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研究課題名（和文）街区レベルGHGインベントリに基づく低炭素都市政策の数量的評価手法と中国への応用

研究課題名（英文）District-level GHG-inventory-based low-carbon policy analysis methods and the application to China

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研究成果の概要（和文）：低炭素都市計画や都市政策を評価する際には都市の温室効果ガス（U-GHG）を（1）街区レベルで推定することが望ましい。また、国レベルと違って、（2）統計データへの依存が少なく簡素な方法で推定し、（3）政策決定者や市民に分かりやすい結果を出すことが望ましい。特に（2）に関しては、統計データが不十分で排出量削減が急務となっている新興国にとってもたいへん重要であり、世界的に関心を集めている。
本研究は日本現行のU-GHG排出量推定方法を検証したうえ、その経験を生かしながら、以上の3点を満たす新しい推定方法を開発し、さらに二酸化炭素排出量世界一の中国の低炭素都市計画・政策評価への応用を試みた。

研究成果の概要（英文）：When evaluating low-carbon city planning and urban policy, it is desirable to estimate urban greenhouse gas (U-GHG) at block levels (Point 1). Also, unlike the national level, it is desirable to estimate with a simple method with little dependence on statistical data (Point 2), and (Point 3) to make it easy to understand to policy makers and citizens. Especially for Point 2, it is essential for emerging countries where statistical data are insufficient and emissions reduction is an urgent task.
This study examines the existing U-GHG emissions estimation methods in Japan and the world, develops a new estimation method that satisfies the above three points. By making full use of Japan's experience, the research contributes to China's low carbon city planning and policy evaluation.

研究分野：　工学

キーワード：　環境政策　都市計画　温室効果ガスインベントリー　低炭素　中国

１．研究開始当初の背景

As the threat to ecosystems due to the increase of greenhouse gas (GHG) had been scientifically verified, GHGs from the rapid economic growth and urbanization in China attracted great attention from the world. In 2010, China's energy-origin GHG emissions accounted for 24.0% of the world, being the largest emitter for the fourth consecutive years. In contrast, Japan's emissions only shared 3.7%. Although it was still necessary to continuously reduce GHGs from Japan, reducing the emissions from China was of greater significance. Meanwhile, the Chinese government also clearly set targets such as "green growth" and "low carbon development", and had focused greatly on the construction of low-carbon ecological cities.

Since emissions from cities shared more than 70% of world's CO2 emissions, actions at the city level were urgently needed to stop climate change. Japan had set high reduction targets on its own and pursued its policy toward that. Since 2008, it has enacted a law to enforce local governments of above a certain population size to make action plans to combat the climate change. For this purpose, the Ministry of Environment and the Ministry of Land, Infrastructure and Transport support the formulation of the GHG reduction plan through providing manuals, guidelines and support websites. However, there are still points to be verified and improved regarding the Urban GHG (U-GHG) inventory estimation method. Meanwhile, the United Nations, the World Bank and international organizations at the city levels also emphasized the creation of a common U-GHG inventory; however the goal had not been reached. Therefore, it was necessary to propose U-GHG inventory estimation method which can be applied in emerging countries with high emissions, making full use of Japan's method and experience.

２．研究の目的

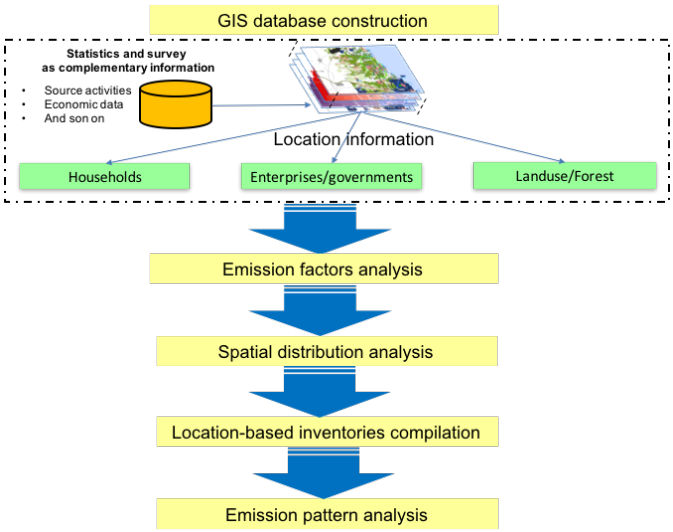
When evaluating low-carbon city planning and urban policy, it is desirable to estimate urban greenhouse gas (U-GHG) at block levels (Point 1). Also, unlike the national level, it is desirable to estimate with a simple method with little dependence on statistical data (Point 2), and (Point 3) to make it easy to understand to policy makers and citizens. Especially for Point 2, it is essential for emerging countries where statistical data are insufficient and emissions reduction is an urgent task. This study examines the existing U-GHG emissions estimation methods in Japan and the world, develops a new estimation method that satisfies the above three points. By making full use of Japan’s experience, the research contributes to China's low carbon city planning and policy evaluation. Specifically,

- To clarify the consistency and problems between "proportional division method" (Top-down) and "accumulation method" (Bottom-up) which are existing methods of U-GHG inventory preparation.
- To develop a new method of estimation in which emissions at the block levels can be visualized. The accuracy and effectiveness of the new method should be compared with the results of the existing method.
- To propose a new estimation method through its case study in Chinese cities for its practicality and evaluation on China's low-carbon city planning and policy.
- To contribute to the creation of a common U-GHG inventory method for the world.

３．研究の方法

For the research achievement ① introduced in the next section, The principal investigator adopted the existing inventory method called “The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories” (abbreviated as GPC) which were developed by WRI, C40, and ICLEI.

In research achievement ②, emission activity data from households, enterprises/governments and land use/forests were retrieved from location-based statistics and were integrated by Geographical Information System for visualization (refer to the figure below).



Framework of the proposed location-based GHG inventories compilation

4．研究成果

① Inventory of Greenhouse Gas Emissions of Chinese Cities: A case study of Beijing

A comprehensive GHG inventory provides an overview and the information of sources of emissions, and can serve as a sound scientific basis for mitigation actions. This study was the first initiative to develop a complete and transparent GHG inventory of Beijing, to document the current situation and to help governmental officials to clarify their priorities for reducing GHG emissions. The principal investigator investigated and calculated the emission sources defined by the GPC, and assessed data accuracy. The contents of the detailed inventory were documented and are open for research verification and for methodological references for other cities.

Summary of the Beijing GHG inventory for 2014 (unit: 1000 ton)

Sector	Sub	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Total	Share	Total	Share	Scope 1	Scope 2	Scope 3
Energy	Fossil fuel consumption*	**162,063**	789	635				163,487	91.6%	164,906	93.4%	67,424	89,924	6,139
	Biomass combustion		37	9				46	0.0%			46		
	Fugtive emissions of mining industries		950					950	0.5%			950		
	Fugtive emissions of oil & gas		423					423	0.2%			423		
IPPU	IPPU	**7,081**		?	0	?	?	7,081	4.0%	7,081	4.0%	7,081		
Agriculture	Rice cultivation		8	0				8	0.0%	1,402	0.8%	8		
	Cropland fertilization			318				318	0.2%			307		
	Livestock enteric fermentation and manure		824	252				1,076	0.6%			1,123		
Waste	Waste Landfill		**1,974**					1,974	1.1%	3,080	1.7%	1,958		17
	Waste Incineration	507						507	0.3%			507		0
	Household Wastewater		203	388				591	0.3%			591		0
	Industry Wastewater		7	0				7	0.0%			7		0
Total		169,652	5,215	1,602	0	?	?	**176,469**	98.9%	**176,469**	100.0%	80,425	89,924	6,156
Share (CO_2e)		**97.3%**	**3.0%**	0.9%	0.0%	?	?	100%				46.1%	51.6%	3.5%
Forestry, Land use change	Forestry	-2044						-2044	-	-	-	-2044		
	Land use change							0	?			?		

* Including out-of-boundary electricity and heat

Note that these emissions were what could be estimated with available data sources

Source: prepared by the authors.

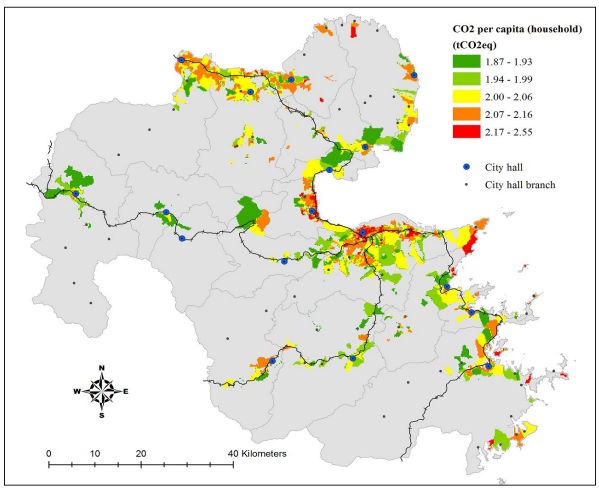
The average accuracy levels of the GHG sectoral emissions in Beijing during 2014

The results showed that three emission sources, i.e. CO2 emissions from fossil fuel consumption, CO2 emissions from industrial production and CH4 emissions from landfills, contributed 97% of Beijing's GHGs. Considering the problem of missing data and low data quality, The principal investigator suggested that instead of seeking to compile a complete inventory, Chinese cities should first report their GHG emissions from these sources, while improving the data quality for the long run. The principal investigator anticipates that the findings reported in this paper will help to strengthen city-level GHG inventory research in China and throughout the world.

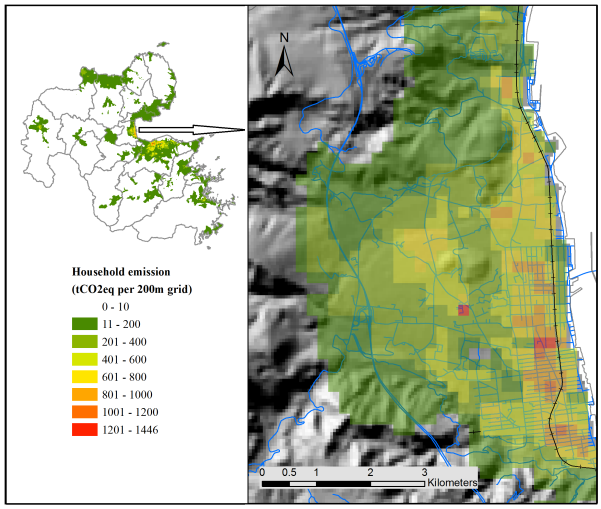
② Exploring spatial explicit Greenhouse Gas Inventories: Location-based accounting

approach and implications in Japan

Cities are both the main source of greenhouse gases (GHGs) and the main arena of emission reductions. However, many cities have difficulties to compile the GHG inventories to support their mitigation plans and actions scientifically. Currently, the IPCC framework of inventories is mostly sector-based, within which the emission from a certain sector is estimated as an aggregated volume based on statistical yearbooks. Since the data is only available above some administration level, emissions are difficult to scale down to a specific geographical boundary. With this circumstance, a spatial explicit accounting approach on the city-level GHG inventory is required to provide sophisticated information for the better decision-making on the local mitigation actions. The aim of this study is to propose a location-based GHG inventory approach to fill the gap. The proposed inventory framework uses sampling surveys, enterprise GHG reports and the geo-referenced data to estimate the emissions and the spatial distributions. Geographic Information Systems (GIS) are used to integrate the results. The proposed framework is applied to Oita Prefecture, Japan as an implication to test the approach's feasibility and offering enlightening insights.



Per capita household emissions and the spatial distribution in Oita Prefecture, Japan



Scaling down household emissions to Beppu area

Since the emission sources are visible on maps and one can zoom to any necessary level of scale, the location-based inventory can better provide the spatial explicit information for better mitigation policy-making and environmental education at community levels. It will also provide enlightening insights to the in-depth investigation on the relationships between distribution of GHG emissions and the city landscapes, hence benefitting the low-carbon city research and practice in the future.

③ Comparison of the proposed inventory framework (bottom-up, or precisely the "location-based" method proposed by the principal investigator) and the IPCC framework (top-down); refer to the figure below

Through the case study of Oita, Japan, we argue that our location-based method can provide much more detailed information and can enable to scale down and visualize to the any scale levels, which can strongly complement the lacked information of IPCC report.

Categories by the proposed framework		Emission Factor (t/household or t/person)	Number of (household/ employee)	tCO2eq
Household (residence)	One-person household	1.9	148,321	287,743
	Two-person household	3.5	143,826	501,953
	Three-person household	4.1	86,023	353,555
	Household with 4 or more persons	4.9	103,731	510,357
Household (transportation)	One-person household	0.8	148,321	111,241
	Two-person household	1.5	143,826	208,548
	Three-person household	1.9	86,023	163,444
	Household with 4 or more persons	2.6	103,731	264,514
Industries	Agriculture, Forestry & Fisheries	72.8	8,812	641,124
	Mining	173.8	770	133,848
	Construction	17.5	47,868	835,503
	Manufacture of pulp, paper and paper products	701.7	587	411,919
	Manufacture of petroleum and coal products	1893.3	514	973,141
	Manufacture of ceramic, stone and clay products	1264.4	4,816	6,089,285
	Manufacture of iron and steel	3858.5	2,717	10,483,514
	Other manufacture	123.3	68,599	8,458,572
	Utility	166.1	2,822	468,872
	Information and communications	9.8	6,339	61,957
	Railway transport	46.8	932	43,657
	Water transport	1204.3	1,194	1,437,985
	Air transport	217.2	103	22,368
	Road transport and other	19.1	24,662	470,083
	Wholesale and retail trade	9.1	110,847	1,008,382
	Finance and insurance	9.1	12,185	111,480
	Real estate and goods rental and leasing	62.8	10,322	647,919
	Scientific research, professional and technical services	32.4	12,471	404,340
	Accommodations, eating and drinking services	14.7	51,241	750,875
	Living-related services and amusement services	26.6	23,336	620,609
	Education, learning support	8.6	25,887	221,926
	Medical, health care and welfare	8.5	74,440	631,695
	Compound services	12.3	5,043	62,046
	Services, n.e.c.	48.8	34,286	1,673,969
	Government, except elsewhere classified	24.4	21,301	518,918
	Waste disposal business	153.3	3,733	572,119
Change of land use	Urban land	NE	NE	NE
	Agriculture land	NE	NE	NE
	Forest land	NE	NE	NE
	Rivers and others	NE	NE	NE

(a) The categories and results of the proposed inventory

Categories by the IPCC framework (used by the Oita Prefecture)	Results by proposed framework	Results of Prefecture report
	tCO2eq	tCO2eq
STATIONARY ENERGY	36,863,501	33,301,323
Residential buildings	1,653,607	1,899,240
Commercial and institutional buildings and facilities	6,714,115	1,704,758
Manufacturing industries and construction	27,251,935	29,243,885
Energy industries	468,872	NE
Agriculture, forestry, and fishing activities	641,124	453,440
Non-specified sources	NE	NE
Fugitive emissions from mining, processing, storage, and transportation	133,848	NE
Fugitive emissions from oil and natural gas systems	NE	NE
TRANS PORTATION	2,721,839	2,716,069
On-road	1,217,829	2,226,495
Railways	43,657	61,620
Waterborne navigation	1,437,985	354,101
Aviation	22,368	73,853
Off-road	IE	NE
WASTE	572,119	311,557
Solid waste disposal	-	44,428
Biological treatment of waste	-	19,193
Incineration and open burning	-	238,729
Wastewater treatment and discharge	-	9,207
INDUSTRIA L PRO CESSES AND PRODU CT USE (IPPU)		2,111,091
Industrial processes	IE	-
Product use	IE	-
AGRI CULTURE , FORESTRY AND OTHER LAND USE (AFOLU)		
Livestock	IE	226,419
Land	NE	94,202
Aggregate sources and non-CO2 emission sources on land	NE	NE
SUM	40,157,460	38,440,040

IE: Included elsewhere
NE: Not estimated
"-" : individual items are not estimated but included in the subtotal

The definition of industrial sectors refer to:
http://www.stat.go.jp/english/data/e-census/2009/pdf/sangyo_e.pdf

(b) The categories and results of IPCC framework used by Oita prefecture

５．主な発表論文等

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〔産業財産権〕
○出願状況（計　0　件）

〔その他〕
ホームページ等

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