Modeling of environmental load generation by household with household production and lifestyle model

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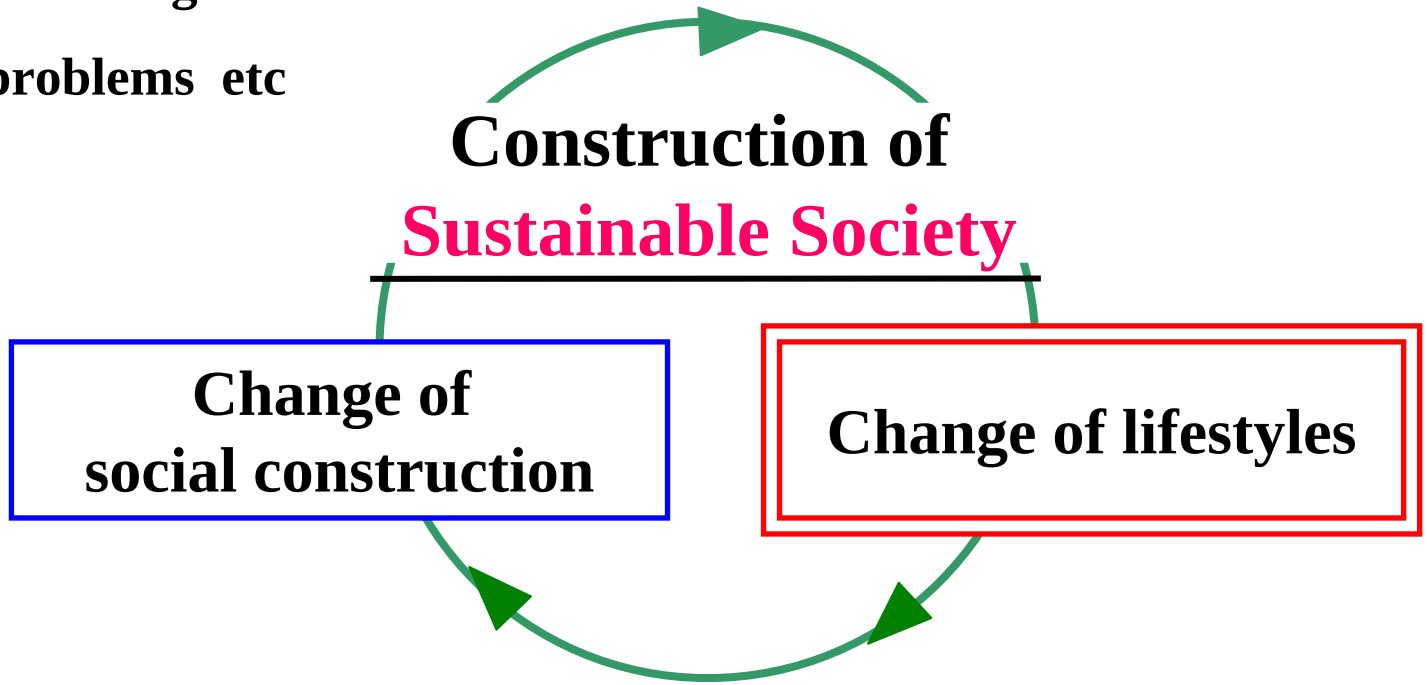
1. Background and objective

Environmental problems・・・

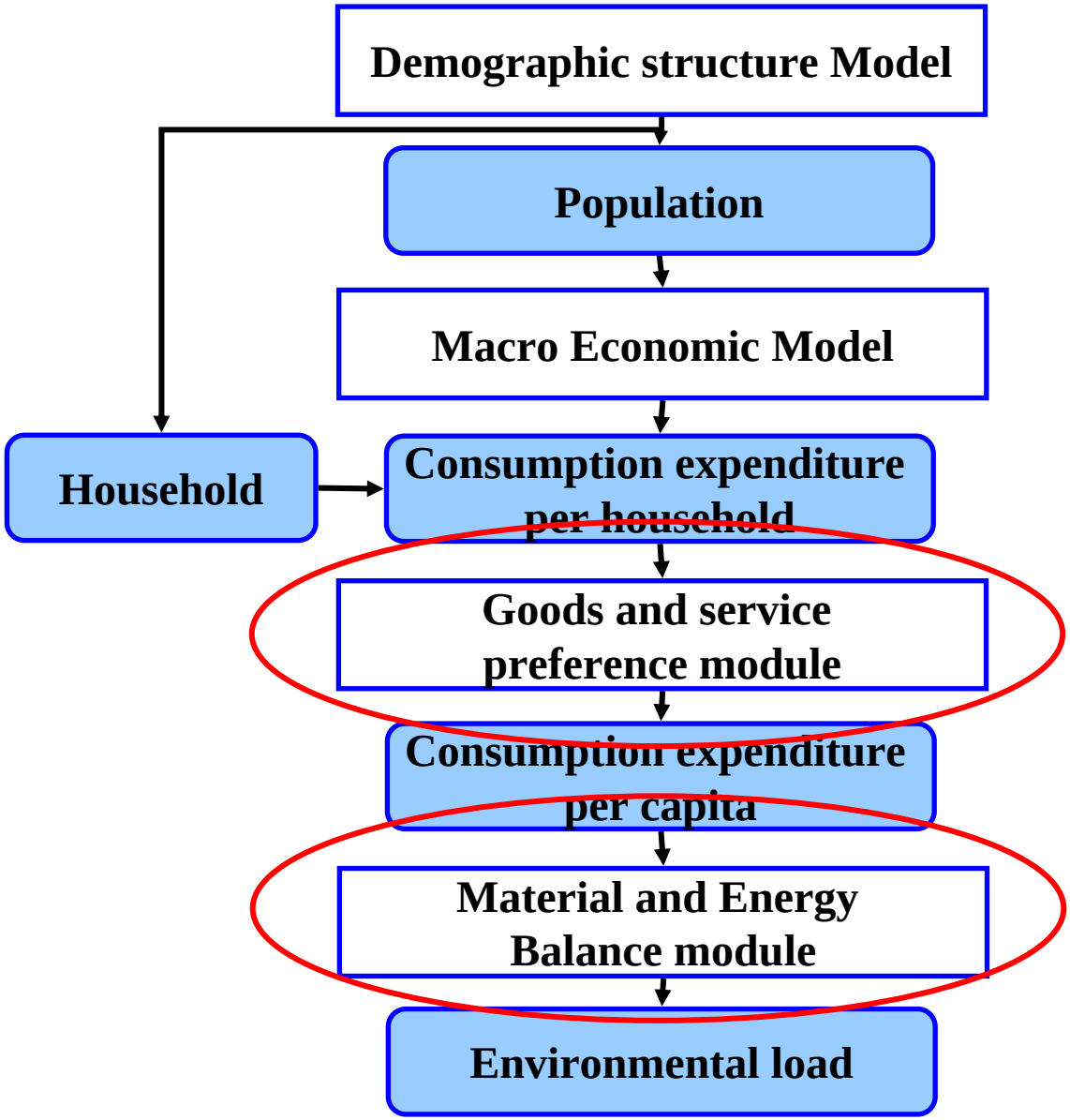
Global warming

Waste problems etc



To estimate relationship between household consumption and generated environmental load

2. Household Production and Lifestyle Model



[Main]

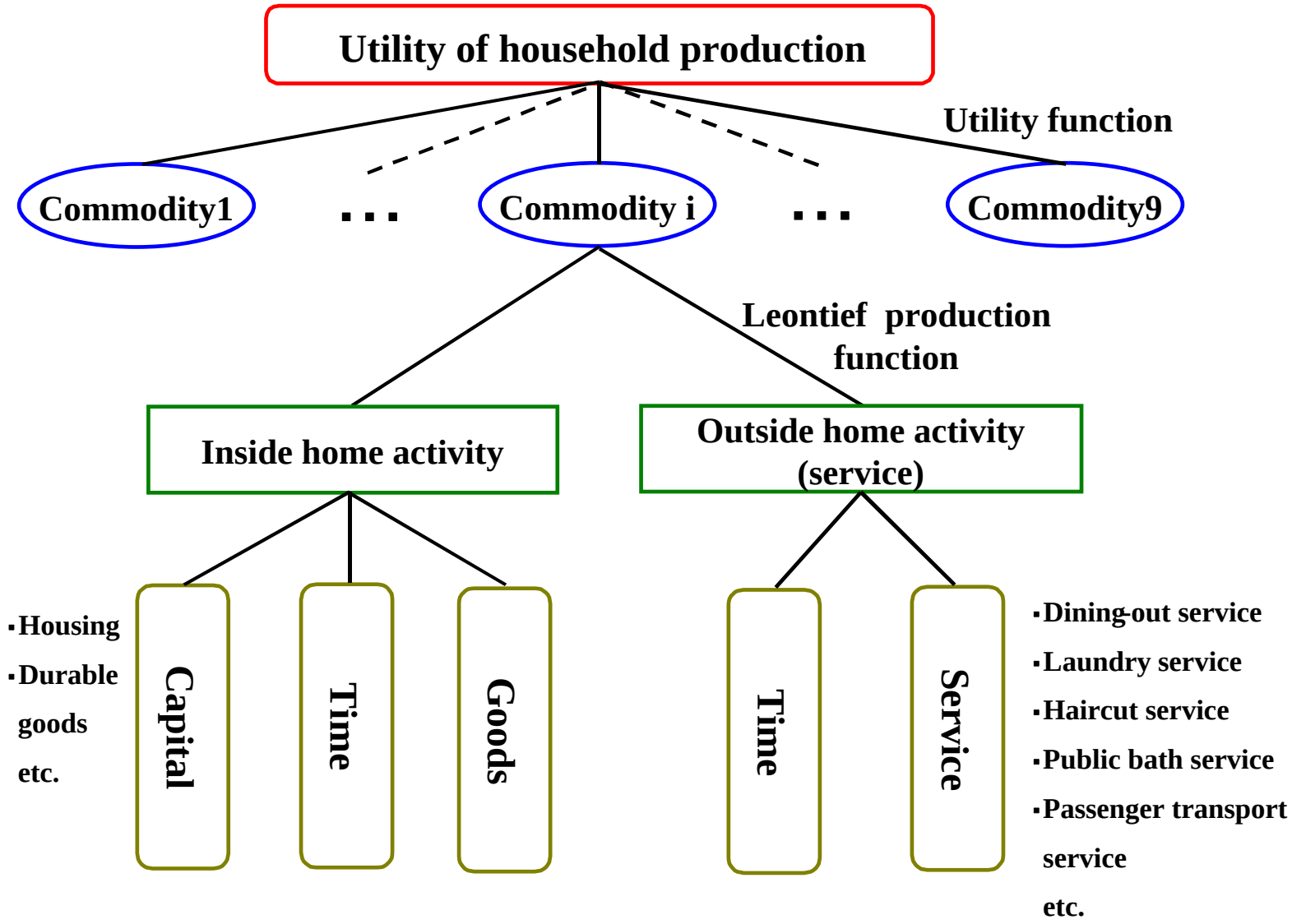
・2 modules are the main part to estimate lifestyle change.

[Sub]

・Demographic structure model・・・Composition of population and household are estimated.

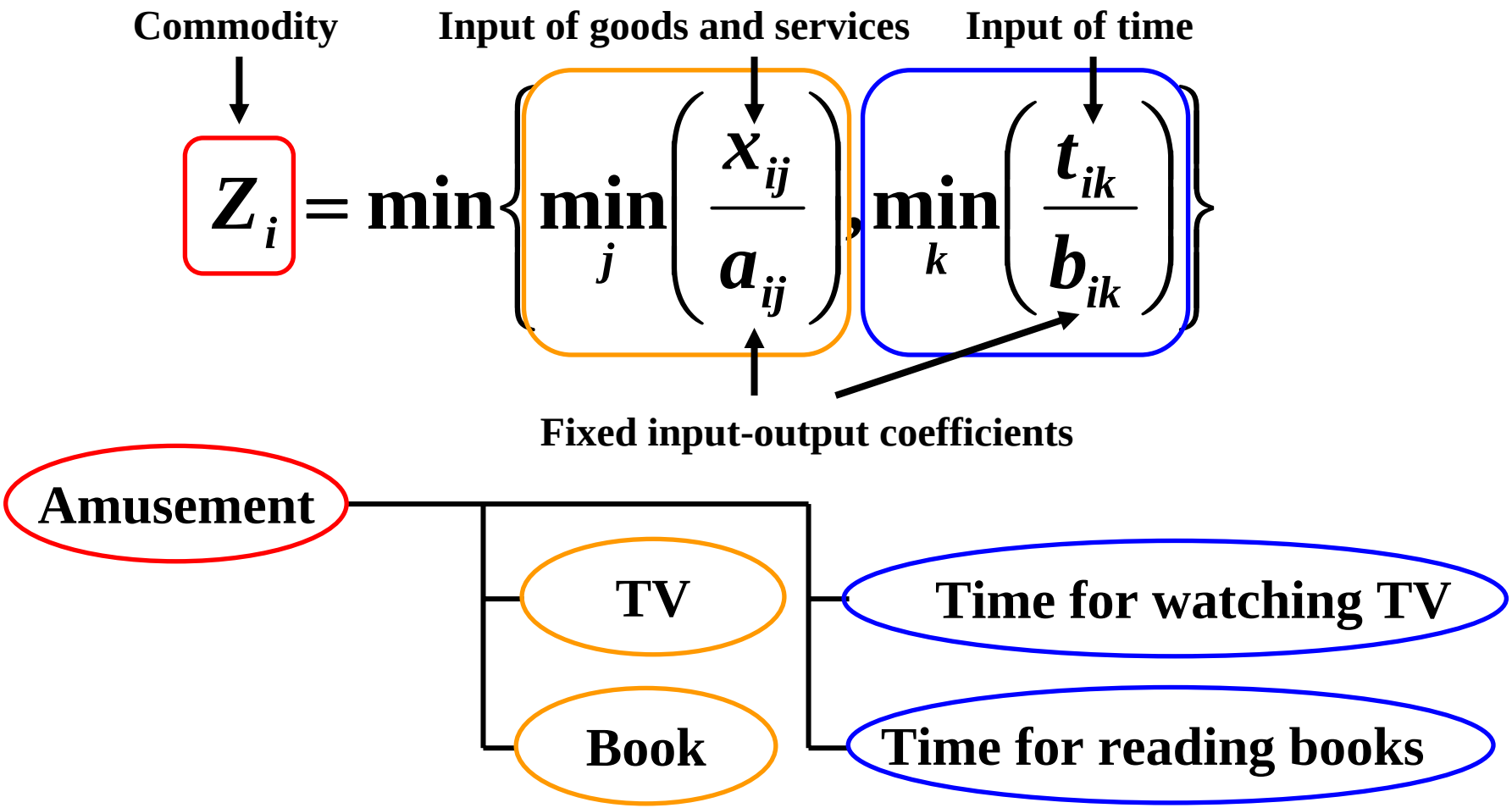
・Macro economic model・・・Economic values are estimated. In this model, household consumption is estimated.

2-1. Goods and Service Preference Module



2-1. Equations of Household Economy 1

The production function of Becker's commodity



2-1. Equations of Household Economy 2

- **The separate goods and time constraints can be converted into a single total resource constraint**

Full income: F — Unearned income: V — Saving: S — Price of commodity: π_i — Commodity: Z_i

$$F = wT + V - K = S + \sum_i \pi_i Z_i$$

Wage rate: w — Total time: T — Non-living expenditure: K

$$\pi_i = \sum_{j=1}^{J} p_{ij} a_{ij} + w \sum_{k=1}^{K} b_{ik}$$

Price of goods and services: $\sum_{j=1}^{J} p_{ij} a_{ij}$

Price of time: $w \sum_{k=1}^{K} b_{ik}$

2-1. Equations of Household Economy 3

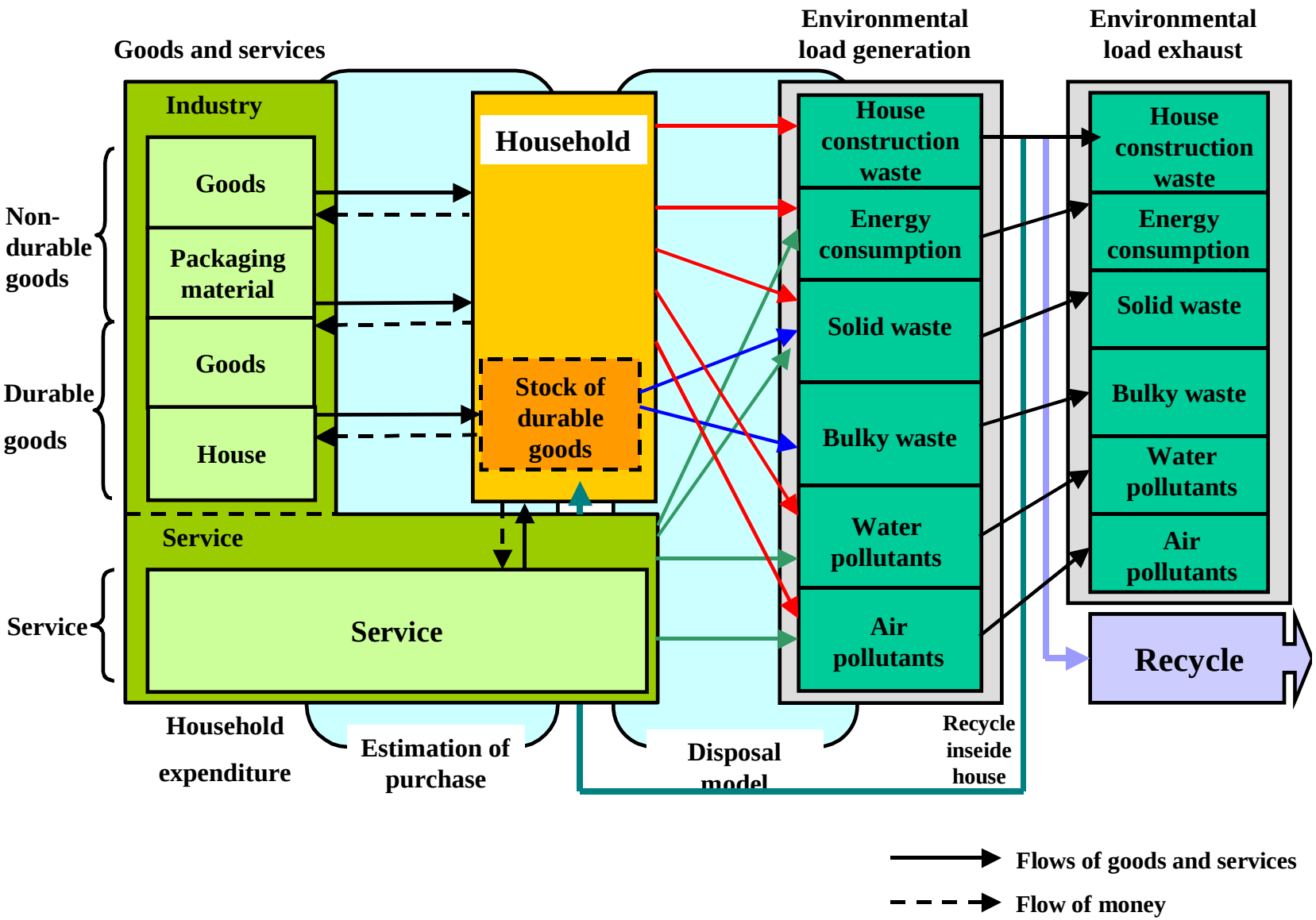
Preference function of commodity

$$U = f\left(Z_1, \cdots, Z_i, \cdots, Z_n\right) \rightarrow \max$$

Which function does fit the Japanese consumption expenditure data?

- **LES (Linear expenditure system)**
- **AIDS (Almost Ideal Demand System)**
- **Logit model**

2-2. Material and Energy Balance Module



2-2. Equations of Material and Energy Balance Module (Goods and Packaging materials)

Goods

$$X_{j,t}^{h} = E_{j,t}^{h} / p_{j,t}$$

Consumption expenditure

Price

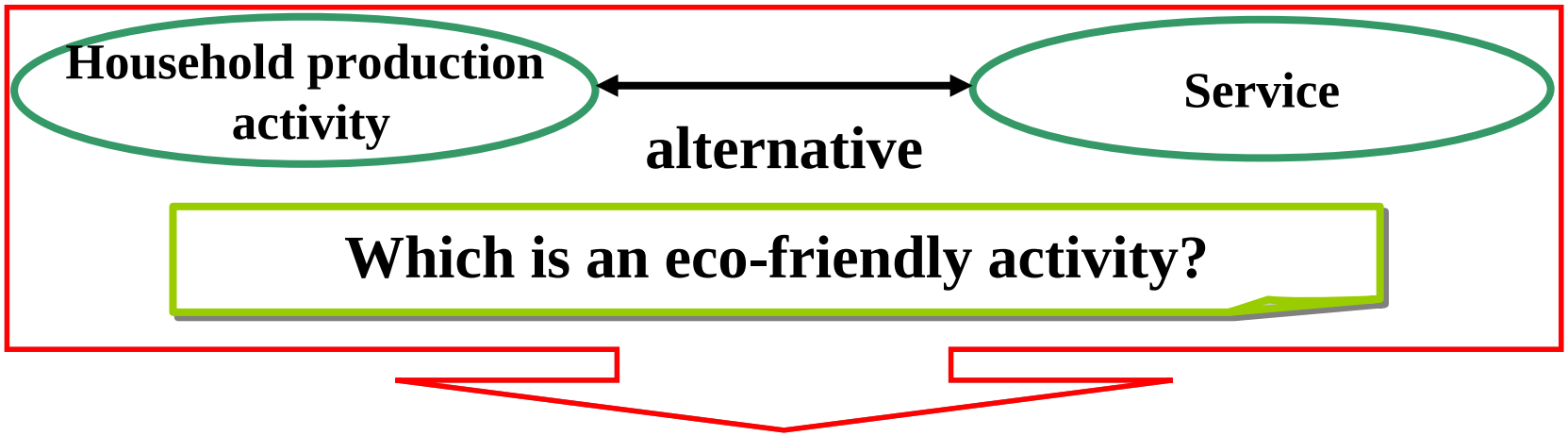
Packaging materials

$$XP_{j,t}^{h} = c_{pc,j}^{\prime} \cdot X_{j,t}^{h}$$

Rate of packaging material carried in to the amount of purchased goods

$$WG_{w,t}^{h} = \underbrace{\sum_{j \in GND} C_{j,w} \cdot X_{j,t}^{h}}_{\text{Non-durable goods}} + \underbrace{\sum_{j \in GD} C_{j,w} \cdot D_{j,w}^{h}}_{\text{Durable goods}}$$

2-2. Equations of Material and Energy Balance Module (Service)



Service

①Dining-out service　②Laundry service

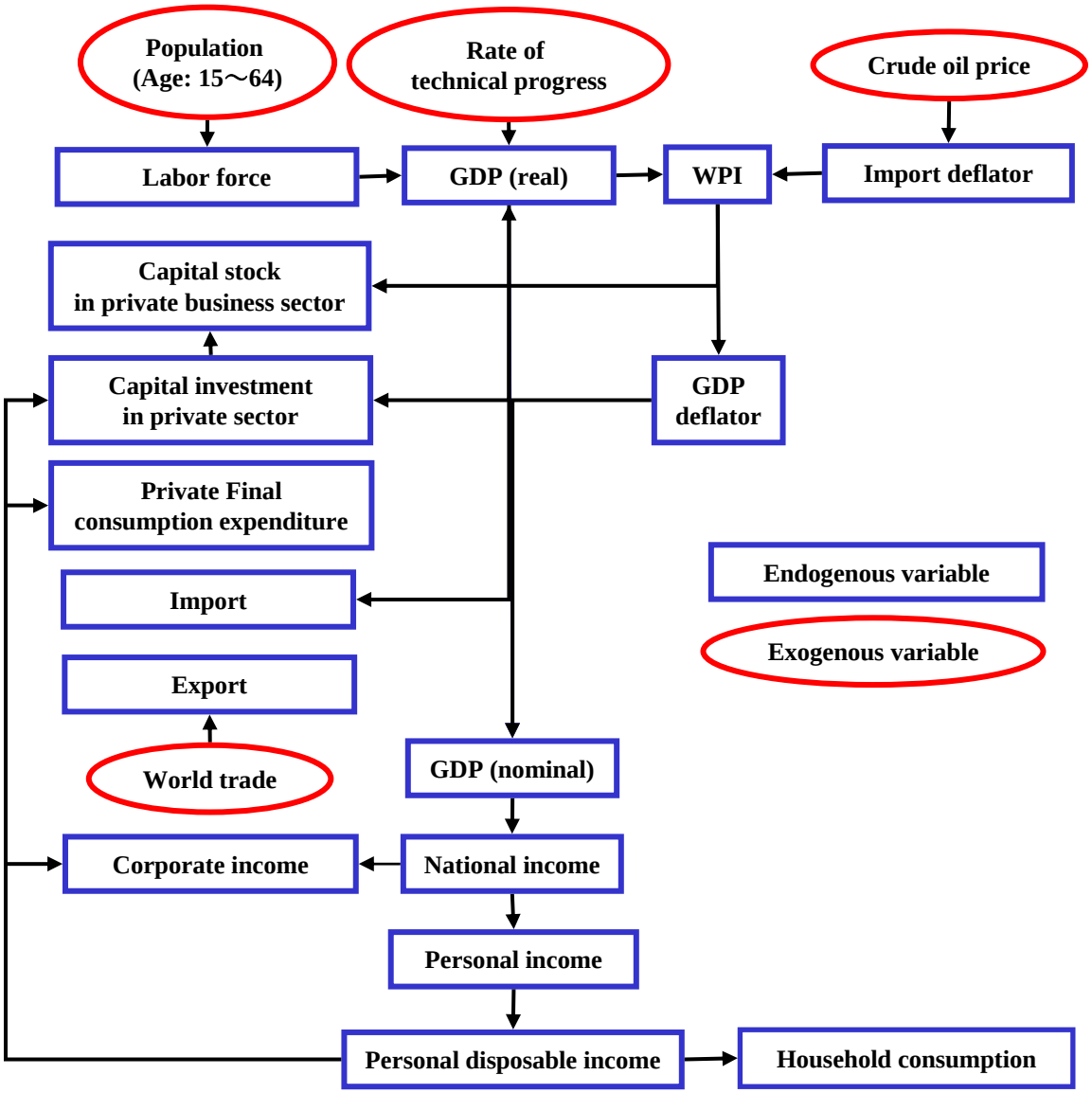
③Haircut service　④Public bath service

⑤Passenger transport service

$$WG_t^j = \left(E_{j,t}^h / p_j\right) \cdot UW^j$$

Unit service　Amount of environmental load per unit service

2-3. Macro Economic Model



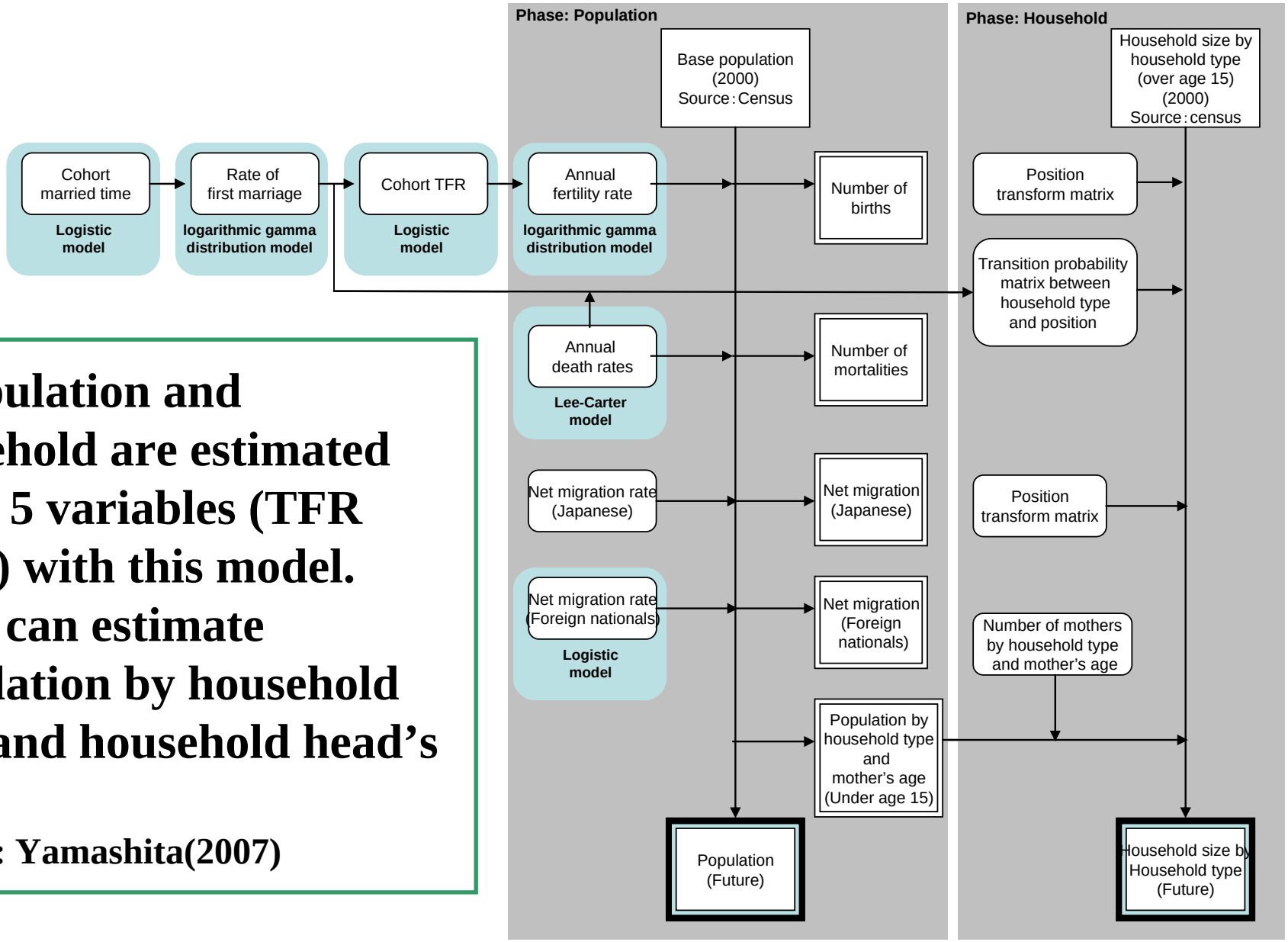
- This model is based on Murakami's macro economic model. (Murakami, 2006)

- We estimate consumption expenditure per capita by household type using this model.

- Structure equations: 65
- Definitional equation: 31

- Endogenous variables: 80

2-4. Demographic structure model



- **Population and household are estimated using 5 variables (TFR etc…) with this model.**
- **We can estimate population by household type and household head's age.**

Source: Yamashita(2007)

3. Model Description 1

The household type was taken into consideration as a factor which effects a household behavior.

- **Household type (4type)**
- **Household head's age (2 type)**
- **Income classification (3 type)**

4 × 2 × 3=24 type

Ex.) Classification of household type

Type 1 Single-person household
Type 2 Household with husband, wife and unmarried child or no child
Type 3 Household with single parent and unmarried child
Type 4 Others

3. Model Description 2

- ○ Country Japan
- ○ Commodity 11 commodity
- ○ Goods and service About 300 goods and services
- ○ Environmental Load 39 environmental load

- Estimation of parameters (1987～2002)

  Consumption expenditure data

  Annual Report on the Family Income and Expenditure Survey

- Simulation period : 2003～2030

3. Verification (material and energy balance module)

Input data: Consumption expenditure data (1995)

Reported value

Household waste
Waste treatment in Japan
Survey on waste composition in Kyoto city

Electricity consumption・・・
Outline of electricity demand

Town gas・LPG・Kerosene consumption・・・
Comprehensive energy statistics

Water supply・・・
Water system statistics

Environmental load		Estimated value (E)	Reported value (R)	(E) / (R)
Household waste (10^3t)	Paper	2290	3920	0.58
	Plastic	466	478	0.97
	Texitile	887	886	1.00
	Rubber	101	105	0.96
	Skin	182	152	1.20
	Glass	173	210	0.82
	Metal	394	338	1.17
	Wood	121	140	0.86
	Pottery	94	105	0.90
	Kichen garebage	11400	12600	0.90
Packaging material (10^3t)	Drink can	964	1000	0.96
	Drink glass bottle	1330	1400	0.95
	PET bottle	145	142	1.02
CO_2 emission (10^3t-C)	Electricity (h)	18600	22449	0.83
	Town gas (h)	4030	5384	0.75
	LPG (h)	3860	4356	0.89
	Kerosene (h)	8080	8498	0.95
	Gasoline・Light oil (h)	21410	21057	1.02
	Taxi (s)	66.4	72.95	0.91
	Bus (s)	1290	1359	0.95
	Rail (s)	216	225	0.96
Water consumption (10^6m^3)		5660	5540	1.02

3. Result---Macro economic model and Population model---

- **Macro economic model**

  2 type scenarios

  Disposable income per capita in 2030

  (comparing to 2000)

  1.701 times (scenario A)

  1.135 times (scenario B)

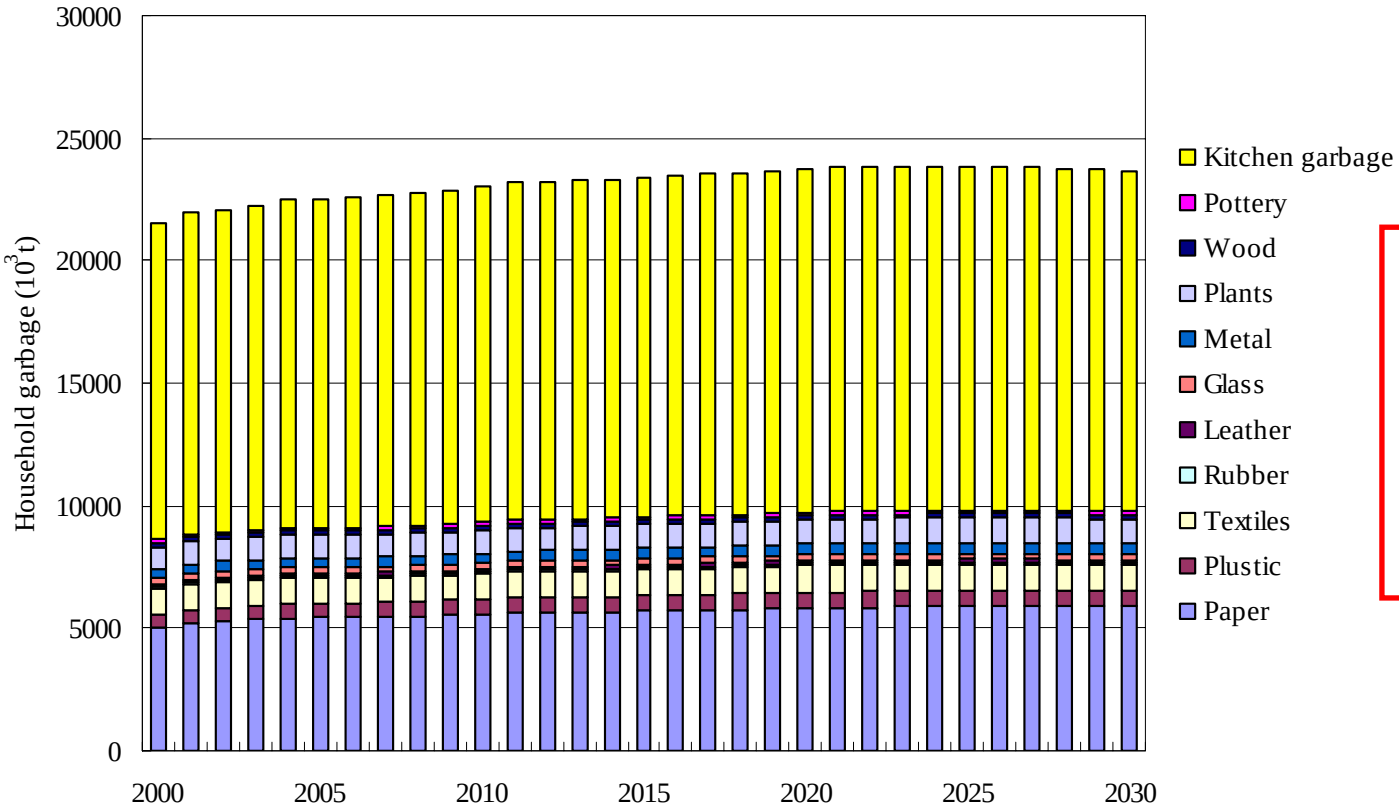
- **Demographic structure model**

  Population in 2030

  About 116 (million people)

3. Household garbage

Scenario A



Household garbage is not included materials which is brought in household at no cost, like containers and wrappings.

Factors

- **With a peak of 2007, population starts to decrease.**
- **Household size becomes small and single-person household increases especially.**
- **Consumption expenditure per capita increases.**

4. Conclusion

- **We develop “Household production and lifestyle model” to estimate relationship between lifestyle and environmental load.**
- **The model consists of 2 main modules “Goods and service preference module” and “Material and energy balance module”, and 2 sub models “Macro economic model” and “Demographic structure model”.**
- **With a peak of 2023, the amount of household garbage generation will start to decrease in scenario A.**