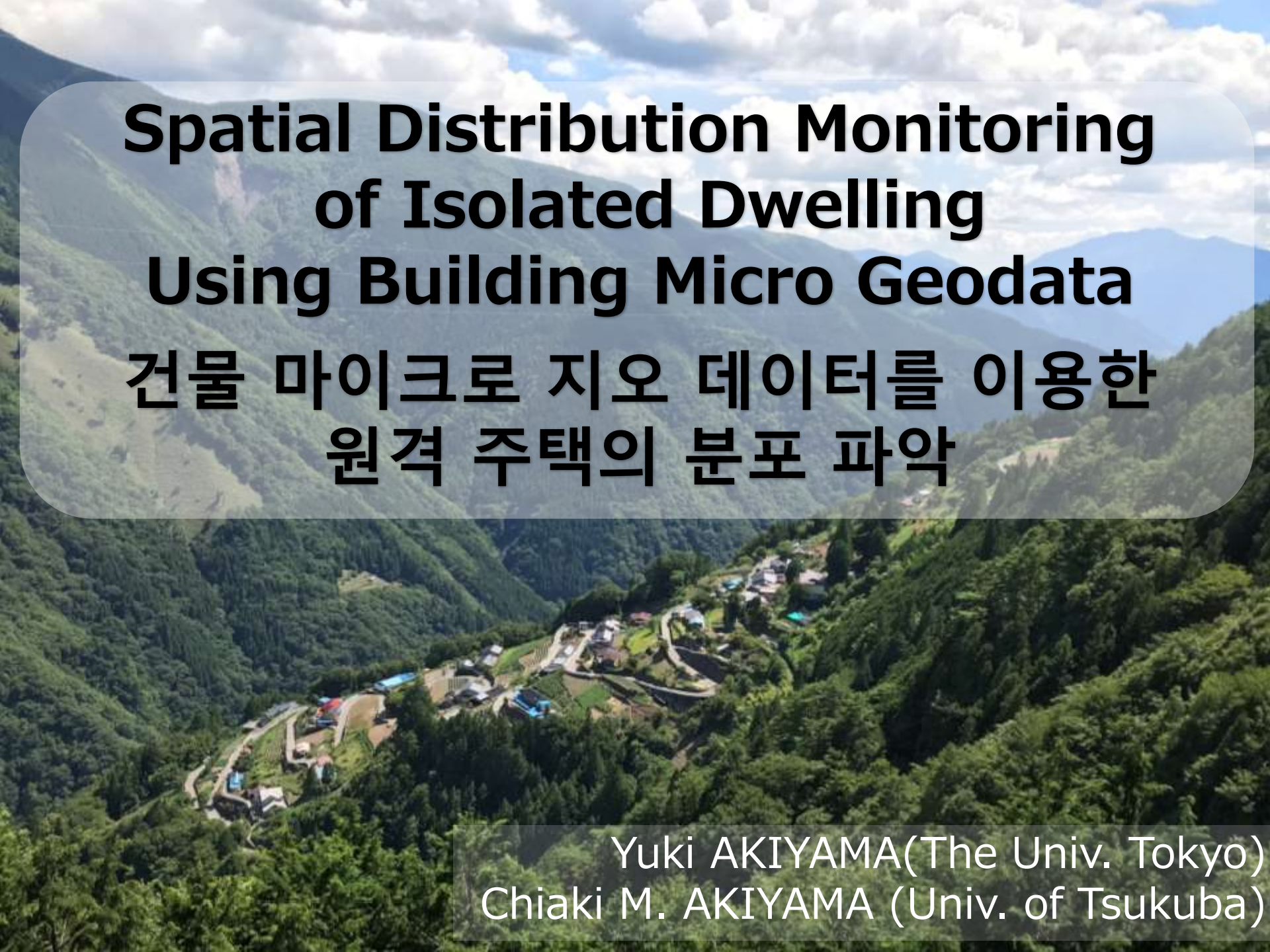
Spatial Distribution Monitoring of Isolated Dwelling Using Building Micro Geodata

건물 마이크로 지오 데이터를 이용한 원격 주택의 분포 파악



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Chiaki M. AKIYAMA (Univ. of Tsukuba)

Today's Contents

1. Background and objective
2. Data development of isolated dwelling in Japan
3. Results: distribution of isolated dwelling
4. Trial calculation on location optimization of isolated dwelling
5. Summary and future work

Acknowledgments:

This research is supported by **the Grant-in-Aid for Scientific Research-KAKENHI-** (15K12453: Geography) and by the collaborative research budgets of Research Center for San-En-Nanshin Regional Collaboration, **Aichi University** (2018-06). In addition, the residential map used in this presentation was received from **the CSIS collaborative research utilization system (JoRAS)** in cooperation with the University of Tokyo Spatial Information Science Research Center (**CSIS**) collaborative research (No. 122) under the provision of housing maps throughout Japan.

1. Background and objective

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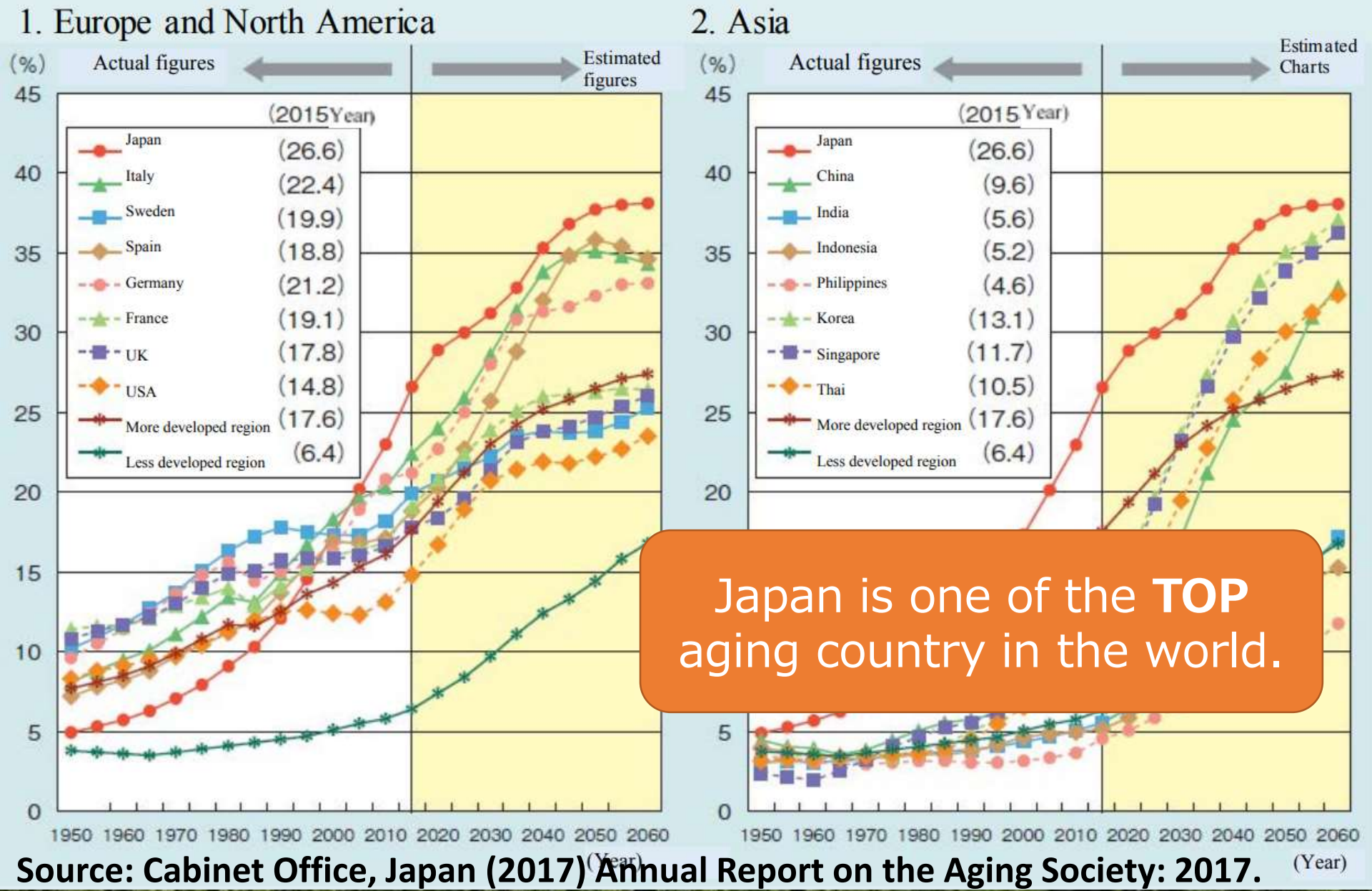

Japan is one of the **TOP** aging country in the world.

Source: Cabinet Office, Japan (2017) Annual Report on the Aging Society: 2017.

1. Background and objective

- Young generation moves to more urbanized area than their hometown.

- At origin of migrants, **aging and depopulation** are accelerating…
- Especially at hilly and mountainous areas and remote island areas.

1. Background and objective

Maruyama, Kiwa-cho, Kumano-city, Mie prefecture

Photo by C. Akiyama(May. 2017)

Isolated detached house that does not have neighboring residents in the vicinity, is named as "**isolated dwelling**"

1. Background and objective

Isolated dwelling is spatially isolated from other dwellings.

Future concerns:

- **Decrease in the cost effectiveness of infrastructure maintenance**
- **Increase the risk of disaster**
  > It is difficult to get help from others because of no neighborhoods
- **Isolated dwelling would be "vacant house" ?**
  Vacant house is big issue in the current Japan.

It is important **to grasp spatial distribution of isolated dwelling** in national scale and **to address the future picture** in the sense of sustainable municipality management.

1. Background and objective

Marginal settlement in remote island

- Deserted village in mountainous area(Sakaguchi, 1975)
- Geographical characteristics of non-resident settlements of hilly mountainous regions in Japan (Sakuno, 2013)

However, **these researches are case study** of a settlement/ municipality…**Few research works on national scale analysis**↓

National-scale research

- Classification of mountain village using existed statistics (Okahashi, 1986)
- Distribution change of settlement using topographical maps (Kaneki, 2003)

Resolution is relatively macro-size aggregated unit: municipalities, or settlement

There is no study to grasp nationwide spatial distribution of isolated dwelling by building unit!

1. Background and objective

Objective

1) **to grasp** the spatial distribution of isolated dwellings throughout Japan
2) **to compare** the distribution of isolated dwellings **at two time points** so that the spatial distribution of increase and decrease of isolated houses, and
3) **to estimate the economic burden** of local governments by relocation promotion for isolated dwellings in the future, and examined the possibility of site location optimization.

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2. Data development of isolated dwelling in Japan

Flow of data development

Digital residential map
(whole of Japan)

↓

Building Micro Geodata
(Appr. Num. 100 Millions)

↓

Residential Micro Geodata
(Appr. Num. 27 Millions)

↓

Isolated dwelling point data
(Appr. Num. 15 Thousands)

2. Data development of isolated dwelling in Japan

Digital residential map
(whole of Japan)

Building Micro Geodata
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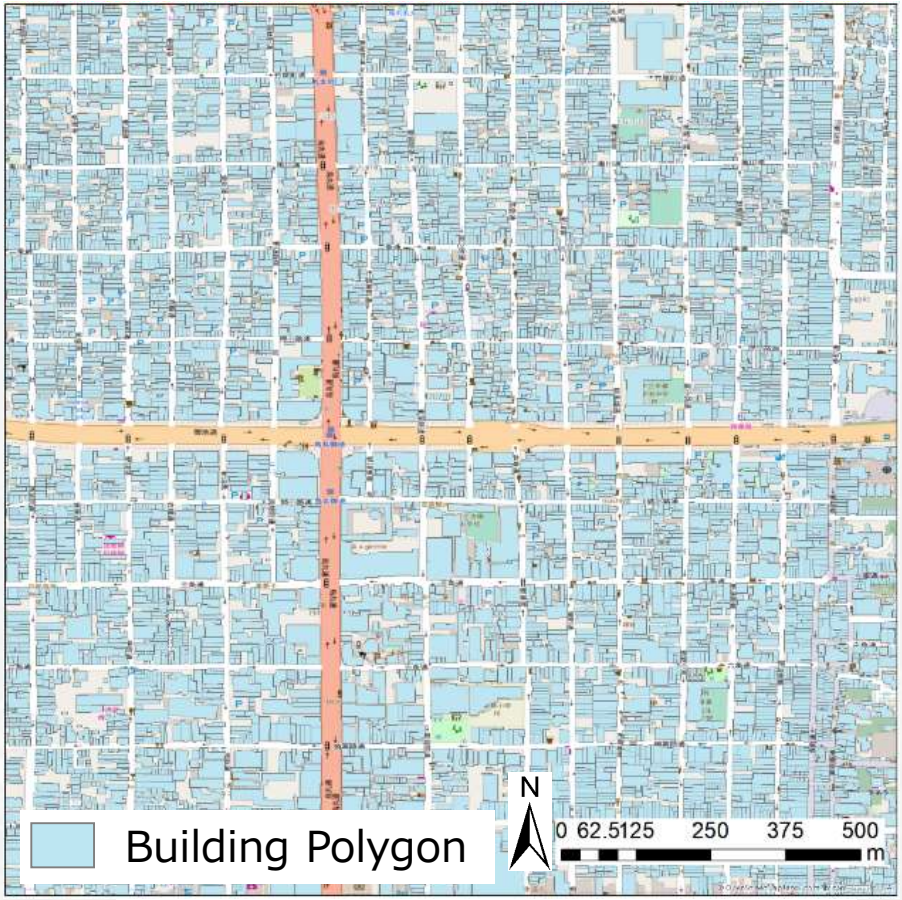

Source data: Digital residential map

Product of ZENRIN Maps to the Future

2. Data development of isolated dwelling in Japan

Digital residential map
(whole of Japan)

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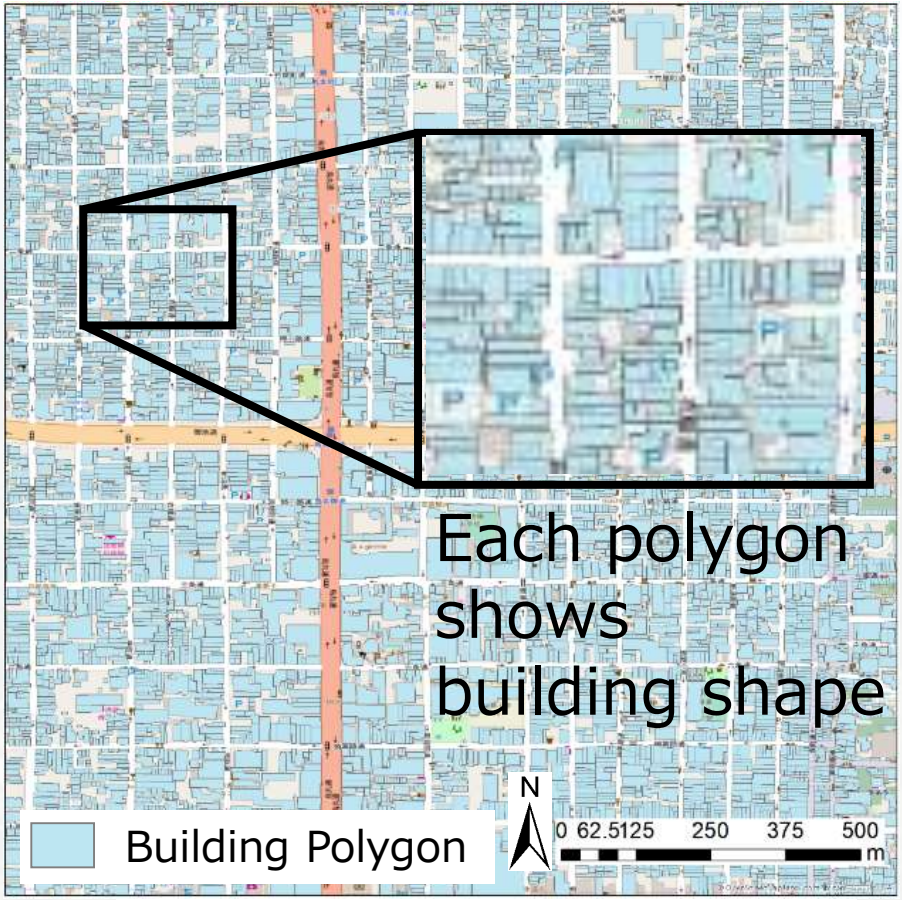

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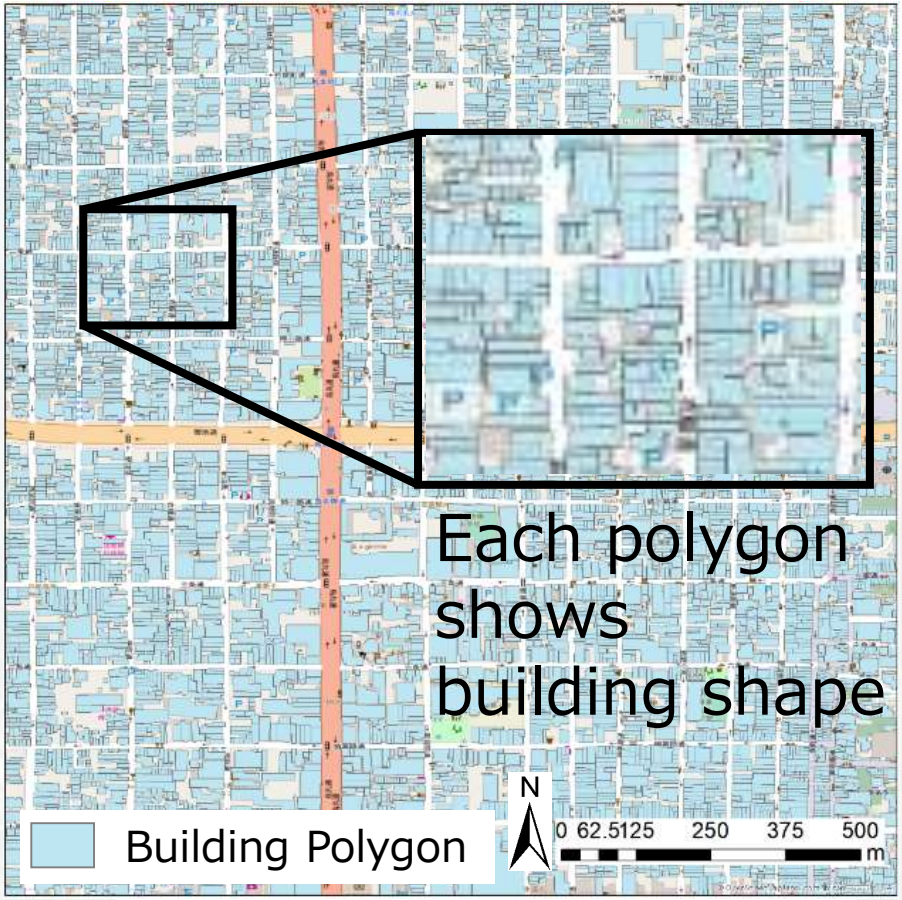

Thanks to Joint Research Program No.122 at CSIS ,UTokyo to support to use ZENRIN digital residential map.

2. Data development of isolated dwelling in Japan

Digital residential map
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Building Micro Geodata
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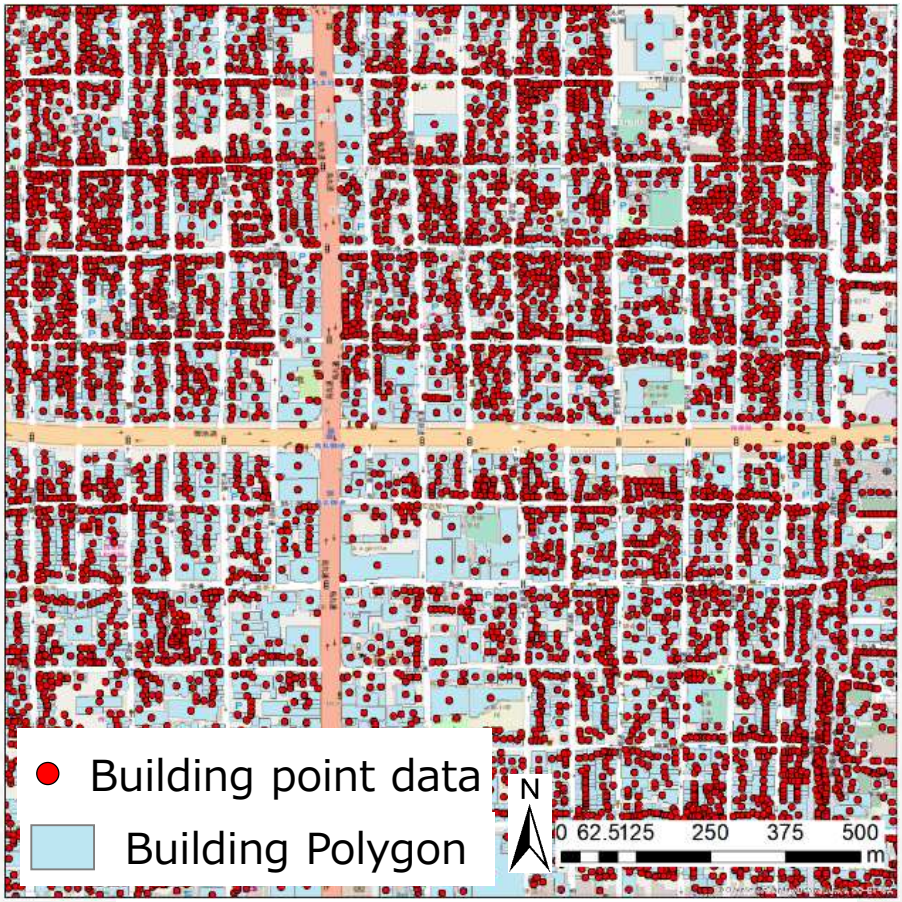


Convert ALL building polygons to point (Appro. Num. 100 Millions) from whole of Japan (appr. 1800 municipalities)

2. Data development of isolated dwelling in Japan

Digital residential map
(whole of Japan)

↓

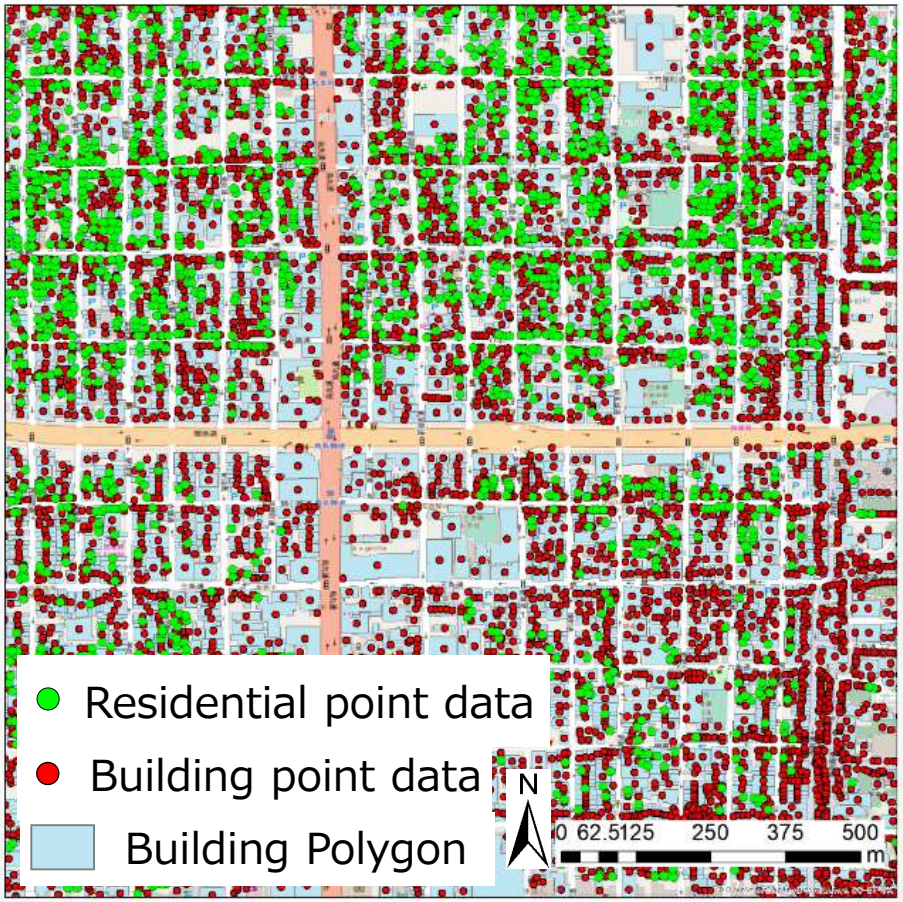
Building Micro Geodata
(Appr. Num. 100 Mill.)

↓

Residential Micro Geodata
(Appr. Num. 27 Mill.)

↓

Isolated dwelling point data
(Appr. Num. 15 Thou.)



Select RESIDENTIAL USE building point (Appr. Num. 27 Mill.) from Building Micro Geodata.

2. Data development of isolated dwelling in Japan

Digital residential map
(whole of Japan)

↓

Building Micro Geodata
(Appr. Num. 100 Mill.)

↓

Residential Micro Geodata
(Appr. Num. 27 Mill.)

↓

Isolated dwelling point data
(Appr. Num. 15 Thou.)

Def. of Isolated dwelling

There are not residential building in walking distance.

・Walking distance is **500m in road network distance**
(Nagata , 2015)

・**Search nearest residential point** from each residential point within 500 m. If there is no point, the residential point is defined as isolated dwelling.

2. Data development of isolated dwelling in Japan

Flow of data development

Year of 2009

- Digital residential map (whole of Japan)
- Building Micro Geodata (Appr. Num. 100 Millions)
- Residential Micro Geodata (Appr. Num. 27 Millions)
- Isolated dwelling point data (Appr. Num. 15 Thousands)

Year of 2014

- Digital residential map (whole of Japan)
- Building Micro Geodata (Appr. Num. 100 Millions)
- Residential Micro Geodata (Appr. Num. 27 Millions)
- Isolated dwelling point data (Appr. Num. 15 Thousands)

Spatial temporal changes between 2009 and 2014 in throughout of Japan

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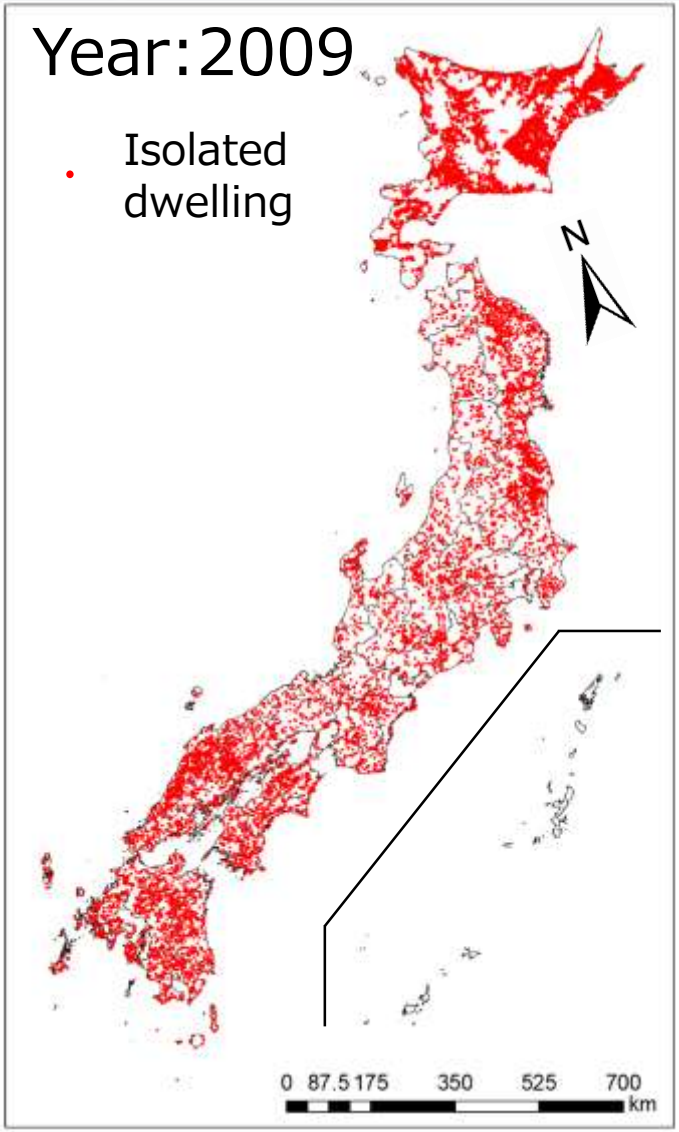
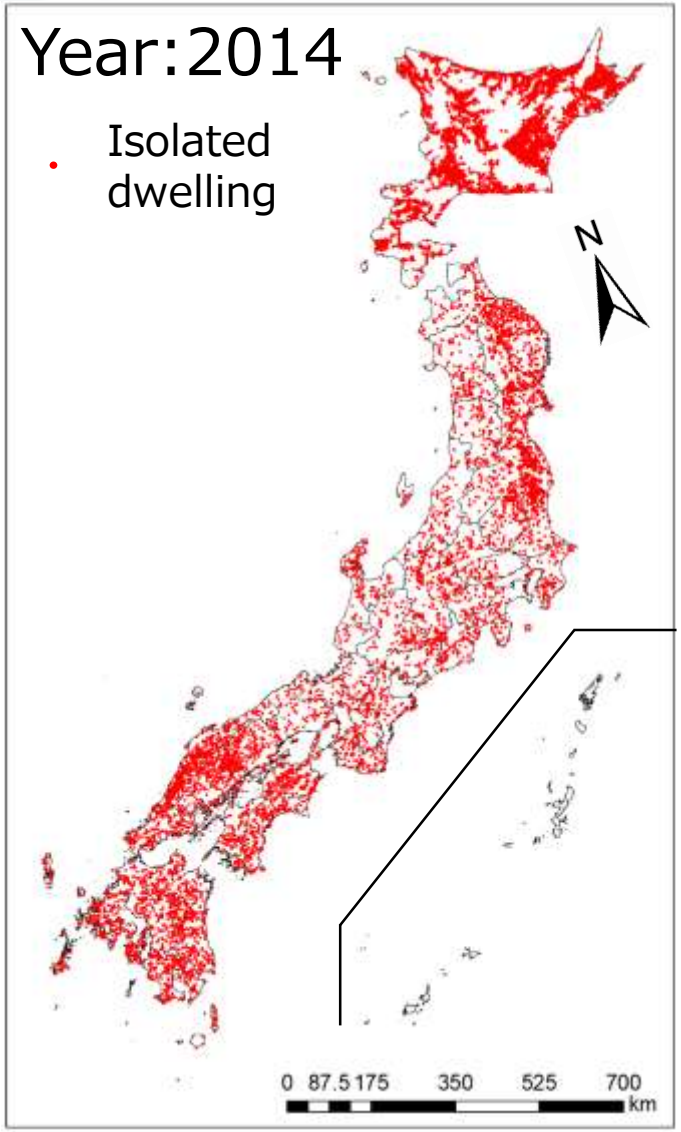
Distribution of isolated dwelling





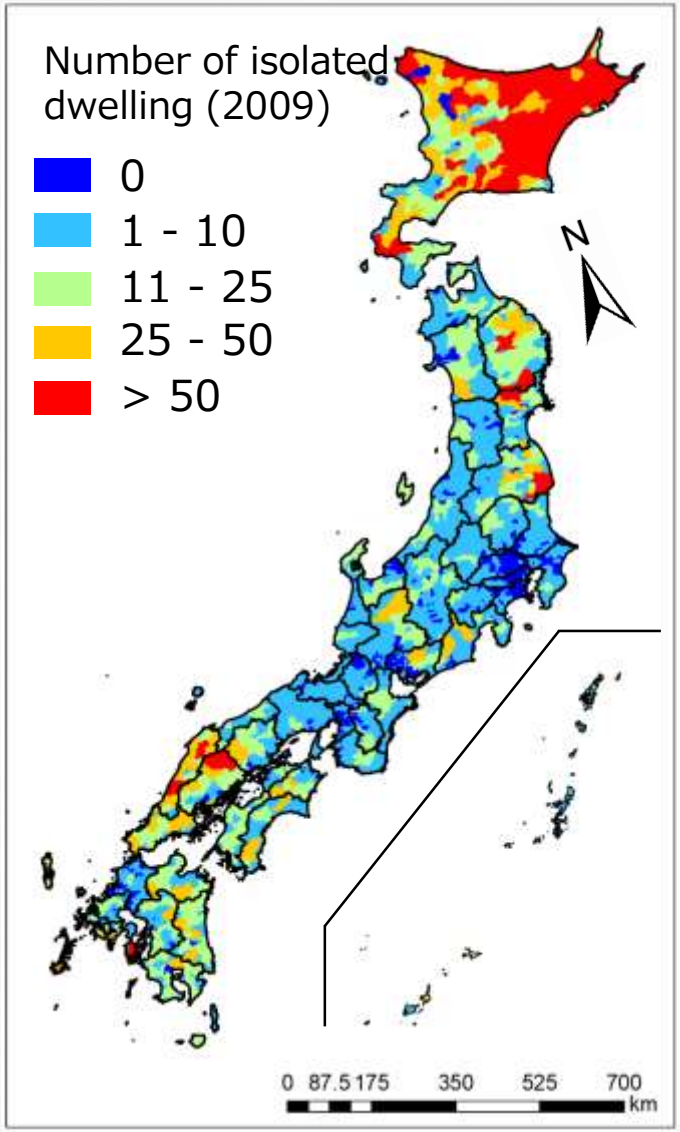
Num. of isolated dwelling in Japan:

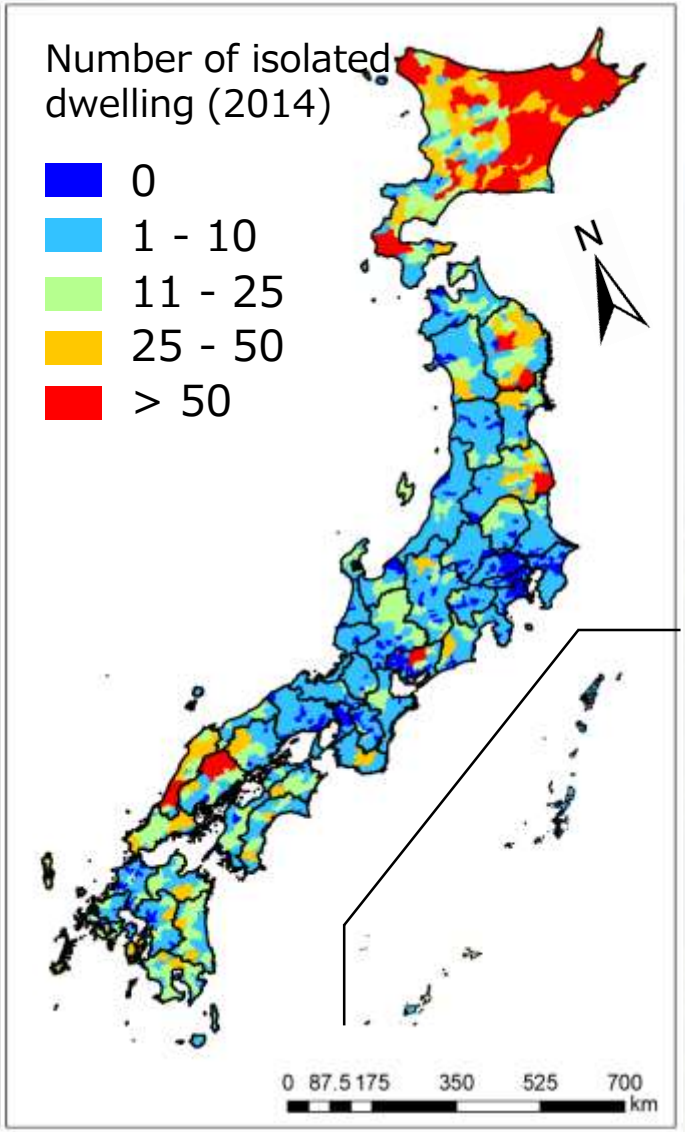
17,106 in 2009
15,052 in 2014

Total number of isolated dwelling decrease in Japan.

3. Results:

Distribution of isolated dwelling in municipality level



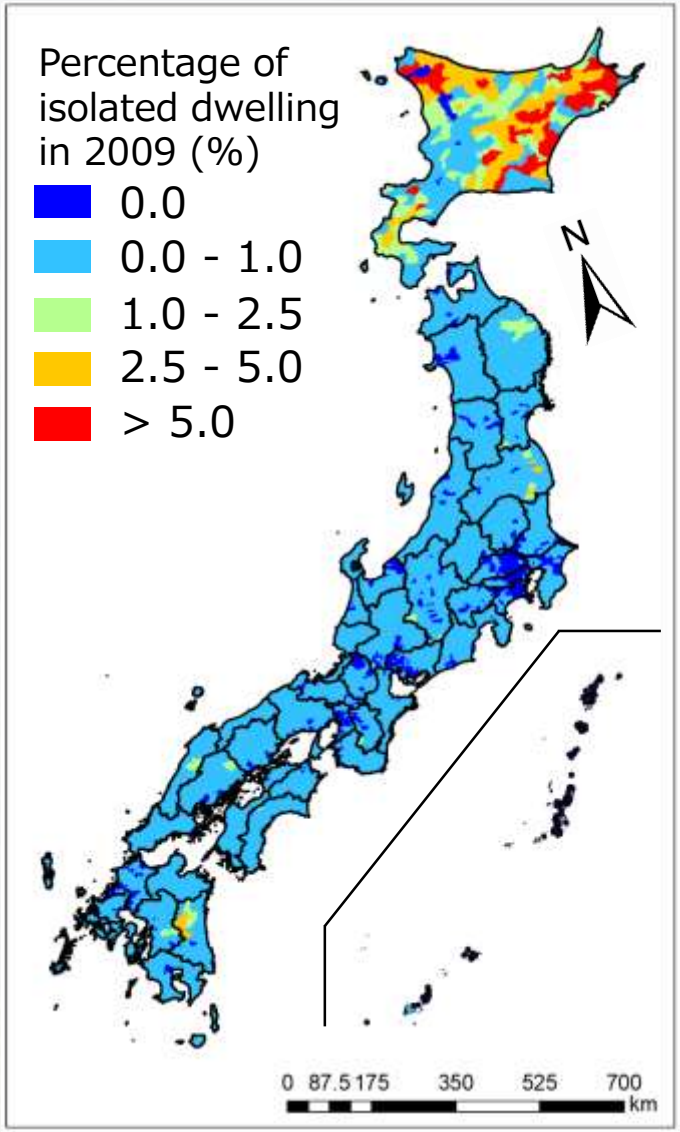


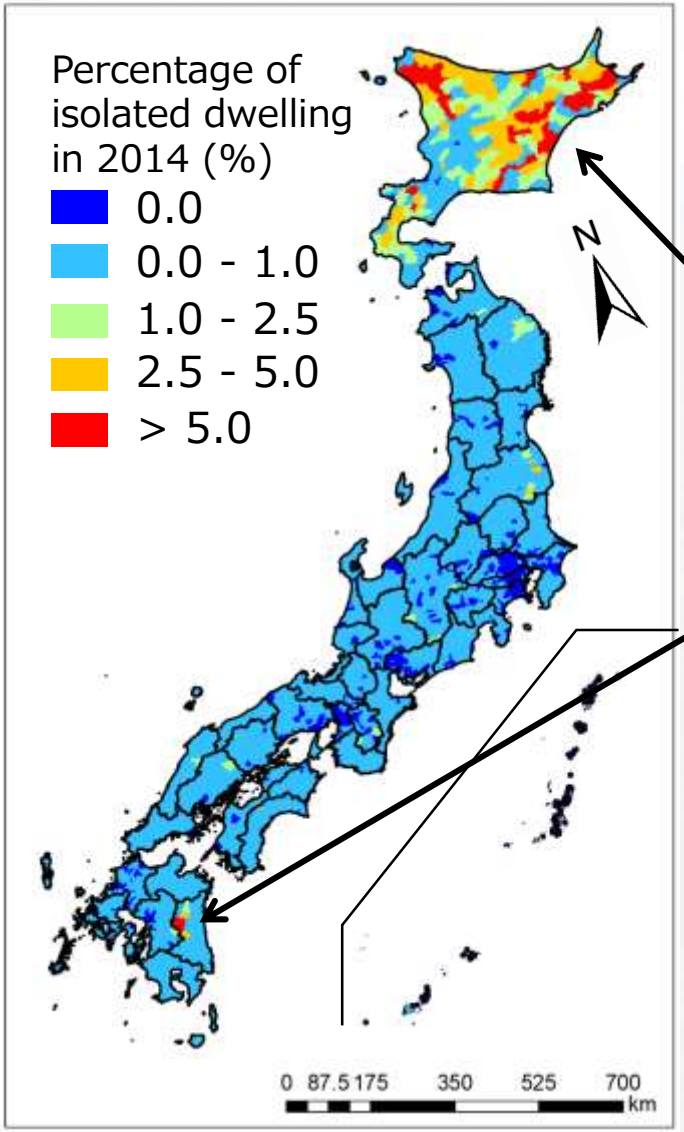
Both 2009 and 2014, Many isolated dwellings are in

- **North and East of Hokkaido**,
- Mountainous areas in Tohoku, Chugoku, Shikoku, and Kyusyu Regions.

3. Results

Percentage of isolated dwelling in municipality level



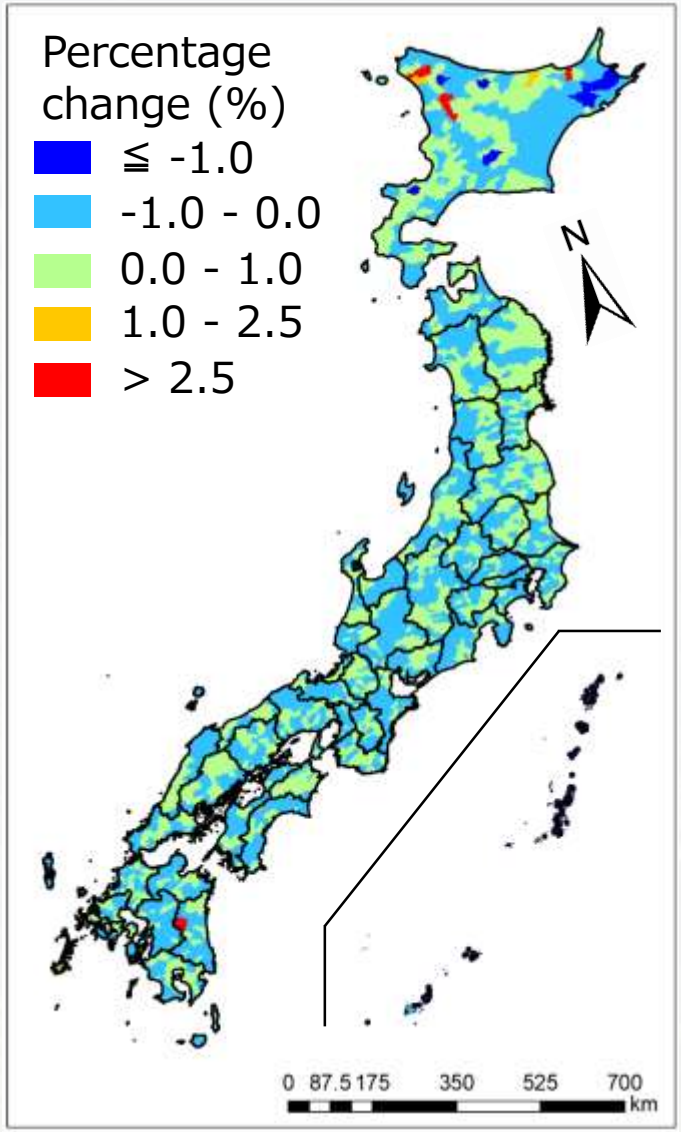


Highest % is 10.46 % at Toyokoro-cho, Hokkaido

Highest % (except Hokkaido) is 6.08 % at Shiiba-son, Miyazaki

3. Results

Increase/decrease of percentage of isolated dwelling

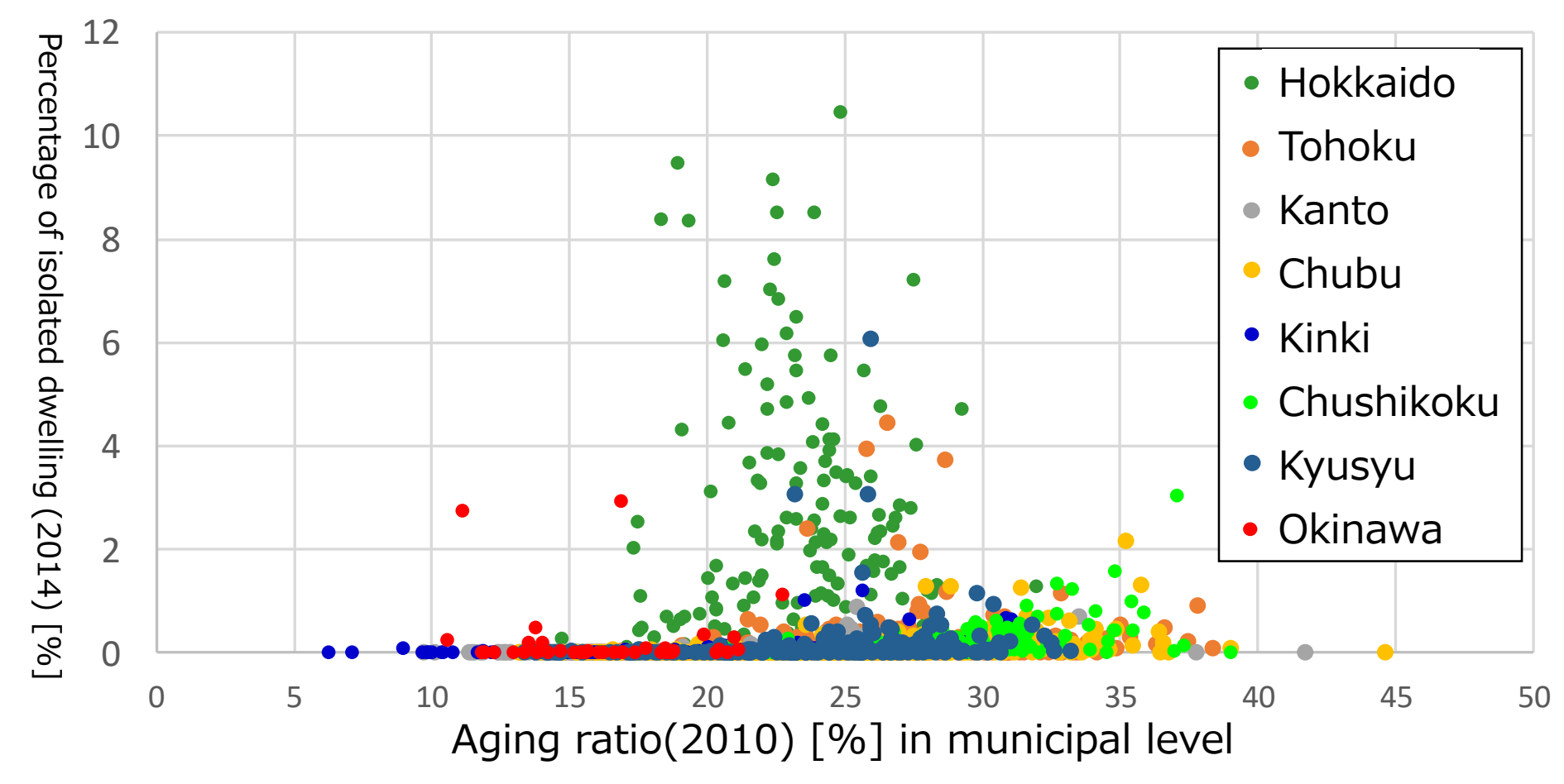


Top 10 municipalities in large increase/decrease of percentage of isolated dwelling (2009-2014)

Municipality	Islated dwelling rate		
	2009	2014	Difference
Horonobe, Hokkaido	0.00	8.39	8.39
Horokanai, Hokkaido	0.00	7.23	7.23
Koshimizu, Hokkaido	5.04	8.51	3.47
Shiiba, Miyazaki	3.24	6.08	2.84
Kitadaito, Okinawa	0.00	2.74	2.74
Satoma, Hokkaido	3.51	5.75	2.23
Teshio, Hokkaido	6.44	8.51	2.07
Minamidaito, Okinawa	1.27	2.94	1.67
Okawa, Kochi	1.73	3.03	1.30
Oketo, Hokkaido	3.79	4.78	0.99

3. Results

Scattering plot for aging rate **in municipality level** and isolated dwelling rate

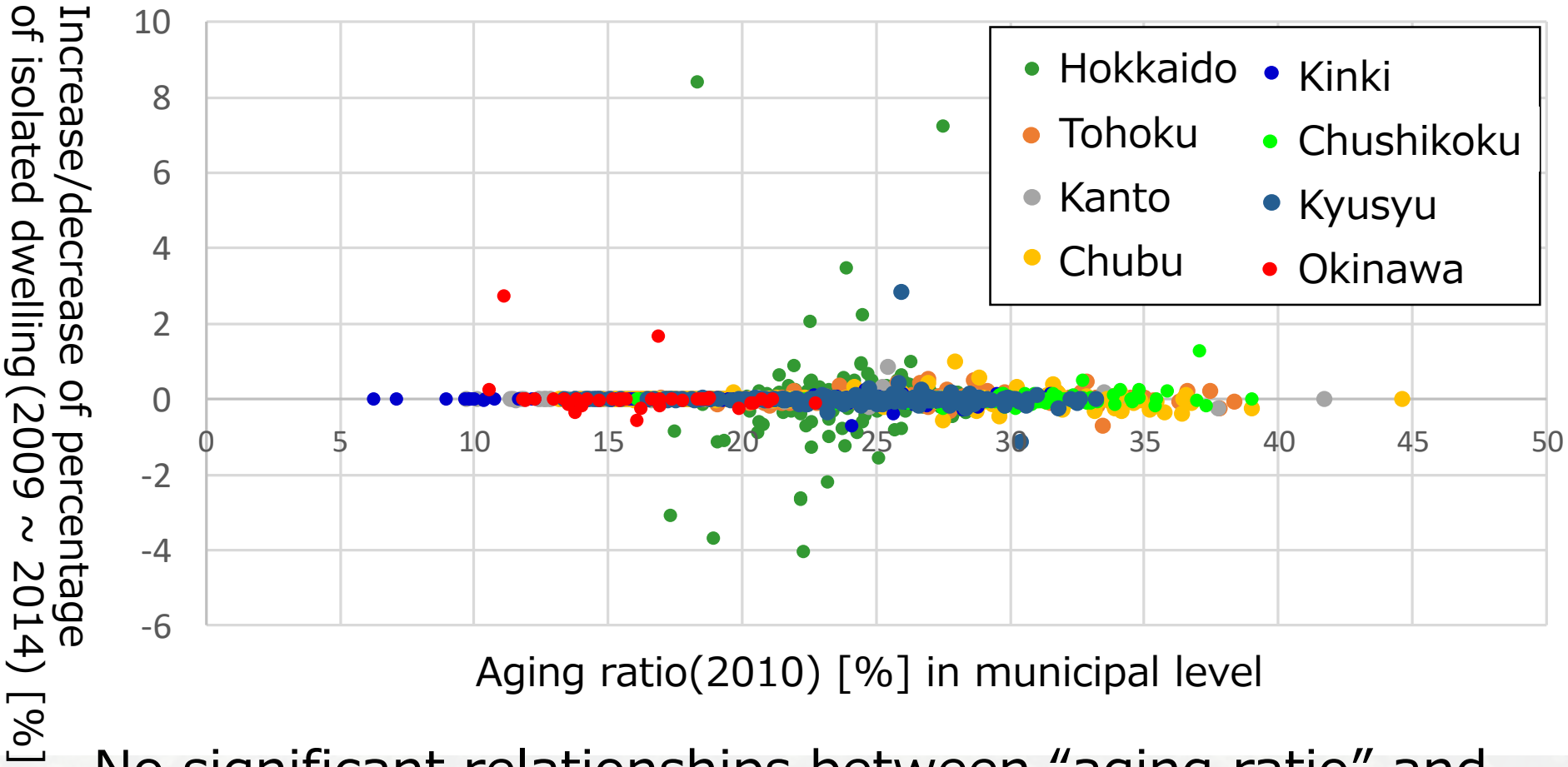


High aging rate ≠ **High** percentage of isolated dwelling

⟺ Regional Characteristics

3. Results

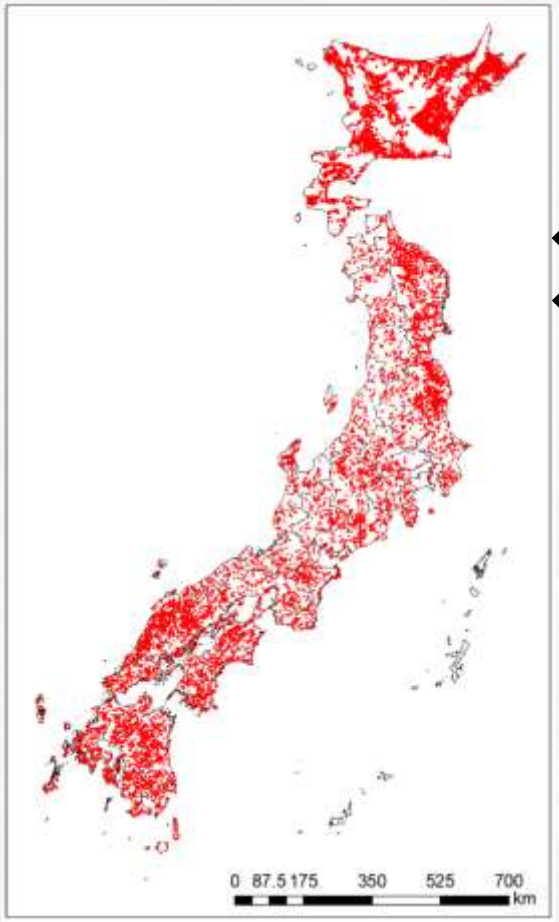
Relationships between “aging ratio” and “changes in percentage of isolated dwelling” in municipal level



No significant relationships between “aging ratio” and “changes in percentage of isolated dwelling”.

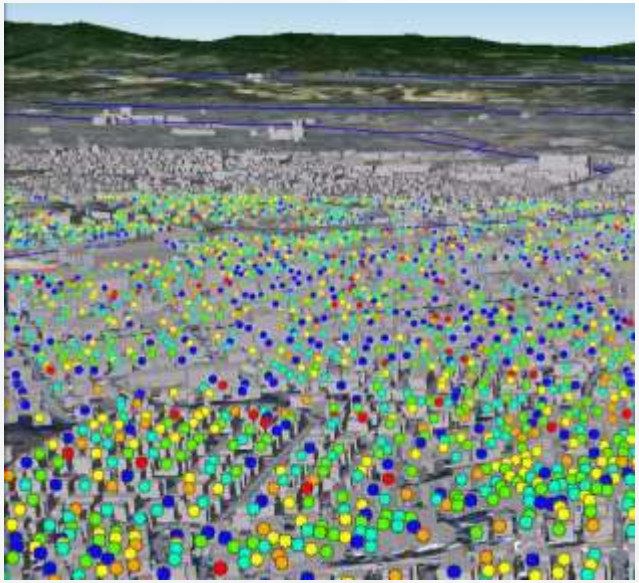
3. Results

Let's see relationships bet. isolated dwelling and population using pinpoint residential building data



Isolated dwelling point data(2014)

×



Micro Population Census (2010)

Estimated residence/household number for **each building point based on population census and digital residential map**
(Akiyama et al., 2013)

= **Calculate "aging rate" and "single household rate" in each residential point**

3. Results

Compare "aging rate" and "single household rate" for isolated dwelling and non-isolated dwelling

	No. of residents	No. of residents over 65	Aging rate [%]	No. of Households	Single Household no.	Single Household rate [%]
Isolated dwelling	31,856	10,819	33.96	8,686	847	9.75
Non-isolated dewlling	126,249,157	24,914,140	19.73	25,536,883	2,606,494	10.21

- About 34 % of residents in isolated dwellings in Japan are over 65 years old ➡ **High risk** in natural disaster/**High possibility** to be vacant house in the future

- Single Household rates [%] are similar values:

⬌ Many (young) single household in urban area

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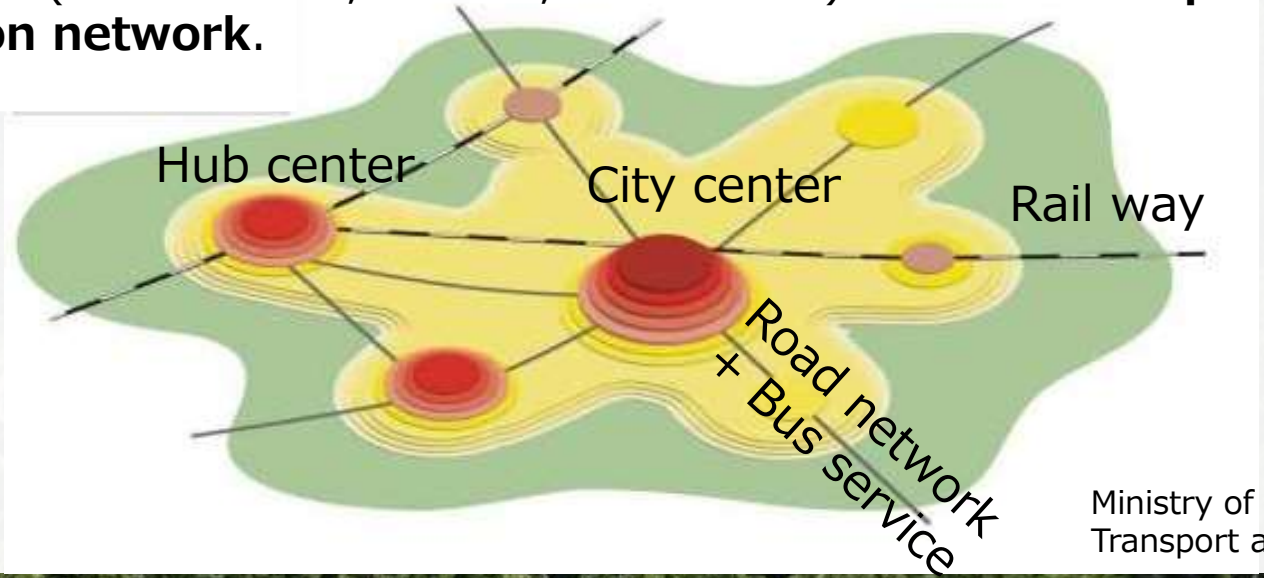
4. Trial calculation on location optimization of isolated dwelling

Hypothesis: **If the residents living in isolated dwelling moves to city center, how much can they save lifeline expenditure of the municipality?**

"Urban Facility Location Plan" has similar concept.

・Amendment to Act on Special Measures concerning Urban Reconstruction in 2014
→Each municipality can develop "**Urban Facility Location Plan**".
→For reforming **to compact city**, the plan designs attraction district **to attract urban facilities**(medical care, welfare, commercial) and **to create public transportation network**.



Ministry of Land, Infrastructure, Transport and Tourism(MLIT)

4. Trial calculation on location optimization of isolated dwelling

Hypothesis: **If the residents living in isolated dwelling moves to city center, how much can they save lifeline expenditure of the municipality?**

If isolated dwelling disappeared…

・**Save lifeline expenditure**
(water and municipal road maintenance and management etc…)

・The cost of expected **future lifeline expenditure** for isolated dwelling can **be assigned to relocation promotion expenses**

・**We Estimate**

-Lifeline expenditure for isolated dwellings for the future in each municipal level

-Relocation promotion expenses for each isolated dwelling

4. Trial calculation on location optimization of isolated dwelling

Estimate minimum annual public-work cost for isolated dwelling

Lifeline expenditure is cost of **minimum public-works for isolated dwelling: water service and municipal road to isolated dwelling**

$$\boxed{c_i} = \boxed{d_i}\left(\boxed{w + r1 + r2}\right) \quad \text{[JPY/year]}$$

where

c_i :minimum annual public-work cost for isolated dwelling (i) [JPY/year]

d_i :distance from isolated dwelling(i) to nearest neighborhood [m]

w :annual replacement cost of **water supply pipe** per meter [JPY/m/year]

r1:annual maintenance cost of **municipality roads** (**cleaning fee for road surface**) per meter [JPY/m/year]

r2:maintenance cost of **municipality roads** (**road construction expenses**) per meter [JPY/m/year].

4. Trial calculation on location optimization of isolated dwelling

Estimate minimum annual public-work cost for isolated dwelling

$$c_i = d_i(w + r1 + r2)$$

Calculation method of w, r1, r2

・***W:*** annual replacement cost of water supply pipe per meter [JPY/m/year]
= replacement of water pipe (Ozeki et al. 2009) ×replacement rate JWWA, 2016)
= **32,147[JPY/m] * 0.79 % = 253.96 [JPY/m/year]**

・***r1:*** cleaning fee for municipal road surface [JPY/m]
= cleaning fee for road surface (Ozeki et al. 2009) ×mini. road width(Mlit, 1970)
= 145[円/㎡] × 3[m]=**435[円/m]**

regular updating fee convert into annual average cost.

・***r2:*** road construction expenses [JPY/m]
={road maintenance **(every 10 yr) /10**+ replacement **(every 20 yr)/20** (Ozeki et al. 2009)} × mini. road width(Mlit, 1970)
={(1,526[JPY/㎡] /10)+(3,406[JPY/㎡] /20)}×3[m]=**968.7 [円/m]**

4. Trial calculation on location optimization of isolated dwelling

Estimate minimum annual public-work cost for isolated dwelling

$$c_i = d_i(w + r1 + r2)$$

$$= 1{,}657.66\ [\text{JPY/m/year}] \times d_i\ [\text{m}]$$

Cost for each isolated dwelling

C_j : Total minimum cost for isolated dwellings of municipality *(j)*

$$C_j = y\sum_{k=1}^{n} c_k = y\sum_{k=1}^{n}(1657.66 d_k) = 1657.66\, y \sum_{k=1}^{n} d_k$$

Cost for Each municipality

Where:

y: number of years to maintain isolated dwelling

n: the number of isolated dwelling in municipality *j*

4. Trial calculation on location optimization of isolated dwelling

Supposition of relocation promotion expenses

M_j : Total relocation promotion expense of municipality *(j)*

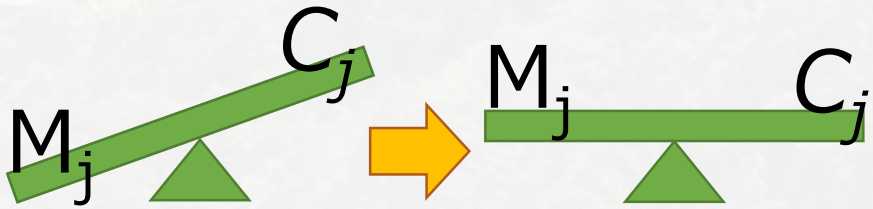
$$M_j = n_j \cdot m_{\mathrm{j}}$$

Where:

n_j :the number of isolated dwelling in municipality *j*

m_j :**relocation promotion expense**
for each isolated dwelling household in municipality *j*
(Set m a lump sum: 2.5, 5, 10, 25, 100 million JPY)

Compare ***M_j*** and ***C_j***
How many years does it take ?



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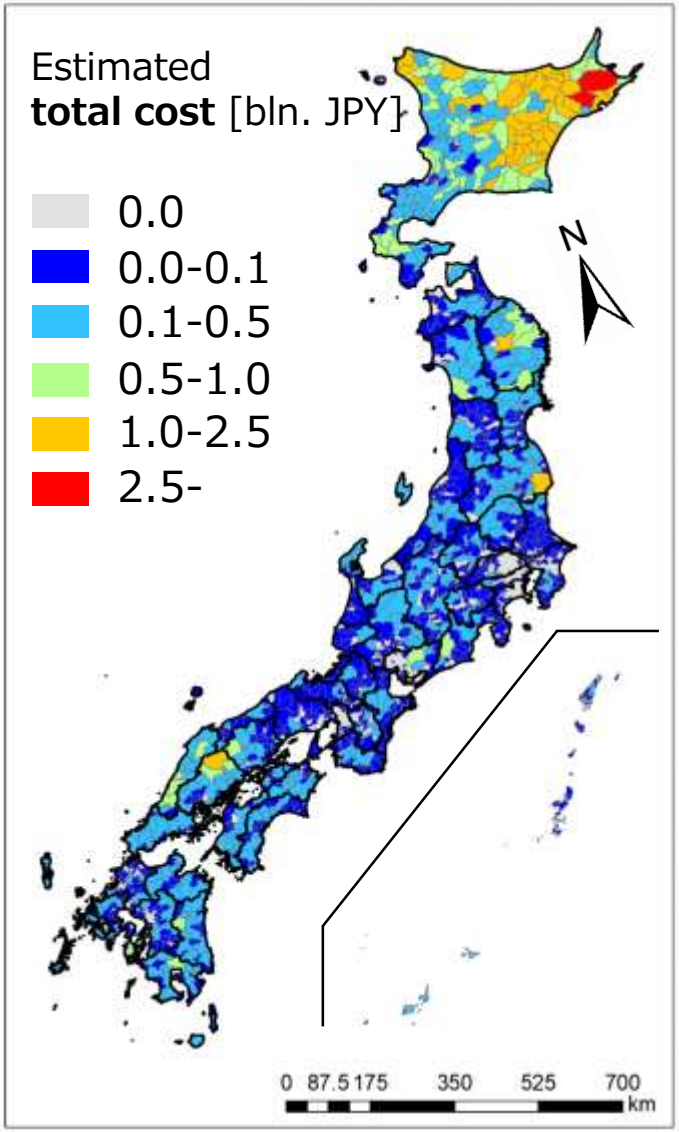
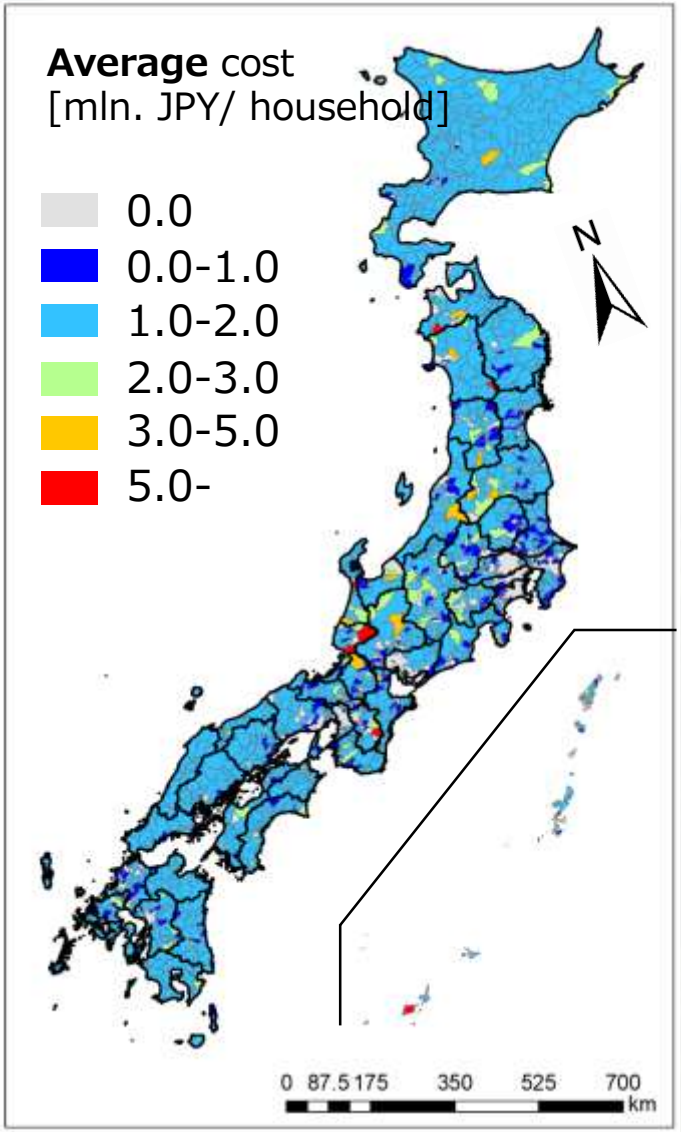
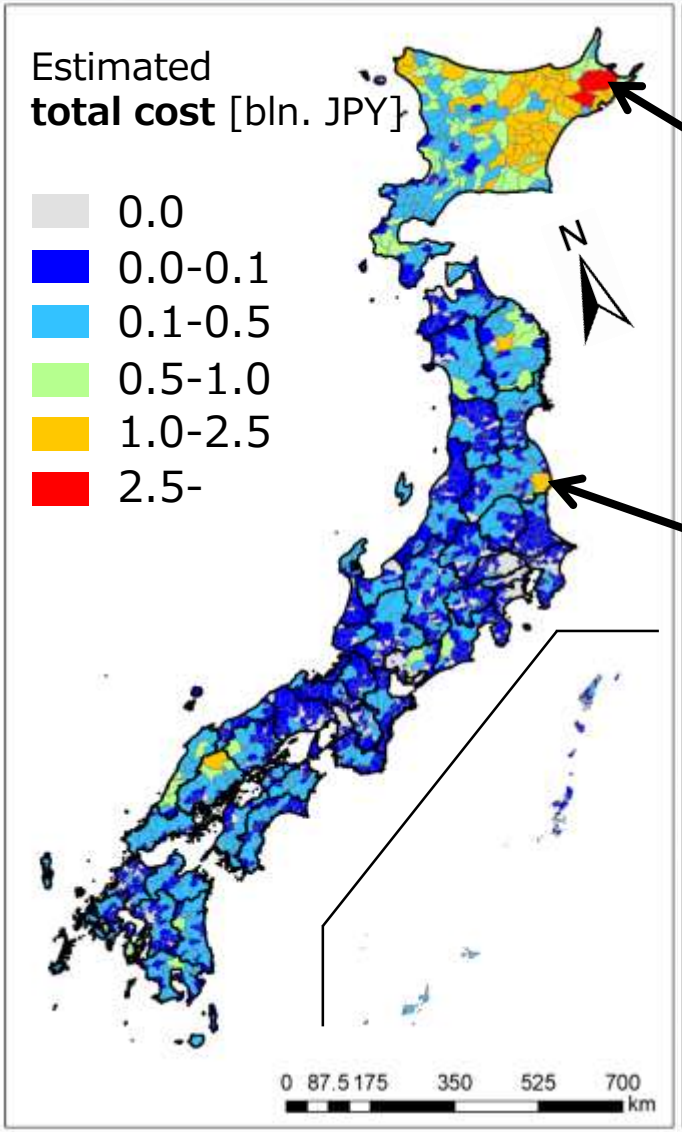
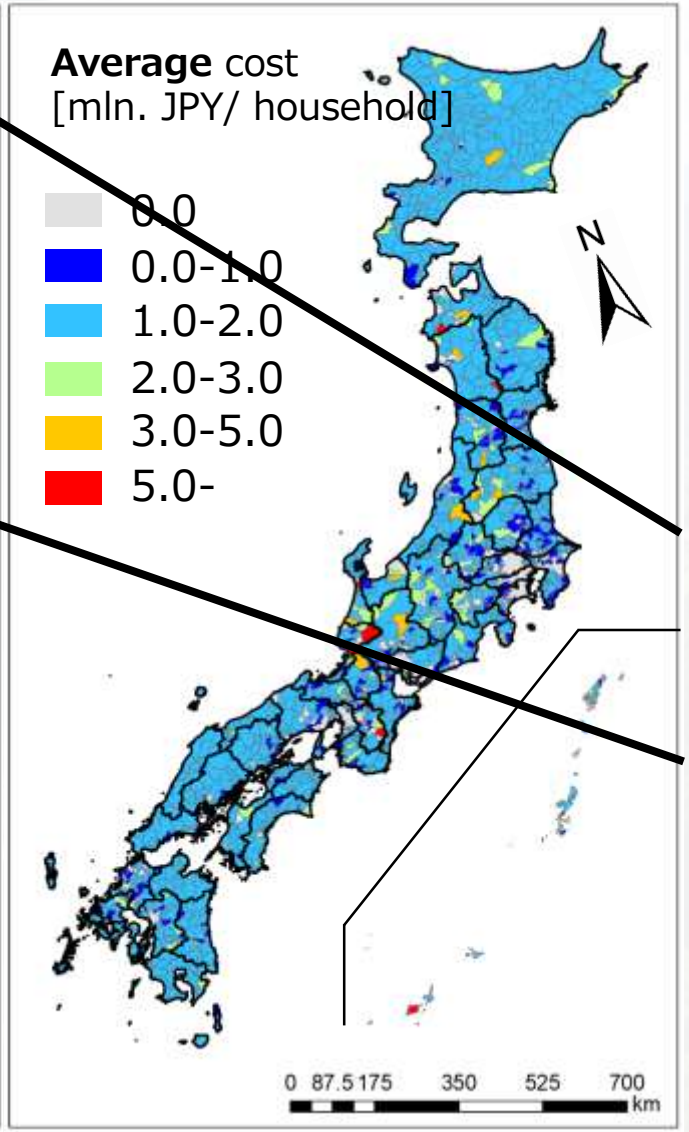




National total of estimated **minimum annual public-work cost**
: 21.77 bln JPY

4. Trial calculation on location optimization of isolated dwelling



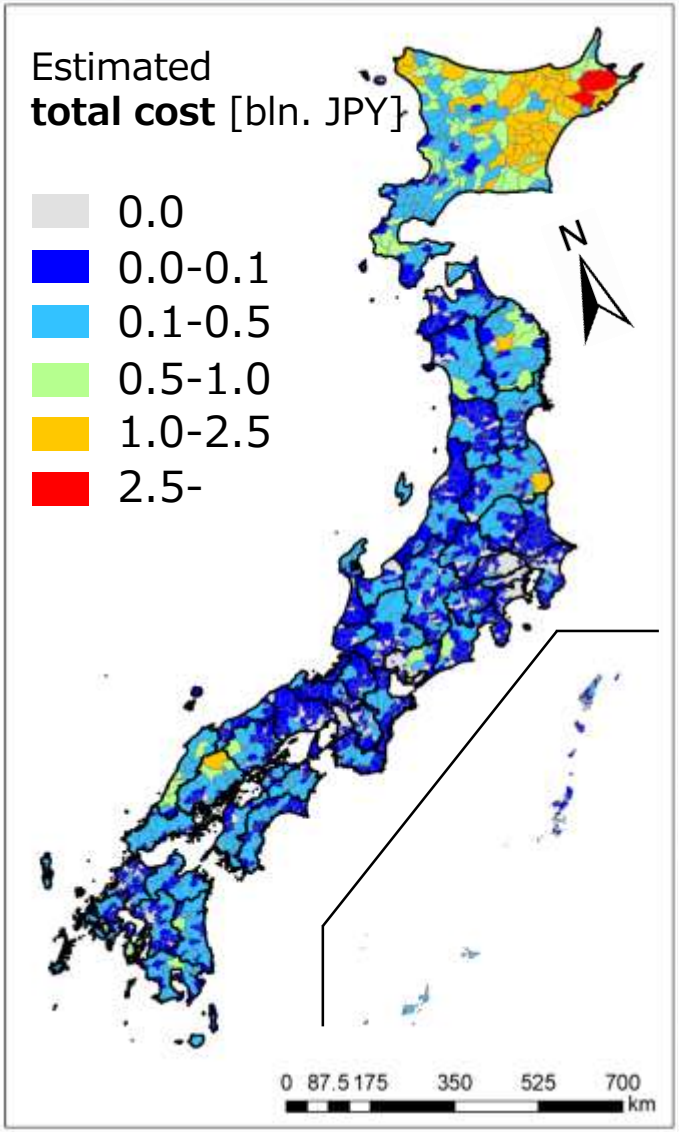


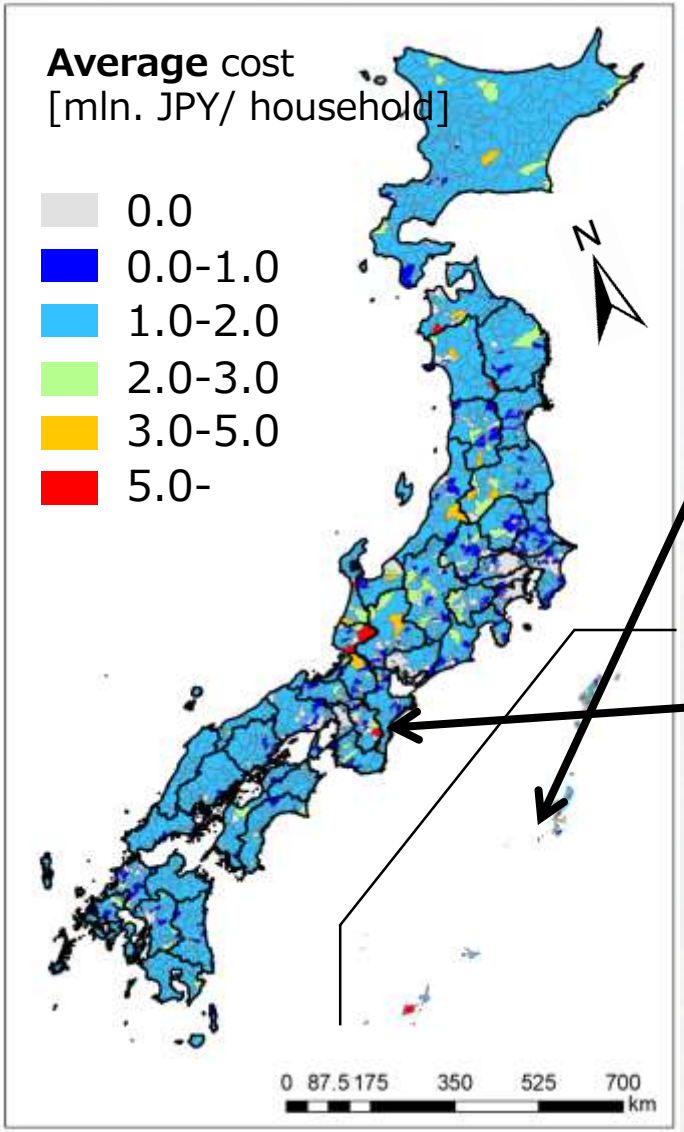
National total of estimated **minimum annual public-work cost**
: 21.77 bln JPY

Most expensive cost:
5.58 Bln JPY
at Betsukai-cho, Hokkaido
No. of Isolated dwelling:300

Most expensive cost (ex.Hokkaido):1.87 Bln JPY at Iwaki city, Fukushima
No. of Isolated dwelling: 146

4. Trial calculation on location optimization of isolated dwelling





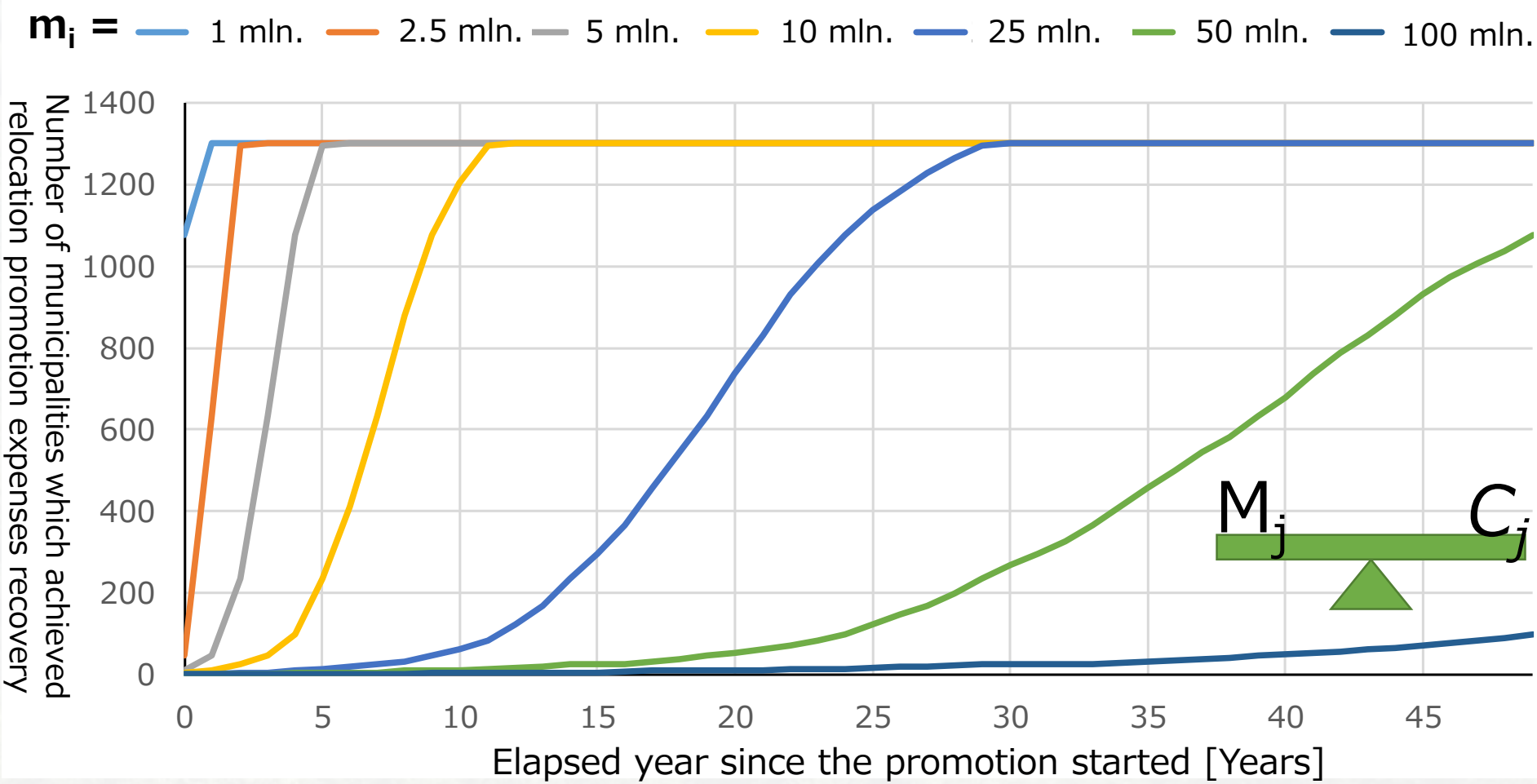
Average estimated minimum annual public-work cost /isolated dwelling : 1.446 mln JPY

Most expensive average cost: 17.77 mln JPY at Tokashiki-mura, Okinara
No. of Isolated dwelling:**1**

Most expensive average cost (multiple isolated dwelling) :6.23 mln JPY at Kamikitayama-mura, Nara
No. of Isolated dwelling: **3**

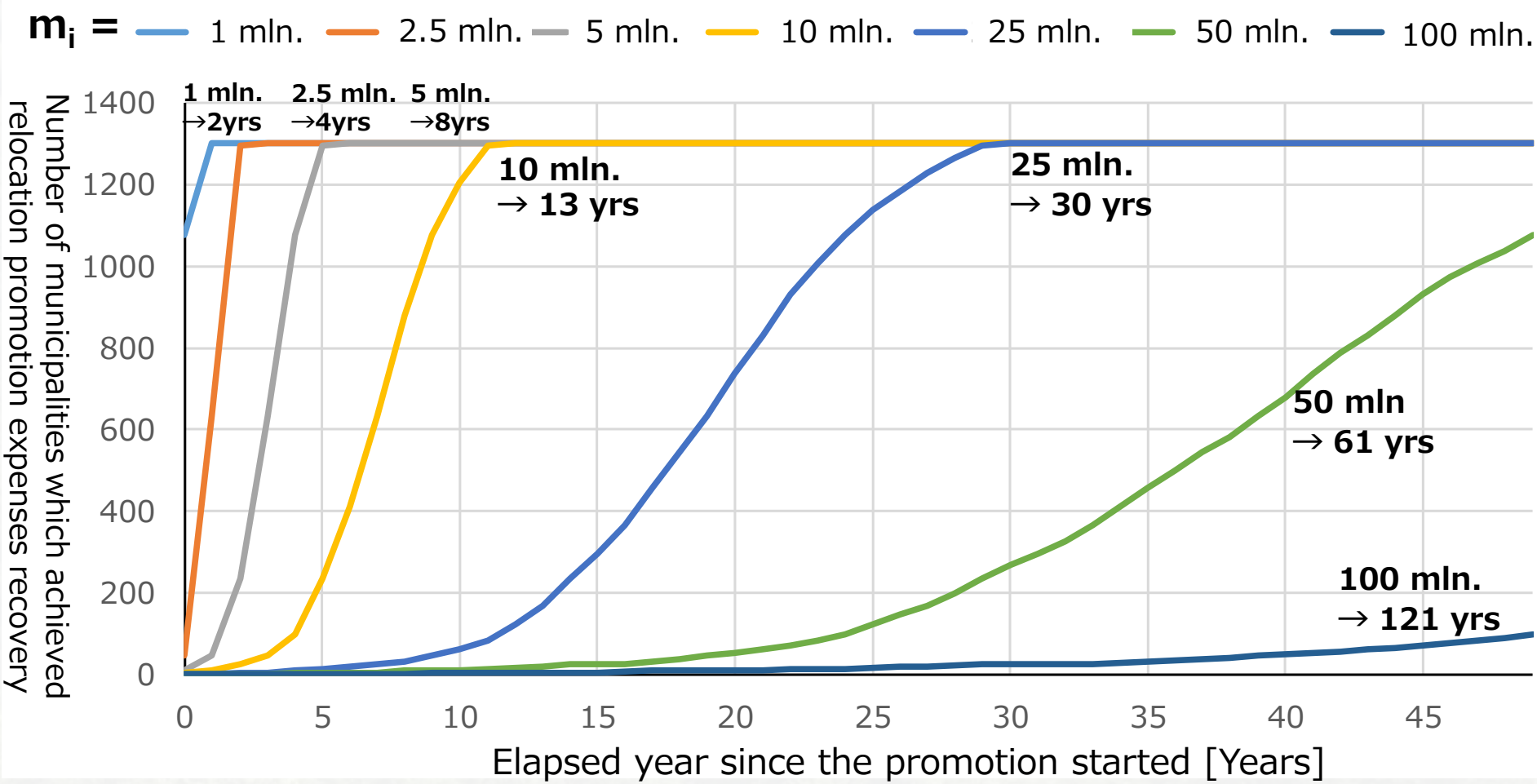
4. Trial calculation on location optimization of isolated dwelling

Relocate promotion expenses for each isolated dwelling (JPY)



4. Trial calculation on location optimization of isolated dwelling

Relocate promotion expenses for each isolated dwelling (JPY)



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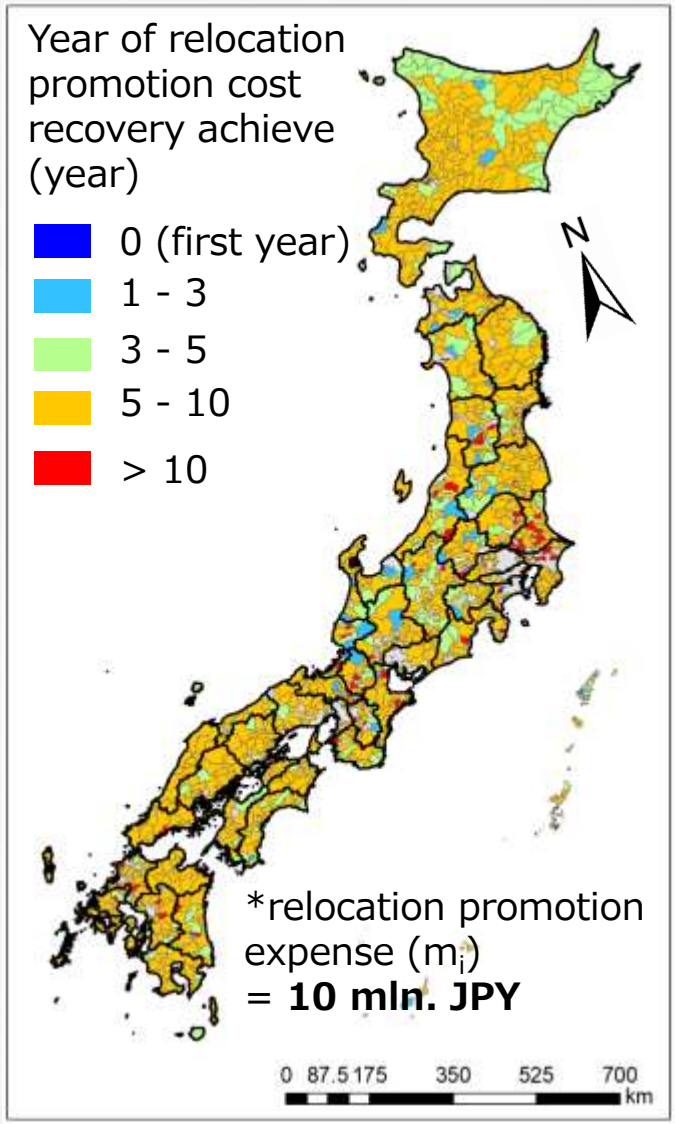

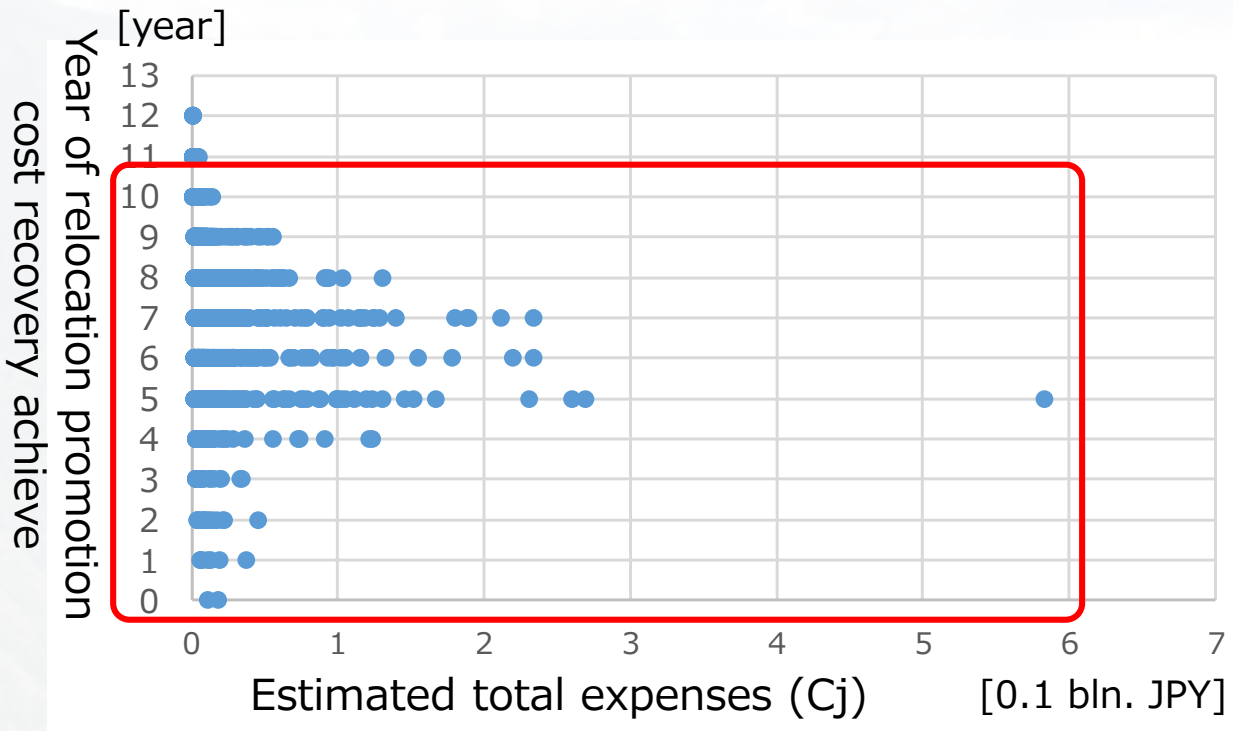

If all isolated dwelling residents **agree to move** to city center to get **10 mln. JPY relocation promotion expense**, many municipalities expect to be compact city **within 10 years**.

4. Trial calculation on location optimization of isolated dwelling

Isolated dwelling should be excluded? NO WAY!!

There are good practices to sustainable life style for isolated dwellings.
Ex. **Satoyama*** in Japan
Hilly and Mountainous areas in Switzerland
*one of Japan's traditional agricultural landscapes

Small community has fostered cultural and traditional society, harmonious human-nature interactions, ecotourism resources…

It needs to discuss from the **multiple view points**, not only lifeline cost but also ecotourism, cultural and traditional society to keep **freedom of residence.**

Today's Contents

1. Background and Objective
2. Data Development of Isolated Dwelling in Japan
3. Results: distribution of Isolated dwelling
4. Trial calculation on Location Optimization of Isolated dwelling
5. Summary and future work

5. Summary and future work

Summary

-**Developed isolated dwelling database** using building MGD for all of Japan.

-**Mapped distribution of Isolated dwelling**, relationships isolated dwelling and aged rate and so on.

-**Estimated both relocation promotion expenses and life line maintenance cost** for isolated dwelling for each municipality

Future work

-**Examination method** for isolated dwelling from digital residential map (such as home office, guest-house,…)

-**Calculation of relocation promotion expenses** according to isolated distance

-**Interview with municipal officers** to check our estimation result

Thank you for your kind attention!

How about this kinds of issues in Korea?

경청해 주셔서 감사합니다!

<u>Related papers</u>

Akiyama, M.C., Akiyama, Y., Spatial Distribution Monitoring of Isolated Dwelling Using Building Micro Geodata and Its Issue, International Conference on Spatial Analysis and Modeling (SIM 2018), B-2-5, 2018. http://ua.t.u-tokyo.ac.jp/sam2018/abstract/B-2-5

秋山祐樹・秋山千亜紀，建物マイクロジオデータを用いた全国の孤立住宅の分布把握，日本地理学会発表要旨集, 93, 217, 2018.