Land Cover/Land Use Change SARI International Regional Science Meeting in South/Southeast Asia
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Impacts of Economic Development and Urbanization in South/Southeast ASIA for Estimating Future GHGs Emissions - CH_4 Emissions from Landfill -

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AIM ASIA-PACIFIC INTEGRATED MODEL

Asia-Pacific Integrated Model
http://www-iam.nies.go.jp/aim/index.html

NIES JAPAN

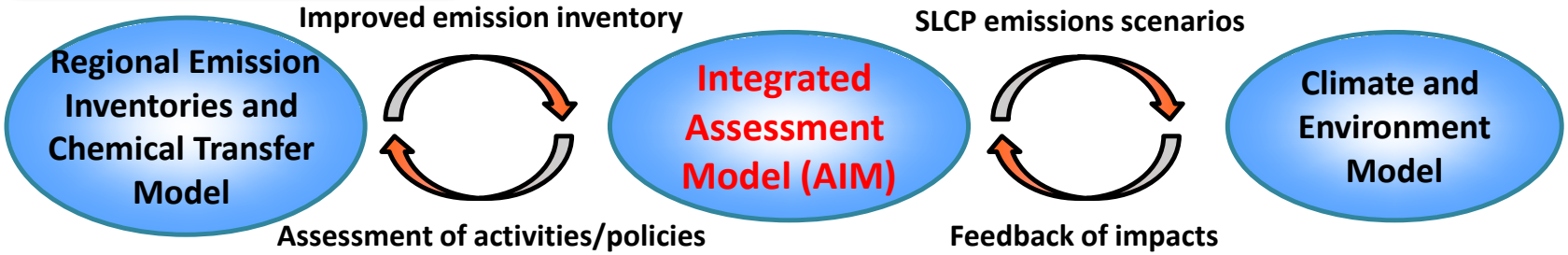
MOEJ-S12: Promotion of climate policies by assessing environmental impacts of SLCP and seeking LLGHG emission pathways (FY2014 – FY2018)

Goal: To develop an integrated evaluation system for LLGHG and SLCP mitigation policy, by interconnecting emission inventory, integrated assessment models, and climate models.

Theme 1: Air quality change event analysis
- Analysis on regional AQ change
- Development of emission inventory
- Inversion algorithms of emission estimation

Theme 2: Integrated model and future scenarios
- Global socio-economic scenarios
- National & regional emissions scenarios
- Urban & household emissions AQ assessment

Theme 3: SLCP impacts on climate & environment
- Impact assessment of aerosols & GHG
- Assessment of health, agriculture, water cycle, sea level rise



Chemical transfer model and emission inventory in Asia

AIM/Enduse model
Socio-economical & emissions scenario

Climate model, earth system model
Climate change impact & adaptation

Theme 4: Integrated operation system (Toolkits, data archive)

Science → Model improvement → Experiment setup, Database development, Metric definitions

Stakeholders, Policy makers → System utilization → CCAC, UNFCC, IPCC, EANET, Proposal and assessment of climate and air pollution policies

Society → Information transmission → MDG・SDG・Future Earth

Regional strategy ⇅ Global strategy

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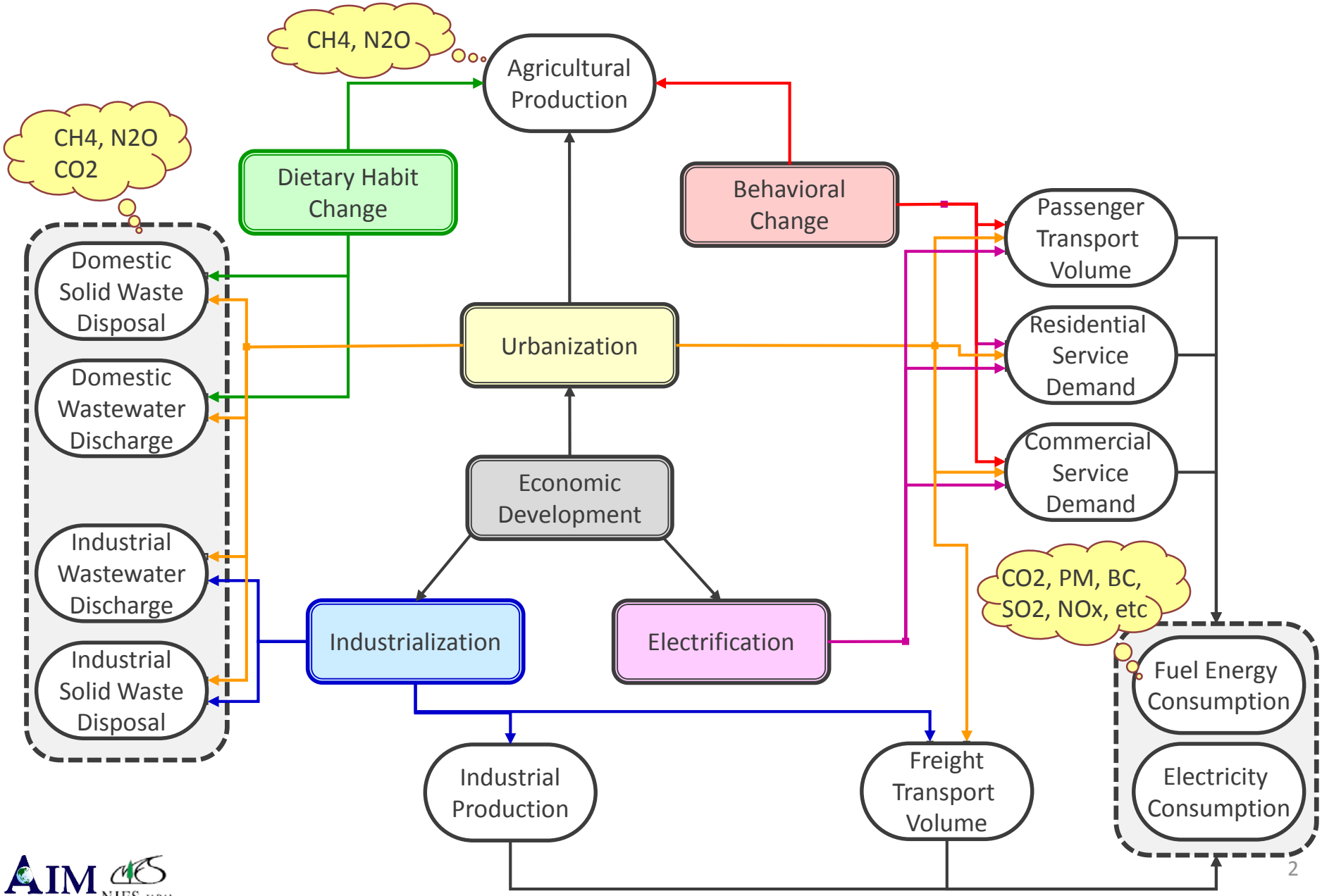
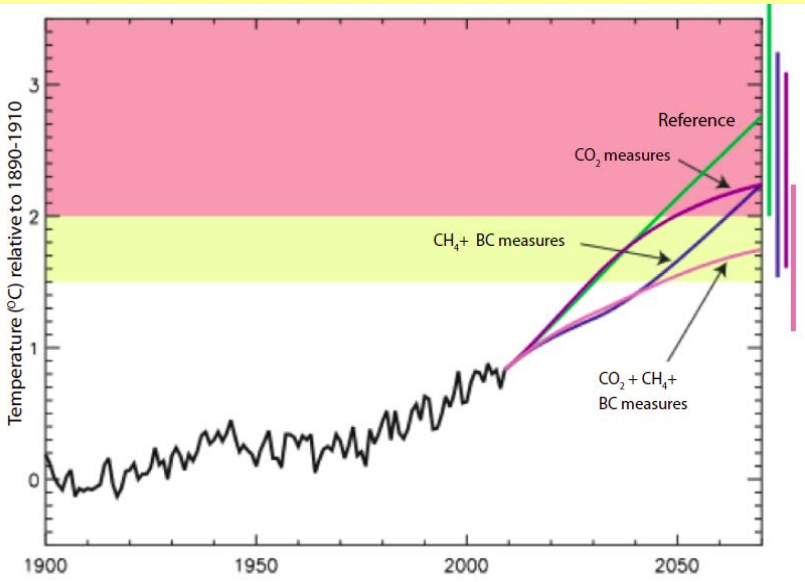
Overview of Key Research Topics



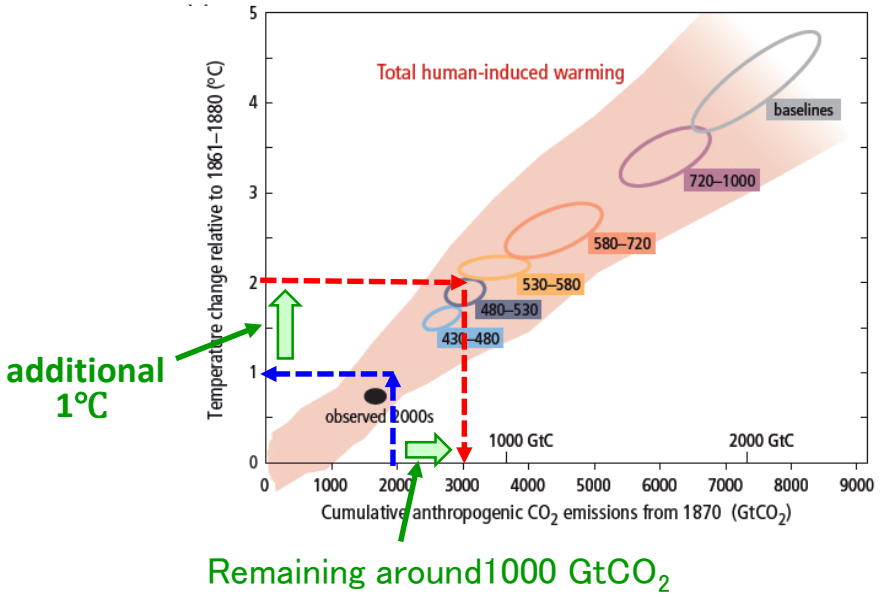
Research Motivations
- how to achieve emissions pathways of the 2℃ target? -

If SLCPs reductions are fully implemented by 2030, it reduces global warming between 2010 to 2040 by about 0.4 – 0.5 ℃



Source）UNEP (2011), Figure ES-2

Remaining cumulative CO_2 emissions (i.e. carbon budgets) staying below 2℃ are around 1000 $GtCO_2$



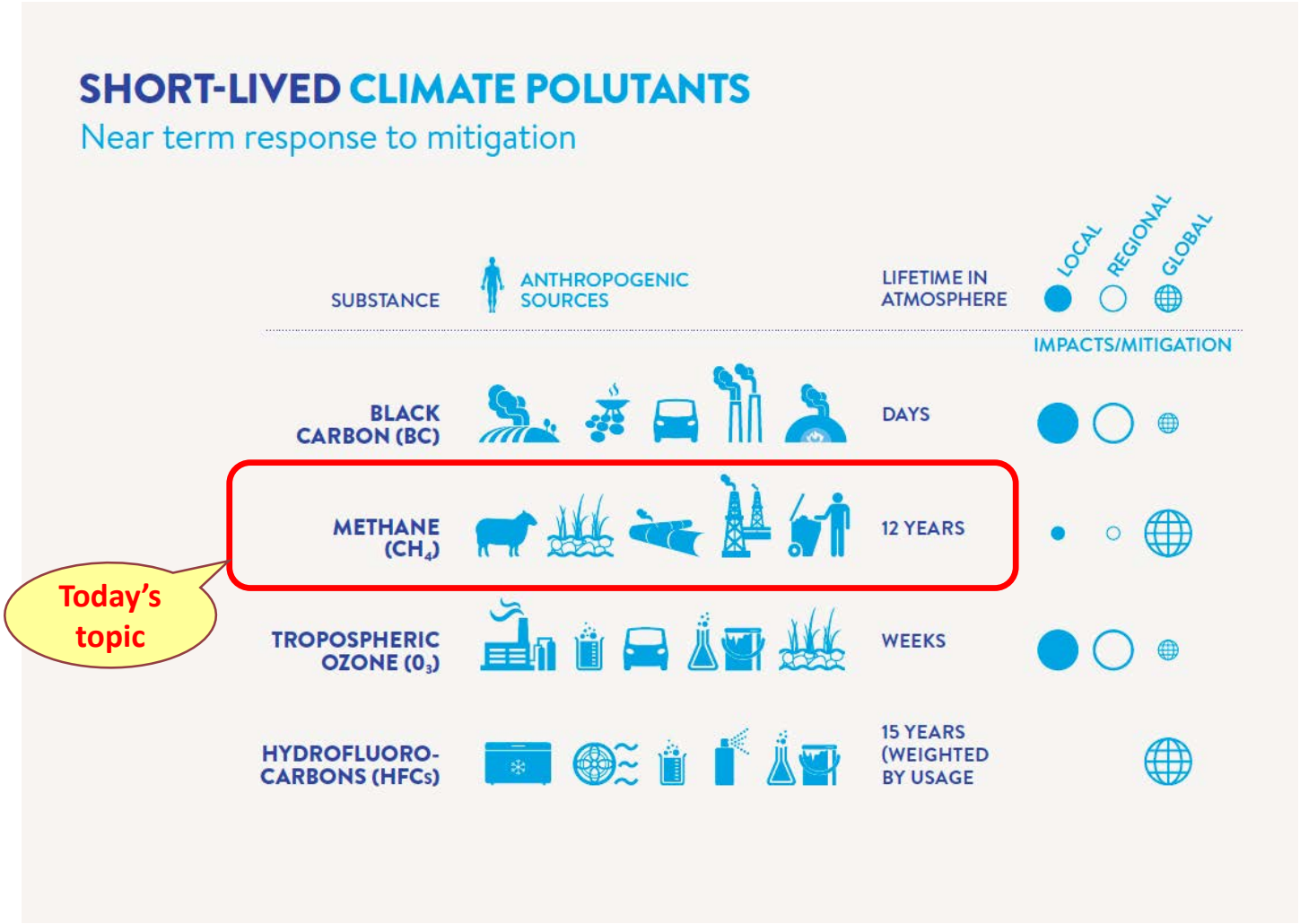
Source) IPCC AR5 Synthesis Report (2015) Figure SPM.5

What kinds of SLCP measures can be? How drastic it should be?

How about air pollutants reductions and their benefits and trade-offs, when achieving 2 degree?

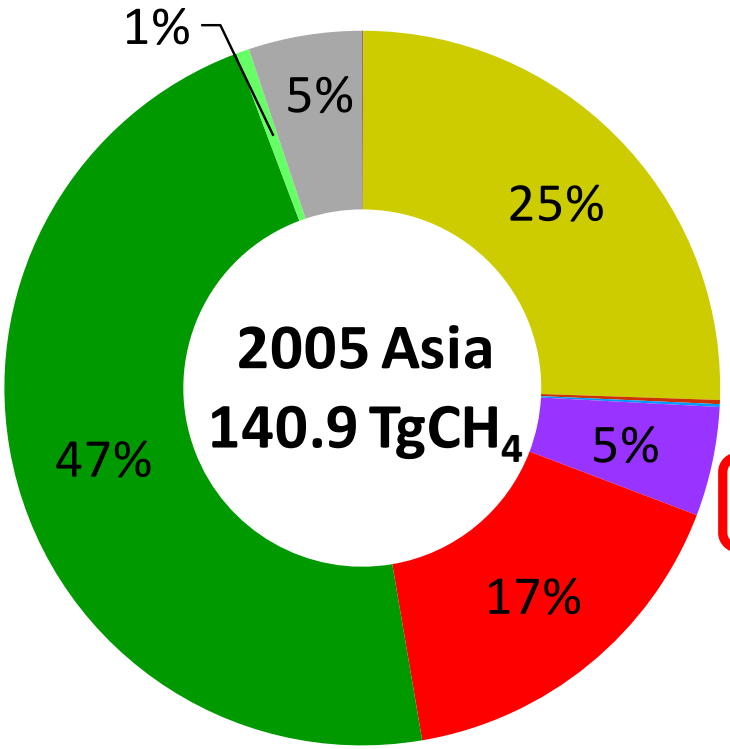
This study aim to seek for balanced emissions scenarios of LLGHGs, SLCPs, air pollutants and evaluate cobenefits and tradeoffs of mitigation measures

Short-Lived Climate Pollutants
- How much can we reduce SLCPs? -



Source）Climate and Clean Air Coalition http://www.ccacoalition.org/en/science-resources

Backgrounds
- Sources of CH_4 emission from Asia



- Power
- Mining
- Industry
- Transport
- Buildings
- Waste
- Agriculture
- Agriculture waste burning
- Savannah burning etc

We have mitigation measure for waste.
We can reduce landfill waste.
But how?

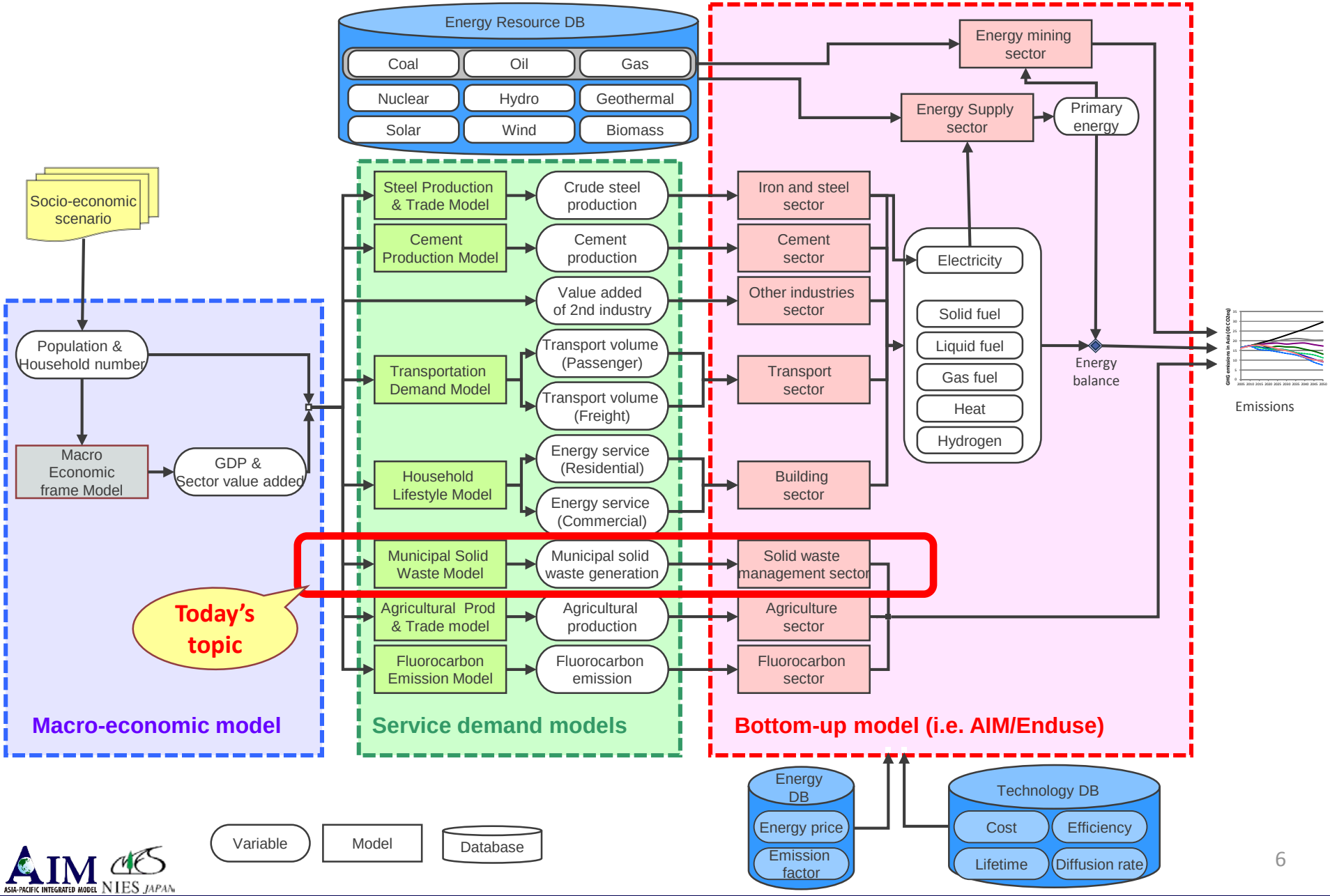
relation with economic development

relation with lifestyle

relation with landuse (i.e. landfill)

Source）EDGER4.2

AIM/Enduse[Global] Model and Element Models



Sub-Sectors in the Waste Sector

- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories

GHG emissions in the Waste Sector

4A Solid Waste Disposal
CH_4 emissions from landfilled municipal, industrial and other solid waste are reported.
Generally, this category is the largest source of GHG emissions in the Waste Sector.

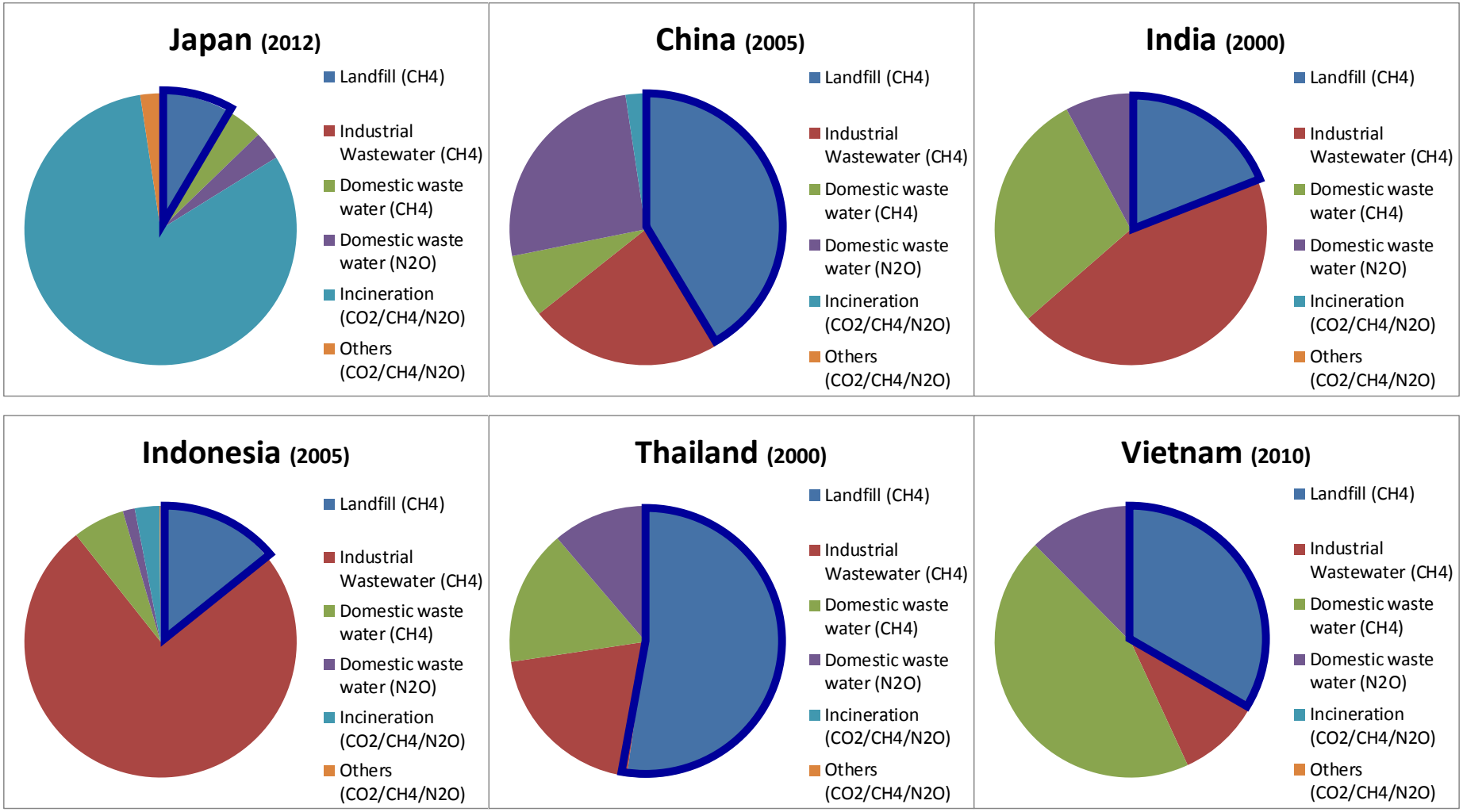
4B Biological Treatment of Solid Waste
CH_4 and N_2O emissions from Composting and Anaerobic digestion of organic waste are reported.

4C Incineration and Open Burning of Waste
CO_2 and CH_4 and N_2O emissions from waste incineration are reported. GHG emissions from incineration with energy recovery are reported in the Energy Sector.

4D Wastewater Treatment and Discharge
CH_4 and N_2O emissions from the wastewater treatment and discharge are reported.

4E Other

GHG Emissions from Waste Sector in Asian Countries



Note)

In Indonesia and India, methodology of CH_4 emissions from industrial wastewater need to be carefully investigated whether emissions are over-estimated.

GHG Emissions from Waste Sector from Asian Countries

Soure	Japan Inventory (2012)	China SNC (2005)	India SNC (2000)	Indonesia SNC (2005)	Thailand SNC (2000)	Vietnam JICA (2010)
Landfill※2 (CH_4)	2,928	46,284	10,252	24,409	4,864	5,005
Industrial waste water (CH_4)	103	25,620	23,163	124,673	1,902	1,617
Domestic waste water (CH_4)	1,361	8,400	15,036	10,298	1,504	6,827
Domestic waste water (N_2O)	1,175※1	28,830	4,101	2,366	1,023	1,838
Incineration・Open burning (CO_2, CH_4, N_2O)	28,068	2,658	NE	4,886	23	65
Others (Compost etc)	826	0	---	199	0	0
Total	**34,460**	**111,792**	**52,552**	**166,831**	**9,316**	**15,352**

Unit : $ktCO_2(CO_2eq)$

※1 : N2O emission from domestic sewage includes industrial waste water

※2 : Solid waste includes industrial solid waste in Japan and Viet Nam. Solid waste in China, India, Indonesia, Thailand are supposed not to include industrial solid waste.

Methodology in the IPCC Guideline
- how to estimate CH_4 from solid waste in landfill -

- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories

$$CH_4\ Emissions = \left[\sum_x CH_4\ generated_{x,T} - R_T\right] \bullet \left(1 - OX_T\right)$$

$$CH_4\ generated\ potential = W \bullet DOC \bullet DOC_f \bullet MCF \bullet F \bullet (16/12)$$

Where

T : inventory year,
x : waste category or type/material,
R_T : recovered CH_4 in year T,
OX_T : oxidation factor in year T,
W : mass of waste deposited,
DOC : degradable organic carbon in year of deposition,
DOC_f: fraction of DOC that can decompose,
MCF : CH_4 correction factor for aerobic decomposition in the year of deposition,
F : fraction of CH_4 in generated landfill gas.

How to estimate MSW generation is one of keys for the future GHG emissions scenarios

Research Questions and Methodologies

[Research question 1]

What kinds of socio-economic variables can explain the historical trends of MSW generation per capita?

① Urbanization ratio
② Energy consumption per capita
③ GDP per capita
④ Income per capita

Note)
We need to choose the type of socio-economic variables by considering data availability.

Research Questions and Methodologies

[Research question 2]

- What kinds of equations can be applied, in order to explain MSW generations increase?
- If the linear regression is used for estimating MSW generations, it means that generated MSW amounts will keep increasing as explanatory variables increase. But, after reaching a certain level, will it be saturated and/or declined ?

Single linear approximation $Y = aX + b$

Logarithmic approximation $Y = a\ln(X) + b$

Quadratic approximation $Y = aX^2 + bX + Z$ ← Environmental Kuznets curve

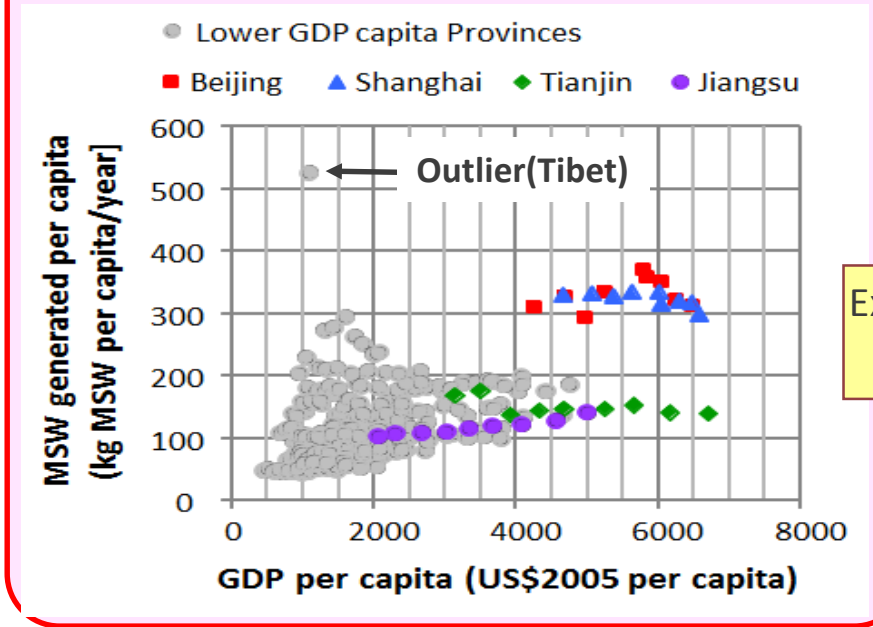
Where

Y : MSW generation per capita,
X : Socio-economic variables
a, b : constant value
Z : intercept coefficient.

Historical Municipal Solid Waste (MSW) Generation
- China: rapid growing and urbanizing country -

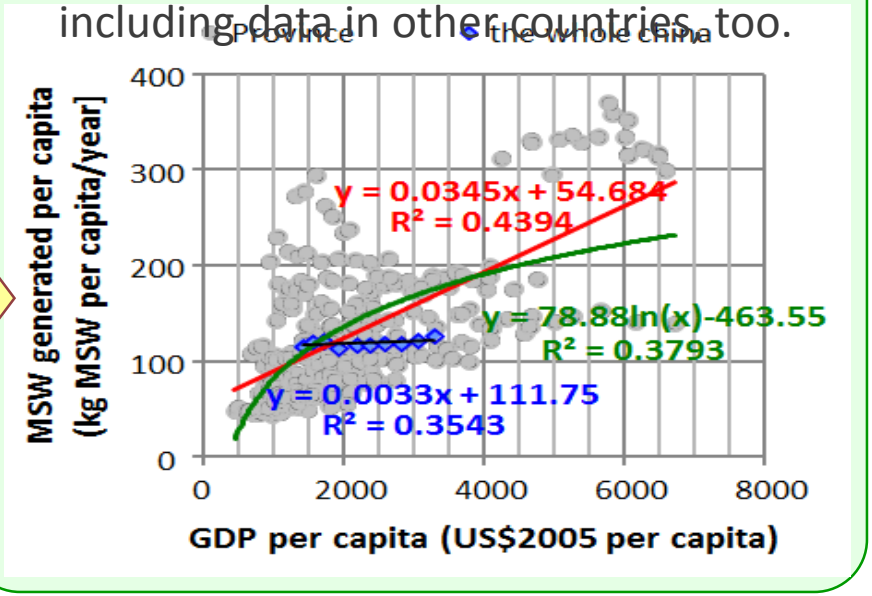
Is there correlation between “provincial GDP per capita” and “provincial MSW generated per capita”, to comprehend features of urbanization ?

- Large provinces have linear correlations between GDP per capita and MSW generated per capita in each provinces.
- But difficult to see correlations among provinces. Size and growth rate of MSW per capita are different in large provinces



Excluding outlier

- If data in the whole China is compared with provincial data, its characteristic is different because of provincial diversities.
- No superior correlations between linear or logarithm functions, in China’s data. Thus It is better to investigate features including data in other countries, too.



Source) provincial data from 2003 to 2012 in Chinese Statistical Yearbook

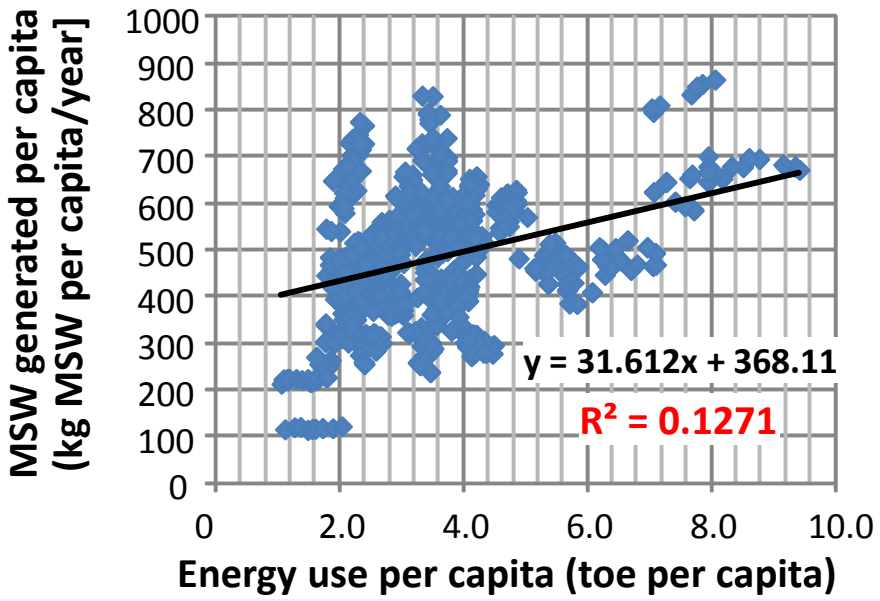
Verification of Research Questions
- Correlation with energy use and urbanization -

[Question]

The more energy use per capita increase, the more MSW per capita are generated ?

Answer: there is a weak correlation.

(maybe because energy consumption data includes industries as well as residential ?)

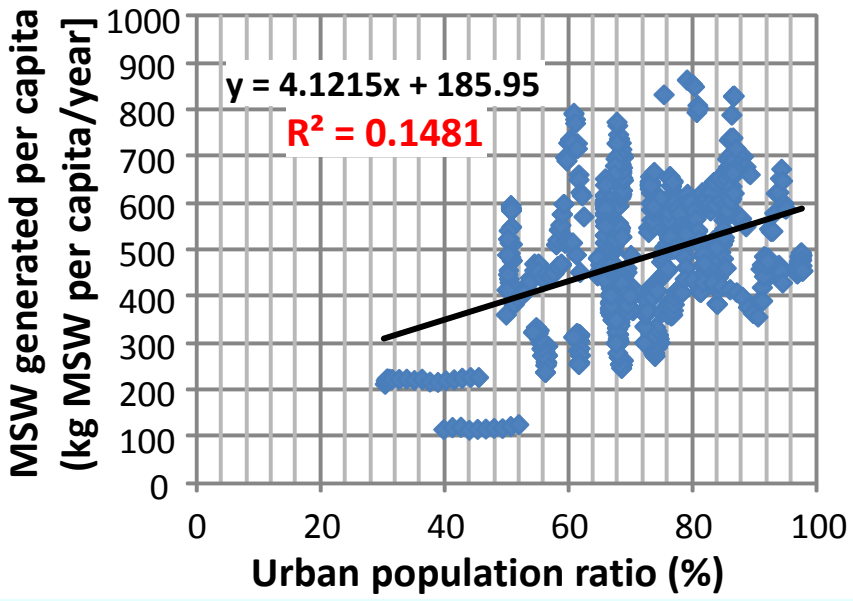


[Question]

The more urbanization increase, the more MSW per capita are generated ?

Answer: there is a weak correlation.

(because urban ratio may be one element but not a major for waste generation?)



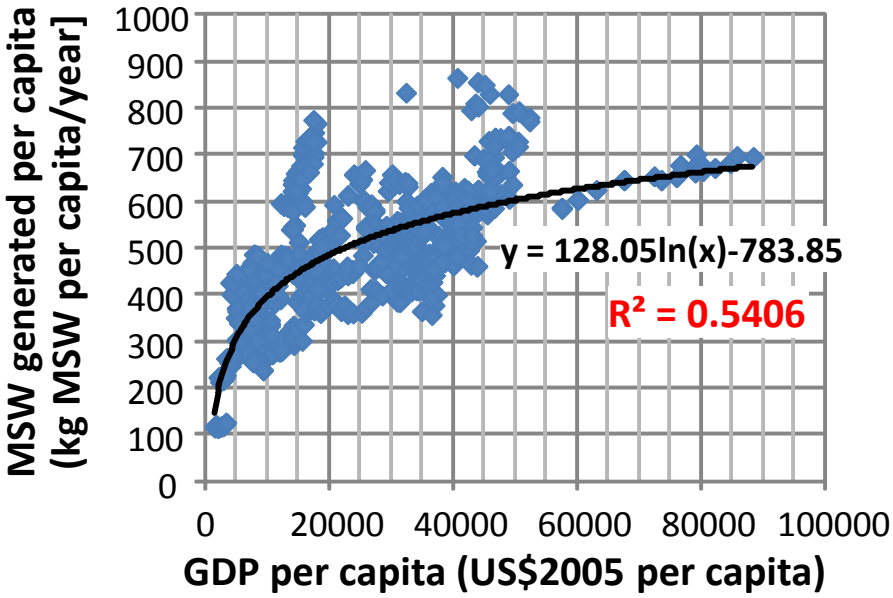
Source) Panel data include Japan, China, Thailand, USA, EU27

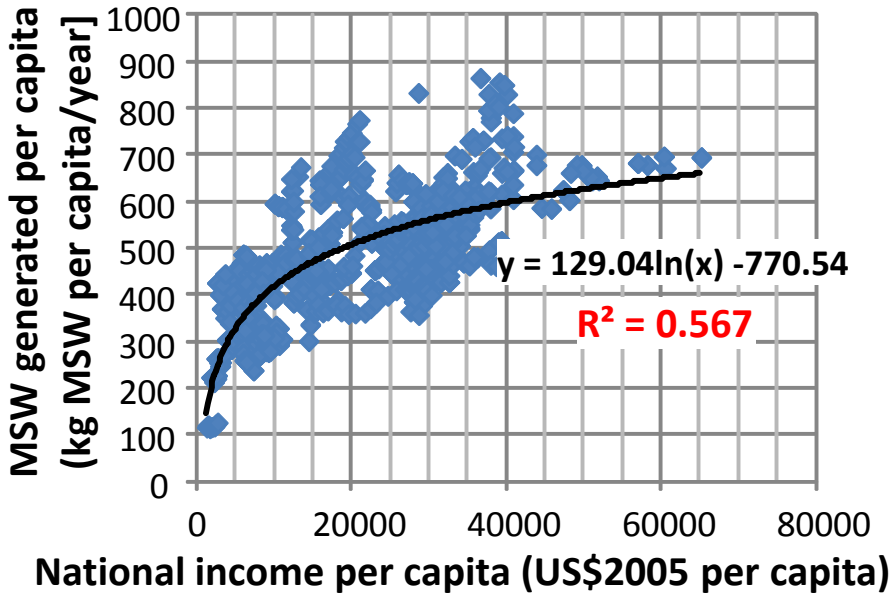
Verification of Research Questions
- Correlation with GDP per capita and income per capita -

The more GDP per capita increase, the more MSW per capita are generated?
The more income per capita increase, the more MSW per capita are generated?

Answer:

- Coefficient of determinations are almost similar between these two cases, and it can be reasonable to use GDP per capita as an explanatory variable.
- However, R^2 is not high enough, thus it is necessary to check outliers carefully and also to include more reliable data especially in lower-income countries.

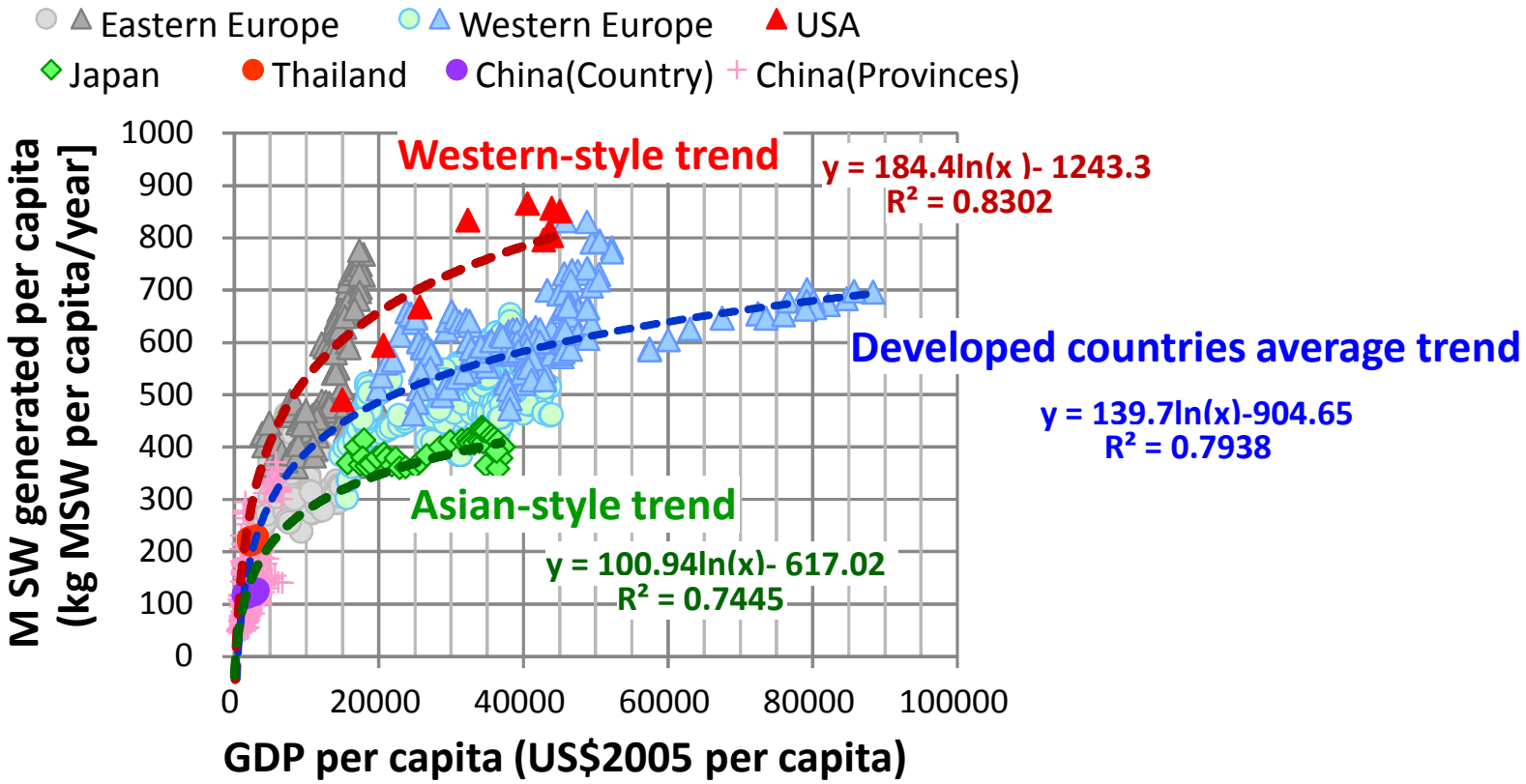




Source) Panel data include Japan, China, Thailand, USA, EU27

Verification of Research Questions
- Correlation with GDP per capita -

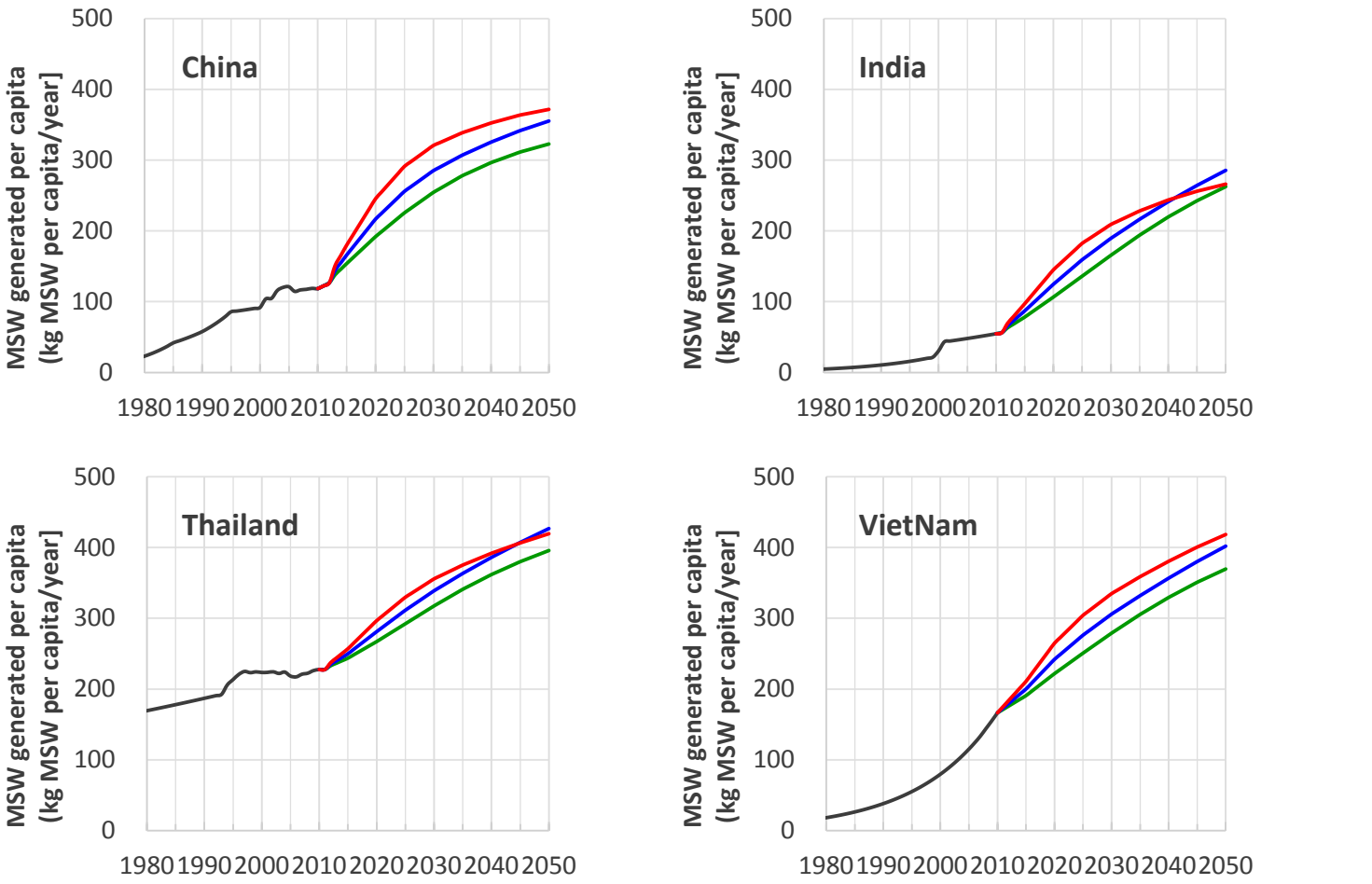
- R^2 become increased and reliable if data in the lower-income level is added.
- However, it is necessary to carefully discuss methodologies when GDP per capita reaches the level beyond 5000 US$ per capita, because the increasing trends are different, which trends developing countries will follow.



Source) Panel data include Japan, China, Thailand, USA, EU27, China provincials

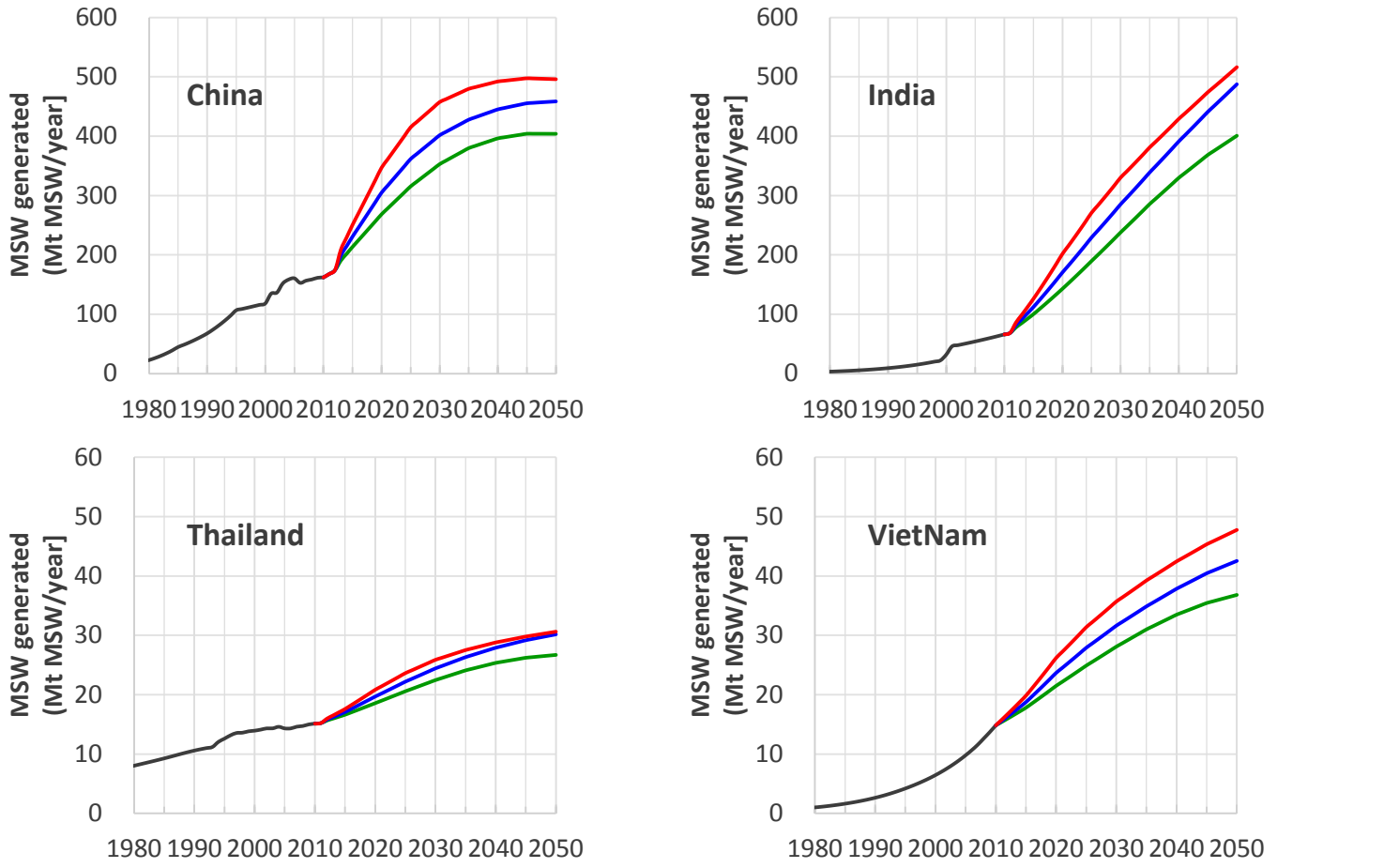
Future MSW Generation per capita
- Example in Asian Developing Countries -

- MSW generated per capita will increase as GDP per capita increase in all countries.



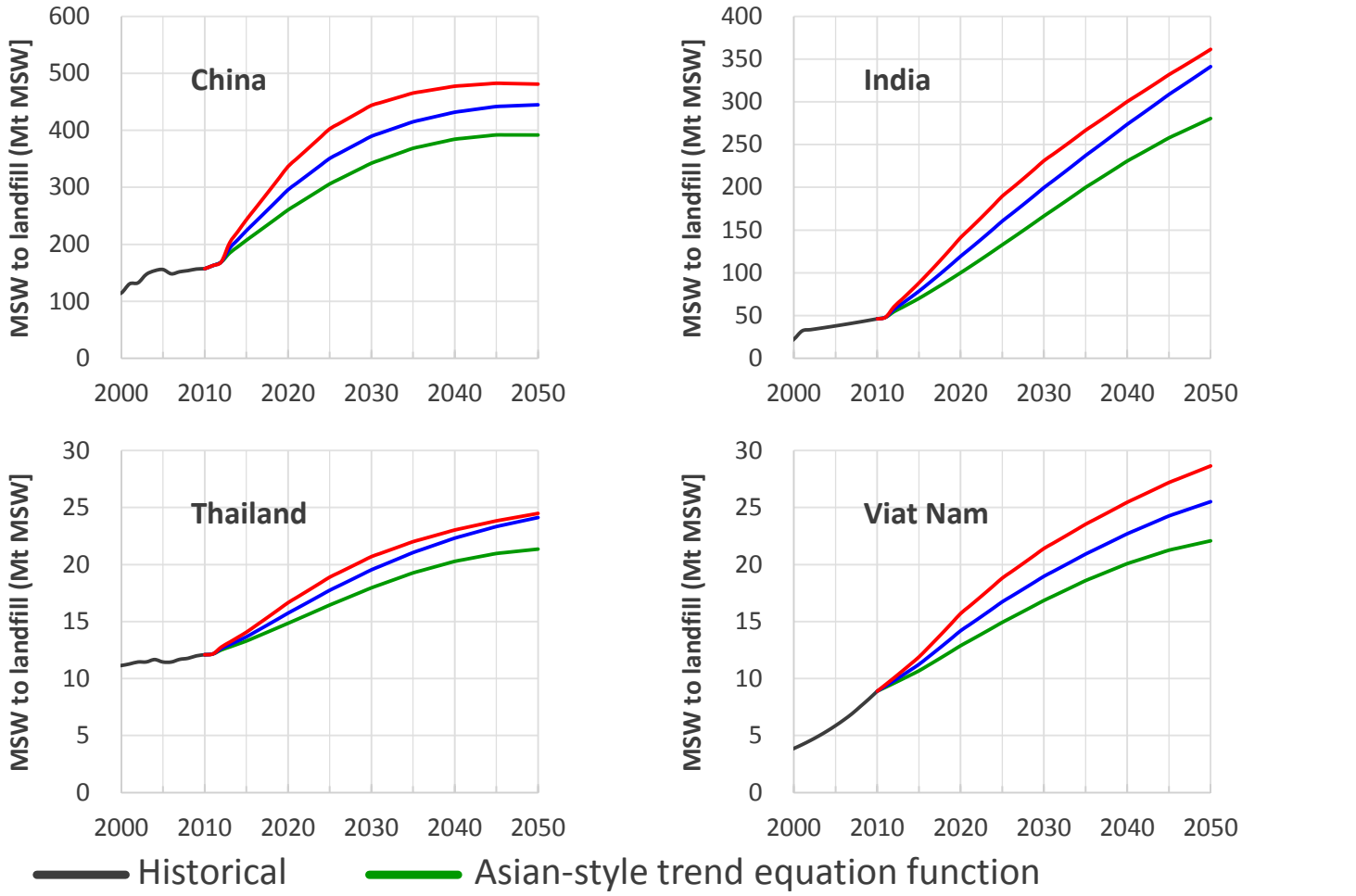
Future MSW Generation
- Example in Asian Developing Countries -

- MSW generated amount = MSW generated per capita × population



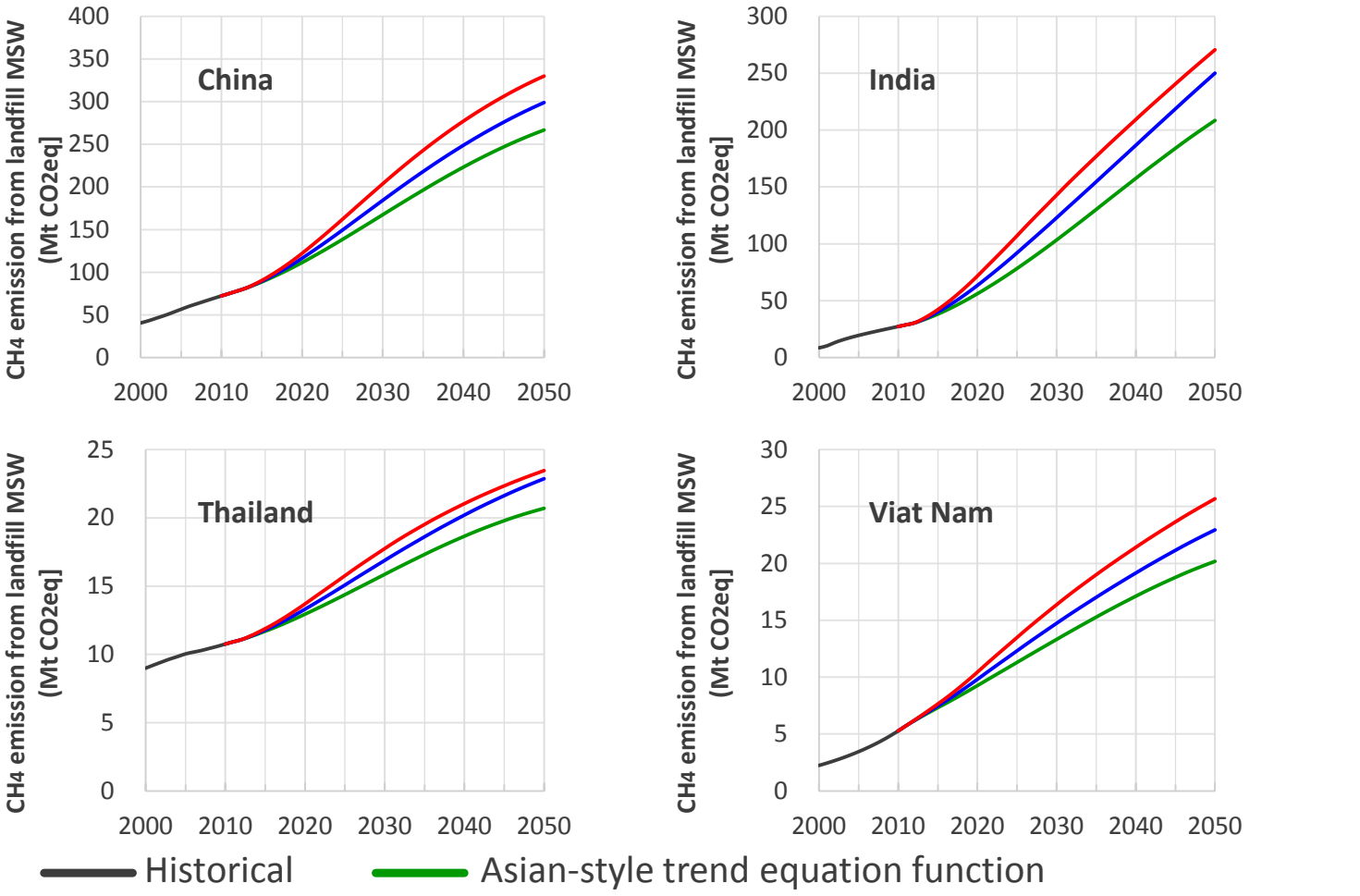
Future MSW to Landfill
- Example in Asian Developing Countries -

- Landfill ratios are set at 97%, 70%, 80% and 60% in China, India, Thailand, Viet Nam respectively based on national specific values and the IPCC guideline default values



Future CH_4 emissions from Landfill MSW
- Example in Asian Developing Countries -

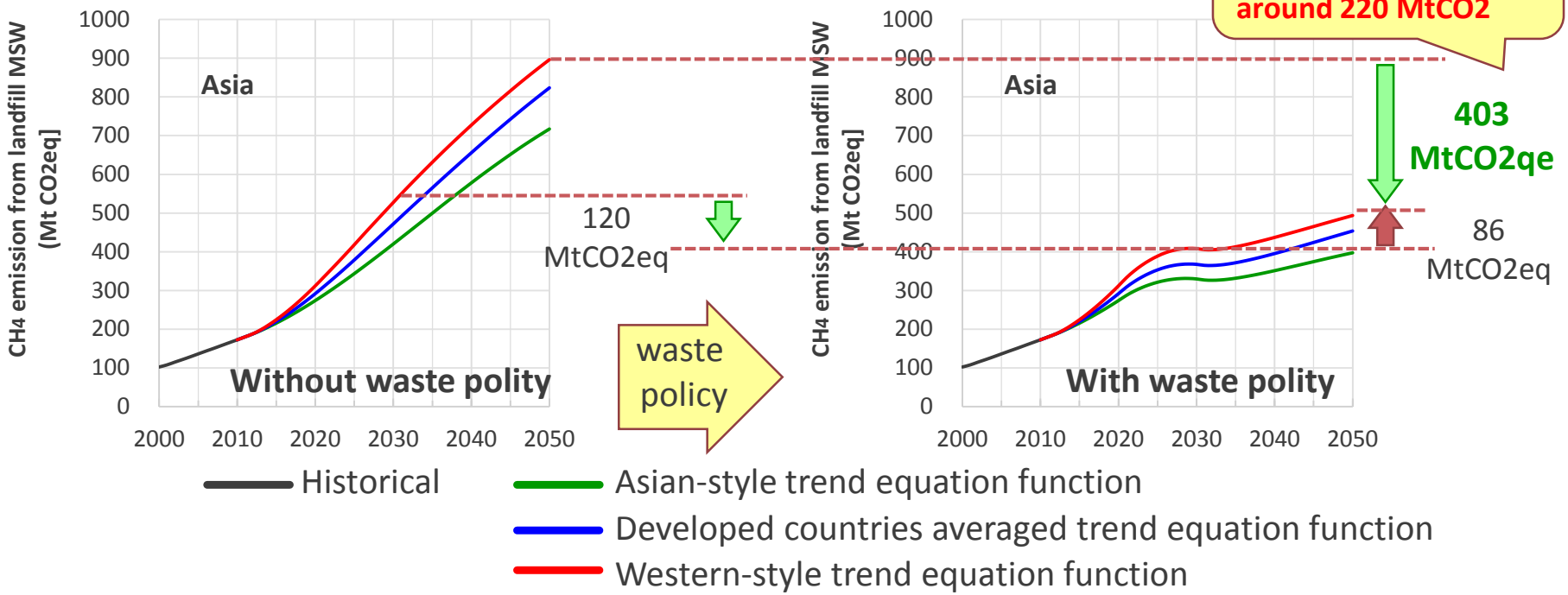
- Parameters such as waste compositions, degradable organic carbon, aerobic decomposition, etc, are set at based on national specific values and the IPCC guideline default values



Effects of Reducing Landfill and Introduce Incineration
- Example in Asian Developing Countries -

- Considering a scenario if the whole Asia countries take waste policy to cut landfill ratio by half by 2030 and to increase incineration.
- After 2030, keep the same landfill ratio as same as the 2030 level.

Note) CO2 emission in Thailand in 2010 was around 220 MtCO2



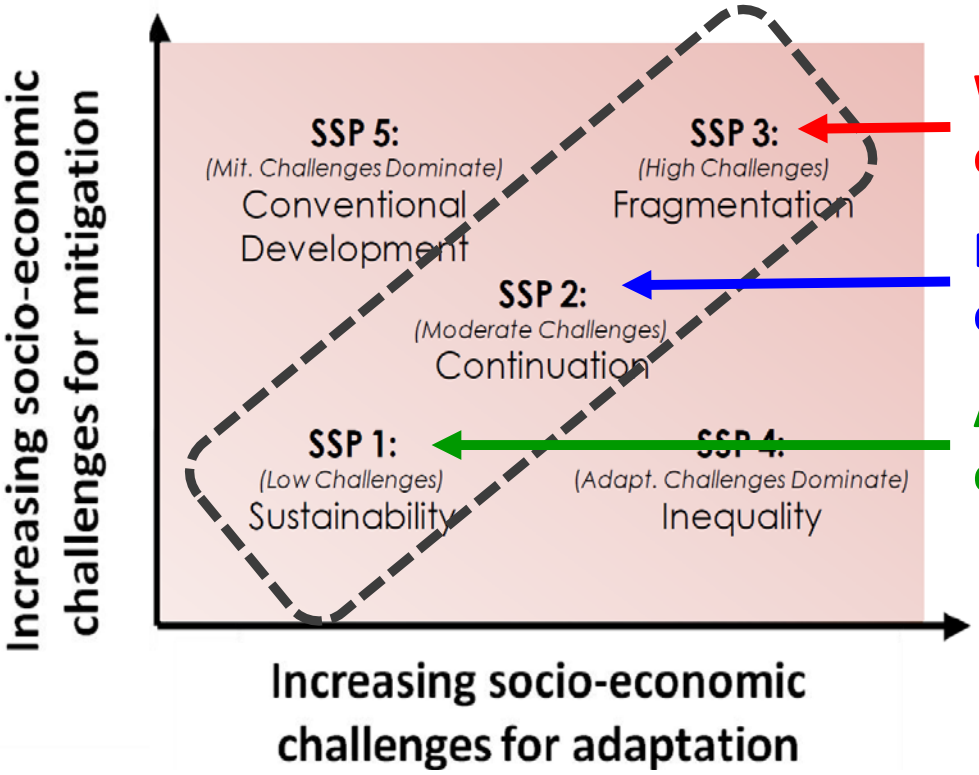
- Reduction of landfill can reduce CH_4 emission largely
- However, if the same landfill ratio continues after 2030, CH_4 emission from landfill will increase again due to waste generation growth. Thus necessary to keep accelerating landfill reduction or recovering CH_4 from landfill, to peak out CH_4 emission from landfill.

ご清聴ありがとうございました

Thank you for your attention

Scenario Dimensions
- SSP (Shared Socioeconomic Pathways) -

This study applied three different equation functions to the three different concepts of socio-economic scenarios.



Western-style trend equation function

Developed countries averaged trend equation function

Asian-style trend equation function

(O'Neill, 2012)

Details quantitative data and qualitative stories:
https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about
Peer-reviewed paper: Riahi, K. et al (2017) Global Environmental Change, 42:153-168
http://www.sciencedirect.com/science/article/pii/S0959378016300681

Population and GDP in Asia in SSP Scenarios

Characteristics of GDP per capita will effects on MSW per capita are generated