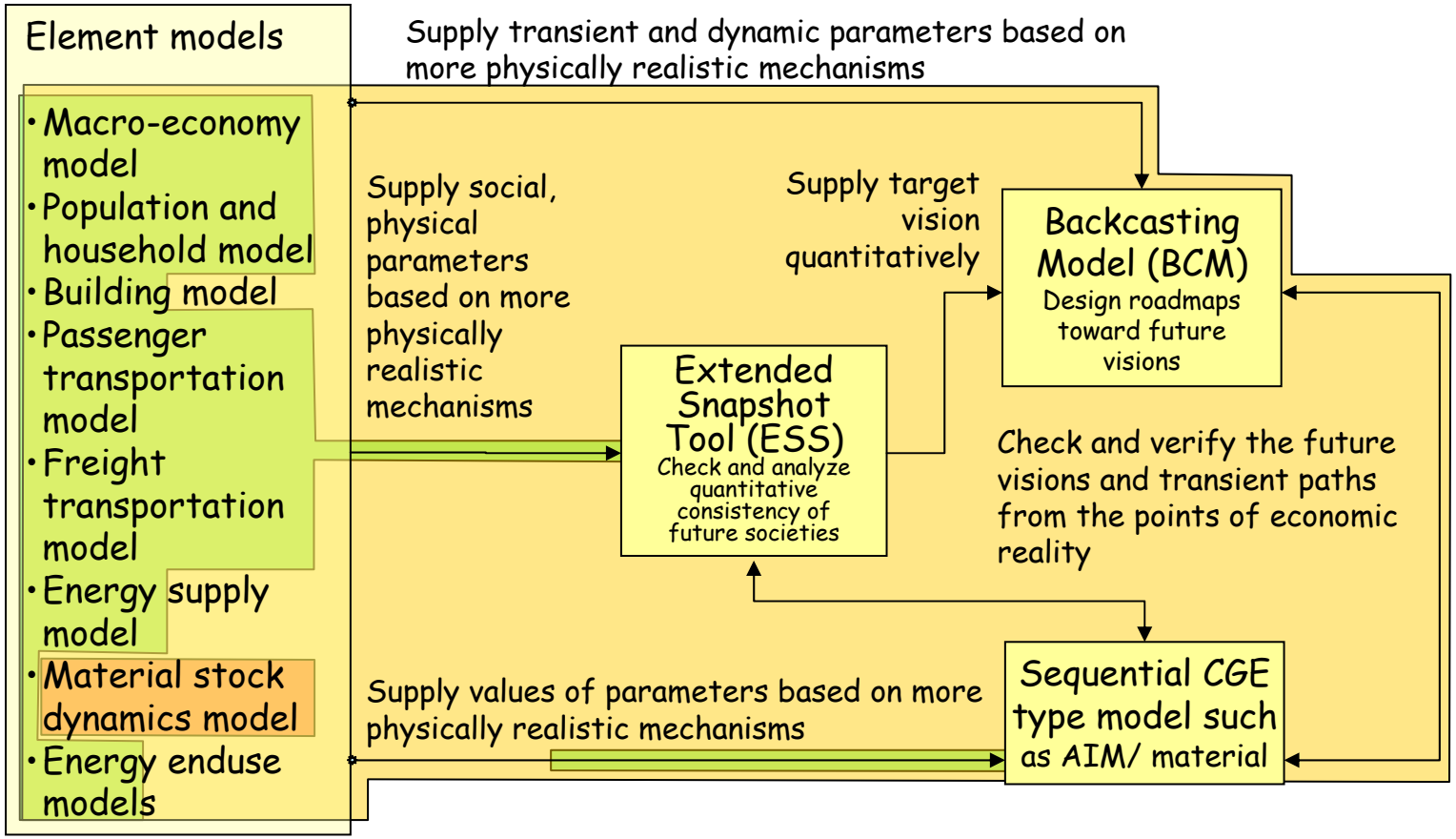
APPLICATION

- Japan 2050 LCS study
- Shiga 2030 Sustainable Society study
- Kyoto 2030 LCS study
- Iskandar Sustainable Society study

REMAINING AND REQUIRED IMPROVEMENT

- Linking with BCM
- Friendly interface and good operationality
- Systematic extension to other environmental loads

Linkage among ESS, BCM, and Element models

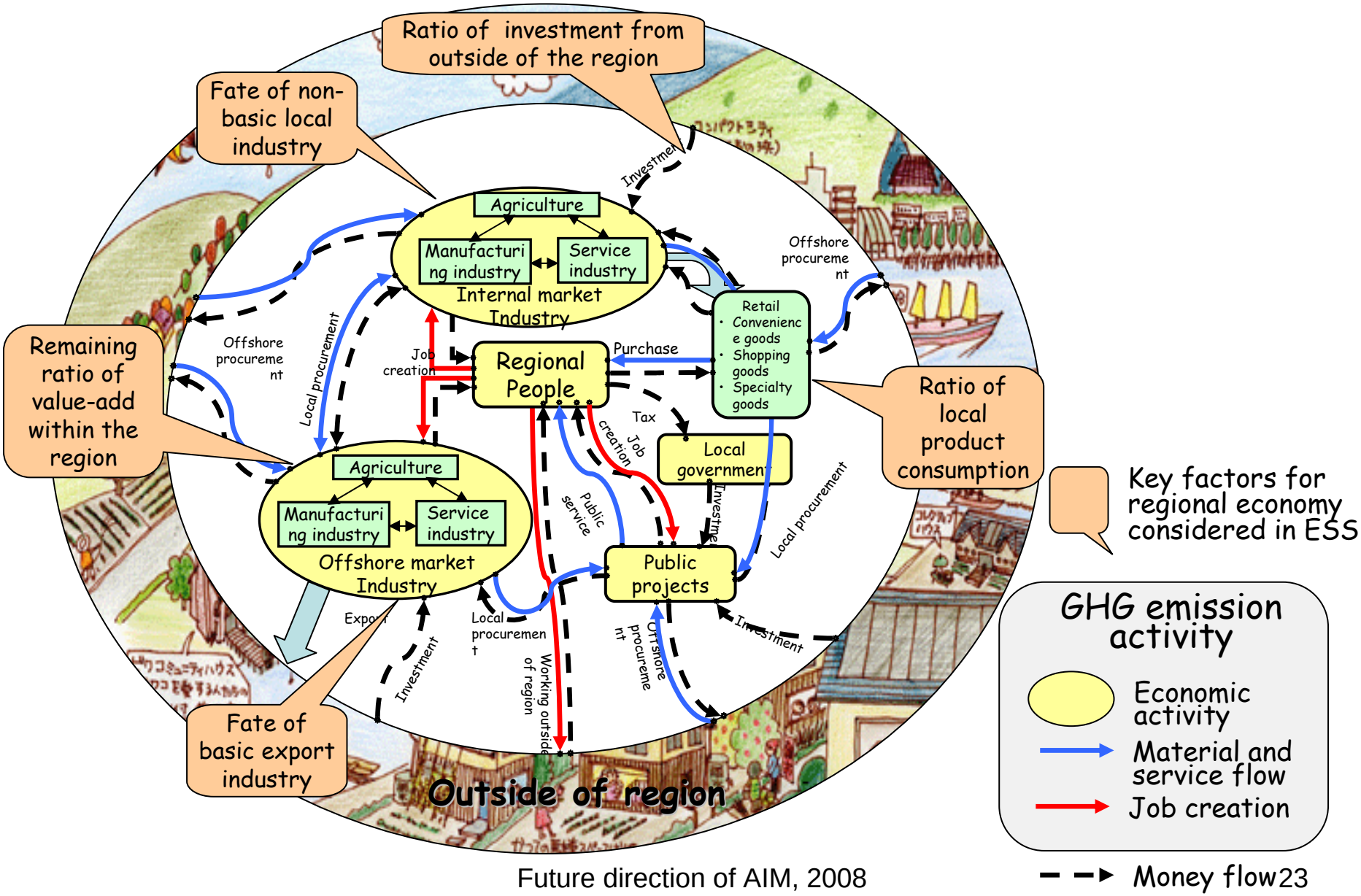


We have completed most of element models, ESS and the 1st version of BCM.

Now preparing the operational version of BCM and also material stock model.

After completing them, we will assemble them to one Integrated Model for Sustainable Society.

More comprehensive model for regional LCS study:
Key modeling parameters in regional ESS from a view point of regional development



Future direction of AIM, 2008

AIM model family, FY2008

Category	Name	Category	Objective	Model type	Target year	FY 2006-2007 activity
Top-down models	Ecosystem	Conservation of ecosystem/ water stress/ landuse/ pollution in developing countries	Modeling of relationship among economic activities, land use and ecosystem	Multi-regional CGE + various environmental process models	~2100	Merge and extend to one global/CGE model as a plat home of AR5 scenario activity
	Global/CGE	Energy, GHG Control	Projection of long-term GHGs emission	Multi-regional CGE model	~2100-2150	
	Material	CO2 reduction, energy consumption, waste management. environmental industry	Economic and material flow impact by climate and other environmental policy	One regional national CGE model	~2030-2050	Connecting with stock models, houshold models, transport models and so on.
	Econometric	Forecasting macro-economic frame	Quantification and analysis of macroeconomic and energy variables	Country-level econometric model	~2050	Extend to a multi-regional world model
	Backcasting	GHG, Energy, Low carbon society	Establishing scenarios toward saustainable society from view points of environment and economy	Country-level dynamic optimization model	~2050	Implementation and Operation
Models /Tools for scenario making	Population/Household	Population, household	Establishing scenarios toward saustainable society from view points of environment and economy	Cohort-component model, houshold transition matrix model	~2050	Quantitative shinario making tools for mid-term
	Building	Residential, non-residential building	Estimation of building demands related to houshold change, economic change and so on	Stock dynamics model	~2050	
	Transport	Passenger and Freight transport demand	Estimation of transport demand related to national/regional/urban land planning	Trip generation, modal share modeling	~2050	
	Stocks	Infrastracture, capital, buildings	Estimation of raw material needs, waste generation related to recycling and economic activity	Stock dynamics model	~2050	
	Extended Snapshot	Integrating tool of element models	Comprehension of economic activity and environmental loadings with Social Accounting Matrix and energy balancing approach	Accounting tool	~2050	
	Energy supply and demand regulation	Temporal and spatial regulation of electlicity, heat and hydrogen	Adjustment among temporal and spatial fluctuation of energy demand and supply	Simulation and optimization type model	~2050	
	Enduse[global]	GHG,SO_2,NO_X,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2050	Still developing. Estimation of feasibility and economic burdens of low carbon world
	Enduse[country]	GHG,SO_2,NO_X,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2050	Keep maintainance
	Enduse[local]	GHG,SO_2,NO_X,PM abatement technology	Technology selection for global warming, regional air pollution	Country-level or regional-level bottom-up model	~2030	
	Impact	Impact assessment of climate change	Impact assessment at global scale	Process model based on raster GIS data	~2100	Keeping maintainance and reinforcement？ Anyway, it is necessary to reconfirm the developing policy, to review and to reorganize it.
	Impact[Country]	Impact assessment of climate change	Impact assessment at country scale	Process model based on raster GIS data	~2100	
	Impact[policy]	Integration of mitigation policy evaluation and impact assessment	Investigation of stabilization level and mitigation policy with considering consequent impacts	Calculating global GHGs paths	~2200	Change to multi-regional emission model, improve climate and carbon cycle modules
	Water	Impact assessment	Integrated assessment of water supply and demand focusing on urban area	Coupling process model with and statistics	~2050	Coupling with AIM/GBDB(Global basin database)
	Enduse[Air]	Environmental Assesment	Regional and country scale atmospheric environmental analysis	Atmospheric quality model + GIS	~2050	Coupling with AIM/Enduse[local], for assessing long-range and urban air pollution issues.

→Dr.Masui

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→Ms.Kawase

→Mr.Hibino
Mr.Gomi

→Dr.Hanaoka
Dr.Kanamori
Mr.Akashi

→Dr.Hijioka