環境研究総合推進費S-6　一般公開シンポジウム　　Symposium
アジア低炭素社会へのチャレンジ　ーアジアはリープフロッグで世界をかえられるか？
Challenges to Low Carbon Asia　-　Can Asia change the world through leapfrogging ?
国連大学ウ・タント国際会議場　U Thant International Conference Hall, United Nations University

平成25年10月17日（木）　13:00 - 17:00, Thursday, October 17, 2013

資源生産性からみた低炭素社会への道

Resource productivity toward Low Carbon Society

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(独)国立環境研究所	(National Institute for Environmental Studies)
みずほ情報総研	(Mizuho Information & Research Institute)
名古屋大学	(Nagoya University)
立命館大学	(RitsumeikanUniversity)

内容

1. はじめに～デカップリングと資源生産性～
2. アジア低炭素社会プロジェクトにおける資源チームの役割
3. 資本の蓄積に着目した資源消費と炭素排出の分析

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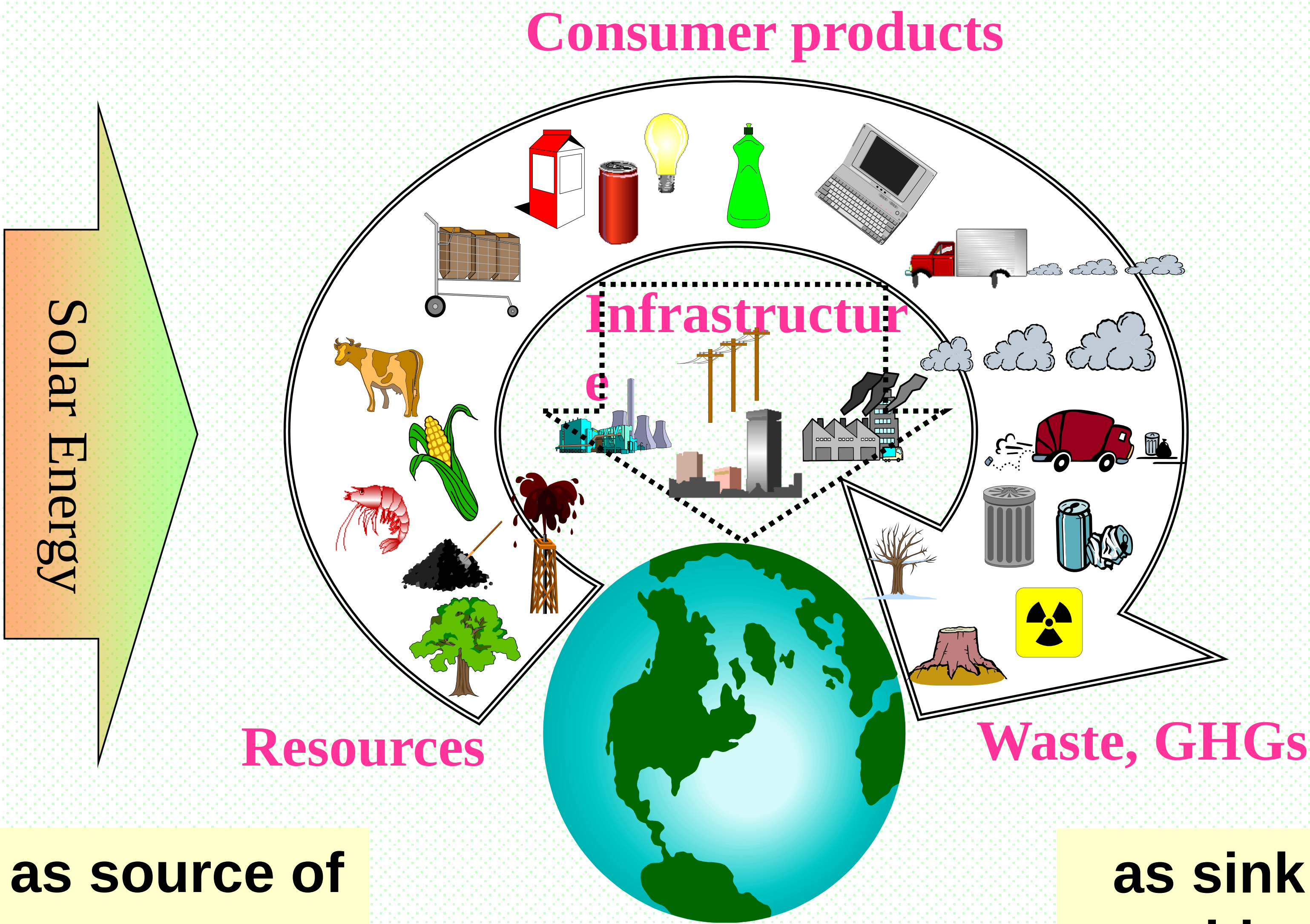
Massive flow of materials on the globe

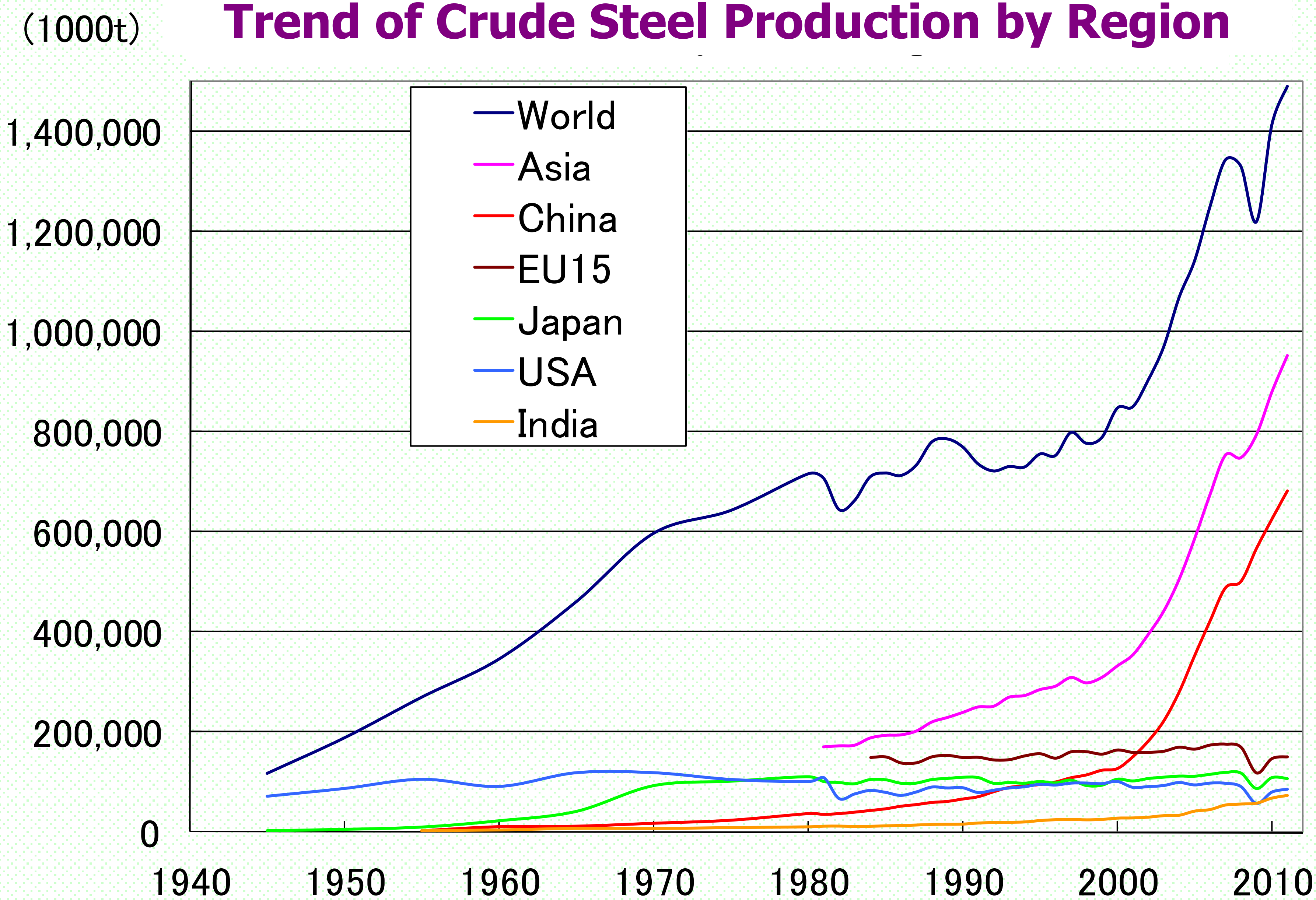


as source of resources

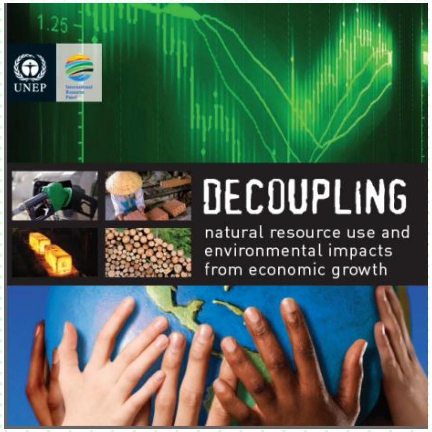
The earth is finite

as sink of residuals

Trend of Crude Steel Production by Region



UNEP国際資源パネルによる「デカップリング」報告書
“Decoupling” report by UNEP International Resource Panel

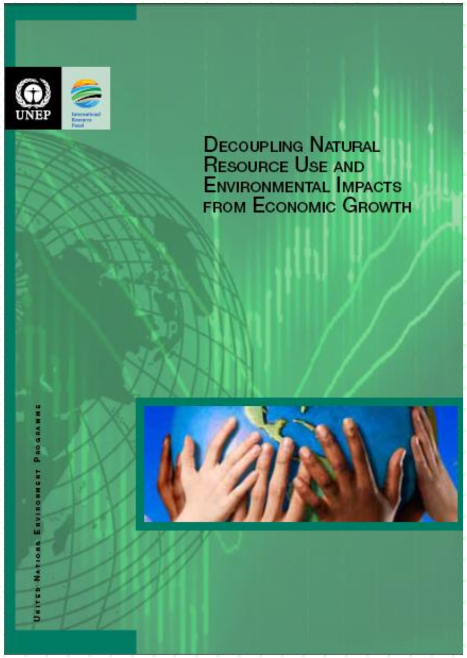


برنامج الأمم المتحدة للبيئة: يمكن
للإنسانية أن تحقق المزيد بمواردٍ أقل
بل ويتحتم عليها ذلك

L’humanité peut et doit faire plus avec moins, souligne le PNUE

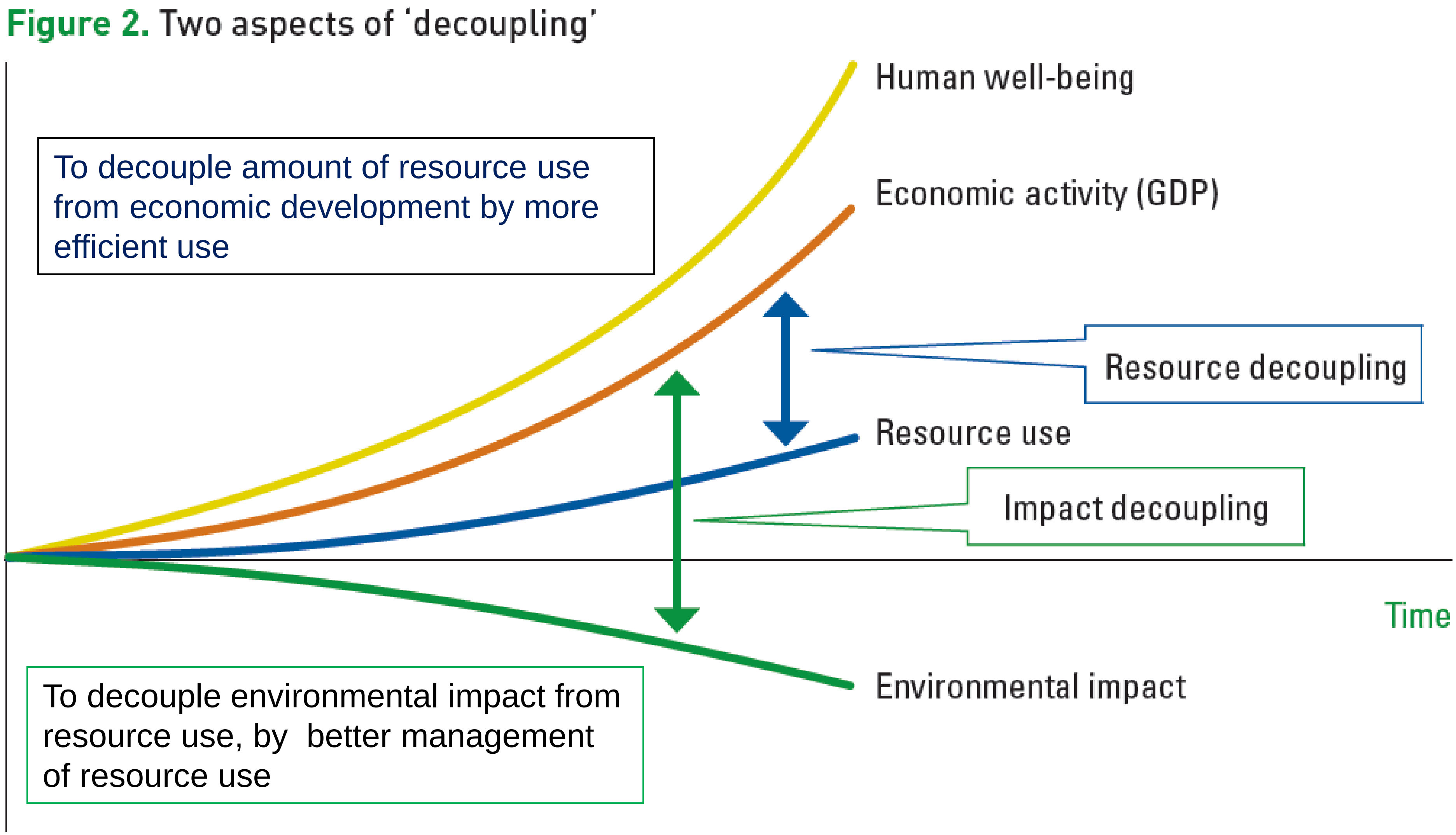
人类能够而且必须
少消耗多办事：环境规划署

Humanity Can and Must Do More with Less: UNEP



http://www.unep.org/resourcepanel/Publications/Decoupling/tabid/56048/Default.aspx

Concept of "Decoupling"



Source:UNEP/IRP

International Resource Panel

- Established on November 9th, 2007
- Secretariat : UNEP/DTIE
- Co-chair:

  Ernst von Weizsäcker and Ashok Khosla
- The overall objective :
- to provide independent scientific assessment of the environmental impacts due to the use of resources over the full life cycle,
- and to advise governments and organizations on ways to reduce these impacts.

http://www.unep.org/resourcepanel/

What is "Resource Productivity" ?

- Increase of resource productivity means obtaining more output or better utility for human well-being from products (i.e. goods and services) while using less natural resources, such as fossil fuels, metals and minerals, biomass, land, water, etc.

- The term "decoupling" is often used in the same context.

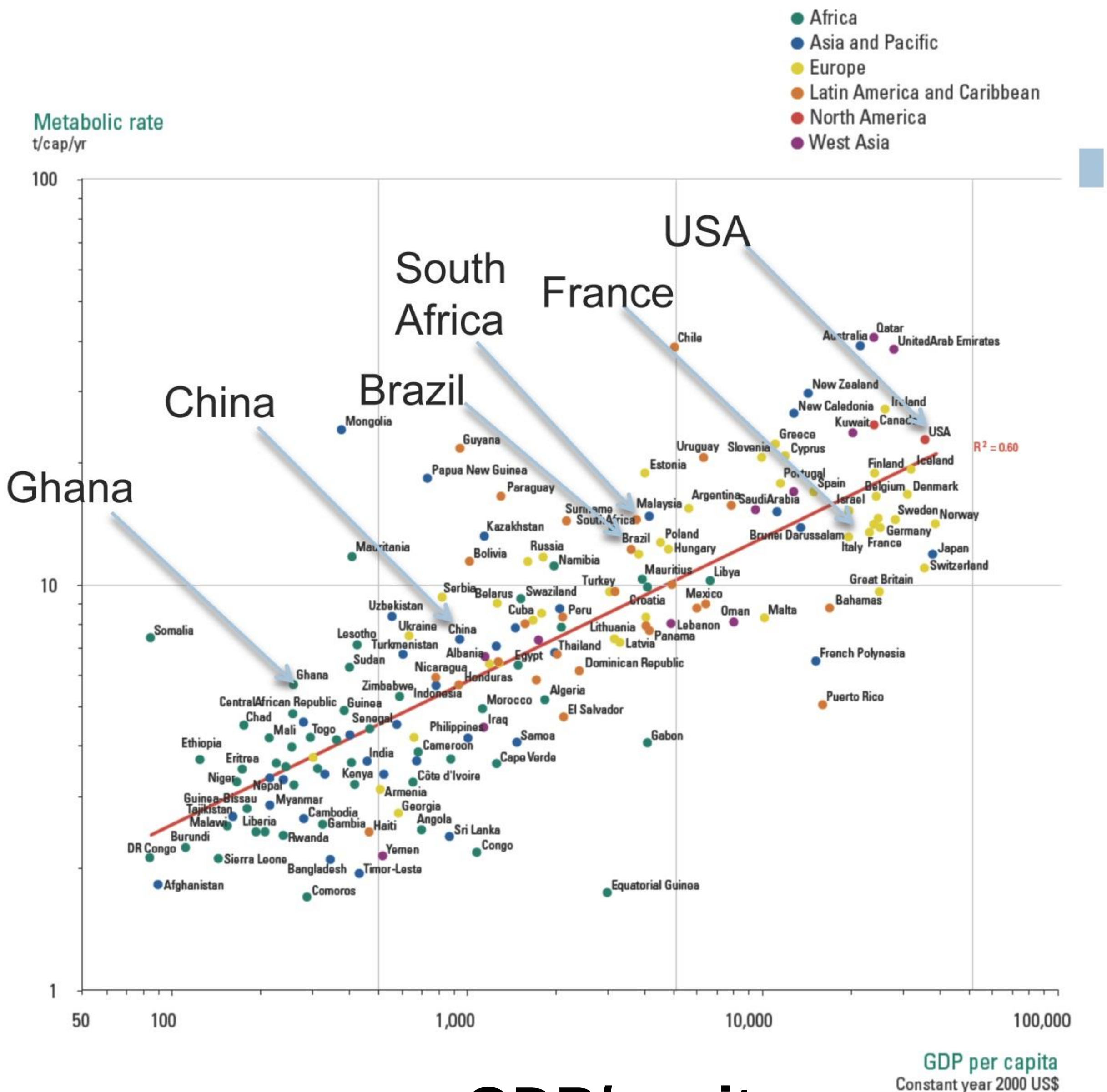
- I=PAT equation

$$\underbrace{\text{Impact}}_{I} = \underbrace{\text{Population}}_{P} \times \underbrace{\frac{\text{GDP}}{\text{Population}}}_{A} \times \underbrace{\left(\frac{\text{Resource Use}}{\text{GDP}} + \frac{\text{Pollution/Waste}}{\text{GDP}}\right)}_{T}$$

The global interrelation between resource use and income

Resource use /capita

Interrelation between resource use & income



GDP/capita

Source: UNEP/IRP

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Alternative development path in terms of resource consumption ?

（Possibility of Circular Economy/Society）

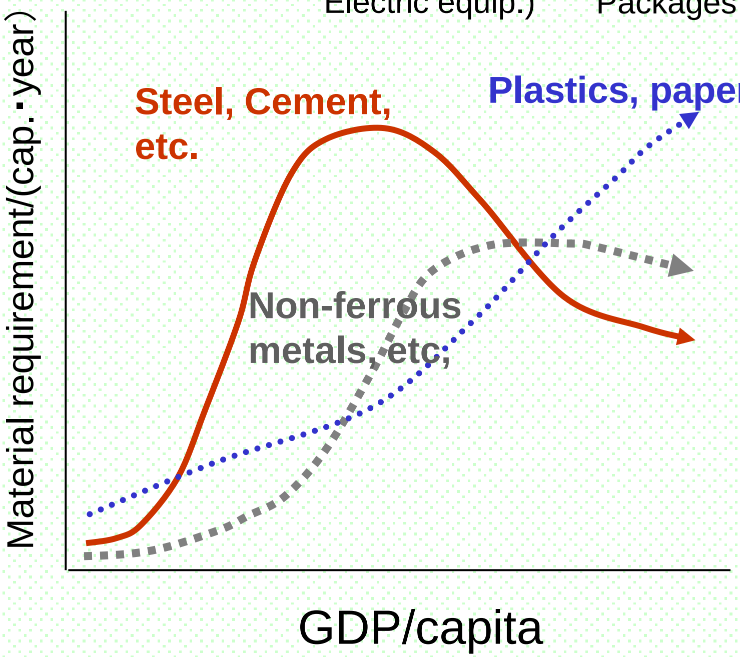
$$\frac{CO_2\ \text{Emission}}{\text{GDP}} = \frac{\text{Material Req.}}{\text{GDP}} \times \frac{\text{Energy Consump.}}{\text{Material Req.}} \times \frac{CO_2\ \text{Emission}}{\text{Energey Consump.}}$$

Traditional growth pattern with mass consumption of materials

Infrastructure
（Buildings, Roadways, etc. ）

Consumer durables
（Automobiles, Electric equip.)

Mass consump. of disposables
（Daily necessaries, Packages & containers ）

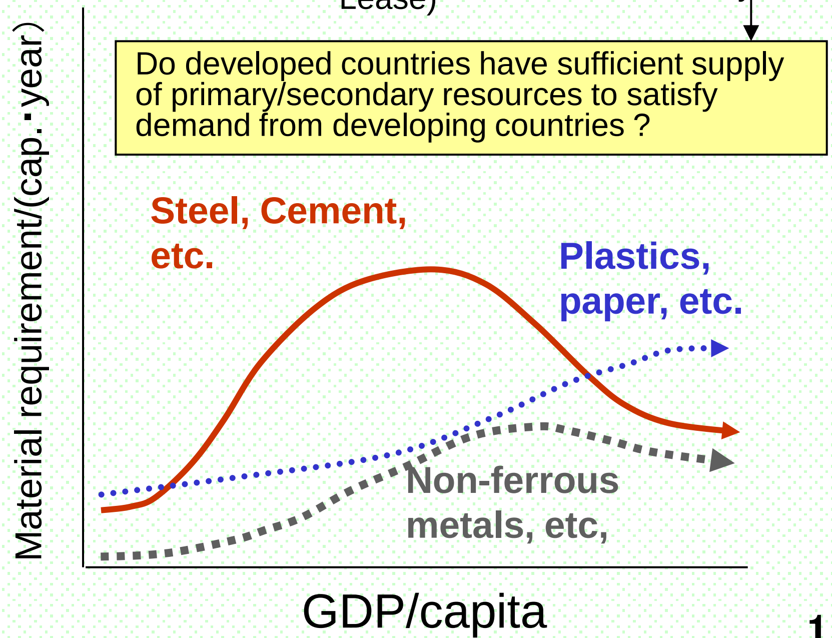


Alternative development pattern with low material, low carbon

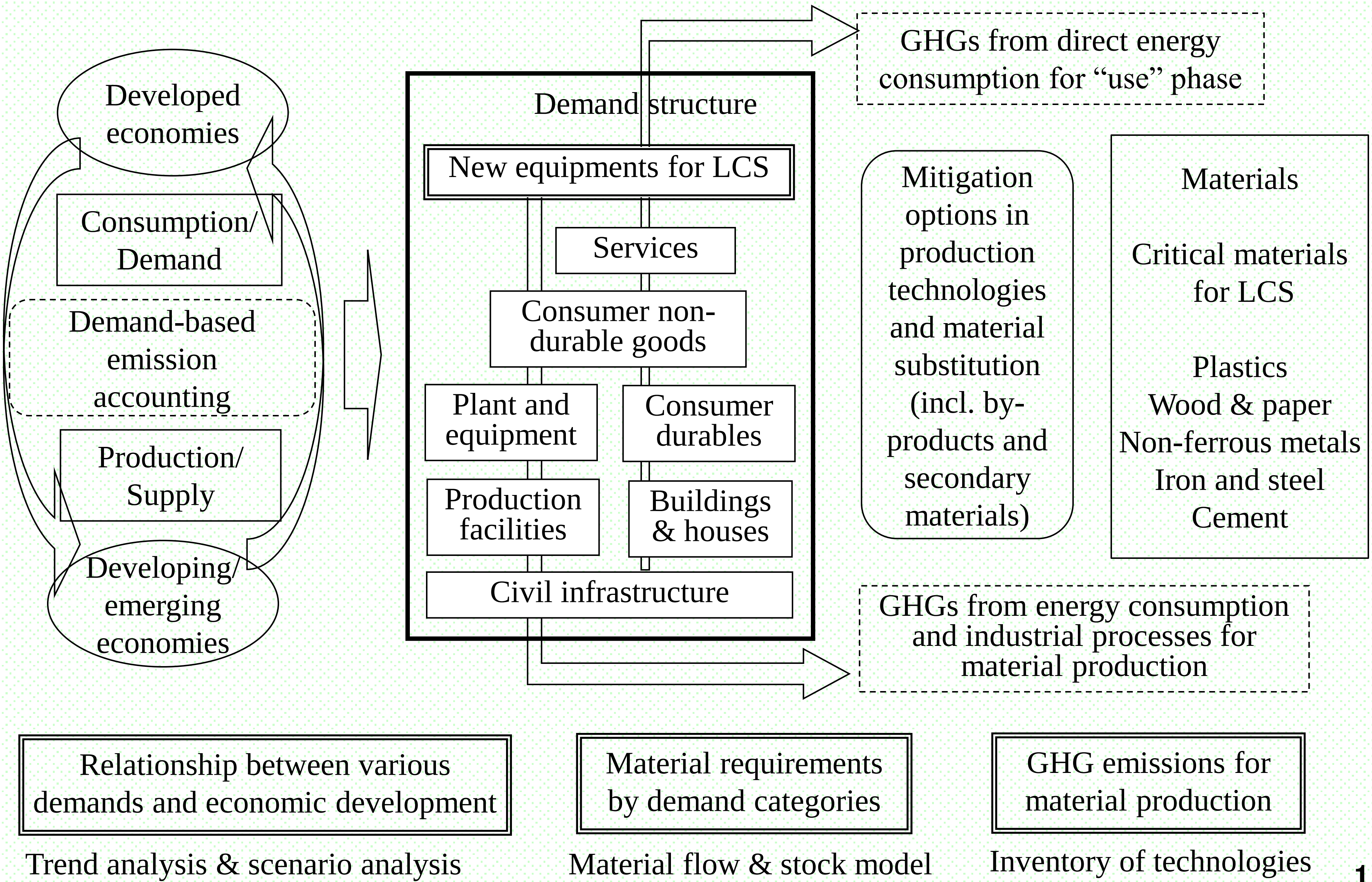
Infrastructure
（Compact city)

Consumer durables
（Reuse, Rental, Lease)

Proper consump. of commodities
（Reduce, Recycle）



GHG emissions by various material requirements with economic development



物質資源と低炭素社会に関する主要課題
Key Issues for Material Resources vs. LCS

- 炭素集約度の高い原材料(鉄鋼、セメント)の需要予測
- 資源集約度の高い財の国際貿易に内包された温室効果ガスおよびその削減ポテンシャルの消費国・輸入国ベースでの勘定スキームの適用可能性
  →OECD Green Growth Strategyの指標
- 低炭素技術に必要な稀少金属(白金族、リチウム、希土類等)の供給制約
- 炭素排出の抑制のための二次資源・副産物の賢明な利用
  - 低炭素電力を用いた電炉での鉄スクラップ利用
  - 廃木材や廃プラのカスケード利用(再生材料として利用した後にエネルギー利用)
  - セメント生産におけるスラグや石炭灰利用による石灰石代替

- Demand for carbon-intensive material production (e.g. Steel, cement)
- Possibility of consumer/importer-based accounting scheme to consider GHGs and their reduction potential embodied in international trade of resource-intensive commodities → An indicator for OECD's Green Growth Strategy
- Availability of critical metals for Low-Carbon Technologies (e.g. PGMs, Lithium, Rare-earths, etc.)
- Wise use of secondary resources as potential to reduce carbon emissions, e.g.,
  - Scrap iron to EAF with low-carbon electricity
  - Efficient cascading use of waste plastics
  - Use of slag as substitute of limestone in cement production

Critical Metals for Low Carbon Society

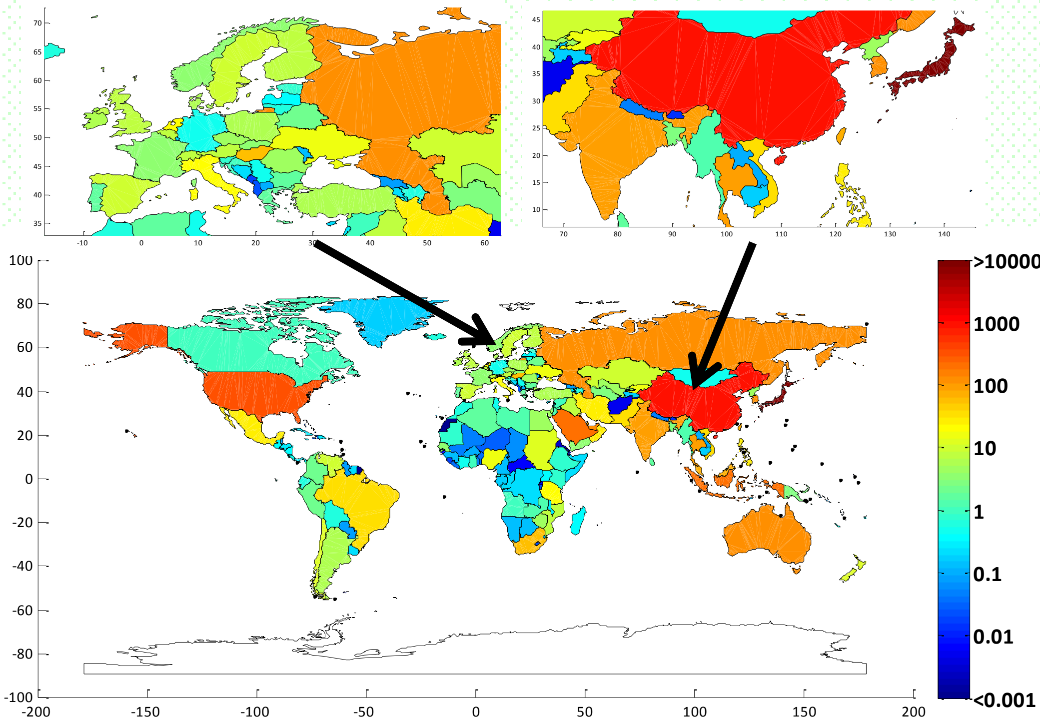
Critical metals for technology options

- Photovoltaic
  - Cd, Te: Cd-Te PV
  - In, Ga: CIGS PV
  - Sn, Ag: Si PV
- Magnet (Wind turbine, EVs) : REE (Dy, Nd)
  - Dy contents for Nd-F-B magnet is being reduced
  - Hf, In: Nuclear reactor
- Ni, V, Nb: Pipeline for CCS
- Cu: Not rare, but maybe most critical, indispensable and not substitutable, as far as LCS is further "electrified"

Dependence of energy consumption on Asia associated with production of goods consumed in Japan

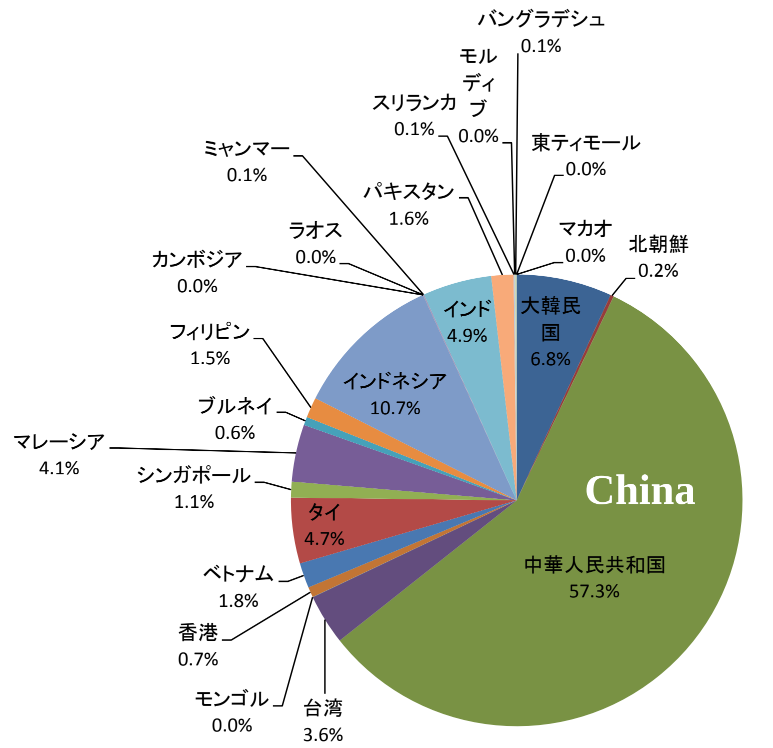
Energy consumption in Asian region induced by final demand of Japan

2292 PJ（53% of total overseas induced emission)



Map of consumer based energy consumption account (2005）

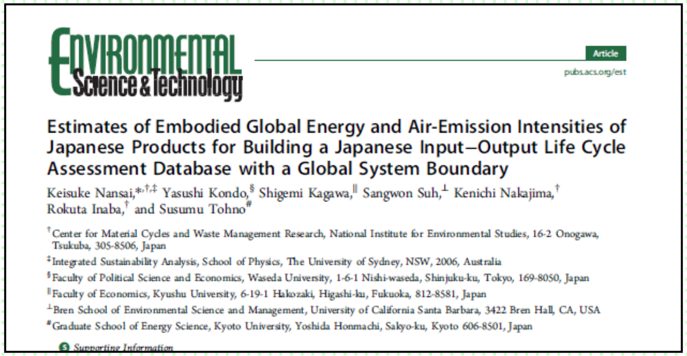
unit PJ-NCV



Energy consumption in Asian region induced by Japanese final demand (2005)

Dependence of energy consumption on Asia associated with production of goods consumed in Japan

Journal paper and Database


Environmental Science & Technology

Article

pubs.acs.org/est

Estimates of Embodied Global Energy and Air-Emission Intensities of Japanese Products for Building a Japanese Input–Output Life Cycle Assessment Database with a Global System Boundary

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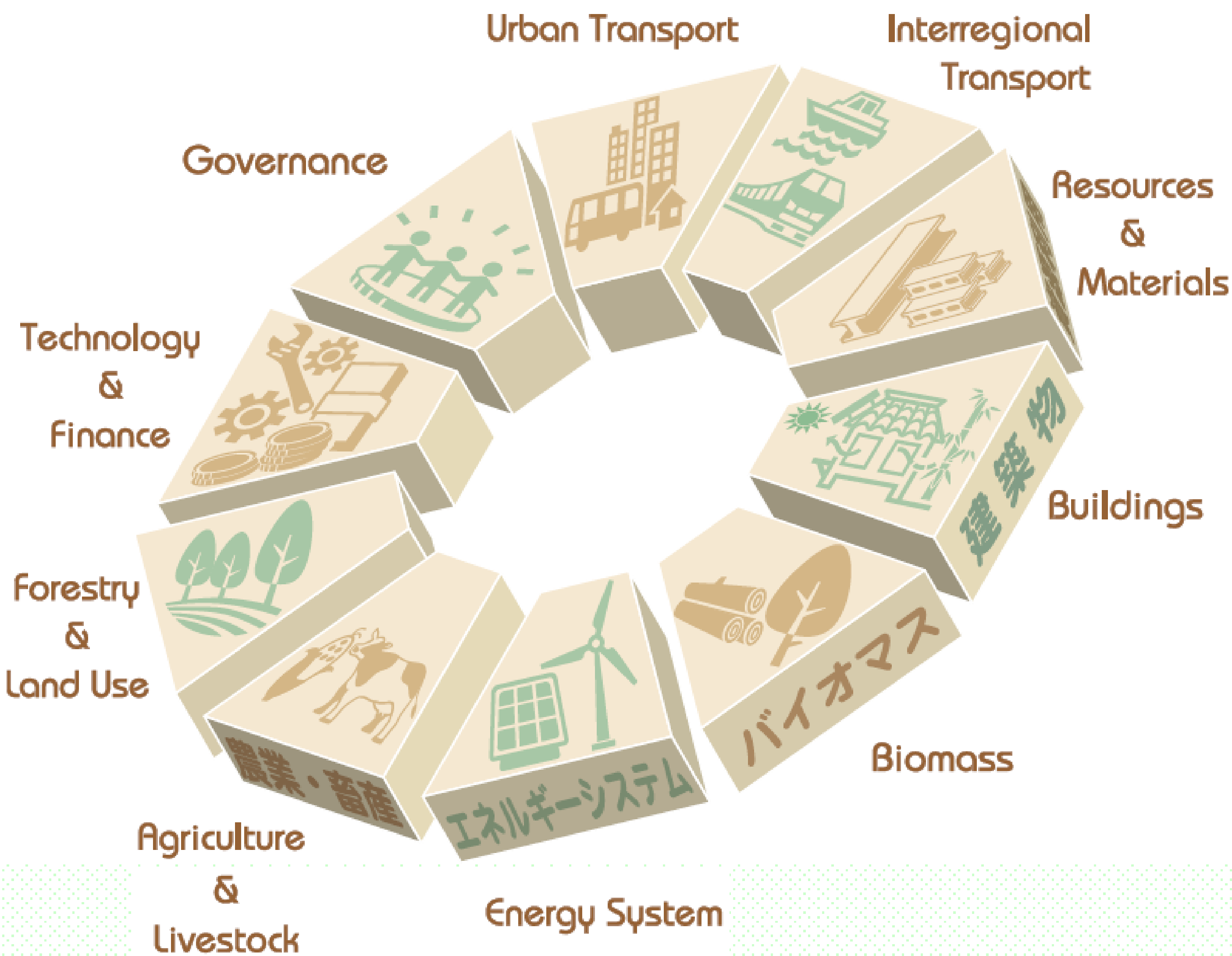
Supporting Information

Application of GLIO to compilation of Japanese IO-LCA database with global system boundary

Nansai et al. (2012), Estimates of Embodied Global Energy and Air-Emission Intensities of Japanese Products for Building a Japanese Input-Output Life Cycle Assessment Database with a Global System Boundary, *Environ. Sci. Technol.*, 46(16), 9146-9154 .

Role of resources management subproject in S-6 LCS Asia project

Ten actions toward Low Carbon Asia



Action 3 : Smart Ways to Use Materials that Realize the Full Potential of Resources

Production that dramatically reduces the use of resources,

Material Resource Use

Use of products in ways that extend their lifespan

Development of systems for the reuse of resources

Action 3: Smart Ways to Use Materials that Realize the Full Potential of Resources

3.1 Production that dramatically reduces the use of resources

- **3.1.1 Development & active employment of technologies for weight reduction & raw material substitution**
  - 3.1.1.1 Support for R&D of technologies
  - 3.1.1.2 Support for diffusion of technologies
- **3.1.2 Creation of materially simple lifestyles while still enjoying richness**
  - 3.1.2.1 Utilization of new evaluation indices
  - 3.1.2.2(3.2.4.1) Diffusion of product evaluation systems

3.2 Use of products in ways that extend their lifespan

- **3.2.1 Development & active employment of product life-extension technologies & maintenance systems**
  - 3.2.1.1 Support for R&D of technologies
  - 3.2.1.2 Support for diffusion of technologies
- **3.2.2 Development of cities & national land from a long-term perspective**
  - 3.2.2.1 Design of cities and national land from a long-term perspective
  - 3.2.2.2 Support for construction of long-lasting infrastructure
  - 3.2.2.3 Establishment of institutions for evaluation of public projects
- **3.2.3 Construction of long-lasting housing & replacement of housing**
  - 3.2.3.1 Support for construction of long-lasting housing
  - 3.2.3.2 Diffusion of housing evaluation systems
- **3.2.4 Selection of less resource consuming, long-lasting, recyclable, & reusable products**
  - 3.2.4.1(3.1.2.2) Diffusion of product evaluation systems
  - 3.2.4.2 Creation of incentive systems

3.3 Development of systems for the reuse of resources

- **3.3.1 Development & active employment of recycling & reuse technologies**
  - 3.3.1.1 Support for R&D of technologies
  - 3.2.1.2 Support for diffusion of technologies
- **3.3.2 Establishment of recycling & reuse systems for various goods**
  - 3.3.2.1 Establishment of various recycling laws
  - 3.3.1.2 Establishment of institutions related to reuse
- **3.3.3 (3.2.4) Selection of less resource consuming, long-lasting, recyclable, & reusable products**

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Journal of Industrial Ecology
Vol. 16, No.4. Special Issue (August 2012)
Greening Growing Giants

Editorial

Greening Growing Giants :

A Major Challenge of Our Planet

(pages 459–466)

Seiji Hashimoto, Marina Fischer-Kowalski, Sangwon Suh and Xuemei Bai

Journal of Industrial Ecology
Vol. 16, No.4. Special Issue (August 2012) Greening Growing Giants

Resource Use in Growing China : Past Trends, Influence Factors, and Future Demand (pages 481–492)

Heming Wang, Seiji Hashimoto, Yuichi Moriguchi, Qiang Yue and Zhongwu Lu

Toward a Low Carbon–Dematerialization Society : Measuring the Materials Demand and CO_2 Emissions of Building and Transport Infrastructure Construction in China (pages 493–505)

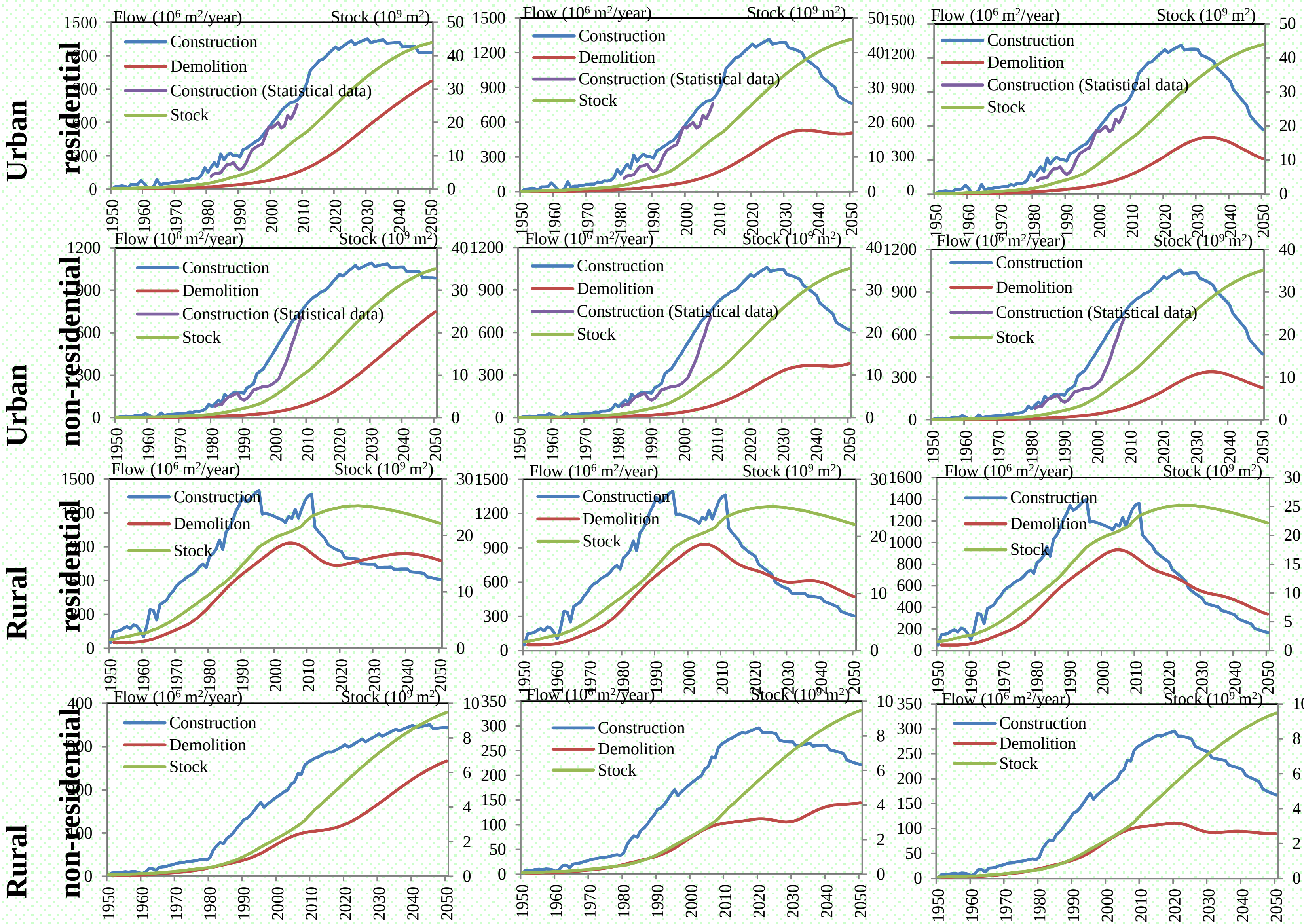
Feng Shi, Tao Huang, Hiroki Tanikawa, Ji Han, Seiji Hashimoto and Yuichi Moriguchi

Paper and Paperboard Demand and Associated Carbon Dioxide Emissions in Asia Through 2050 (pages 529–540)

Chihiro Kayo, Seiji Hashimoto and Yuichi Moriguchi

Result of MF modeling :Buildings (by SHI Feng et al.)

Short lifetime | Medium lifetime | Long lifetime

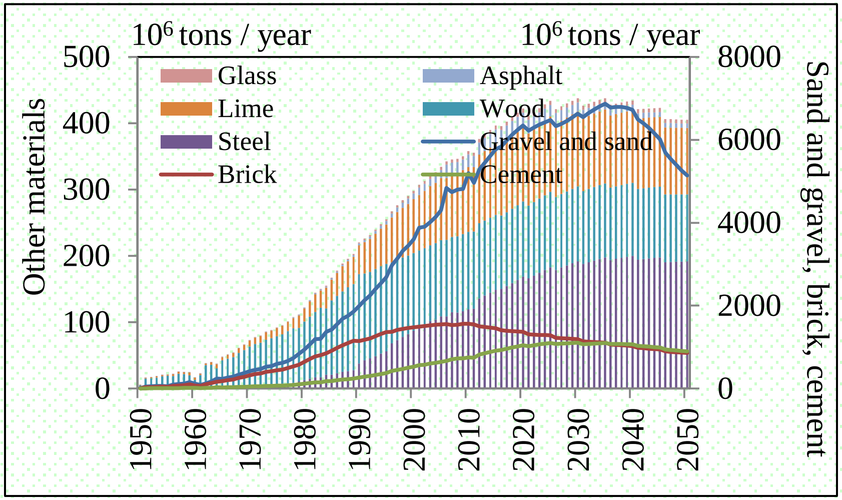


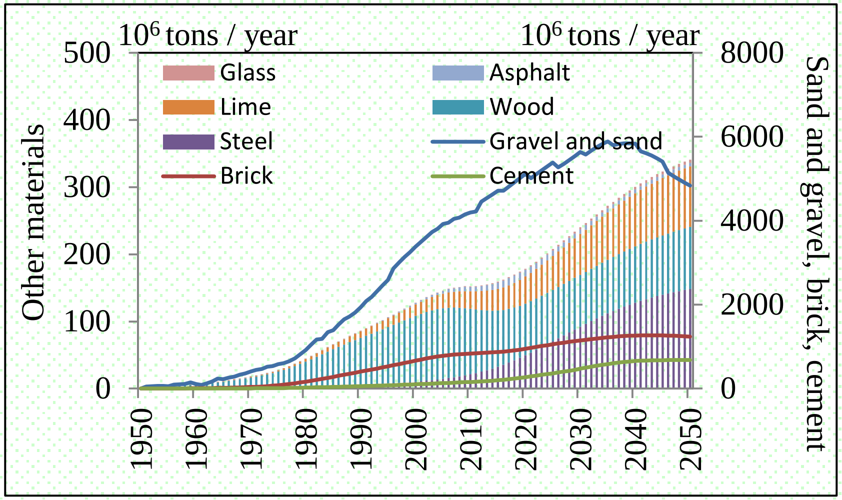
Result of MF modeling : MF with recycling

Materials input

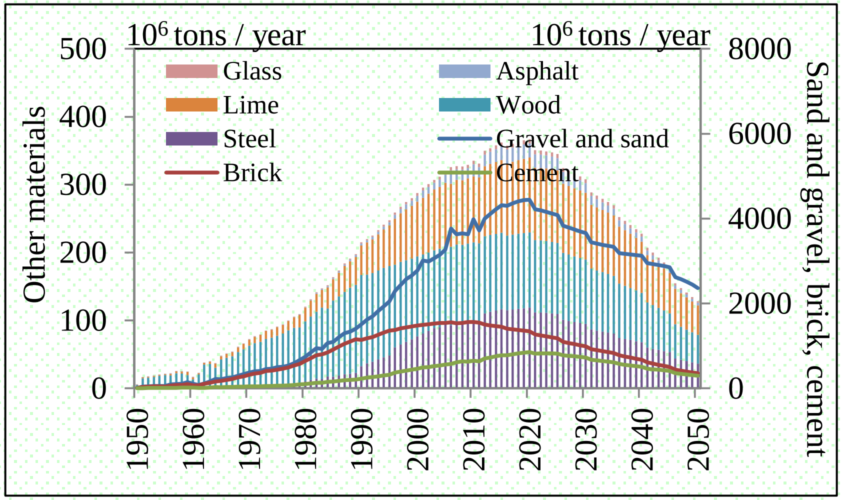
Materials output

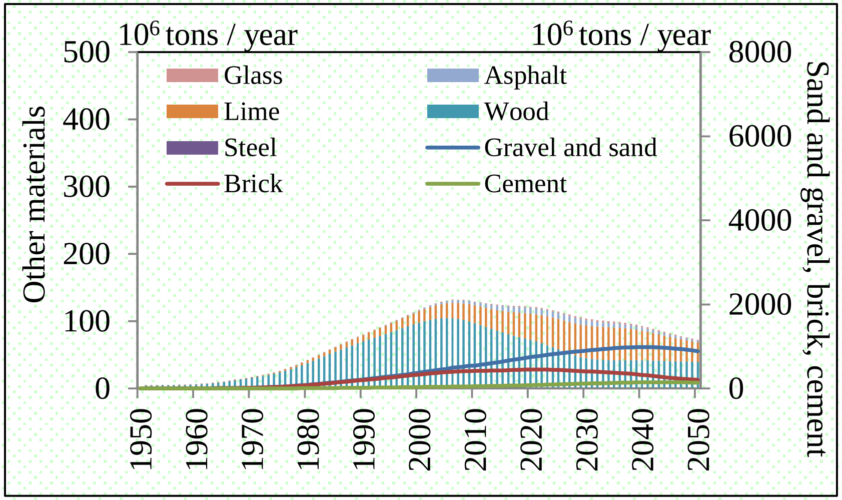
Short lifetime, Non-recycling



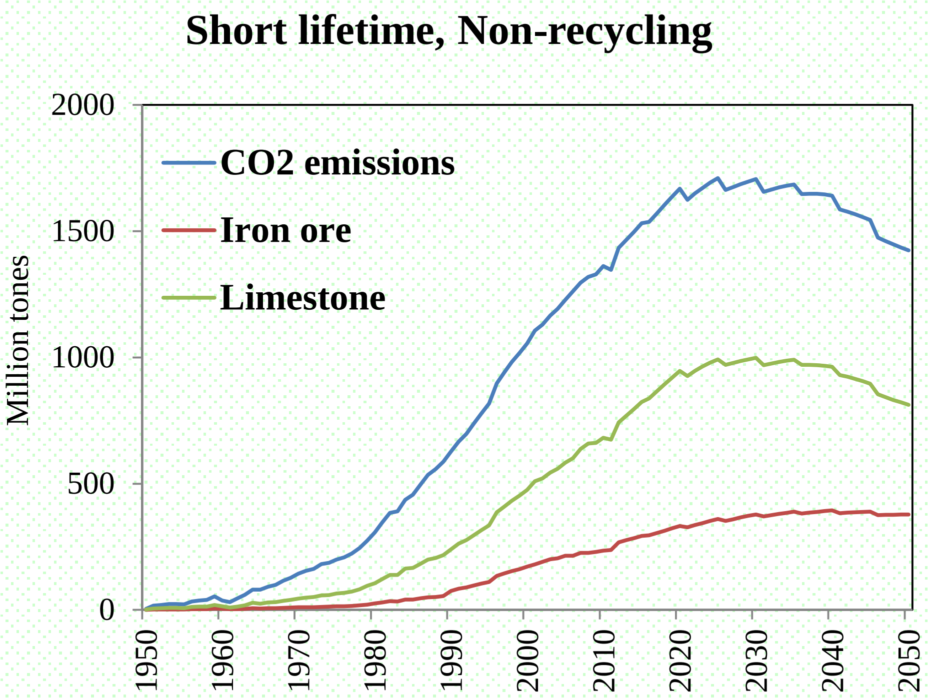


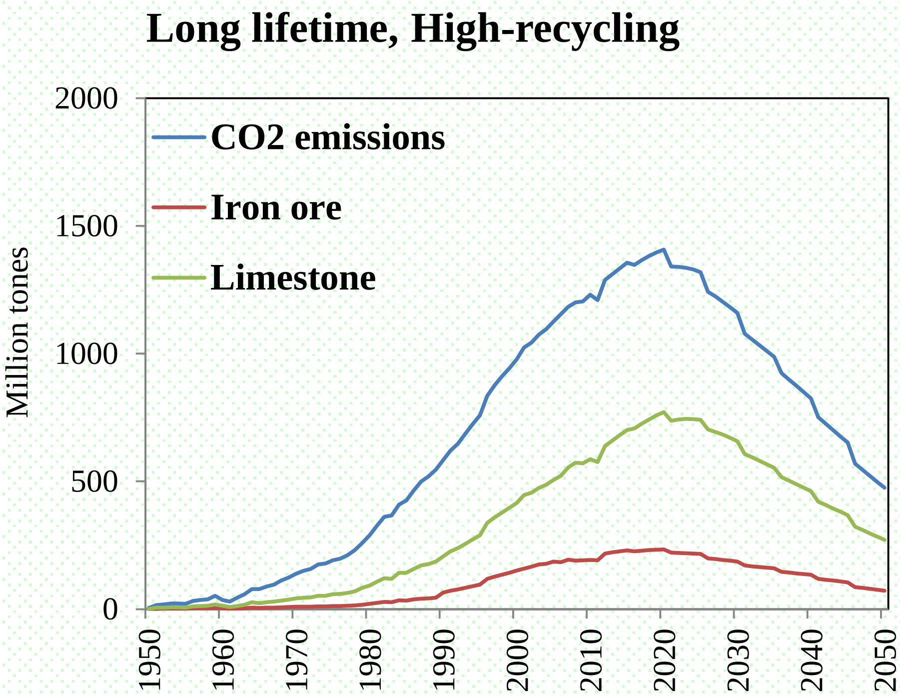
Long lifetime, High recycling





Result of MF modeling : CO_2 emission and raw material consumption (by SHI Feng et al.)

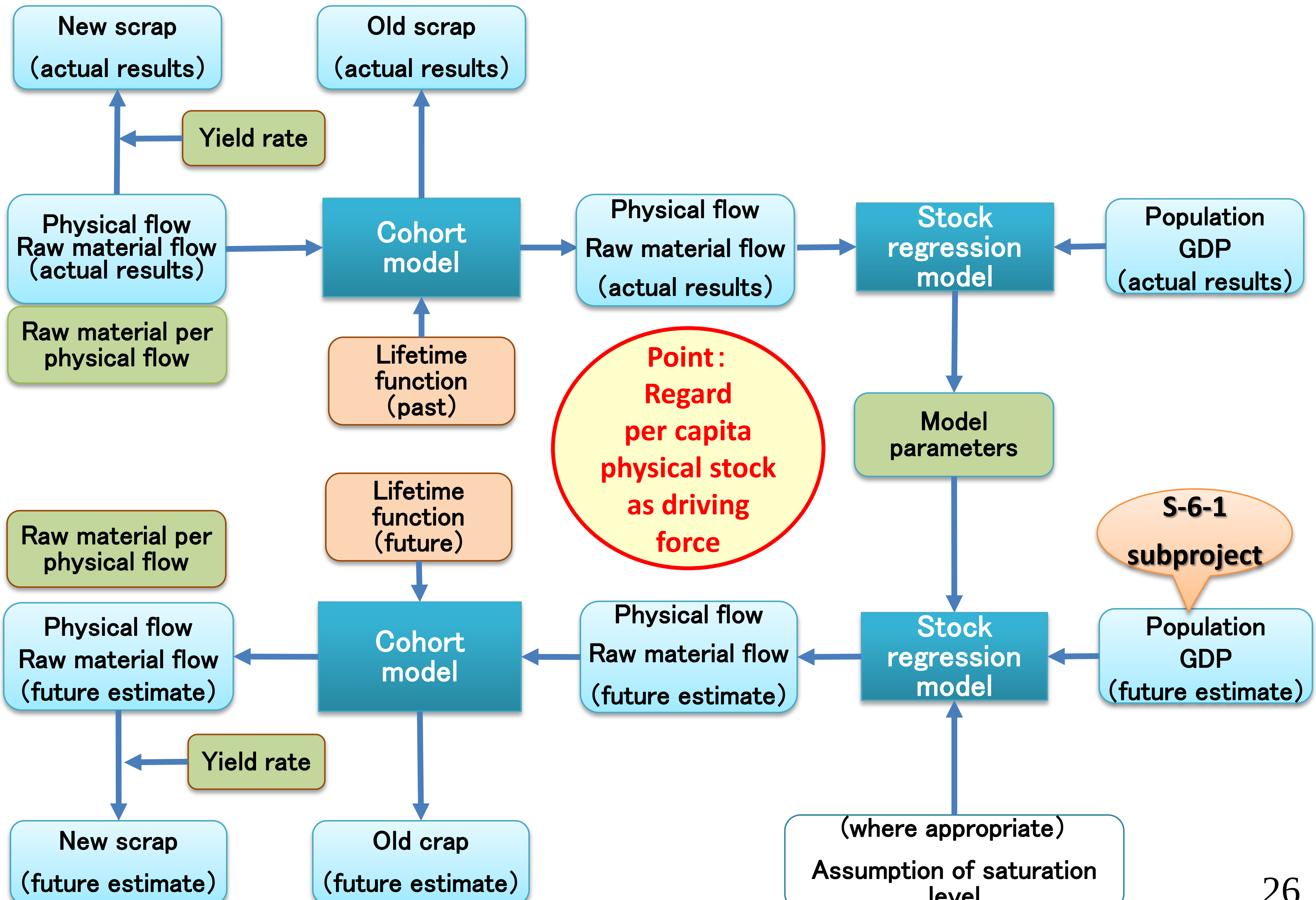




The iron ore and limestone will continue increased until around 2030, which means China must import more and more limestone and iron ore in the future and faces depletion under current cement consumption in China.

Prolonging the lifetime of buildings, railway and roadways and strengthening materials recycling obviously decreased demand for iron ore and limestone, and CO_2 emissions.

Structure of our dynamic material flow and stock model



Use categories applied for the flow and stock model

- Target material resources: Iron & Steel, Cement （Carbon intensive at production stage）
- Use categories as tabulated below

Category	Sub category	Iron & steel	Cement	備考
Building	Residential (Urban)	○	○	"Type A :Steel and cement intensive" and "Type B : Steel and cement less intensive" Load factors of raw materials per floor space (kg/m2) were set for type A & B. Ratio of A & B was assumed for urban and rural areas
	Residential (Rural)	○	○	
	Non-residential	○	○	
Civil infrastructure		○	○	
Transport machinery	Passenger car	○	―	
	Freight vehicles	○	―	
	Others	○	―	
General machinery		○	―	
Others		○	―	

Major variables assumed in flow and stock model

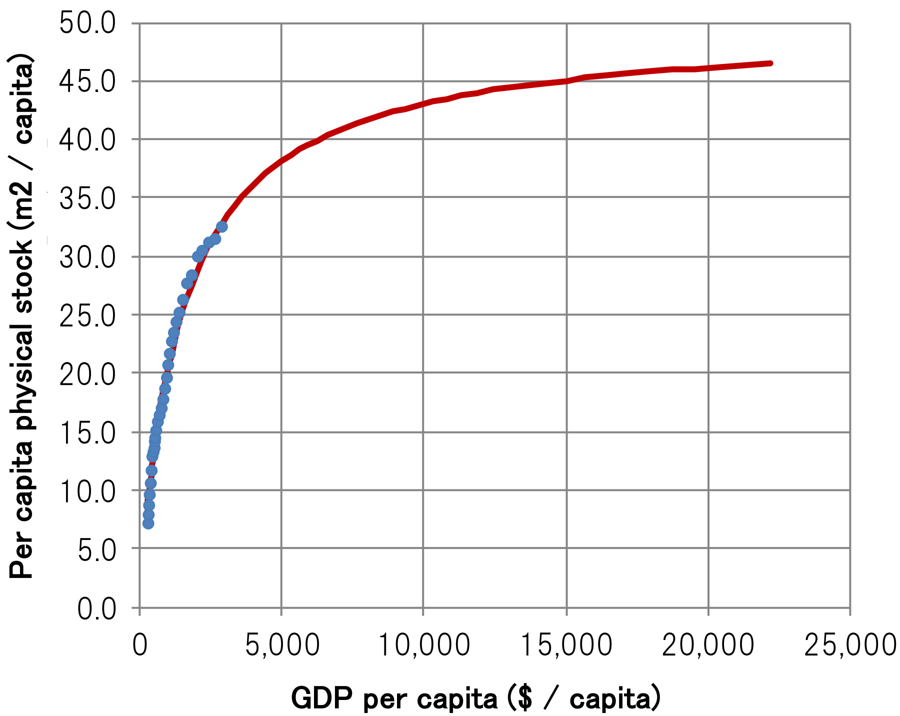
Category	Sub category	Explained variable (Y)	Regression model	Lifetime	Saturation (*Ymax*) (Baseline)
Building	Residential (Urban)	Per capita floor space	S2	30	50m2/capita
	Residential (Rural)	Per capita floor space	S2	30	55m2/capita
	Non-residential	Per capita floor space	S2	30	40m2/capita
Civil infrastructure		Per capita steel demand	S2	40	3 tons/capita
		Per capita cement demand	S2	40	15 tons/capita
Transport machinery	Passenger car	Per capita ownership	S2	15	0.6vehicles/capita
	Freight vehicles	Total registration	E	15	–
	Others	Per capita steel demand	S1	15	0.6 tons/capita
General machinery		Per capita steel demand	S1	20	1.3 tons/capita
Others		Per capita steel demand	S1	10	0.5 tons/capita

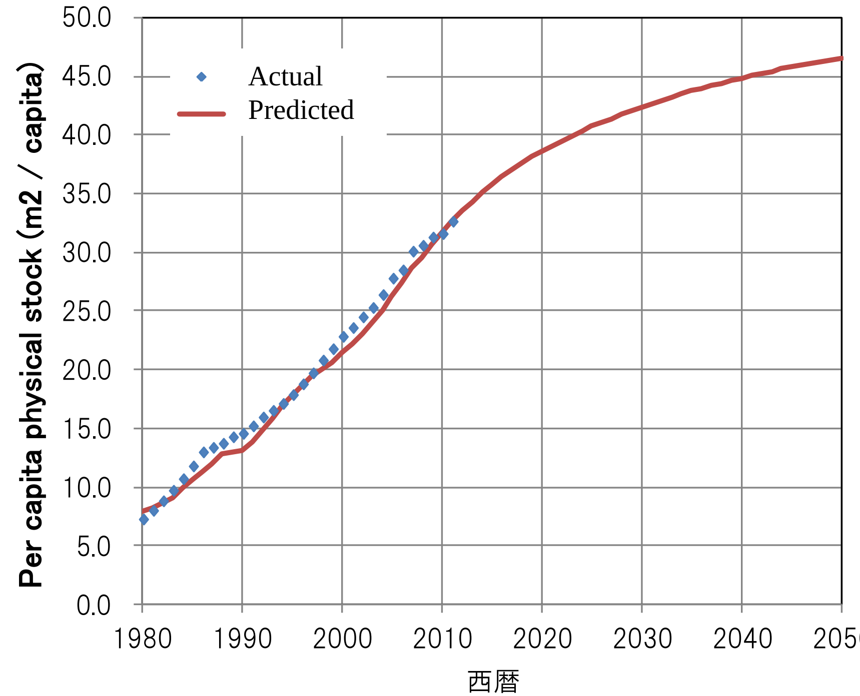
S1: sigmoid func., S2: Quasi-sigmoid func. , E: Elasticity, Explanatory variable (X): GDP per capita

$$y = \frac{y_{max}}{(1 + ae^{-bx})}$$

$$y = \frac{y_{max}}{(1 + e^{ax^{-b}})}$$

An example of the modeling parameters
- Per capita stock of floor space in urban residential building -





Iron demand by use categories in China

Per capita iron stock by use categories in China

Chinese CO_2 emission for steel and cement production（Baseline）

Chinese CO_2 emission for steel and cement production by mitigation scenarios

Above-titled four slides presented at the Symposium are excluded from this version.

Summary

- Decoupling natural resource consumption and accompanied environmental burdens from economic growth and increase of resource productivity attract global attention.

- Lowering energy intensity in material production, carbon intensity of energy as well as improvements in resource productivity are effective in CO_2 emission reduction associated with raw material production.

- Action3 “Smart Ways to Use Materials that Realize the Full Potential of Resources” was proposed as the action 3 of 10 actions toward LC-Asia.

- Scenario analysis on future CO_2 emission by steel and cement production in China and its mitigation opportunities was conducted by applying material flow and stock model, regarding physical stock level as driving force.

- Issues such as supply and demand of critical metals for low carbon technologies and CO_2 emissions embodied in international trade are key subject in sustainable resource management, and they are relevant to Japan and its relationship with Asian economies.