Analysis of Vehicle Tracking Maps in Iwate Prefecture Following the 2011 Tohoku Earthquake

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***Abstract*—We calculated the usable distance of the main roads in the coastal area of Iwate prefecture following the 2011 Tohoku Earthquake. Calculations were based on a vehicle tracking map built from G-BOOK telematics data using QGIS, an open source geographic information system. The main findings are as follows.**

(1) The change in the accumulative usable road distance ratio during the research period differed by city.

(2) The ratio increases in the usable distance of Kuji, Iwaizumi, and Noda were extremely delayed.

We could determine related roads by analyzing the maps generated by QGIS software. For Kuji and Iwaizumi, delays were mostly dependent on Iwate Prefectural Road number 7 (Kuji-Iwaizumi line). For Noda, the delay was mostly dependent on Iwate Prefectural Road number 273 (Akka-Tamagawa line).

(3) In our previous study, we determined that the use of the main road in the southern coastal area of Iwate prefecture was completely recovered by April 29, 2011.

However, in this study, when we precisely observed the change in the usable road distance ratio during the research period for each city, the ratio increase in the usable distance of Kamaishi was delayed compared to other southern coastal cities.

***Index Terms*—2011 Tohoku Earthquake; G-BOOK telematics data; Iwate prefecture; big data**

I. Introduction

A. The 2011 Tohoku Earthquake

When the March 11, 2011 Tohoku Earthquake[Fig. 1] struck, the northeastern coast of Japan was severely affected by the subsequent tsunami.

Following the earthquake, electricity, water, and gas supplies were shut down in both coastal and inland areas. In addition, road travel was shut down in many locations in the region.

B. Previous study

Our previous study [1] focused on the use of the main roads in the southern coastal area of Iwate prefecture [Fig.2]. The usable distances of the main roads following the 2011 Tohoku Earthquake were calculated from G-BOOK telematics data [2].

The main findings were as follows.

1) The usable distance of the roads in a weekly period increased continuously from March 18 to April 7, 2011, but fluctuated thereafter.

2) Defining the accumulative usable distance up to September 30, 2011 as 100%, it was determined that 80% of the road distance was usable by April 7, 2011 and 90% by April 29, 2011.

3) Use of the main road in the coastal area of Iwate prefecture was completely recovered by April 29, 2011.

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II. Telematics data and vehicle-tracking map

Telematics is a general term encompassing telecommunications and informatics. A telematics service provides various personalized information for users, especially for drivers of automobiles. G-BOOK is a telematics service provided by Toyota Motor Corporation.

To calculate the usable distance of the main roads, we applied the vehicle tracking map originally created by Hada et al. [3] after the 2007 Niigataken Chuetsu-oki earthquake.

That vehicle tracking map was based on telematics data provided by Honda Motor Company. Similarly, in our study, we used the vehicle tracking map based on telematics data provided by Toyota 's G-BOOK system [Figs. 3 and 4].

Registered members of G-BOOK can access telematics services to acquire GPS data for car navigation systems and interactive driving data, such as traffic jam points, road closures, and weather reports.

Such comprehensive data acquisition is possible because the telematics system server receives accurate location data (geographic coordinates) from its registered members.

Telematics services are extremely useful to drivers. Because the accurate driving routes of registered users remain in the system server, they are accessible to traffic researchers in various fields.

III. Research Methods

A. Research area

Our previous research [1] focused on only the southern coastal area of Iwate prefecture [Fig. 4].

The current study has focused on the entire coastal area of Iwate prefecture (i.e., both the southern and northern coastal areas).

B. Research materials

This study used the vehicle tracking map built from G-BOOK telematics data, which, in the aftermath of the 2011 Tohoku Earthquake, was made available on the Internet on March 17, 2011 [2].

The data used in this study were collected between March 3 and September 30, 2011 (approximately six months after the 2011 Tohoku Earthquake).

C. System

Hardware:

Calculations were performed on a standard laptop PC with a Core i5-4200U CPU (1.6 GHz) and 4 GB memory (SONY VAIO PRO 11).

Software:

The software used in this study was QGIS version 2.6.1 (the latest version at the time) [5] and LibreOffice Calc 4.2.7

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spreadsheet software (the most stable version at the time) [6] running on the Windows 7 Professional operating system. QGIS is one of the most popular geographic information systems in the world.

Prior to using the above applications, we used the ogr2ogr software [7] on the Linux operating system for geographical data processing. We used Vine Linux 4.2 [8], which is a Linux distribution developed by a Japanese Linux community.

Note that QGIS, LibreOffice Calc, ogr2ogr, and Vine Linux are open source software distributed freely on the Internet. Anyone can utilize them for their research or business.

D. Data Processing

1) The vehicle tracking maps constructed from G-BOOK telematics data were provided in Google map KMZ format. We first converted the KMZ files to SHP files (i.e., shapefiles), which are compatible with ArcGIS, using the ogr2ogr software.

2) Next, the data coordinates were converted from terrestrial latitude and longitude to x and y coordinates in a rectangular coordinate system.

3) To reduce computation time, the data file was clipped to small files containing only the research area.

4) After merging daily data into weekly data and removing duplicate data, we were able to calculate the exact usable road distance available for a given week.

The purpose of converting the daily data to weekly data was to smooth daily fluctuations in traffic flows.

5) We then calculated the proportion of accumulative distance up to the specified date. Note that the accumulative distance up to September 30, 2011 was considered 100%.

IV. Results

We calculated the usable distance of the main roads in the coastal area of Iwate prefecture following the 2011 Tohoku Earthquake.

Calculations were based on a vehicle tracking map built from G-BOOK telematics data utilizing open source software, i.e., Linux, ogr2og2, QGIS, and LibreOffice Calc.

We calculated the accumulative usable road distance ratio of the main roads for each city in the region [Fig. 5].

(1) The change in accumulative usable road distance ratio during the research period differed by city.

(2) The ratio increases in the usable distance of Kuji, Iwaizumi, and Noda were extremely delayed.

We could determine related roads by analyzing the maps generated by QGIS software.

For Kuji and Iwaizumi, delays were mostly dependent on Iwate Prefectural Road number 7 (Kuji-Iwaizumi line).

For Noda, the delay was mostly dependent on Iwate Prefectural Road number 273 (Akka-Tamagawa line).

(3) In our previous study [1], we defined the accumulative usable distance up to September 30, 2011 as 100%. Note that 80% of the distance was usable by April 7, 2011 and 90% by April 29, 2011. And we determined that the use of the main road in the southern coastal area of Iwate prefecture was completely recovered by April 29, 2011.

However, in this study, when we precisely observed the change in the usable road distance ratio during the research period for each city, the ratio increase in the usable distance of Kamaishi was delayed compared to other southern coastal cities.

For Kamaishi City, the delay was mostly dependent on Iwate Prefectural Road number 249 (Sakuratoge-Heita line).

V. Discussion

In this study, all application software used was open source software. The performance of the software used was very high and could satisfy all the required functions properly.

According to our results, we consider that the recovery condition of the regional roads after the 2011 Tohoku Earthquake differed by city.

To improve the resilience of regional roads, we should enhance roads whose utilization was more delayed compared to other roads.

Alternatively, construction of bypass roads for such roadways would significantly contribute to the resilience of the region.

We believe that the recommended enhancements should be realized before the next large disaster occurs.

Acknowledgements

We would like to thank all the people worldwide who assisted the people of Japan following the 2011 Tohoku Earthquake.

In addition, we would like to thank the people who created and maintained the useful software and telematics archives used in this study.

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http://www.jaee.gr.jp/stack/submit-j/v09n02/090211_paper.pdf

[4] Vehicle Tracking Map Constructed by G-BOOK Telematics Data
http://g-book.com/disasterMap/ALL/Tohoku-Jishin_YYYYMMDD.kmz
(For example, Tohoku-Jishin_20110318.kmz. The data files of tracking map are still available on February 3, 2015.)

[5] Official website of QGIS, A Free and Open Source Geographic Information System
http://www.qgis.org/en/site/

[6] Official Website of the LibreOffice Project
http://www.libreoffice.org/

[7] Official website of GDAL: ogr2ogr
http://www.gdal.org/ogr2ogr.html

[8] Official website of Vine Linux (In Japanese)
http://www.vinelinux.org/

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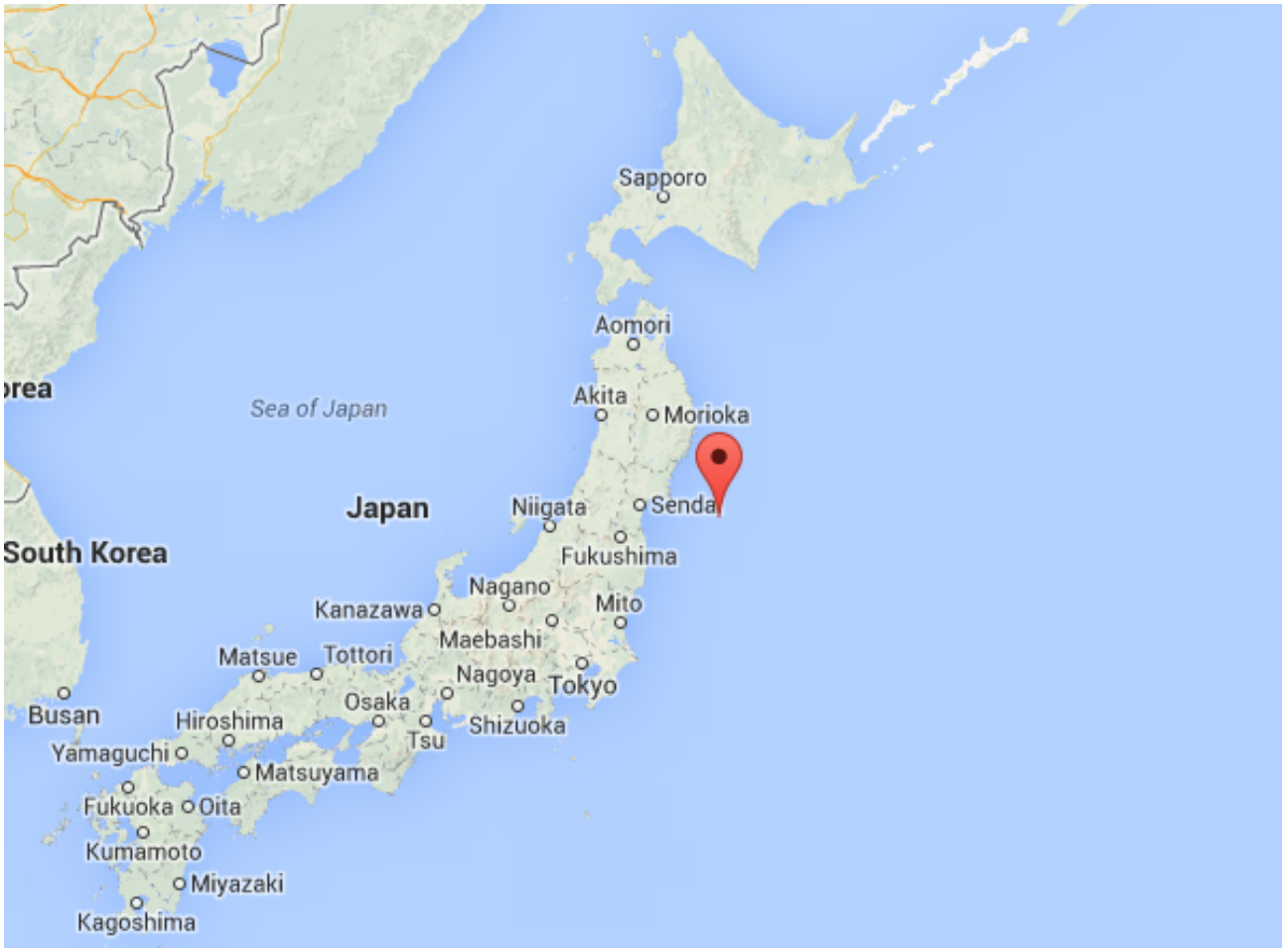

Fig. 1. Center of the 2011 Tohoku Earthquake occurred on March 11,2011.

Fig. 2. Main roads in the southern coastal area of Iwate prefecture.

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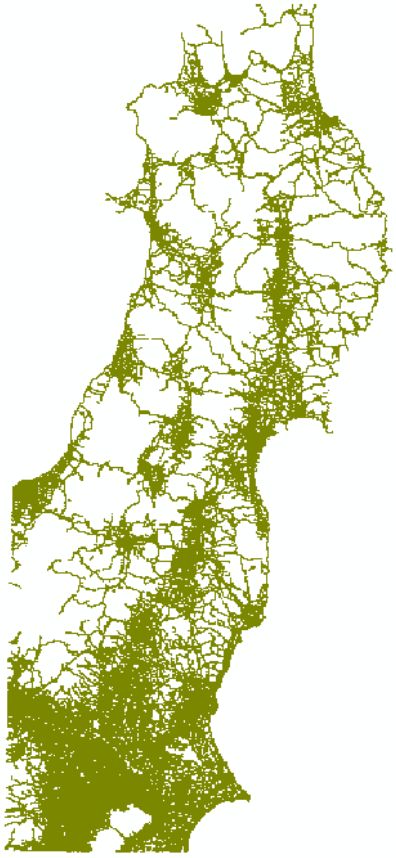

Fig. 3. Vehicle-tracking map of eastern Japan.

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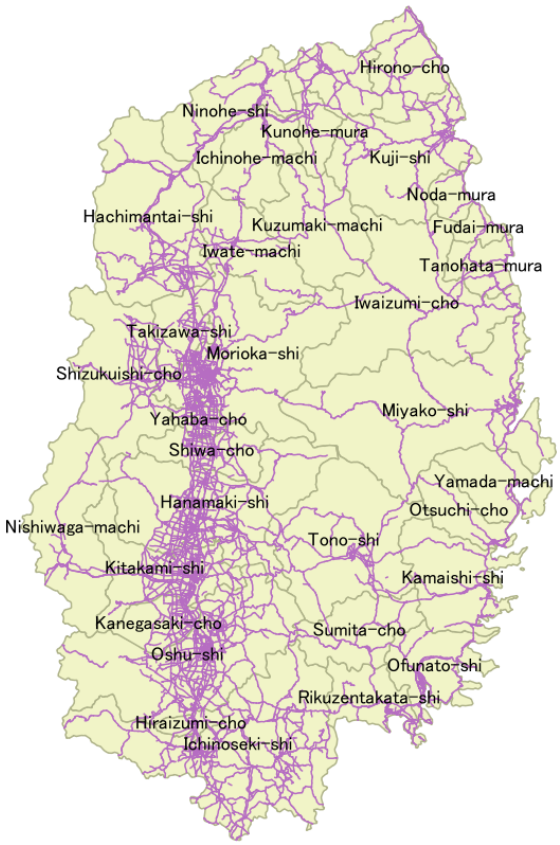

Fig. 4. Vehicle-tracking map of Iwate prefecture, shown by violet lines. The perimeter of a city is shown by a gray polygon.

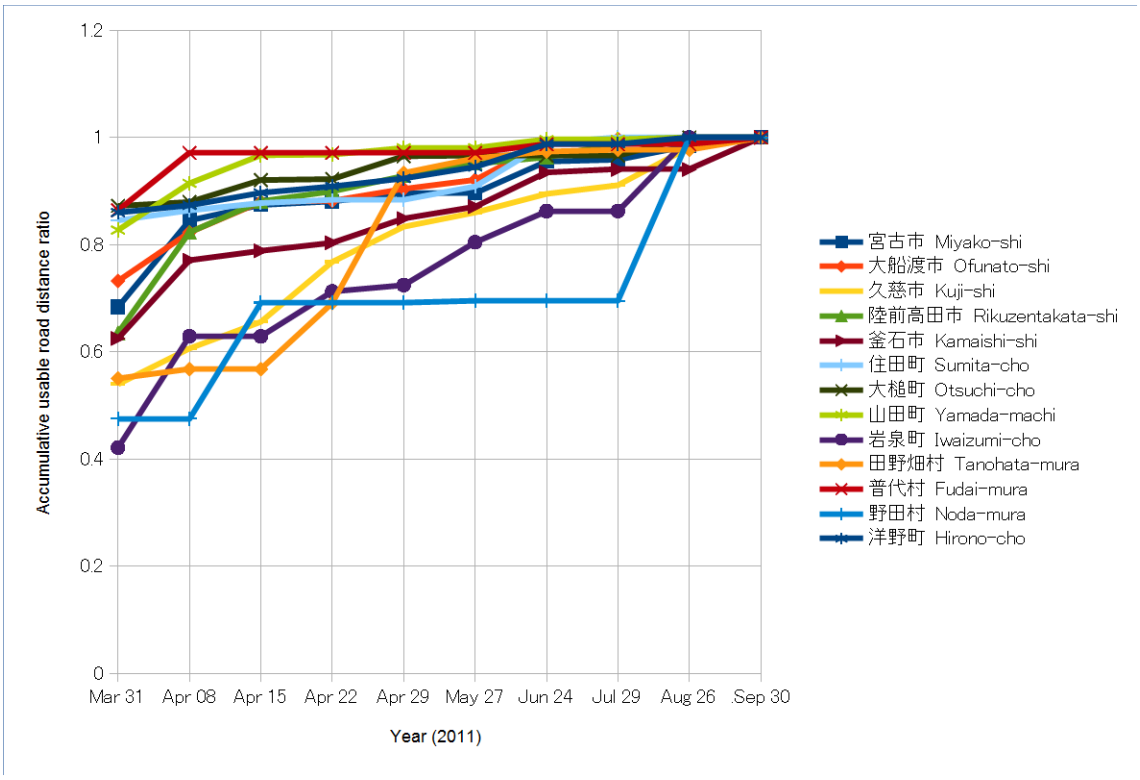

Fig. 5. Accumulative usable road distance ratio. Vertical scale displays the accumulative distance proportion of usable roads (relative to accumulative distance on September 30, 2011) for each date.

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