Convenience Rating of Post-disaster Recovery Housing Complexes Constructed in Iwate 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 Iwate 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 three major cities in the southern coastal area of Iwate Prefecture that were most heavily struck by the earthquake-triggered tsunami: Kamaishi, Ofunato, and Rikuzentakata. 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 Ofunato City, the post-disaster recovery housing complexes were shown to have better access to key infrastructure than the temporary housing complexes, and in Rikuzentakata City, the two types of complexes were shown to have comparable access. In Kamaishi City, however, the post-disaster recovery housing complexes were shown to have poorer access to key infrastructure than the temporary housing complexes. These results suggest that the daily life of evacuees has not greatly improved in Rikuzentakata and Kamaishi. These results were not in line with our prior expectations.**

***Index Terms*—2011 Tohoku Earthquake; convenience; network analysis; post-disaster recovery housing complexes; temporary housing complexes**

I. Introduction

Following the 2011 Tohoku Earthquake [1], several people were relocated to temporary housing [2]. 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 [3], [4] 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.

The convenience of living environments is often evaluated considering the distance between the dwelling and surrounding infrastructure [5]. Our usability findings confirmed that the score for a complex increases as the distance from the key infrastructure decreases.

Temporary housing complexes are not designed for permanent occupation. However, in the case of many post-disaster recovery housing complexes built in the stricken area, we assume that the evacuees will remain there for an extended period. In this study, therefore, we compared the convenience of post-disaster recovery housing complexes with that of temporary housing complexes. We expected that five years on from the disaster, the evacuees would find life there more convenient.

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II. Methodology

A. Research area

The research focused on three cities in the southern coastal area of Iwate Prefecture [Fig. 1], Kamaishi, Ofunato, and Rikuzentakata, all of which were inundated by the tsunami that struck after the Tohoku Earthquake of 2011.

B. Research materials

The data used in the study were the coordinates of the post-disaster recovery housing complexes [Figs.2, 3, 4] and the infrastructure supporting daily life in December 2011.

C. 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.

1) Retail
   a. Large supermarkets (3 km)
   b. Mid-sized supermarkets (1 km)
   c. Convenience stores (0.5 km)
2) Financial services
   a. Post offices (1 km)
   b. Banks (1 km)
   c. ATMs (1 km)
3)Medical
   a. Large hospitals (3 km)
   b. Private clinics (emergency department: internal medicine, pediatrics, surgery) (1 km)
   c. Private clinics (no emergency department: others)(1 km)

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Fig. 1. Southern coastal area of Iwate Prefecture.

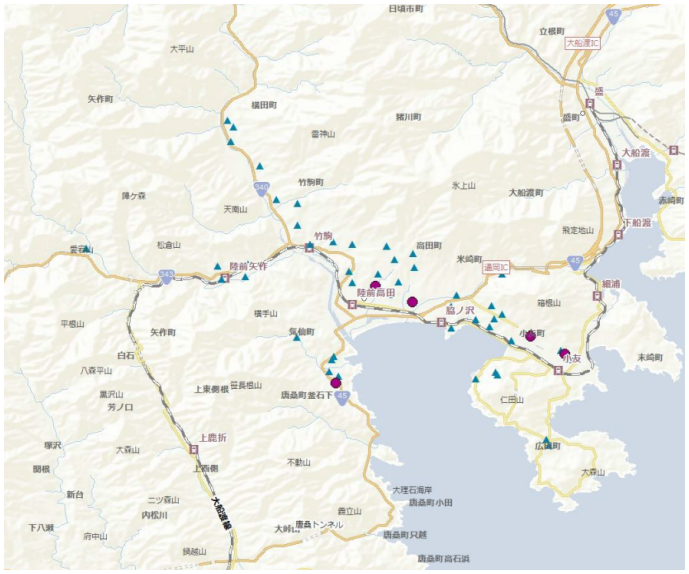

Fig. 2. Rikuzentakata City: post-disaster recovery housing complexes (permanent housing sites) are denoted by red circles and temporary housing complexes by blue triangles.

D. Data sources

The post-disaster recovery housing data were retrieved from the Iwate 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.

E. Analysis

After plotting the infrastructure sites on a map, we conducted network analysis using the ArcGIS 10.0 software with the Network Analyst function. 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.

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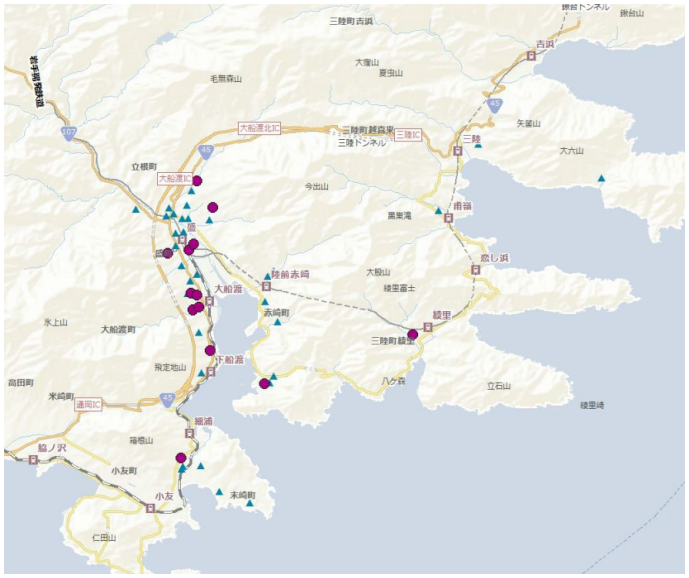

Fig. 3. Ofunato City: post-disaster recovery housing complexes (permanent housing sites) are denoted by red circles and temporary housing complexes by blue triangles.

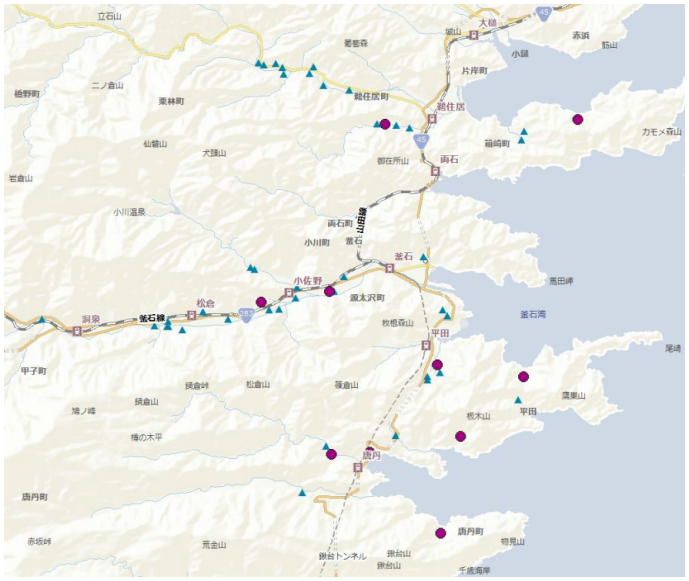

Fig. 4. Kamaishi City: post-disaster recovery housing complexes (permanent housing sites) are denoted by red circles and temporary housing complexes by blue triangles.

III. Results

Post-disaster recovery housing complexes within the radius of a defined service area were assigned a score of 10, complexes within 2 × of the defined service area were assigned a score of 5.0, and those within 3 × 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 II.C. For example, for Mid-sized 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.

Figures 5 to 7 compare the scores of the housing complexes of each targeted city, while Tables I to III show the average scores given to the facilities of each city.

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

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

In Rikuzentakata City, the convenience scores of the post-disaster complexes and temporary housing complexes were almost the same, suggesting that they offered the same accessibility to essential facilities.

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

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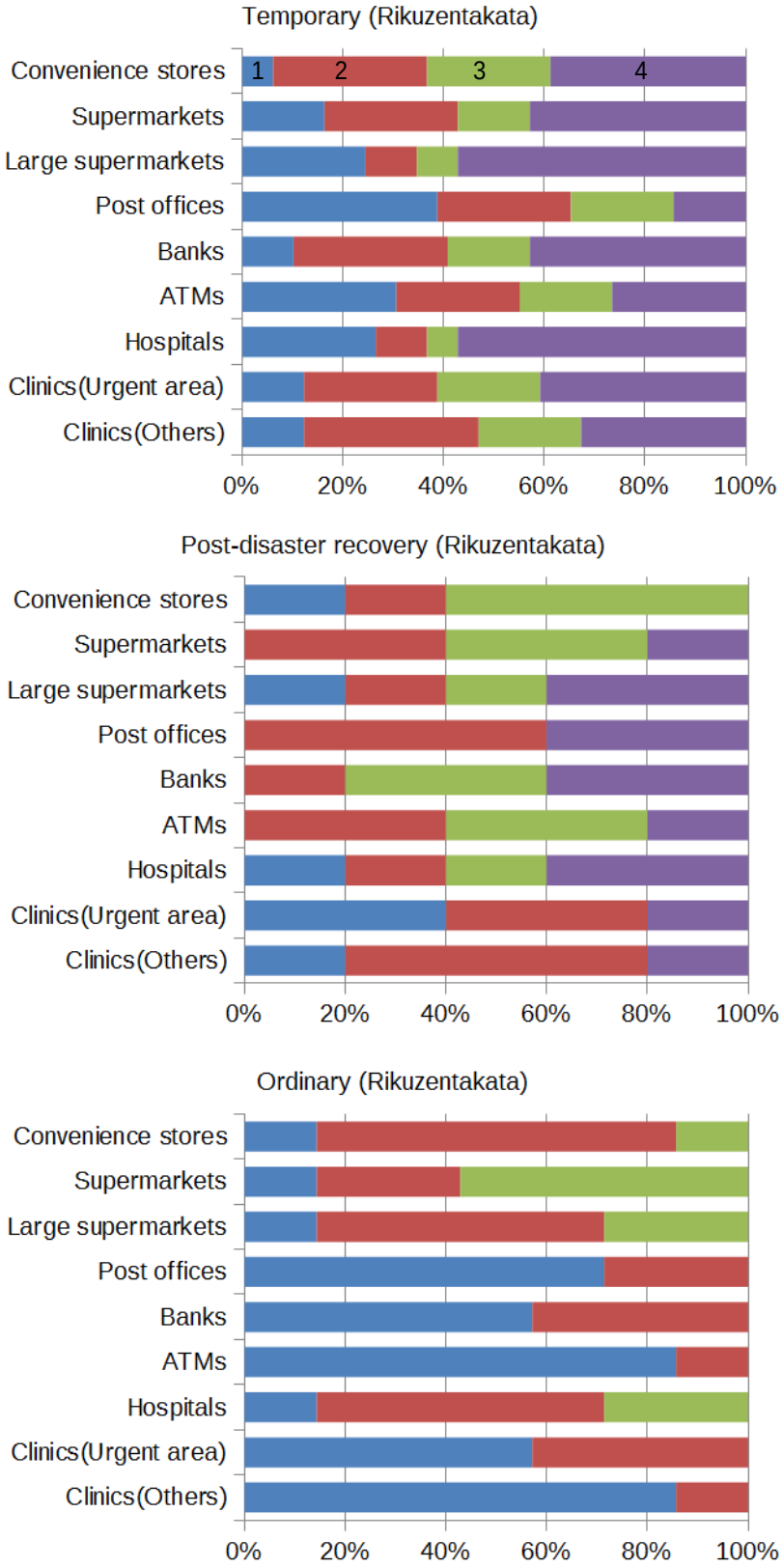

Fig. 5. Comparison of scores for Rikuzentakata's three kinds of housing complex (Upper: temporary housing complexes. Center: post-disaster recovery housing complexes. Lower: ordinary public housing complexes). Blue (1) regions indicate the percentage of temporary housing complexes located within the 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 (for large supermarkets and hospitals: 1.33 and 1.66 times, respectively). Violet (4) regions indicate the percentage of temporary dwellings more than three times the distance from the defined service area.

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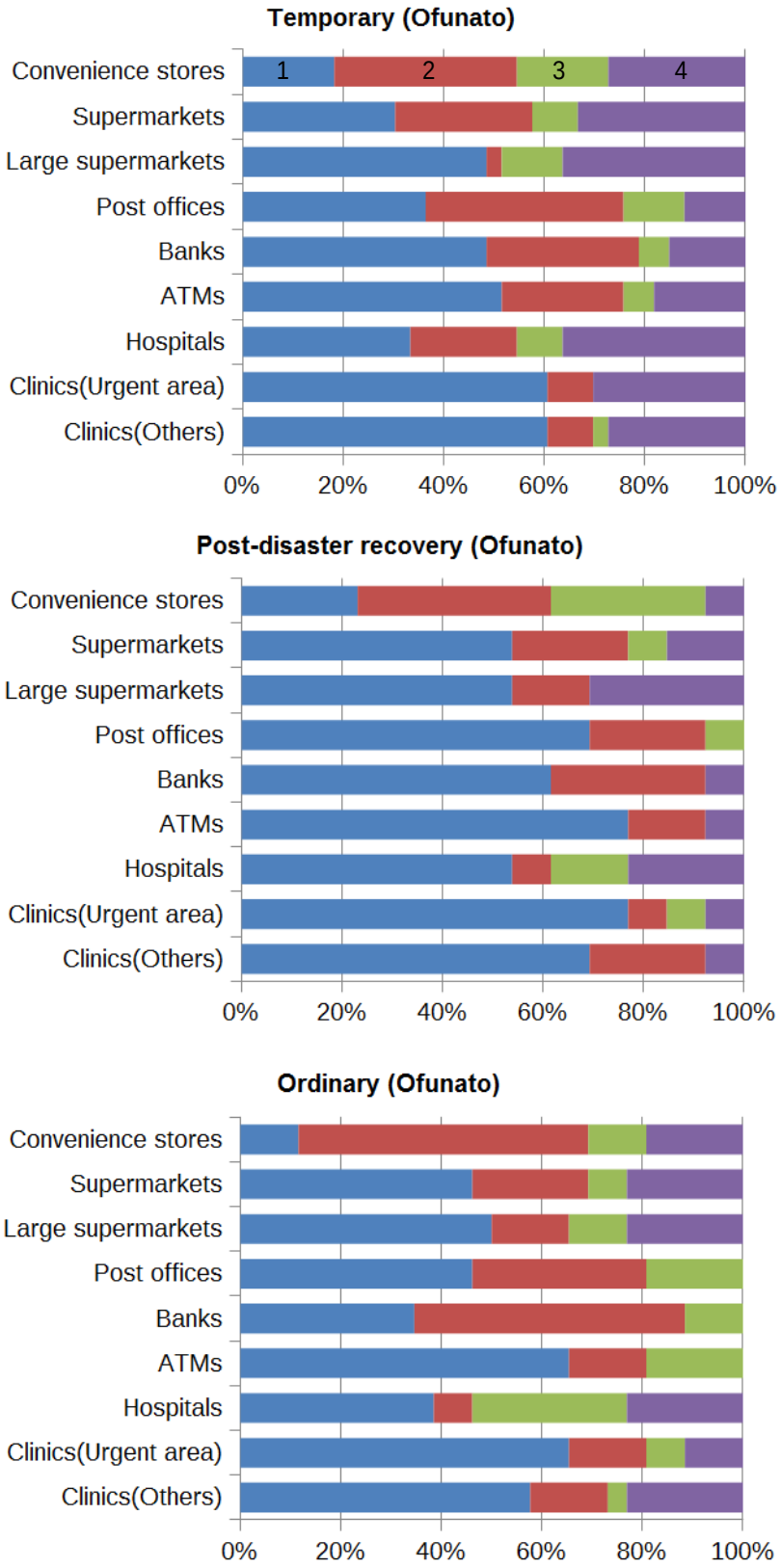

Fig. 6. Comparison of scores for Ofunato's three kinds of housing complex (Upper: temporary housing complexes. Center: post-disaster recovery housing complexes. Lower: ordinary public housing complexes). Blue (1) regions indicate the percentage of temporary housing complexes located within the defined 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 (for large supermarkets and hospitals: 1.33 and 1.66 times, respectively). Violet (4) regions indicate the percentage of temporary dwellings more than three times the distance from the defined service area.

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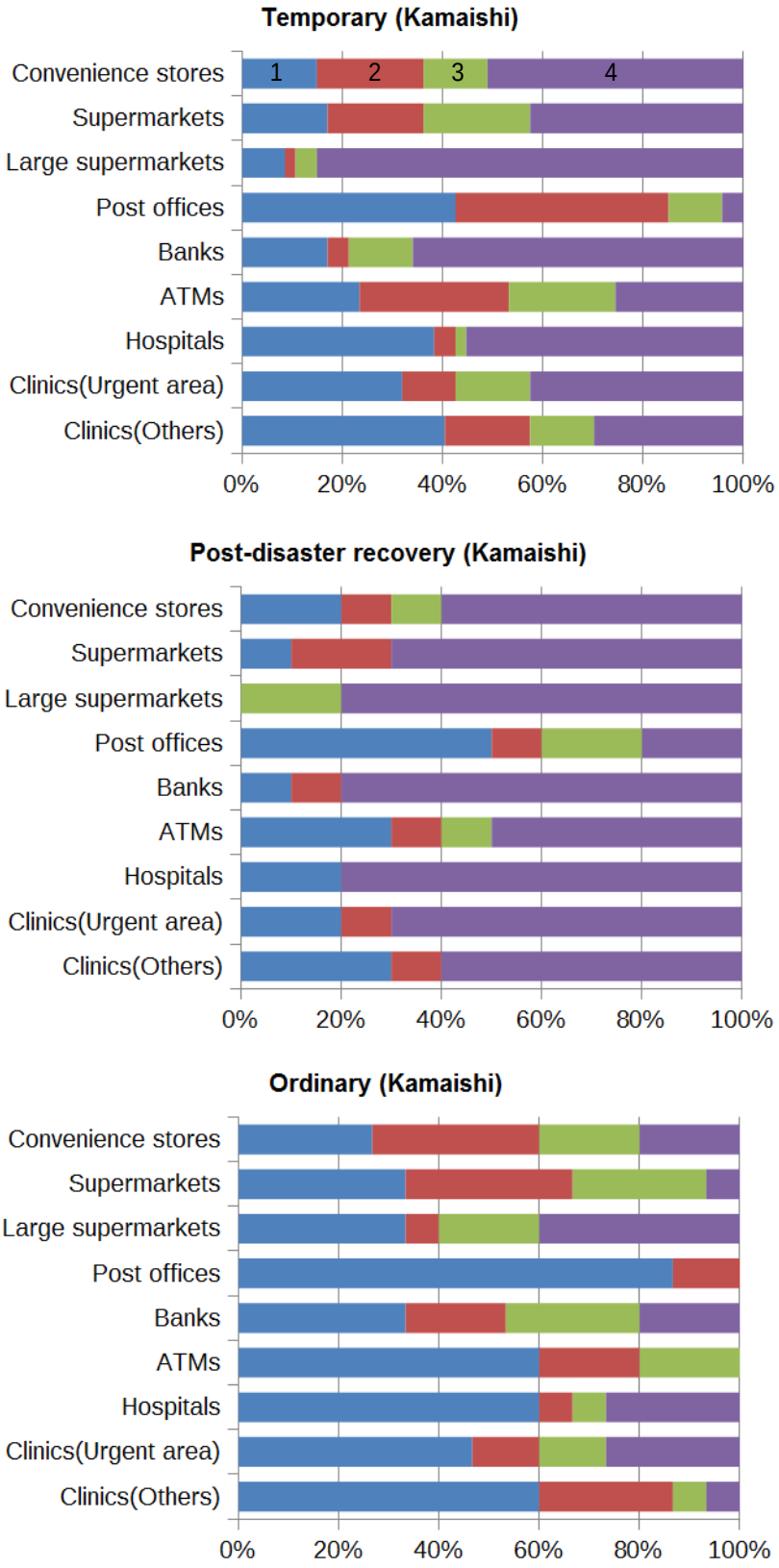

Fig. 7. Comparison of scores for Kamaishi's three kinds of housing complex (Upper: temporary housing complexes. Center: post-disaster recovery housing complexes. Lower: ordinary public housing complexes). Blue regions (1) indicate the percentage of temporary housing complexes located within the defined 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 (for large supermarkets and hospitals: 1.33 and 1.66 times, respectively). Violet (4) regions indicate the percentage of temporary dwellings more than three times the distance from the defined service area.

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TABLE I
SCORES FOR RIKUZENTAKATA

	Temporary complexes	Post-disaster complexes	Ordinary complexes
Convenience stores	2.95	3.66	5.47
Supermarkets	3.97	3.32	4.76
Large supermarkets	3.70	4.70	7.43
Post offices	5.88	3.00	8.57
Banks	3.09	2.32	7.86
ATMs	4.89	3.32	9.29
Hospitals	3.78	4.70	7.43
Clinics(Urgent areas)	3.22	6.00	7.86
Clinics(Others)	3.63	5.00	9.29
Averages	3.90	4.00	7.55

TABLE II
SCORES FOR OFUNATO

	Temporary complexes	Post-disaster complexes	Ordinary complexes
Convenience stores	4.24	5.25	4.42
Supermarkets	4.69	6.79	6.02
Large supermarkets	5.48	6.54	6.85
Post offices	6.01	8.33	6.98
Banks	6.56	7.69	6.53
ATMs	6.56	8.46	7.94
Hospitals	5.47	6.88	6.27
Clinics(Urgent areas)	6.52	8.33	7.56
Clinics(Others)	6.62	8.08	6.67
Averages	5.79	7.37	6.58

TABLE III
SCORES FOR KAMAISHI

	Temporary complexes	Post-disaster complexes	Ordinary complexes
Convenience stores	2.97	2.83	4.99
Supermarkets	3.36	2.00	5.88
Large supermarkets	1.27	1.20	5.03
Post offices	6.73	6.16	9.33
Banks	2.37	1.50	5.21
ATMs	4.53	3.83	7.66
Hospitals	4.28	2.00	6.90
Clinics(Urgent areas)	4.21	2.50	5.77
Clinics(Others)	5.31	3.50	7.55
Averages	3.89	2.84	6.48

IV. DISCUSSION

These results suggest that the daily life of evacuees has not greatly improved in Rikuzentakata and Kamaishi. These results were not in line with our prior expectations.

We selected Ofunato for study as we supposed that the convenience of access to facilities had been the first priority when deciding the location of the post-disaster housing complexes, whereas in the case of Kamaishi, we assumed that the key consideration had been connection to the local community.

We assumed that the criteria for the location of Rikuzentakata had been intermediate between those applied to the other two cities.

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