

# Changes in the Level of Convenience of the Iwate Prefecture Temporary Housing Complexes Constructed after the 2011 Tohoku Earthquake

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**Abstract**—We evaluated changes in the convenience of temporary housing complexes between 2011 and 2014 in the Iwate Prefecture following the 2011 Tohoku Earthquake. The study was targeted at three major cities in the southern coastal area of Iwate Prefecture, namely, Kamaishi, Ofunato, and Rikuzentakata, which were heavily struck by the earthquake-triggered tsunami.

We conducted a network analysis in GIS software using the coordinate data of several everyday infrastructures. We determined that the temporary housing complexes within the defined service area of each infrastructure were convenient. Comparing the results of July 2014 with those of November 2011, the difference between the three cities was reduced. The convenience of middle-sized supermarkets and "banks and post offices" in Rikuzentakata city had improved, but the convenience of large supermarkets, clinics, and convenience stores had improved less, compared to the other two cities up to July 2014.

**Keywords**—2011 Tohoku earthquake, Convenience, Iwate Prefecture, Network analysis, Temporary housing complexes.

## I. INTRODUCTION

FOLLOWING the 2011 Tohoku Earthquake [1], many people who had lost their homes in the disaster and lacked the financial means to rebuild were relocated to temporary housing [2]. In the Iwate Prefecture, which was seriously damaged by the earthquake-triggered tsunami, 94.6% of its temporary dwellings were occupied in December 2011.

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

Therefore, our previous study [3] compared the convenience of temporary housing complexes in the southern coastal area of the Iwate Prefecture constructed after the 2011 Tohoku Earthquake. The three target cities, Kamaishi, Ofunato, and Rikuzentakata, had been severely stricken by the tsunami that followed the earthquake.

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In this study, subsequent infrastructure changes in the same region were evaluated using data from 2011 to 2014.

The convenience of living environments is frequently evaluated by the distance between the dwelling and surrounding infrastructures [4]. Similarly, we found that the usability score for a complex increases as the distance from the infrastructures decreases.

## II. METHODOLOGY

### A. Research Area

The research focuses on three cities in the southern coastal area of the Iwate Prefecture (shown in Fig.1 and Table 1), namely, Kamaishi, Ofunato, and Rikuzentakata city, all of which were inundated by the tsunami that struck after the Tohoku earthquake in 2011.

### B. Research Materials

The data used in the study were the coordinate data of temporary housing complexes (Fig. 2) and the infrastructures for daily life in December 2011 and July 2014.

### C. Daily Life Infrastructures

The daily life infrastructures evaluated in this study are listed below. The assumed service areas are given in parentheses.

- 1) Commerce field
  - a. Large supermarkets (3 km)
  - b. Middle-sized supermarkets (1 km)
- 2) Service field
  - a. Banks and post offices (1 km)
- 3) Medical field
  - a. Hospitals (3 km)
  - b. Clinics (1 km)

### D. Obtaining the Research Data

The address data of the temporary housing complexes were retrieved from the Iwate Prefecture website [5].

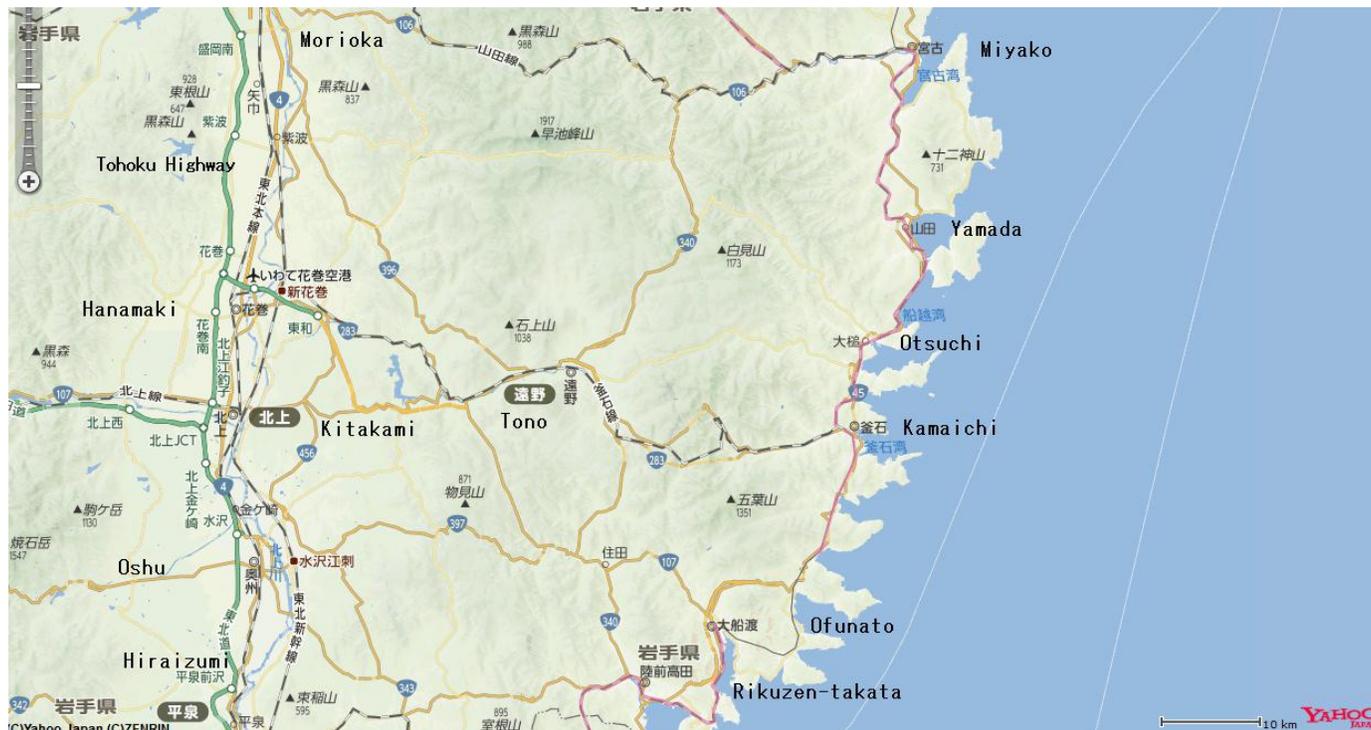


Fig.1 Southern coastal area of Iwate Prefecture

The address data for the daily life infrastructures were obtained from NTT i-Town Pages (a telephone number search service available on the Internet) [6]. The real infrastructure coordinates and service states were confirmed from internet sites and maps.

TABLE I. POPULATION AND OCCUPIED RATIO OF TEMPORARY HOUSINGS

	Population	Temporary Housings	Occupied	Occupied Ratio(%)
Kamaishi	39,574	3,164	2,865	90.5
Ofunato	40,737	1,811	1,784	98.5
Rikuzen-Takata	23,300	2,168	2,141	98.8
Iwate Prefecture	1,330,147	13,984	13,233	94.6

E. Analysis

First, we conducted geocoding processes to convert the addresses of the temporary housing complexes and the everyday infrastructures to geographic coordinates. The geocoding method used in this study was slightly different from that of previous study [3], using a house number level [7] instead of the previously used block level geocoding [8]. Therefore, we processed not only the 2014 data but also the 2011 data once again for this study.

After plotting the temporary housing complexes and the everyday infrastructures on the map, we conducted a network analysis using the ArcGIS Network Analyst function that enables the measurements of actual road distances in addition to linear distance between two features.

In this study, we created network datasets from simple road distances, neglecting road bends and speed limit data. From the network datasets, we determined the service areas of the infrastructures, representing individual features by polygons.

Based on the distance from the infrastructures and the service area covered by the infrastructure, we then assigned a usability

score to each temporary housing complex.

III. RESULTS

Comparing two research points in time, all everyday infrastructure numbers had increased, except hospitals (Tables 2 and 3). In Rikuzentakata particularly, the figure for July 2014 was over twice that for November 2011 with regard to large and middle-sized supermarkets and convenience stores (Tables 2 and 3).

TABLE II. NUMBER OF EACH INFRASTRUCTURE ON NOVEMBER 2011

	Kamaishi	Ofunato	Rikuzen-Takata	Total
Convenience stores	8	14	4	26
Clinics	28	32	12	72
Banks and Post Offices	22	12	9	43
Middle-sized supermarkets	6	13	6	25
Hospitals	4	1	1	6
Large supermarkets	6	2	0	8

The increase in middle-sized supermarkets was mainly due to the reopening of shops built in the temporary malls.

TABLE III. NUMBER OF EACH INFRASTRUCTURE ON JULY 2014

	Kamaishi	Ofunato	Rikuzen-Takata	Total
Convenience stores	12	18	8	38
Clinics	31	37	14	82
Banks and Post Offices	24	16	12	52
Middle-sized supermarkets	9	17	16	42
Hospitals	4	1	1	6
Large supermarkets	9	5	1	15

A. Kamaishi City

In Kamaishi, the main change was as follows. For large supermarkets in November 2011, 44% of the housing complexes were located within a three kilometer service area. In



Fig.2 Locations of temporary housing complexes (Upper: Kamaishi city, Center: Ofunato city, Lower: Rikuzentakata city)

July 2014, 58% of the housing complexes were located within the service area.

### B. Ofunato City

In Ofunato, changes were few but some improvement was noticed. For banks and post offices, in November 2011, 38% of the housing complexes were located within the service area of

three kilometers, compared to 43% in July 2014.

### C. Rikuzentakata City

In Rikuzentakata, the main changes were as follows. For large supermarkets, there was no shop at all in November 2011. A shop was built by July 2014. By this time, 21% of the housing complexes were located within the service area.

For middle-sized supermarkets, in November 2011, only 13% of the housing complexes were located within the service area of three kilometers. By July 2014, this had increased to 32%.

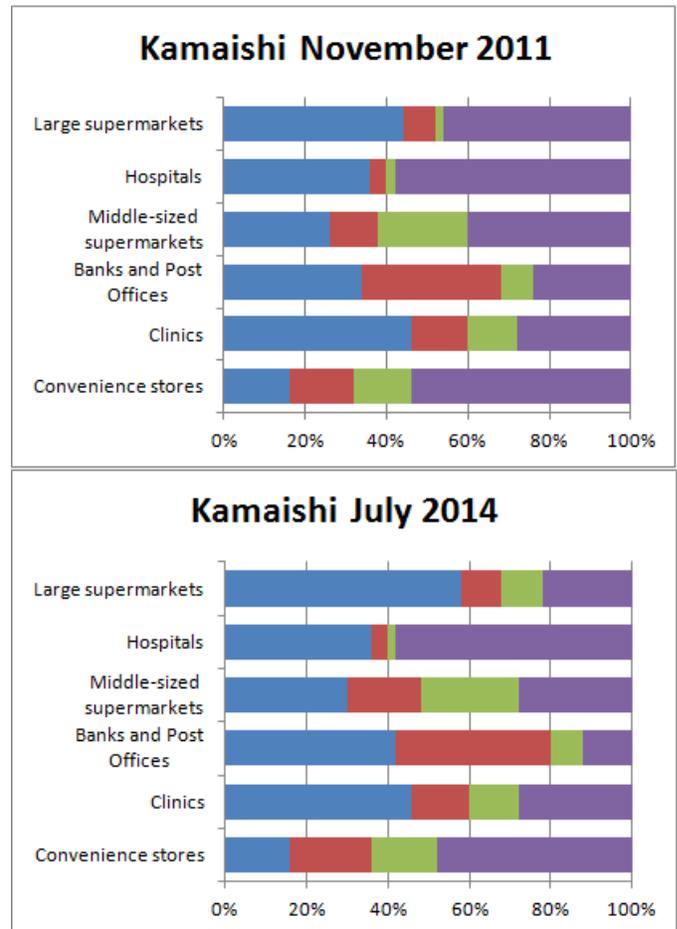


Fig. 3 Convenience of infrastructures of Kamaishi city. Blue regions indicate the percentage of temporary housing complexes located within the defined service area of each infrastructure. Red and green regions denote the percentage of temporary dwellings within two and three times the defined service area, respectively (except large supermarkets and hospitals, 1.33 and 1.66 times, respectively). Violet regions indicate the percentage of temporary dwellings outside the previously described area.

For banks and post offices, in November 2011, 30% of the housing complexes were located in the three kilometer service area, compared to 42% by July 2014.

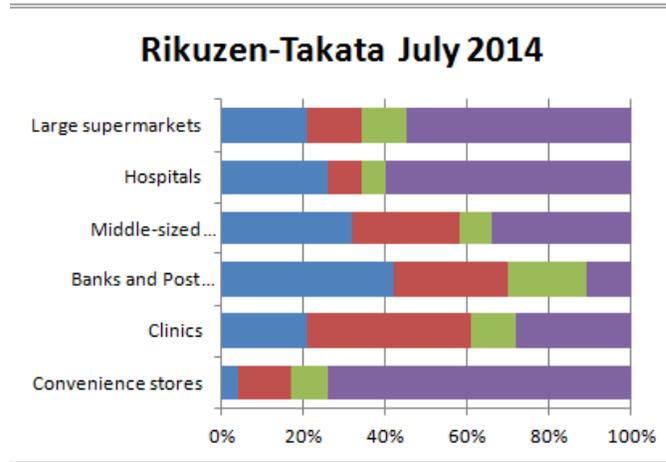
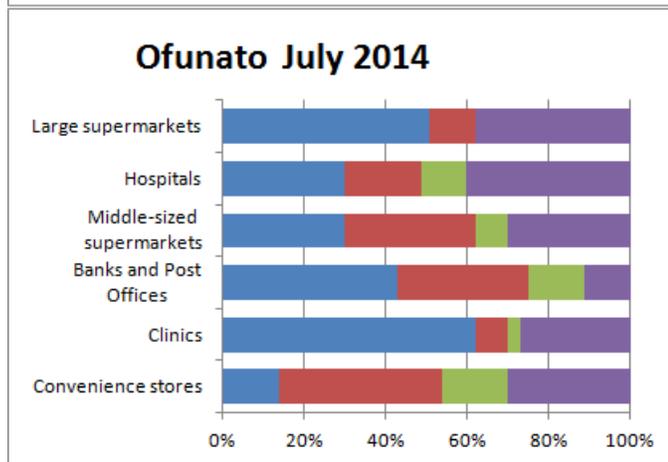
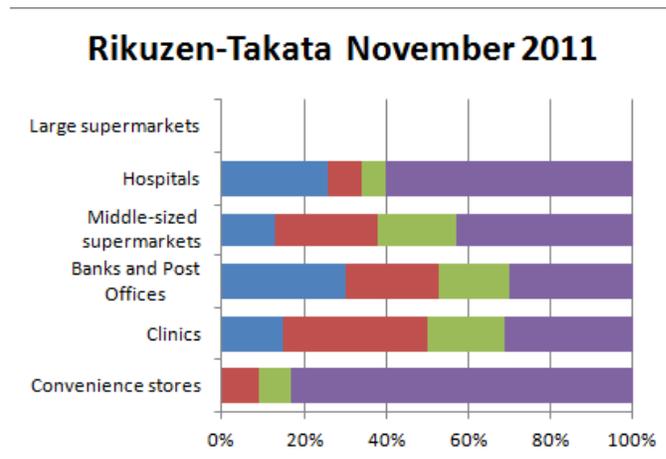
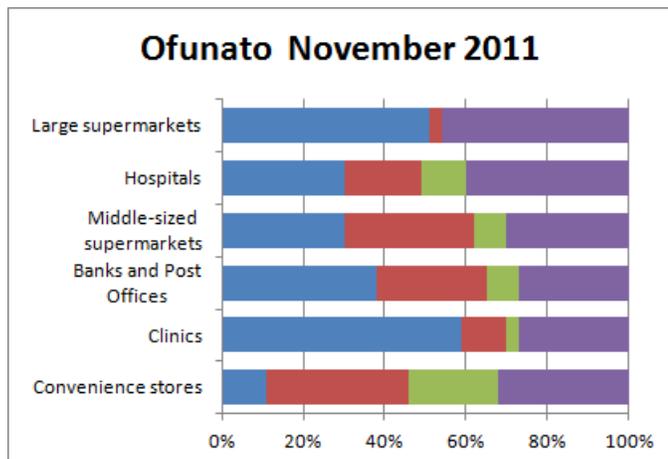


Fig. 4 Convenience of infrastructures in Ofunato city. Blue regions indicate the percentage of temporary housing complexes located within the defined service area of each infrastructure. Red and green regions denote the percentage of temporary dwellings within two and three times the defined service area, respectively (except large supermarkets and hospitals, 1.33 and 1.66 times, respectively). Violet regions indicate the percentage of temporary dwellings outside the previously described area.

Fig. 5 Convenience of infrastructures in Rikuzentakata city. Blue regions indicate the percentage of temporary housing complexes located within the defined service area of each infrastructure. Red and green regions denote the percentage of temporary dwellings within two and three times the defined service area, respectively (except large supermarkets and hospitals, 1.33 and 1.66 times, respectively). Violet regions indicate the percentage of temporary dwellings outside the previously described area.

#### IV. DISCUSSION

In the previous study [3], we described how infrastructures are far less accessible to temporary housing dwellers in Rikuzentakata city than to those in the other cities. Nevertheless, comparing the results of July 2014 with those of November 2011, the difference had shrunk between the three targeted cities.

The convenience of middle-sized supermarkets and "banks and post offices" in Rikuzentakata city had improved in line with the other two targeted cities. However, the convenience of large supermarkets, clinics, and convenience stores had not improved as much as the other two targeted cities by July 2014.

We consider the convenience of clinics to be very important, especially for elderly persons in Rikuzentakata. Therefore, we conclude that some kind of transportation system for visiting clinics at any time should be provided for them.

#### ACKNOWLEDGMENT

We thank the citizens of the world who assisted the 3.11 million people of Japan affected by the earthquake. In addition, we thank those who created and maintained the useful systems which assisted them. The authors would like to thank Enago for the English language review.

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