

Convenience Rating of Post-disaster Recovery Housing Complexes Constructed in Miyagi Prefecture following the 2011 Tohoku Earthquake

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Abstract

This study evaluated the convenience of post-disaster recovery housing complexes constructed in Japan's Miyagi Prefecture following the 2011 Tohoku Earthquake. We expected that five years on from the disaster, the evacuees would find life there more convenient. The study was targeted at five municipalities in the northern coastal area of Miyagi Prefecture that were most heavily struck by the earthquake-triggered tsunami: Kesennuma, Minami-Sanriku, Onagawa, Ishinomaki, and Higashi-Matsushima. Using geographical information system software, we conducted a network analysis of the coordinate data on the location of crucial infrastructure. Housing complexes within the defined service area of each infrastructure facility were assigned a score of 10, while those within two and three times the defined service area were assigned scores of 5.0 and 3.3, respectively. The convenience of the housing complexes was evaluated using these scores. In Kesennuma City, the post-disaster recovery housing complexes were shown to have better access to key infrastructure than the ordinary housing complexes, and in other three municipalities, the two types of complexes were shown to have comparable access. In Onagawa Town, however, the post-disaster recovery housing complexes were shown to have poorer access to key infrastructure than the ordinary housing complexes.

keywords: 2011 Tohoku Earthquake; convenience; network analysis; ordinary housing complexes; post-disaster recovery housing complexes

1 Introduction

Following the 2011 Tohoku Earthquake (1), many people were relocated to temporary housing. These were people who had lost their homes in the disaster and who lacked the financial means to rebuild. In Iwate Prefecture, which was seriously damaged by the earthquake-triggered tsunami, 94.6% of the temporary dwellings were occupied in December 2011.

However, these temporary housing complexes are not always conveniently located. For example, daily shopping and banking is problematic for residents located beyond a certain distance from the precincts.

Our previous studies (2; 3) compared the convenience of temporary housing complexes in the southern coastal area of Iwate Prefecture, which was constructed after the 2011 Tohoku Earthquake. The three target cities, Kamaishi, Ofunato, and Rikuzentakata, had been most severely impacted by the tsunami that followed the earthquake.

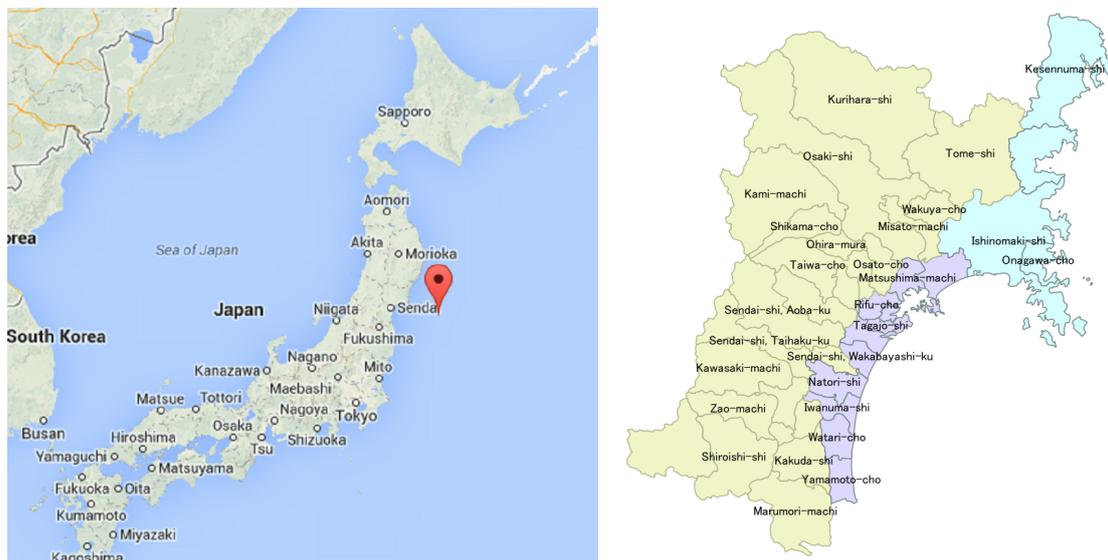


Figure 1: Left: Center of the 2011 Tohoku Earthquake on March 11, 2011. Right: Miyagi Prefecture divided into Inland, Northern Coastal, and Southern Coastal areas.

The convenience of living environments is often evaluated considering the distance between the dwelling and surrounding infrastructure (4). So, we also used the the score which increases as the distance from the key infrastructure decreases to evaluate the usability of a housing complex. Temporary housing complexes are not designed for permanent occupation. For this reason, many post-disaster recovery housing complexes have been built in the stricken area. We assume that the evacuees will remain there for an extended period. In a previous study, therefore, we compared the convenience of post-disaster recovery housing complexes with that of ordinaly housing complexes (5). In this research, we changed the target field from Iwate Prefecture to Miyagi Prefecture which had been also most severely impacted by the tsunami that followed the earthquake.

2 Methodology

2.1 Research area and materials

The research focused on three cities and two towns in the northern coastal area of Miyagi Prefecture [Figure 1], Kesennuma, Minami-Sanriku, Onagawa, Ishinomaki, and Higashi-Matsushima, all of which were inundated by the tsunami that struck after the Tohoku Earthquake of 2011.

The data used in the study were the coordinates of the post-disaster recovery housing complexes [Figure 2], the ordinary housing complexes [Figure 2], and the infrastructure supporting daily life in December 2016. Post-disaster recovery housing complexes are the permanent public housing sites built after the disaster. On the other hand, ordinaly housing complexes are the permanent public housing sites built before the disaster.

2.2 Daily life infrastructures

The infrastructure evaluated in this study comprised the facilities listed below. The area assumed to be serviced by the facilities is given in parentheses. These service areas were defined considering the distance which could be accessed easily on foot.

- 1) Retail
 - a. Supermarkets (1 km)
 - b. Convenience stores (0.5 km)
- 2) Financial services
 - a. Post offices and banks (1 km)
- 3) Medical services
 - a. Clinics (emergency department: internal medicine, pediatrics, surgery) (1 km)
 - b. Clinics (no emergency department: others)(1 km)

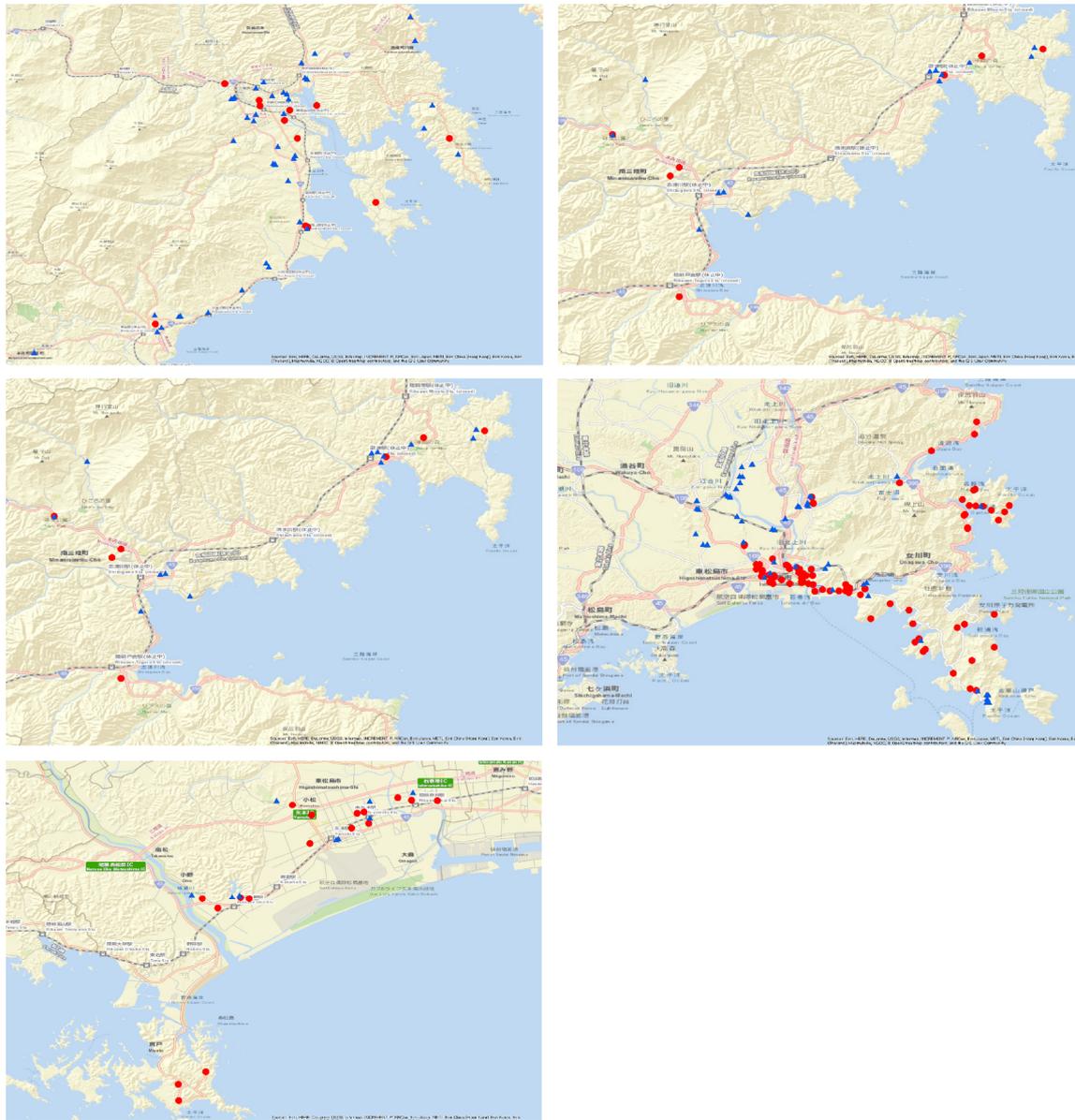


Figure 2: Left upper: Kesennuma City, Right upper: Minami-Sanriku Town, Left middle: Onagawa Town, Right middle: Ishinomaki City, Left lower: Higashi-Matsushima City: post-disaster recovery housing complexes (permanent public housing sites built after the disaster) are denoted by red circles and ordinaly housing complexes (permanent public housing sites built before the disaster) by blue triangles.

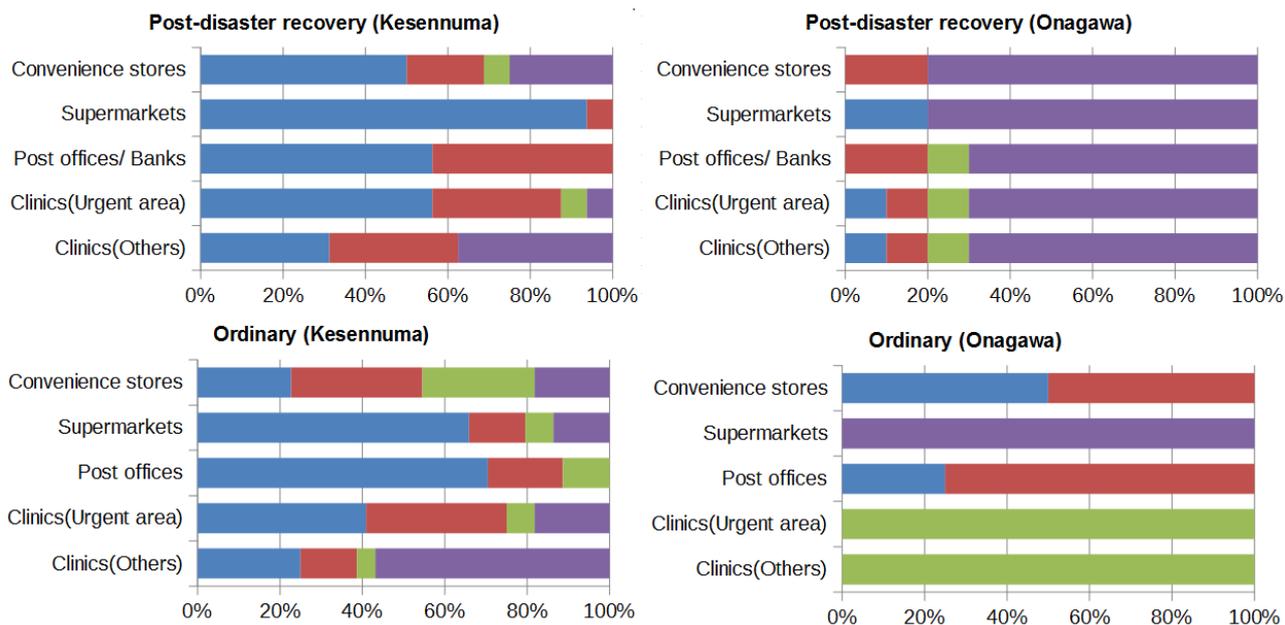


Figure 3: Comparison of scores for two kinds of housing complex (Upper: post-disaster recovery housing complexes. Lower: ordinary public housing complexes). Blue (1) regions indicate the percentage of housing complexes located within the defined service area of each infrastructure facility. Red (2) and green (3) regions denote the percentage of temporary dwellings within two and three times the distance from the defined service area, respectively. Violet (4) regions indicate the percentage of housing complexes more than three times the distance from the defined service area.

2.3 Data sources

The post-disaster recovery housing data were retrieved from the Miyagi Prefecture website (6). Data on infrastructures were obtained from NTT i Town Pages (a searchable telephone directory available on the Internet) (7). The true infrastructure coordinates and services were confirmed using Internet sites and maps.

2.4 Analysis

At first, we conducted geocoding procedure (address matching procedure) using the building-level geocoding system which could be operated on the Internet (8).

After plotting the infrastructure sites on a map, we conducted a network analysis using the ArcGIS 10.2.2 software with the Network Analyst function (Esri Inc., Redlands, CA, USA). This software enables the true measurement of road distances, as well as the linear distances between two features. The software was run on a standard desktop PC.

We first created network datasets from simple road distances, neglecting bends and speed limit data. These network data sets were used to determine the service areas of the infrastructure, with individual features represented by polygons.

Based on the distance between the infrastructure and the area serviced, we then assigned a usability score to each housing complex. Post-disaster recovery housing complexes within the radius of a defined service area were assigned a score of 10, complexes within 2 \times of the defined service area were assigned a score of 5.0, and those within 3 \times of the service area were assigned a score of 3.3. The service area measured by the road distance for each facility has already been defined in section 2.3. For example, for supermarkets, the defined service area of the road distance is 1 km. These scores were used to assign a convenience rating to the housing complexes.

3 Results

Figure 3 compares the scores of the housing complexes of each targeted city, while Tables 1 to 5 show the average scores given to the facilities of each city.

Table 1: Scores for Kesennuma

	Post-disaster complexes	Ordinary complexes	t test
Convenience stores	6.14	4.76	
Supermarkets	9.69	7.50	** p<0.01
Post offices Banks	7.81	8.33	
Clinics(Urgent areas)	7.39	6.02	
Clinics(Others)	4.69	3.33	
Averages	7.14	5.99	

Table 2: Scores for Minami-Sanriku

	Post-disaster complexes	Ordinary complexes	t test
Convenience stores	6.25	4.09	
Supermarkets	5.00	7.95	
Post offices Banks	7.50	7.55	
Clinics(Urgent areas)	2.29	3.71	
Clinics(Others)	0.00	0.00	
Averages	4.21	4.66	

Table 3: Scores for Onagawa

	Post-disaster complexes	Ordinary complexes	t test
Convenience stores	1.00	7.50	** p<0.01
Supermarkets	2.00	0.00	
Post offices Banks	1.33	6.25	** p<0.01
Clinics(Urgent areas)	1.83	3.30	
Clinics(Others)	1.83	3.30	
Averages	1.60	4.07	

Table 4: Scores for Ishinomaki

	Post-disaster complexes	Ordinary complexes	t test
Convenience stores	4.31	4.09	
Supermarkets	5.61	5.87	
Post offices Banks	6.12	7.86	** p<0.01
Clinics(Urgent areas)	5.36	5.55	
Clinics(Others)	3.55	2.22	
Averages	4.99	5.12	

Table 5: Scores for Higashi-Matsushima

	Post-disaster complexes	Ordinary complexes	t test
Convenience stores	5.19	7.83	
Supermarkets	6.85	6.49	
Post offices Banks	7.55	7.00	
Clinics(Urgent areas)	7.65	8.83	
Clinics(Others)	4.61	4.33	
Averages	6.37	6.90	

Based on these figure and tables, the findings were as follows:

In Kesennuma City, the convenience scores of the post-disaster recovery housing complexes were higher than those of the ordinary housing complexes. This means that the post-disaster complexes were more accessible to essential facilities than the ordinary housing complexes.

However, in Onagawa Town the post-disaster complexes achieved lower convenience scores than the ordinary housing complexes. This means that the post-disaster recovery housing complexes in Onagawa Town were less accessible to essential infrastructure than the ordinary housing complexes.

In other three municipalities, the convenience scores of the post-disaster complexes and ordinary housing complexes were almost the same, suggesting that they offered the same accessibility to essential facilities.

4 Discussion

These results suggest that the daily life of evacuees still had not been convenient in Onagawa. These results were not in line with our prior expectations. For Kesennuma, the convenience of access to facilities might have been the first priority when deciding the location of the post-disaster housing complexes, whereas in the case of Onagawa, we assumed that the key consideration had been connection to the local community. We assumed that the criteria for the location of other three municipalities had been intermediate between those applied to the other two municipalities.

References

- [1] Nobuhito Mori, Tomoyuki Takahashi, Tomohiro Yasuda, and Hideaki Yanagisawa, "Survey of 2011 Tohoku earthquake tsunami inundation and run-up," *Geophysical Research Letters*, Vol.38, No.7, April, 2011. Available at <http://dx.doi.org/10.1029/2011GL049210>
- [2] Risa Shibutani, and Noriaki Endo, "The convenience of temporary housing complexes in Iwate Prefecture constructed after the 2011 Tohoku Earthquake," *Proceedings of the 7th IGRSM International Conference on Remote Sensing and GIS*, 22-23 April, 2014, Kuala Lumpur, Malaysia. Available at <https://doi.org/10.1088/1755-1315/20/1/012043>
- [3] Shin-ichi Konno, Risa Shibutani, and Noriaki Endo, "Changes in the Level of Convenience of the Iwate Prefecture Temporary Housing Complexes Constructed after the 2011 Tohoku Earthquake," *Proceedings of the 2nd International Conference on Innovations in Engineering and Technology (ICCET' 2014)*, 19-20 September, 2014, Penang, Malaysia, pp89-93. Available at <http://iieng.org/images/proceedings.pdf/9122E0914065.pdf>
- [4] Tomoko Sekine, "An Analysis of Residential Environment in Morioka City in Terms of Accessibility (in Japanese)," *Geographical Review of Japan*, 65A-6, pp441-459, 1992.
- [5] Shin-ichi Konno, and Noriaki Endo, "Convenience Rating of Post-disaster Recovery Housing Complexes Constructed in Iwate Prefecture following the 2011 Tohoku Earthquake," *Lecture Notes in Engineering and Computer Science: Proceedings of The World Congress on Engineering and Computer Science 2016*, 19-21 October, 2016, San Francisco, USA, pp230-236. Available at http://www.iaeng.org/publication/WCECS2016/WCECS2016_pp230-236.pdf
- [6] The Addresses of Post-disaster Recovery Housing Complexes in Miyagi Prefecture (In Japanese): <https://www.pref.miyagi.jp/site/ej-earthquake/kannsei.html>
- [7] i Town Page of NTT Corporation (In Japanese): <http://itp.ne.jp/?rf=1>
- [8] Kenji Tani, Japan's Saitama University: Geocoding system which can be operated on the Internet, using Google Map API V3 (In Japanese): <http://ktgis.net/gcode/geocoding.html>