Analysis of CO_2 emissions from daily life and consideration on the low carbon daily activities in Japan

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Introduction

Owing to the growth of quantitative and qualitative needs of consumers, CO_2 emissions from our everyday life has been steadily increasing and the importance of the measures from consumers' side to reduce CO_2 emissions in our lifestyle have been paid attention to as one of the effective ways to reduce further emissions.

Japanese households emit CO_2 by energy use, which are residential electric power / city gas consumption, fuel consumption of private cars and disposal of municipal solid wastes. These "direct" emissions amount to approximately 6 kg per day per capita on an "average". Since the amount of direct emissions is large, there are many attempts to provide household eco-account books to estimate average "direct" CO_2 emissions. In addition, Ministry of the Environment of Japan is now promoting the "I declare CO_2 reduction of 1 kg 1 day 1 person" movement [1], where they are providing some concrete measures to Japanese consumers. Some local governments are promoting measures to their residents. However, these measures have two problems.

One is the amount of the direct CO_2 emissions. The direct CO_2 emissions only account for 20.9% of the total CO_2 emissions (1,303 Mt-CO_2 in FY2007) [2]. From the life cycle point of view, the rest of the CO_2 emissions can be said to be attributed to household, for they are "indirectly" induced by producing, purchasing, possessing and consuming goods and services. Taking meal as an example, emissions by city gas and hot water use for cooking and gasoline used for grocery shopping by private car are included in direct CO_2 emissions. On the other hand, lighting and freezing at grocery stores, food transport, and cultivation / fertilizing in agriculture industry are also induced by households. These induced emissions are not included in "CO_2 emissions from households" generally. They can be called "indirect" CO_2 emissions. If we are to discuss measures to mitigate CO_2 emissions in our lifestyle, it is necessary to figure out the total CO_2 emissions, both directly and indirectly, from our everyday life.

The other is effectiveness of measures to reduce CO_2, which are proposed to consumers. There are many consumers and they have different lifestyles. Considering their various lifestyles, a measure effective for one person may be ineffective for the other person. Taking meal as an example again, saving of city gas and hot water for cooking is an effective measure for consumers who cook their meal themselves. In the meantime, it is an ineffective measure for those who eat out every day. The past policies have been based on average statistics data. However, in order to propose more effective measures to mitigate CO_2 emissions, it is important to pay attention to variety of consumers' lifestyles.

This study aims at estimating Japanese lifestyle CO_2 emissions from LCA perspective with micro data of family expenditure survey so that we can find effective measures that have large potential for reducing CO_2 emissions in our everyday life.

Materials and methods

CO_2 emissions from Japanese lifestyle are evaluated based upon input-output (I-O) tables and family expenditure survey data.

First, the domestic CO_2 emissions by final demands are calculated from 2000 I-O tables for Japan [3] to grasp proportion of the direct and indirect emissions by each final demand item. Nansai et al [4, 5] and Nakano et al [6] have already calculated by similar methodologies. Our estimation followed the

way Nansai et al had used.

Then, the detailed CO_2 emissions from household are estimated. There are two available family expenditure survey data in Japan both implemented by Ministry of Internal Affairs and Communications (MIC; whose name was Ministry of Public Management, Home Affairs, Posts and Telecommunications until September 2004): Family Income and Expenditure Survey (FIES) [7] and National Survey of Family Income and Expenditure (NSFIE) [8]. FIES, a yearly survey, is carried out to comprehend the changes in economic trend. The sample number is small but the monthly or seasonal difference of expenditure is reflected to. On the other hand, NSFIE is carried out every five year with large sample number in a limited period (from September to November of the year for more-than-one-person families and from October to November for single-person families) to understand the situation for the household budget and property in detail. Resampled micro data (primary data) of NSFIE is also available on a trial basis. The expenditure items in this study are listed in Table 1. We can evaluate variety of lifestyles by using micro data of NSFIE. Nakamura et al [9] have already evaluated CO_2 emissions from household based on FIES with 3EID. However, they conducted without micro data of NSFIE and has not evaluated variety of lifestyles. Assuming that the secondary data of NSFIE is more accurate than FIES for expenditure survey, the following procedures are taken to estimate household CO_2 emissions in this study:

(1) The ratio of the sum of FIES expenditure at the same survey period of NSIFE to annual total is calculated for each expenditure item.
(2) The annual expenditure of FIES is adjusted by multiplying the above calculated ratio to expenditure of NSFIE.

Table 1: Expenditure items of household

Category		Item of NSFIE (excluding shift of family income and unknown expenses)
Direct	Electricity	Electricity (Total: 1 item)
	City gas	Gas, manufactured & piped (1)
	LPG	Liquefied propane (1)
	Kerosene	Kerosene (1)
	Other fuel & light	Other fuel & light (1)
	Water & sewerage	Water and sewerage charges (1)
	Sewage disposal	Dealing charges of large-sized discarded, other sewage disposal charges (2)
	Gasoline	Gasoline (1)
Indirect	Food	Rice, fresh fish and shellfish, beef, fresh milk, fresh vegetables, fresh fruits, edible oil, cakes and candies, packed lunch, green tea, “sake”, meals, charges for board, etc. (82)
	Housing	Rents for dwelling, tools for repairs and maintenance, etc. (6)
	Furniture & household utensils	Microwave ovens, lighting appliances, beds, tableware, polyethylene bags and food wrap, domestic help, etc. (37)
	Clothes & footwear	Men's Japanese clothing, men's suits, men's business shirts, men's underwear, cloth and thread, neckties, canvas shoes, tailoring and repair charges, etc. (42)
	Medical care	Medicines, health fortification, paper diapers, medical treatment, etc. (13)
	Transportation & communication	Railway fares, automobiles, postage, etc. (28)
	Education	Elementary school fees (national or public), school textbooks and reference books for study, children and elementary school tutorial fees, etc. (15)
	Reading & recreation	TV sets, stationery durables, newspapers, hotel charges, etc. (55)
	Other living expenditure	Admission fees for hot spring and public baths, electric appliances for personal care, umbrellas, tobacco, religious contribution, obligation fees related to housing, etc (28)

(3) There are also two available price index survey data in Japan both implemented by MIC: Consumer Price Index (CPI) [10] and National Survey of Prices (NSP) [11]. CPI is a monthly survey but the sample number is small. It is suitable to grasp the changes in economic trend. NSP is carried out every five year with large sample number and provides more accurate price indexes including regional difference. The amount of each expenditure item in 2004 is adjusted to the price in 2000 using CPI (2000-base) so that the 2000 I-O tables can be applied to the estimation.
(4) Unknown expenditure items, which are pocket money and social expenses, are allocated to the other expenditure items based on CPI's appendix table.
(5) Wholesale trade and retail trade are allocated to all of the other sectors which have wholesale trade or retail trade margin because these two sectors are hardly associated with the family expenditure items.
(6) The expenditure items are associated with sectors in I-O tables. It is paid attention to that every expenditure item is associated with one or more sectors and every sector associated with one or more expenditure items. However, money gifts, other obligation fees, and remittance among the expenditure items are not associated with the sectors because they are just shift of family income. Materials for ceramics, pulp, scrap iron, non-ferrous metal scrap, reuse and recycling, house rent (imputed house rent), and activities not elsewhere classified among the sectors are not associated with the expenditure items because they do not represent consumption of households in the real world.
(7) CO_2 emissions from household are estimated from the calculated annual expenditure and I-O tables.

"Direct" CO_2 emissions for each kind of energy use are referred to 3EID's appendix table. For the "indirect" emissions, the import coefficient data and the $(I-(I-M)A)^{-1}$ type embodied CO_2 emission intensity data of CY2000 on a household consumers' price provided in 3EID is used for indirect and induced emissions so that the domestic emissions induced by the consumption of common products including domestic and imported are calculated.

The resampled micro data of NSFIE was also analyzed. The analyzing method is similar to abovementioned method for NSFIE data. However, before multiplying the import coefficients and the CO_2 emission intensities, the amount of expenditure is changed from the price by the region where each respondent lives to the price in national average using 2002 NSP. The raw expenditures shown in the micro data include difference in the prices depending on the region.

Results

CO_2 emissions induced by final demand

Figure 1 shows the CO_2 emissions induced by final demands in Japan in CY2000. The total CO_2 emissions per capita per day are 28.2 kg-CO_2, which are 1,308 Mt-CO_2 in total and approximately correspond to the previously described estimation [1] (1,255 Mt-CO_2 in FY2000). The direct and indirect emissions from households account for 6.2 kg (22.1% in the total) and 7.3 kg (26.0%), respectively. Moreover, from an actual final consumption expenditure standpoint, the emissions from consumption expenditure of private non-profit institutions serving households and those from individual consumption expenditure of central / local government are also considered to be induced by consumers' activities. The amount of the emissions is up to 15.0 kg. Since the rest of the emissions except for stock and export can be regarded to be induced by consumers' lives, it can be said that it is important to not reduce only direct emissions in our daily life but also indirect emissions through the changes of our lifestyle. There can be effective measures to mitigate CO_2 emissions among the region of "indirect" emissions.

Direct and indirect CO_2 emissions from households

Figure 1 showed that there are large potential for reducing CO_2 emissions in "indirect" emissions region. Since the estimated results are based upon I-O tables that are not household but industrial statistics, however, pieces of information how we should change our lifestyle to reduce CO_2 emissions cannot be obtained from the results. From this point of view, it is necessary to estimate the emissions based upon the family expenditure survey data.

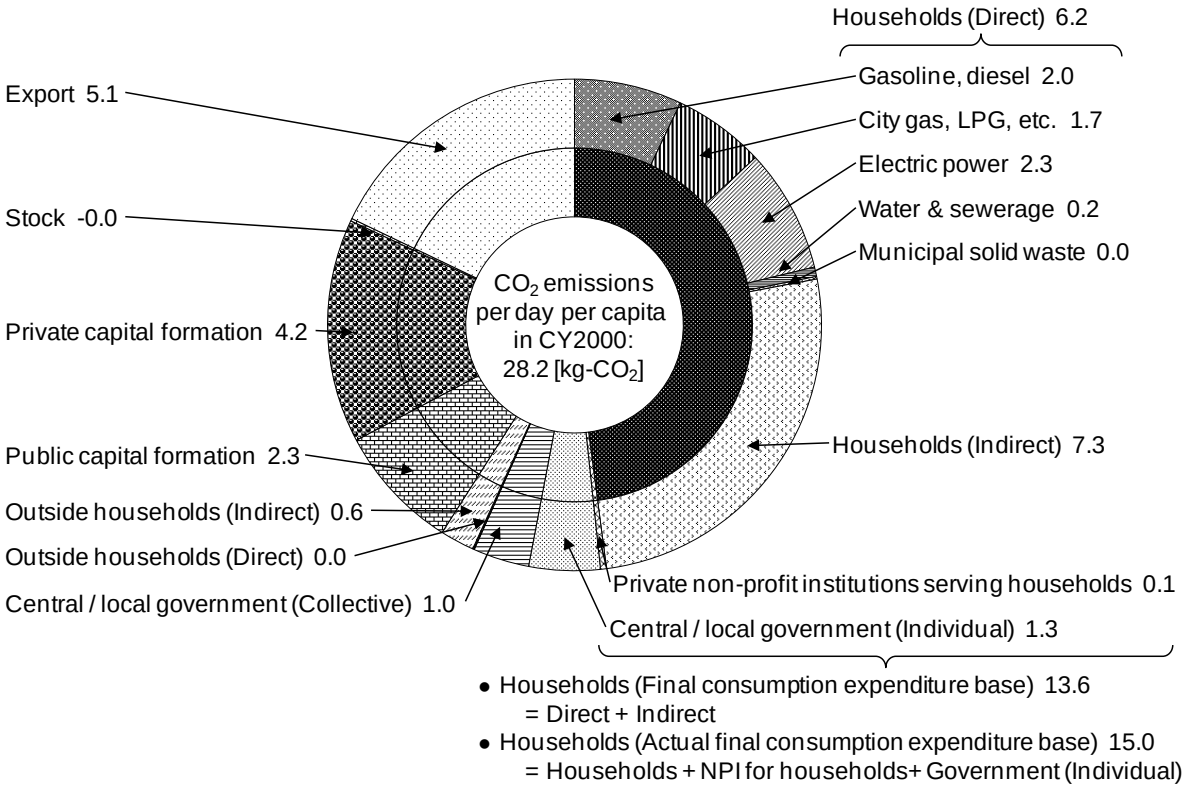

Figure 1: CO_2 emissions induced by final demands

Figure 2 depicts the CO_2 emissions per day per capita from household. Residential place and household size have been chosen as the typical attributes that affects difference in household expenditure and reflected in Figure 2. Please note that the emissions per day per capita shown in Figures 1 and 2 are different owing to the data source. We are now under consideration how to adjust the both values.

The difference in direct emissions, especially for those from energy use, is attributed to what kind of energy is used for heating and cooling system (electricity, kerosene or city gas) and whether or not the passenger cars are used for daily means of transport in each district. Households in Hokkaido & Tohoku where it is cold emit much CO_2 throughout kerosene use. Meanwhile, CO_2 from kerosene in Hokkaido & Tohoku has large standard deviation, too. It is considered that energy saving and replacement with high efficiency heating equipments can reduce CO_2 from kerosene even in Hokkaido & Tohoku. In addition, Households in Kanto and Kinki which have large public transportation network emit less CO_2 than those in other districts. It is important in mitigating CO_2 to construct public transportation network. Figure 2 only shows relationship between regionality / household size and direct emissions. However, for example, Hosaka et al [12] obtained individual data for energy consumption of single-person households. They found large difference in energy consumption for hot water supply by their habit of taking either a bath or a shower. If they can change their habit of taking a bath to shower, large CO_2 emissions may be reduced. It is needed to analysis relationship between other attributes of households and emissions for such a finding.

In terms of indirect CO_2 emissions, those induced by food, transportation & communication, and reading & recreation show the large proportion. Unlike direct emissions, every indirect emissions have large standard deviation. In addition, their regional differences are much smaller than direct emissions' ones. It is considered that indirect emissions are affected by household demographic attributes other than regionality or lifestyle attributes [13]. More detailed analysis on indirect emissions will reveal that there are large potentials for CO_2 mitigation in our everyday life.

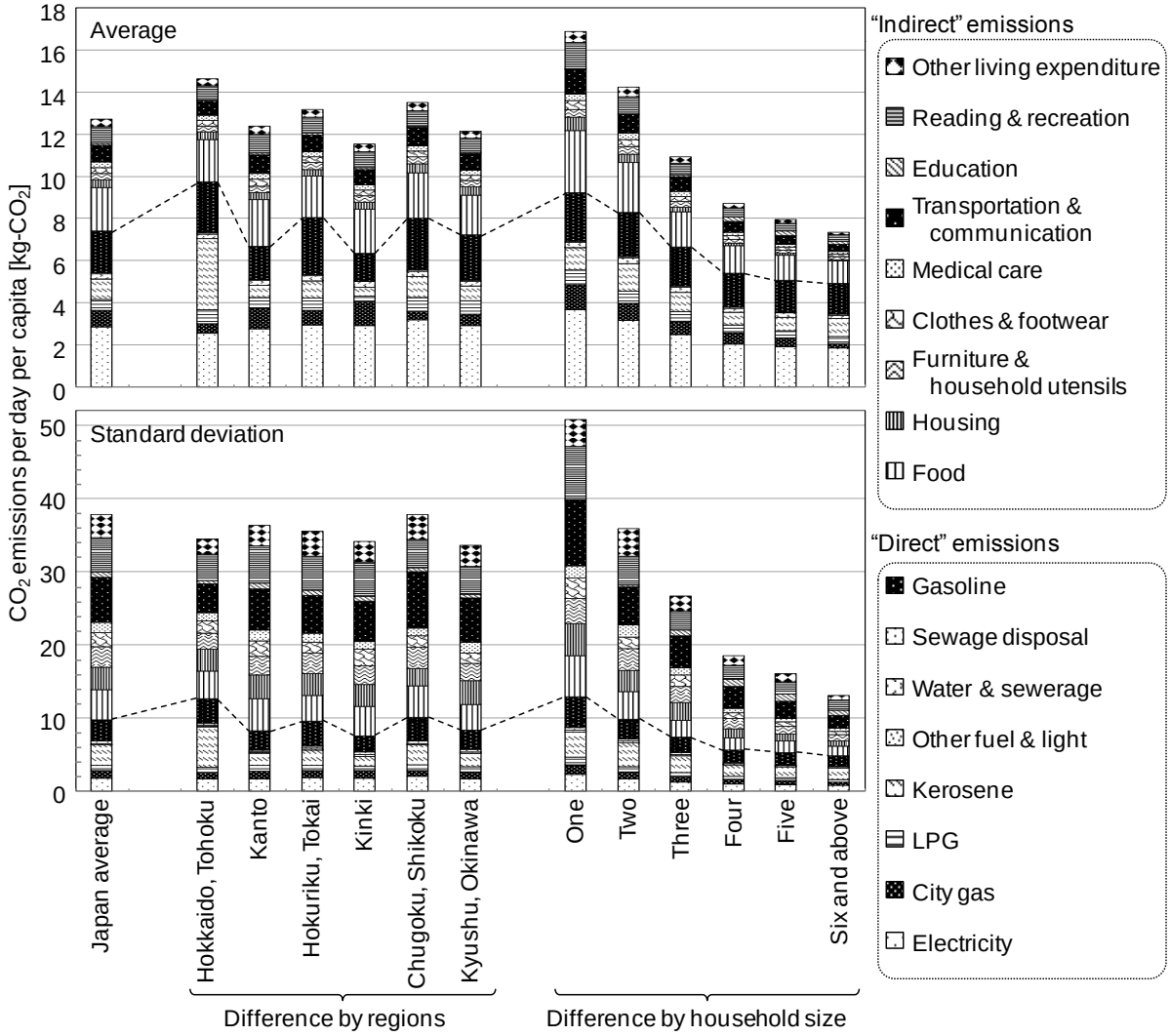

Figure 2: CO_2 emissions from household

Conclusions

Consumers emit CO_2 in various ways throughout not only energy use but also producing, purchasing, possessing and consuming goods and services. This study showed that "indirect" CO_2 emissions induced by them are not small and larger than direct CO_2 emissions. In addition, we also found that some direct emissions are affected by regionalities but indirect emissions would be affected by other household attributes from the analysis of micro data of family expenditure survey. In order to find effective measures to reduce indirect CO_2 emissions, more detailed analysis of micro data is needed.

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