Household waste generation in Asian countries

The 19th AIM International Workshop @NIES

December 14th 2013
National Institute for Environmental Studies
Yuko KANAMORI

Research Background

- Existing research on comprehensive environment sustainability barely analyzes or identifies household consumption behavior in detail for examining impacts on environmental load generation.
  - Because the detailed data required for such analysis are available only in developed countries, which has resulted in limited analysis in relation to data availability.

- In order to establish a sustainable society in the future, developing countries need to find a new way of sustainable development rather than following the development trail of developed countries.
  - In quantitatively identifying a desirable social establishment, the relationship between consumption behavior and related environmental load generation must be ascertained in an explicit manner.

- In considering future environment sustainability, the Asian region—with a large population—is extremely important as rapid economic growth has led to changes in household consumption behavior; a method for estimating environmental load generation that explicitly captures the regional consumption structure has barely been developed thus far.

Analysis on Waste Generation Associated with Household Consumption

Japan

- Japan's small land area has long led to problems related to generation control, appropriate treatment, and disposal of waste, including household waste.
    - The availability of a variety of social and economic statistics as well as data on household waste generation has been the foundation of a number of research activities.

Asian developing countries

- Research in developing Asian countries focuses on specific cities or regions owing to a lack or extremely limited availability of data on household waste generation or insufficient awareness of local waste problems as a nationwide key issue.

- It is expected that household waste generation increases and its composition changes as a result of changes in consumption behavior associated with future population increase or economic growth in the Asian region
    - ⇒ It is also extremely important to identify changes in waste composition from the perspective of not only total waste generation but also of its treatment and disposal.

- To develop a tool that estimates environmental load generation from simplified consumption behavior, which is applicable to Asian countries where such data is limited.
- To apply the tool to 6 Asian countries in order to estimate the household consumption structure and household waste generation until 2020.

Description of the Study

- Target country：Asian 6 countries
  - Japan(JPN), China(CHN), India(IND), Korea (KOR), Indonesia(IDN), Malaysia(MYS)
- Households: are classified by income level
- Identification year of demand function ：2005-2011
- Estimation year: 2005-2020
- Household waste：10type
  - Papers, Kitchen garbage, Plastics, Wood wastes, Textiles, Glasses, Metals, Ceramics, Leather, Others
  - Any household waste generated from posted flyers, crops self-consumed by farmers or containers/packages brought into households as a result of purchasing goods **cannot** be estimated.
    - For estimation method reason
  - Waste generated from durable goods also cannot be estimated.

2 basic equations of the tool

- **Household demand function (LES)**

$$p_i x_i = p_i b_i + a_i \left(\sum_i p_i x_i - \sum_i p_i b_i \right)$$

x_i : Consumption of goods and services i

p_i: Price of goods and services i

a_i : Preference coefficient of goods and services i
     = Parameter representing the strength of preference for household activities

b_i : Lowest level consumption of goods and services i

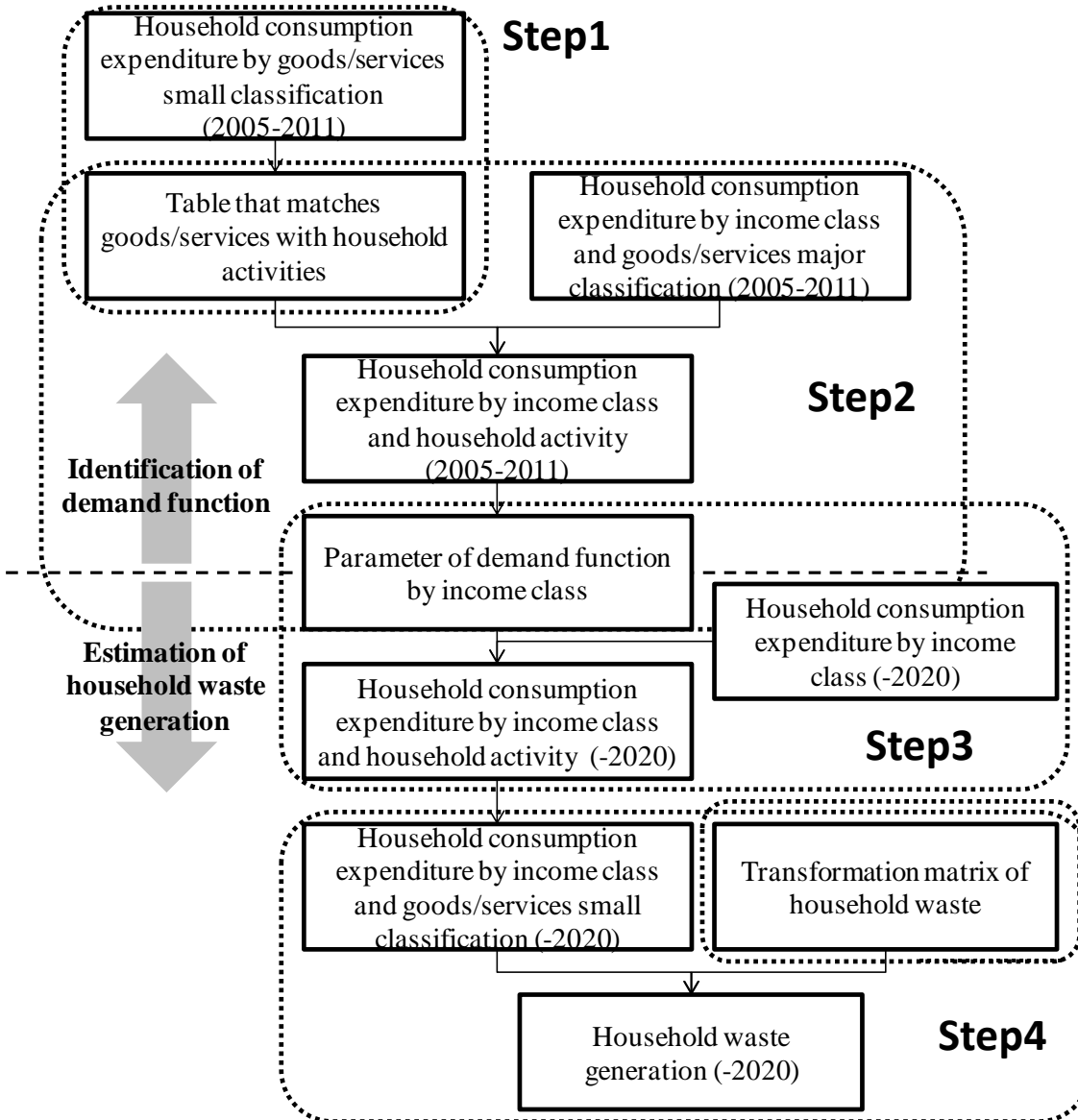- **Estimation of household waste from consumption expenditure**

$$W_{wt,t} = \sum_i \grave{} E_{i,t} \cdot M_{i,wt}$$

$W_{wt,t}$: Amount of household waste type *wt generated in year t*

$E_{i,t}$: Consumption expenditure of goods and services i

$M_{i,wt}$: Amount of household waste type *wt generated per unit consumption expenditure of goods and services i* (=*Transformation* matrix of household waste)

Estimation Flow

Estimation Flow

Step1:Making consumption data by household activities to identify household demand function

Step2: Identification of household demand function

Step3: Estimation of future household consumption by household activities

Step4: Estimation of future household waste generation

Step1: Household activity classification

· 60 goods and services correspond to 10 household activities.

· Why do we use "household activity classification" ?
  ➡ To define a classification **by final purpose** when households consume.

Household activity	Examples
Food (HA1)	Preparation of meals, eating-out, and purchase of cooking ingredients
Clothing (HA2)	Purchase of cloth and cleaning
Housing (HA3)	Purchase of A/C and lighting, housing repairs and maintainance
Care (HA4)	Child care and nursing care
Health care (HA5)	Hospital visit and purchase of medicine
Peraonal care (HA6)	Bath, face-wash, and purchase of makeup
Communication (HA7)	Telephone call and e-mail
Education (HA8)	School expenses
Recreation (HA9)	Trip, thieater visit and playing sports
Other (HA10)	Others

A significant difference from general consumption classification is **how the data on traffic, energy, and water are handled**.

Consumption on traffic, energy, and water are treated not as final purpose but **as intermediate inputs of household activities.**

$M_{i,wt}$

Step2: Identification of demand function

・Household demand function is identified using consumption expenditure data by income class from 2005 to 2011.

➡ To consider impacts of differences in consumption behavior by income.

Preference coefficient

Lowest level consumption

CHN

Food

Education & Recreation
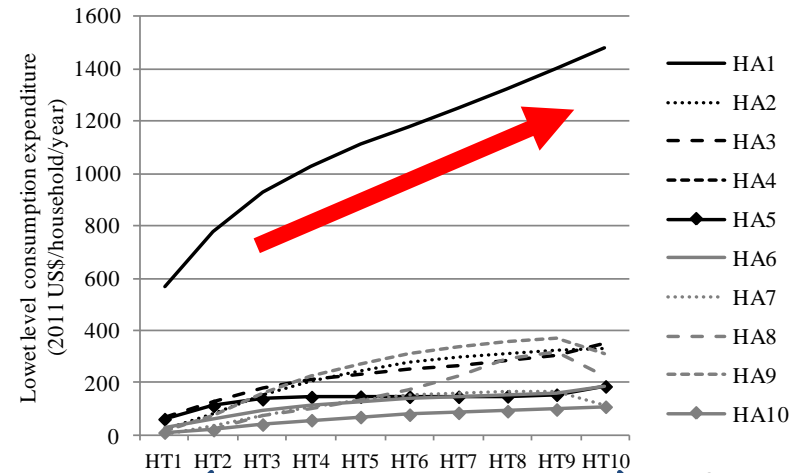
Low income ⟵   ⟶ High income

IND

Food

Education & Recreation

Legend (both rows): HA1, HA2, HA3, HA4, HA5, HA6, HA7, HA8, HA9, HA10

X-axis: HT1, HT2, HT3, HT4, HT5, HT6, HT7, HT8, HT9, HT10

Y-axis (Preference coefficient): Preference coefficient

Y-axis (Lowest level consumption): Lowet level consumption expenditure (2011 US$/household/year)
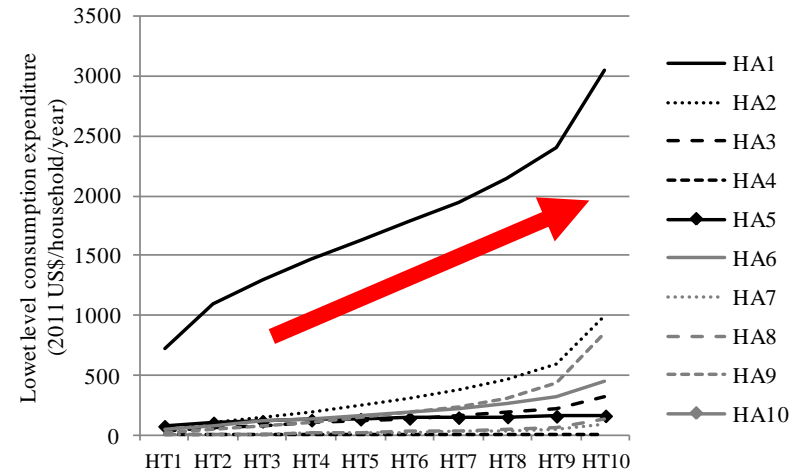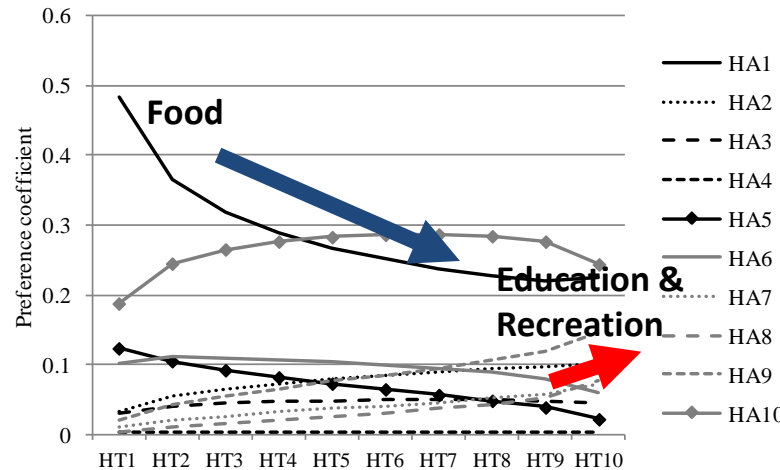
Step3: Estimated result of future consumption expenditure

- **Regression analysis with GDP per capita and average number of household member**

10^3US$ / household		HT1			HT3			HT5			HT8			HT10		
		E	S	Compared to 2005	E	S	Compared to 2005	E	S	Compared to 2005	E	S	Compared to 2005	E	S	Compared to 2005
JPN	2005	24.3	25.3	1.0	42.8	43.6	1.0	54.2	55.3	1.0	71.2	71.3	1.0	101.2	97.2	1.00
	2010	21.8	21.8	0.9	41.9	41.7	1.0	51.1	51.2	0.9	68.6	68.0	1.0	101.3	102.2	1.00
	2015	19.6		0.8	41.6		1.0	47.9		0.9	66.2		0.9	102.6		1.01
	2020	17.3		0.7	43.1		1.0	44.2		0.8	64.1		0.9	109.2		1.08
CHN	2005	1.6	1.4	1.0	2.7	2.5	1.0	3.3	3.1	1.0	4.2	4.2	1.0	5.7	6.3	1.00
	2010	1.4	1.1	0.8	2.9	2.6	1.1	4.1	3.8	1.2	6.3	6.3	1.5	12.3	14.0	2.17
	2015	1.3		0.8	3.3		1.2	4.9		1.5	8.7		2.1	21.5		3.79
	2020	1.2		0.8	3.6		1.4	5.9		1.8	11.5		2.7	34.6		6.10
IND	2005	1.1	1.1	1.0	2.2	2.2	1.0	2.9	2.9	1.0	4.4	4.4	1.0	7.8	7.8	1.00
	2010	1.3	1.2	1.2	2.6	2.6	1.2	3.6	3.6	1.2	5.5	5.4	1.3	10.2	10.0	1.30
	2015	1.5		1.4												1.68
	2020	1.7		1.6												2.15
IDN	2005	1.6	1.5	1.0	3.1	3.0	1.0	4.1	4.0	1.0	5.9	5.9	1.0	9.8	10.0	1.00
	2010	1.9	1.8	1.2	3.7	3.7	1.2	5.0	5.0	1.2	7.3	7.4	1.2	12.5	12.9	1.28
	2015	2.2		1.4	4.7		1.5	6.4		1.6	9.8		1.7	17.7		1.80
	2020	3.2		2.0	6.4		2.1	8.6		2.1	12.6		2.1	21.5		2.19
KOR	2005	12.2	12.0	1.0	18.8	18.6	1.0	23.5	23.3	1.0	32.4	32.3	1.0	52.9	52.9	1.00
	2010	12.0	11.8	1.0	18.8	18.7	1.0	24.0	23.9	1.0	33.8	33.7	1.0	56.9	56.9	1.08
	2015	11.6		1.0	19.0		1.0	24.7		1.1	35.8		1.1	62.7		1.19
	2020	11.3		0.9	19.3		1.0	25.7		1.1	38.2		1.2	70.2		1.33
MYS	2005	3.6	3.6	1.0	8.2	8.2	1.0	11.8	11.7	1.0	19.1	19.1	1.0	40.1	40.1	1.00
	2010	4.2	4.2	1.2	9.8	9.7	1.2	14.2	14.1	1.2	23.7	23.5	1.2	52.8	52.1	1.32
	2015	5.0		1.4	11.8		1.4	17.4		1.5	29.7		1.5	69.2		1.72
	2020	6.1		1.7	14.6		1.8	21.7		1.8	37.5		2.0	90.7		2.26

The estimations reproduce past data well

- **Regression analysis with GDP per capita and average number of household member**

10³US$ / household		HT1 E	HT1 S	HT1 Compared to 2005	HT3 E	HT3 S	HT3 Compared to 2005	HT5 E	HT5 S	HT5 Compared to 2005	HT8 E	HT8 S	HT8 Compared to 2005	HT10 E	HT10 S	HT10 Compared to 2005
JPN	2005	24.3	25.3	1.0	42.8	43.6	1.0	54.2	55.3	1.0	71.2	71.3	1.0	101.2	97.2	1.00
	2010	21.8	21.8	0.9	41.9	41.7	1.0	51.1	51.2	0.9	68.6	68.0	1.0	101.3	102.2	1.00
	2015	19.6		0.8	41.6		1.0	47.9		0.9	66.2		0.9	102.6		1.01
	2020	17.3		0.7	43.1		1.0	44.2		0.8	64.1		0.9	109.2		1.08
CHN	2005	1.6	1.4	1.0	2.7	2.5	1.0	3.3	3.1	1.0	4.2	4.2	1.0	5.7	6.3	1.00
	2010	1.4	1.1	0.8	2.9								1.5	12.3	14.0	2.17
	2015	1.3		0.8	3.3								2.1	21.5		3.79
	2020	1.2		0.8	3.6								2.7	34.6		6.10
IND	2005	1.1	1.1	1.0	2.2								1.0	7.8	7.8	1.00
	2010	1.3	1.2	1.2	2.6								1.3	10.2	10.0	1.30
	2015	1.5		1.4	3.2								1.6	13.2		1.68
	2020	1.7		1.6	3.8								2.0	16.9		2.15
IDN	2005	1.6	1.5	1.0	3.1								1.0	9.8	10.0	1.00
	2010	1.9	1.8	1.2	3.7								1.2	12.5	12.9	1.28
	2015	2.2		1.4	4.7								1.7	17.7		1.80
	2020	3.2		2.0	6.4								2.1	21.5		2.19
KOR	2005	12.2	12.0	1.0	18.8								1.0	52.9	52.9	1.00
	2010	12.0	11.8	1.0	18.8		1.0	24.0	23.9	1.0	35.6	35.7	1.0	56.9	56.9	1.08
	2015	11.6		1.0	19.0		1.0	24.7		1.1	35.8		1.1	62.7		1.19
	2020	11.3		0.9	19.3		1.0	25.7		1.1	38.2		1.2	70.2		1.33
MYS	2005	3.6	3.6	1.0	8.2	8.2	1.0	11.8	11.7	1.0	19.1	19.1	1.0	40.1	40.1	1.00
	2010	4.2	4.2	1.2	9.8	9.7	1.2	14.2	14.1	1.2	23.7	23.5	1.2	52.8	52.1	1.32
	2015	5.0		1.4	11.8		1.4	17.4		1.5	29.7		1.5	69.2		1.72
	2020	6.1		1.7	14.6		1.8	21.7		1.8	37.5		2.0	90.7		2.26

Note box:
・There is a remarkable increase in the amount of consumption expenditure in high-income classes.
・The rate of increase in low-income classes is lower than that in high-income classes.
・In some low income households, the amount of consumption expenditure tends to decrease.

E: Estimated value S: Survival value

Step4: Transformation matrix of household waste

- **The transformation matrix of household waste**
  = the amount of household waste generated by
    consuming unit goods
      ／ the price per unit weight

- The transformation matrix of household waste could vary
  by region or household class.
  - **-Composition of goods**
  - **-Price**

  ➡️ This study focuses **only on the differences in prices**
  among countries.

Step4: Transformation matrix of household waste

▪ **Comparison between estimated value and statistics value**

Japan

(Unit: 10^3t)	Statistical value (S)		Estimated value (E)	E/S
	Volume[*3)]	Rate[*2)]		
Household waste[*1)]	25580			
Paper	9669	37.8 %		
Containers and packaging	2225	8.7 %		
Other paper	7444	29.1 %	1797	24%
Plastic and lether	4528	17.7 %		
Containers and packaging	3223	12.6 %		
Other plastics and lethers	1305	5.1 %	701	54%
Wood waste	1407	5.5 %	699.5	50%
Textile	1688	6.6 %	1635	97%
Kitchen garbage	8007	31.3 %	7270	91%
Metal	128	0.5 %	167.3	131%
Glass	77	0.3 %	78	102%
Others	77	0.3 %	26	34%

*1) Ministry of Environment[3]

*2) Maeda et al[6]

*3) This value is estimated using total household waste generation and household waste rate

The estimations reproduce past data almost well, but in some waste type <u>there are considerable gaps</u> between statistical value and estimated value.

➡Determining the accuracy of statistics is an aspect for future study.

Asia

		JPN	KOR	CHN	IND	IDN	MYS
Domestinc waste generation							
Euromonitor International[14]	10^3t	51607	18252	148565[*1)]			
Research institute of solid waste management engineering[13] [*2)]	10^3t			142987	115706		
China statistical yearbook[22] [*3)]	10^3t			155768			
Household waste generation	10^3t	36125	12776	100091	80994		
(=70% of domestic waste generation）							
Estimated value of household waste generation	10^3t	12753	3082	31921	23085	3674	688
Estimated value / household waste generation		35.3%	24.1%	31.9%	28.5%		

*1) The value is in 2003

*2) The data is calculated using Figure 2 of Research institute of solid waste management engineering[13] by author.

*3) The data only includes waste generation from urban area in China.

The examination attempted to compare the statistics of general waste discharge since the statistics pertaining only to household waste were not available.

70% [*)]**of general waste discharge** is assumed to be **from household waste**.

 * Japan's case

Step4: Transformation matrix of household waste

■ **Household waste generation per capita in 2005**
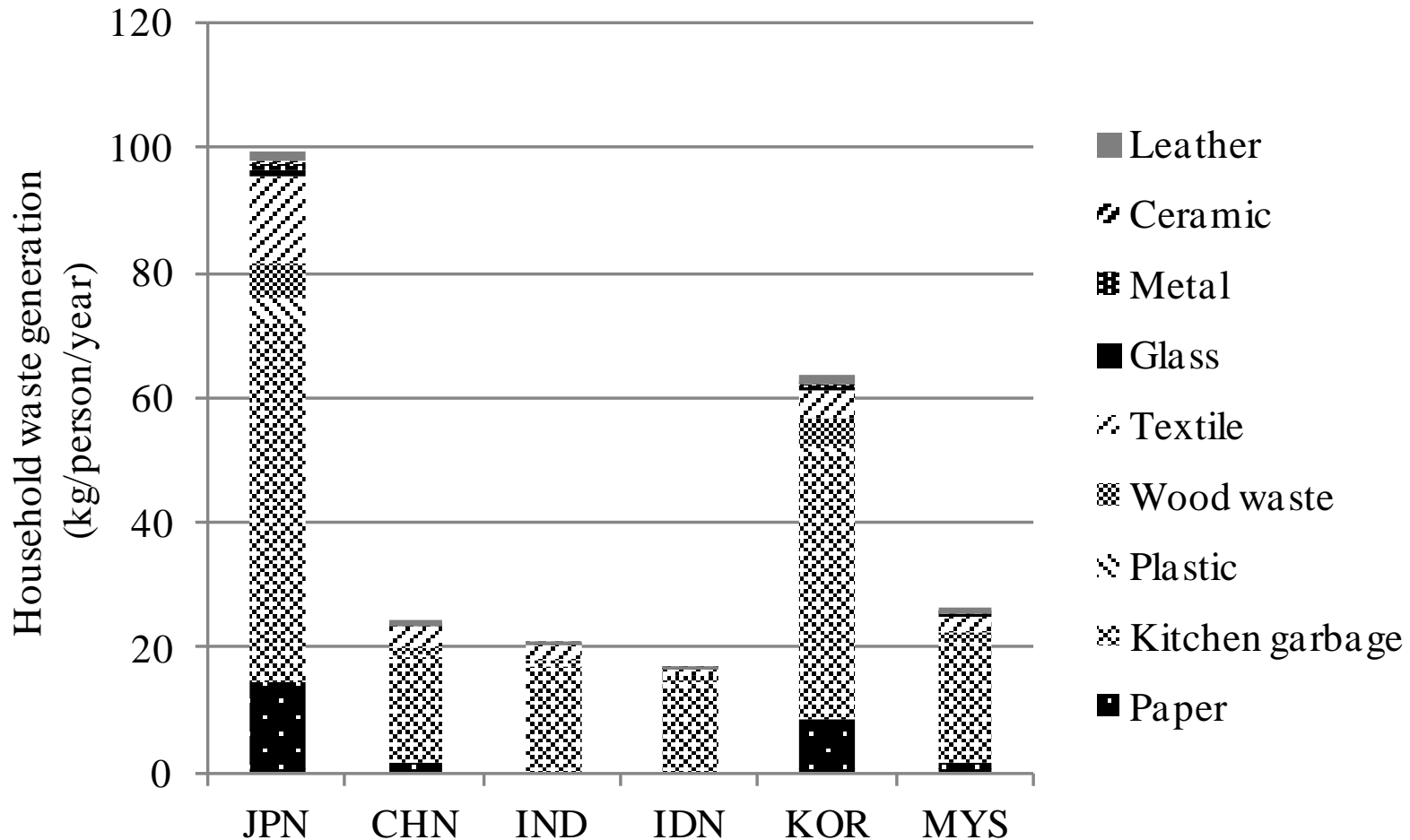
- **In developing country, household waste consists almost entirely of kitchen garbage.**
- **The more country develop, the more paper waste generate.**

Step4: Household waste generation in 2020

Total (Unit: 10^3 t)		2005	2010	2015	2020
JPN	Waste generation	12753	12719	12614	12602
	Growth rate		100%	99%	99%
CHN	Waste generation	31921	46635	65641	90683
	Growth rate		146%	206%	284%
IND	Waste generation	23085	28662	35438	43702
	Growth rate		124%	154%	189%
IDN	Waste generation	3674	5110	7409	10392
	Growth rate		139%	202%	283%
KOR	Waste generation	3082	3538	3904	4207
	Growth rate		115%	127%	136%
MYS	Waste generation	688	991	1407	1984
	Growth rate		144%	205%	288%
Per capita (Unit: kg/perso/year)		2005	2010	2015	2020
JPN	Waste generation	99.8	99.9	100.2	102.1
	Growth rate		100%	100%	102%
CHN	Waste generation	24.6	34.9	48.1	65.5
	Growth rate		142%	196%	267%
IND	Waste generation	20.9	24.0	27.7	32.0
	Growth rate		115%	132%	153%
IDN	Waste generation	16.8	22.0	30.3	40.9
	Growth rate		131%	181%	244%
KOR	Waste generation	64.0	72.4	79.2	85.3
	Growth rate		113%	124%	133%
MYS	Waste generation	26.3	35.1	46.6	61.8
	Growth rate		133%	177%	235%

Summary

・Especially in developing countries, household waste generation will increase significantly by 2020.
・Due to **increases in household waste generation per capita** and **population**, household waste generation in 2020 will be **about 3 times larger** than that in 2005.

・In developed countries, household waste generation in 2020 will remain on the same level or increase slightly due to **slower growth in consumption per capita** and **population decarease.**

Summary

- It was revealed that consumption patterns varied significantly between developed and developing countries and by income class. Although the reference amount of consumption and preference coefficient showed the expected tendency in developing countries, consumption activities that could not be expressed with the simple demand function were identified in developed countries where even low-income classes have attained a satisfactory standard of living compared to the other parts of the world.

- Among the countries studies, Japan accounted for the largest portion of household waste generation per capita in 2005; the amount in Korea was estimated to be approximately 60% and other developing countries to be approximately 20% of the level of Japan.

- In 2020, household waste generation is expected to increase in developing countries in particular owing to an increase in household consumption expenditure. It was revealed that household waste generation per capita in China would rapidly increase by 2.67 times over the 2005 level, which would account for almost 65% of household waste generation per capita in Japan.

- Household waste generation must be estimated as a result of bringing items not associated with the flow of money into households, which is not covered by this study.

Future works

- Resetting parameters (goods price, transformation matrix of household waste etc)

- Target countries (Thailand, Vietnam, etc)

- Target household waste type

- Household demand function

Thank you for your attention!

kanamori@nies.go.jp