REQUIREMENTS OF PUBLIC TRANSPORT PLANNING TAKING INTO CONSIDERATION THE RESPONSE IN CASES OF WIDE-SCALE DISASTER

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This research focuses on some cities in the areas afflicted by the Great East Japan Earthquake Disaster of March 11, 2011 and by the accident at the Fukushima Daiichi Nuclear Power Station, and demonstrates that some of the post-disaster responses and challenges regarding local public transport stem from the peculiar feature of tsunamis and the nuclear accident, in order to make clear the requirements of local public transport planning taking into consideration the response in cases of wide-scale disaster.

Firstly, the responses of bus operators immediately after the disaster were studied through case studies of Hachinohe, Ofunato, and Minamisoma to clarify how the roles of public transport changed with changes in the evacuees’ living situations. Secondly, the restoration process of local public transport services after the emergency phase was analyzed through case studies of Ofunato and Minamisoma. Thirdly, a questionnaire survey of residents and evacuees in Minamisoma on the status of their activities and access to grocery stores was analyzed to make clear the impact of the limitation of residents’ and evacuees’ mobility on their quality of life in the Recovery Phase after the cascading disaster.

Key Words: public transport, bus operators, wide-scale disaster, restoring

1. INTRODUCTION

In the areas afflicted by the Great East Japan Earthquake Disaster of March 11, 2011 (hereinafter: the afflicted regions) and by the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Co., Inc. (hereinafter: the nuclear accident), railways and roadways were out of service for a long time. In addition, many people who were living in the afflicted regions were forced to relocate due to damage from tsunamis and radioactive contamination from the nuclear accident.

An important policy to support evacuees is to secure their access to groceries and other goods, to medical care, and to other indispensable services and activities. Therefore, public transport services have an important role in securing such mobility. The roles and issues of public transport after disasters rapidly change with time and with socioenvironmental conditions. Unlike in normal periods, public transport companies in the afflicted regions experienced damage and were forced to provide mobility limitedly. In this regard, Chang and Nojima developed post-disaster system performance measures and applied them to the urban rail systems in the Kobe region devastated by the 1995 Hyogoken-Nanbu earthquake. Chang also evaluated the performance of urban transport systems in the aftermath of the 1995 Kobe earthquake and the 2001 Nisqually earthquake. Nitta and Matsumura clarified characteristics of the use of alternative buses by residents in the area afflicted by the 1995 Kobe earthquake and the 2001 Nisqually earthquake. Nitta and Matsumura also examined failures in hurricane Katrina and Rita emergency response and their lessons for transportation planning in other communities. However, the effects of wide-scale and cascading disasters on local public transport receive hardly any discussion in the existing literature due to the rarity of massive nuclear disasters.

This research focuses on some cities in the af-
licted regions and demonstrates that some of the post-disaster responses and challenges regarding local public transport stem from the peculiar feature of tsunamis and the nuclear accident. This research aims to clarify the requirements of local public transport planning, taking into consideration the responses in cases of wide-scale disaster from the following viewpoints: Firstly, the responses of bus operators immediately after the disaster are studied through case studies of the afflicted municipalities in the Tohoku Region to clarify how the roles of public transport changed with the evacuees’ living situations. Secondly, the restoration process of local public transport services after the emergency phase, from immediately after the disaster to the beginning of April 2011, is analyzed through case studies of Ofunato and Minamisoma. Thirdly, a questionnaire survey of residents and evacuees in Minamisoma on the status of their activity and access to grocery stores was analyzed to make clear the impact of the limitation of residents’ and evacuees’ mobility on their quality of life in the Recovery Phase after the cascading disaster.

2. RESPONSES OF BUS OPERATORS IMMEDIATELY AFTER THE DISASTER

Public transport companies in the afflicted regions experienced damage from the earthquake. Table 1 summarizes the damage to major bus operators in the Tohoku Region along the Pacific coast. Some depots in the coastal areas of Iwate and Miyagi were washed away, and around 60 vehicles including those of Ibaraki Kotsu Co., Ltd. were damaged by tsunamis (see Fig.1).

Here we will consider the responses by bus operators immediately after the earthquake disaster (from March 11 to April) and the situation regarding recovery. Table 2 presents data pertaining to the damage to and recovery of bus operators in three cities — Hachinohe, Ofunato, and Minamisoma — that experienced different levels of damage from the disaster (see Fig.2). Hachinohe City in Aomori Prefecture is located in the northeast of the Tohoku region along the coast. It was the third most populous municipality, after Sendai and Iwaki, to be damaged by the disaster, although the main business districts of the city largely escaped damage. Ofunato City in Iwate Prefecture was heavily devastated by the tsunami, and even its central business district experienced massive damage. The offices of Iwate-ken Kotsu Co., Ltd., a transport company operating within the city, were washed away and as of this writing many inhabitants of the city continue to reside in emergency temporary housing. Minamisoma City was the most populous municipality included within the “Restricted Area” designated after the nuclear accident. Residential areas, agricultural land, and the fishing port in the eastern coastal areas of the

| Pref. Operator | Deaths | Damaged Vehicles | Damaged Depots |
|---------------|--------|------------------|---------------|
| Aomori        |        |                  |               |
| Hachinohe Transport Division | 0 | 0 | 0 |
| Nanbu Bus Co., Ltd. | 0 | 0 | 0 |
| Iwate         |        |                  |               |
| Iwate-ken Kotsu Co., Ltd. | 4* | 20 | 3 Omato |
| Miyagi        |        |                  |               |
| Miyagi Kotsu Co., Ltd. | 0 | 31 | 3 Kesennuma |
| Fukushima     |        |                  |               |
| Fukushima Kotsu Co., Ltd. | 0 | 0 | 0 |
| Shin-Joban Kotsu Co., Ltd. | 0 | 2 | 2** Kita, Tomioka |

*2 drivers, 2 passengers **off limits due to the nuclear accident

Fig.1 Damage to Miyagi Kotsu Kesennuma Depot as of October 2011 (photo: M. Fukumoto).

Fig.2 Locations of Hachinohe, Ofunato, and Minamisoma.
The transport operator within the city, and the private operator Nanbu Bus Co., Ltd., a transport company providing a network of transport services in Hachinohe and surrounding municipalities, operated for approximately three weeks on a holiday schedule with fewer buses, but were able to return to regular services from April 1, 2011. Similar temporary measures and timelines for return to regular services can be seen in the cases of Iwate-ken Kotsu Co., Ltd. (operating in and around Morioka City), Miyagi Kotsu Co., Ltd. (operating in and around Sendai City) and Fukushima Kotsu Co., Ltd. (operating in and around Fukushima and Koriyama City)

In the case of Ofunato City, the Iwate-ken Kotsu Co., Ltd. offices were destroyed by the tsunami. Additionally, of the 31 buses owned by the company, 9 were washed away with the tsunami and heavily damaged. Since the earthquake and tsunami did not occur at peak transport time, many of the buses were still at the offices, and the office staff and drivers at the offices evacuated to a property owned by the company on higher ground and thus significantly limited damage to the bus fleet. Although a tsunami evacuation and response manual had not been prepared and was not available for reference at these offices, a tsunami warning resulting from an earthquake in Chile during the previous year had spurred an evacuation of areas of Iwate Prefecture along the coast. The staff and drivers of Iwate Transport therefore had some experience with evacuating buses that proved useful and effective during this disaster. Two days after the earthquake, following a request from the Ofunato municipal government,

Table 2 Responses of bus operators immediately after the disaster.

| City            | Operator                  | From the disaster to the end of March 2011 | April 2011 |
|-----------------|---------------------------|--------------------------------------------|------------|
| Hachinohe       | Hachinohe Transport Division | (Mar. 11) There was no bus operation after 3pm. | (Apr. 1) All bus services resumed to normal. |
|                 |                           | (Mar. 12-13) There was no bus operation before 8am and after 5pm. |            |
|                 |                           | (Mar. 14-15) All bus routes are operated according to the holiday schedule, but there was no bus operation after 7pm. |            |
|                 |                           | (Mar. 16-31) All bus routes are operated according to the holiday schedule, but there was no bus operation at 0-4pm, and after 7pm. |            |
| Nanbu Bus Co., Ltd. |                           | (Mar. 11) There was no bus operation after 7pm. | (Apr. 1) All bus services resumed to normal. |
|                 |                           | (Mar. 12) All bus services (except express intercity services) resumed to normal. |            |
|                 |                           | (Mar. 13) There was no bus operation. |            |
|                 |                           | (Mar. 14-31) All bus routes are operated according to Saturday schedule. There was no bus operation after 7pm on Sunday. |            |
|                 |                           | (Mar. 18) Express intercity bus service to Morioka is restored. |            |
|                 |                           | (Mar. 20) Express intercity bus service to Sendai is restored. |            |
| Ofunato         | Iwate-ken Kotsu Co., Ltd. | (Mar. 11) The terminal is swept away by tsunamis. | (Apr. 4) Scheduled bus service within the city is restored. |
|                 |                           | (Mar. 13) The terminal is temporarily restored on a hill. | (Apr. 22) Intercity service to the neighboring city is restored. |
|                 |                           | (Mar. 19) Express intercity bus service to Morioka is restored. | (Apr. 28) Express intercity bus service to Sendai is restored. |
|                 |                           | (Late Mar.) Transport of evacuees starts between emergency shelters and a bathing facility prepared by the Japan Self-Defense Forces. |            |
| Minamisoma      | Fukushima Kotsu Co., Ltd. | After the nuclear accident, bus operators relocated its bus terminal to outside the city. | (Apr. 15) Express intercity bus service to Sendai is inaugurated. |
|                 | Shin Joban Kotsu Co., Ltd |                                                                 | (Apr. 22) Scheduled bus service within the city is restored. |
|                 | Haramachi Travel Ltd.     |                                                                 | (Apr. 27) Intercity service to the neighboring city is restored. |

Source: Interview with the staff of bus operators in August 2011 (Hachinohe, Ofunato) and the Reconstruction Planning Office of Minamisoma in April 2012.
Iwate-ken Kotsu Co., Ltd. reestablished their offices at a bus depot in Takkon-cho. In the initial aftermath of the disaster, Iwate-ken Transport offered transport assistance to rescue efforts conducted by United States military forces stationed in Japan and also operated bus services between evacuation centers and bathing facilities opened by the Japan Self-Defense Forces in late March. In regard to intercity transport, the express bus service between Ofunato and Morioka was reestablished on March 19. What these developments suggest is that while, on one hand, regular bus services were quickly restored by a private transport company operating between cities, at the same time, transport services within the local area were significantly altered in a piecemeal fashion to respond to the urgencies of the recovery phase, as evidenced in the use of buses to help with relief efforts and to transport residents to bathing facilities. Bus services within the city were restored on April 4, albeit in different form than before the disaster and in close consultation with the municipal government.

In Minamisoma, an evacuation order was given on March 12 due to the area being within 20 km of the Fukushima Daiichi Nuclear Power Station. In addition, a directive was issued for people to remain indoors in the area between 20 and 30 km from the power station on March 15. Consequently, the bus operators in the city were temporarily unable to operate their usual service in the city. Restoration of bus service started on April 22, 2011, when the directive to remain indoors was lifted following the designation of new evacuation zones. As of September 2016, when the authors drafted this paper, Shin Joban Kotsu Co., Ltd., whose terminal was in the former restricted area, has not restored bus service.

As noted above, the timeline for the restoration of bus services, as well as the processes whereby these services were restored, varied greatly according to the amount of damage experienced in the local area. However, there are similarities between all three municipalities. One is that local bus routes within each city were restored only well after express bus services to Morioka and Sendai had been restored. Moreover, in Minamisoma City, Haramachi Travel Ltd. (now known as Tohoku Access Co., Ltd.), a bus operator that had not operated any intercity buses before the accident, established a new route to Sendai and was also able to secure transport earlier and more effectively than the substitute services offered by the JR Joban line.

In regard to transport between the Tohoku and Tokyo regions, until all lines of the Tohoku Shinkansen were restored on April 29, bus operators made an effort to increase transport capacity. Consequently, between March 26 and April 1, or the third week after the accident, a daily average of 7,355 people were transported on 31 routes. Since bus operators’ pre-accident transport capacity between the Tohoku and Tokyo regions comprised 30 routes serving 1,980 individuals per day even if buses were operating at full capacity, then post-disaster ridership was four times the previous capacity.

What the above facts begin to suggest is that the early restart of the express buses and the opening of new lines was partially spurred by responsive measures adopted by the Ministry of Land, Infrastructure and Transport (MLIT). To provide means of transport for the affected areas, including most prominently to provide a substitute for the out-of-operation Tohoku Shinkansen, charter bus operators, who are usually not allowed to operate on regular routes, were given special permission to operate new temporary inter-regional services. Additionally, the subsidy requirements of the Securing and Maintaining Local Public Transportation Project—a government subsidy system for fixed route buses—were relaxed for disaster-afflicted municipalities. Moreover, even charter buses operating intercity bus services became eligible for these government subsidies. This system has proved effective for securing intercity transport after the disaster based on these responses, and is a policy that should be considered again in the case of another large-scale disaster.

### 3. LOCAL PUBLIC TRANSPORT RECOVERY PROCESS IN OFUNATO

#### (1) Restoring bus services and formulating the Public Transport Plan

We analyze the restoration process of bus services after the emergency phase, from immediately after the disaster to the beginning of April 2011, through case studies of Ofunato and Minamisoma. Even as of September 2016, when the authors drafted this paper, many residents of these cities were still living in temporary housing or similar housing.

**a) The Continued Emergency Phase**

At the beginning of the Continued Emergency Phase, when people still needed to stay at emergency shelters, Ofunato City commissioned Iwate-ken Kotsu Co., Ltd. and a local chartered bus company to operate free buses with the aim of securing residents’ everyday mobility, such as for shopping, access to medical care and commuting. These operators inaugurated free bus services on eight routes in the city. Seven of the eight routes were operated by Iwate-ken Kotsu stopped at the Sunlia downtown shopping center, the city hall and Iwate Prefectural Ofunato Hospital. Generally, four round-trips were operated...
for each route per day. Such free bus service was provided not only in the city of Ofunato but also in many other afflicted municipalities. One reason for the free service was that many evacuees were not able to make bank withdrawals, so they had little cash on hand.

In late April, the prefectural high schools in the city started the new fiscal year. The prefectural Board of Education started bus services to/from Rikuzentakata, a city adjoining Ofunato, to secure commuting access for students living in Rikuzentakata. Because built-up areas of Rikuzentakata were severely destroyed by the disaster, the residents needed to go to Ofunato for medical care and to shop. Access to hospitals, supermarkets and other services in Ofunato was supported by informal private transport services operated by a nongovernment organization. Such volunteers from outside the cities contributed to the mobility of the evacuees.

b) The Recovery Phase

In the Recovery Phase, when many people moved from emergency shelters to temporary housing, the free bus service was extended to areas with temporary housing so that the evacuees living there could use it. The service gradually began to introduce fares.

The mobility in the affected areas was secured and maintained through a variety of “flexible” responses conditioned to a large extent by transformations in the living conditions of evacuees. However, five years after the disaster, it is not entirely clear whether local public transport networks can be secured and maintained even with the continuation of the generous subsidies and policies that have supported these networks until now.

Additionally, the flexible transport responses have focused on securing mobility to emergency temporary housing, because MLIT’s “Special Disaster Area Transport Research Project” aims to provide financial support to these communities by setting an upper limit for subsidies based on the number of temporary housing units. However, at some point in the future, evacuees will eventually return to permanent housing and, amidst the highly concerning population decreases and aging of the afflicted municipalities along the coast, just as in normal times, each municipality will be required to develop policy guidelines for local public transport and strategically plan to secure, maintain, and improve local public transport networks.

c) Formulating the Public Transport Plan

In March 2014, Ofunato City formulated its “Ofunato Transport Network Master Plan,” a comprehensive, seven-year transport plan aligned with recovery projects. In an attempt to ensure consistency between master plans and recovery plans, the stated objective of architecting transport services and operational systems can be sustainably maintained and improved after government assistance ends in the future. The plan was driven by fiscal concerns about ensuring means of transport. Even after the plan was drawn up, community buses and Demand Responsive Transport (DRT) continued to be run in various districts on a trial basis. Pilots of distribution of taxi coupons targeting elderly citizens (over 75) without driver’s licenses and living in areas without convenient transport also continued. However, both were experiments for four to seven months. In all four districts with community buses, ridership hovered between a paltry three and nine people per day, ending with the service being discontinued. The initial thinking had been to draw up the transport network master plan before the residents affected by the disaster were relocated as groups or to public disaster housing, and run pilots based on that. In actuality, however, pilots of community buses in the Yoshihama district were started prior to that, and the tendency was to give priority to pilots over the master plan. The “FY 2015 Project Management Sheet” described the “City Community Bus Project” encompassing these pilots as “having been made possible by taking advantage of financial resources on favorable terms based on the effective promotion of projects under the recovery subsidies.” The effective promotion of projects, in the case of the intensive recovery period extending through FY 2015, was set up based on the Disaster Recovery Special Zone Tax, with 80% funding from the central government and 20% from the region. This meant that the regional contribution was effectively zero, with wide latitude in how it was used. The disaster subsidies were initially to be limited to the intensive recovery period. As such, the intent was to move ahead with the social pilots, while the “financial resources on favorable terms” were being put to use.

So far few municipalities in the afflicted regions of Iwate, Miyagi, and Fukushima Prefectures have formulated public transport plans. Ofunato eagerly addressed how to ensure transport. However, non-permanent sources of funds such as MLIT’s “Special Disaster Area Transport Research Project” and recovery subsidies were being used, resulting in more expenses being allocated to local public transportation compared to before the disaster. For that reason, while the level of public transport services are better than before the disaster, there is a need for a strategy to reasonably ensure mobility. There is thus great significance in drawing up a master transport network plan, but merely using “financial resources on favorable terms” for a series of short-term pilots does not constitute a strategy. This dilemma is shared not just by Ofunato, but by
many of the afflicted regions. As of this writing, five years after the disaster, many of the perspectives and techniques demanded by ordinary public transport plans also apply to the afflicted municipalities.

(2) Railway recovery process and BRT operation

Railways coming into Ofunato include the JR Ofunato Line and the Sanriku Railway Company's Minami Riasu Line, both of which were damaged by the tsunami and forced out of service for a long time. The recovery process for the two lines is completely different.

The Minami Riasu Line was restored on the entire line on April 5, 2014, with financial support from the MLIT and municipalities along the line, in addition to subsidies from the government of Kuwait. On the JR Ofunato Line, on the other hand, six of the twelve stations between Kesennuma and Sakari were washed away, while approximately half of the entire length of the route (43.8km) was flooded and segments accounting for 35% of the length were swept away. As a result, the right-of-way was used as a dedicated bus lane for provisional restoration of services in the form of Bus Rapid Transit (BRT). However, since JR East abandoned the idea of restoring the rails and proposed full-fledged restoration of service based on BRT (July 24, 2015), three cities along the line (Ofunato, Rikuzentakata, and Kesennuma) accepted the plan (December 25, 2015).

Sanriku Railway was opened on April 1, 1984. In recent years ridership has been falling. In March 2009, twelve municipalities along the line formulated the “Master Plan for Revitalization of Public Transport in Regions Along the Sanriku Railway,” which was approved in November of that year by the MLIT as a “Railway Business Restructuring Action Plan” under the “Act On Revitalization and Restructuring of Local Public Transport”. Under this plan, eight municipalities along the line, including Ofunato, were to let Sanriku Railway use for free railway land they had acquired from it. Twelve municipalities, including Iwate Prefecture and others along the line, were to bear the costs of infrastructure-related capital investment and maintenance costs, in a “vertical division of costs.” Under this plan, the ridership initiatives were also launched to maintain stable operations. The initial plan period was five years, through March 2014, but this was extended due to the impact of the Great East Japan Earthquake to March 2019. Eight municipalities along the line acquiring and holding restored railway facilities and leasing them back to Sanriku Railway were added at no charge. Ridership after restoration of service has not yet reached pre-quake levels (see Table 3).

Table 3: Annual Number of Passengers of Sanriku Railway

| Year | Kita Riasu Line | Minami Riasu Line | Total |
|------|----------------|-------------------|-------|
| 1984 | 1,610,903      | 1,077,832         | 2,688,735 |
| 1989 | 1,402,914      | 865,517           | 2,268,431 |
| 1993 | 1,242,468      | 827,320           | 2,069,788 |
| 1998 | 945,482        | 607,044           | 1,552,526 |
| 2003 | 718,837        | 347,242           | 1,066,079 |
| 2007 | 711,770        | 324,383           | 1,036,153 |
| 2010 | 617,750        | 233,706           | 851,456  |
| 2014 | 513,270        | 177,506           | 690,776  |

Fig.3 A dedicated lane of BRT (photo: M.Fukumoto).

Fig.4 BRT at a platform at Sakari Sta. on the JR Ofunato Line (photo: I.Yoshida).

Fig.5 A seamless transfer from Sanriku Railway trains to BRT (photo: I.Yoshida).
Table 3). Yet the restoration of the complete length of the Sanriku Railway Line, even with the lower population along the line, can be attributed not only to ridership promotion activities started before the quake by Iwate Prefecture and municipalities along the line, but also the shift to the publicly-owned-privately-operated format.

The Ofunato Line, in contrast, is operated by JR East, which runs a surplus, and is thus not eligible for financial support under the current system. JR estimates the cost of full restoration of the line at 13 billion yen. But the segment from Hosoura to Wakinosawa, near the boundary between Ofunato and Rikuzentakata, lies within a non-residential transfer promotion zone affected by an L2 tsunami. Relocating the tracks would thus require an additional 27 billion yen in recovery costs. In addition, the average ridership on the Kesennuma-Sakari segment of 1,349 people/month in 1987 dropped to 250 people/month in 2014. JR is saying that it will be difficult for it to shoulder the entire cost of recovery by itself, and that it cannot be considered at a level where rail is an advantageous solution. Restoration of services using BRT is being discussed separately from restoration of railway services, and agreement was reached on October 4, 2012, for provisional restoration of services on the Kesennuma-Sakari segment with BRT. The BRT introduced in this segment, according to JR East, has five features: (1) it can continue to run on its own to the extent possible in the case of earthquakes and tsunamis; (2) routes can be established and stations added depending on the progress of urban development; (3) on-time record and regularity of services are improved by using the railway right-of-way; (4) service can be more frequent; and (5) ordinary roads can be used to bring about earlier restoration of services. In terms of frequency, BRT now makes 26 runs from Sakari to Rikuzentakata, up from nine runs when running the trains and twelve runs with the substitute bus service after the quake, and has also introduced a fixed-internal daytime schedule. Between Rikuzentakata and Kesennuma, the nine daily train runs dropped to six with the substitute bus service, but went up to 12 at the start of BRT runs and has now been increased to 14 (in both cases, in the direction away from Sakari). On the other hand, the time required to get from Kesennuma to Sakari is now 74 minutes, where the dedicated tracks account for 37% of the total length, with 91.3% of all runs taking less than five minutes than the 65 minutes with the train (FY 2014). Going forward, a portion of the route is expected to be expanded using a dedicated lane (see Fig.3) to about half, which is expected to bring about elapsed time and on-time performance levels rivaling those of the train. In addition, as of September 2016, when the authors drafted this paper, five new stations have been set up, and at Sakari station BRT drives directly into the train platform (see Fig.4), allowing a seamless transfer from Sanriku Railway trains to the bus (see Fig.5). Improvements are also moving forward in both hard and soft terms, with introduction of the prepaid IC card (“odeca”), and location information being displayed at the station and browsable on mobile sites. As a result, average BRT ridership was up over the period when the substitute buses were running (although still not back to pre-quake levels), with ridership at Sakari Station, the busiest station on the line, while down from the 328 people/month in 2010 before the quake, standing at 173 people/month in FY 2013 after BRT operation started, and 226 people/month in FY 2014.

JR East ended up proposing the restoration of full services using BRT (July 24, 2015). A document entitled “Restoration of Full Services on the Ofunato Line using BRT” shows that we will continue to take responsibility for operating BRT as a sustainable means of transport contributing to recovery, at the same working to ensure frequency and further improvements in convenience. The Tohoku regional paper Kahoku Shimpo reports these opinions from users: “There are more runs than with the train and waiting times are shorter. We hope they will listen to the desires of the region and make the services easier to use.” That paper also reports concern from local resident groups demanding restoration of train service, saying that under BRT ridership and interacting populations are down. In addition, the Ofunato Master Transport Network Plan makes frequent use of the term “JR Ofunato Line (BRT)”, and gives BRT treatment equivalent to trains. With the reconstruction of the Ofunato Station Plaza which had been used only by the Ofunato Line, the picture of a public transport network revolving around BRT is already being drawn. It is safe to say that BRT is conceived of as linked to regional transport policies and reconstruction town building projects. In the April 2015 timetable revision, however, runs on the Iwate Prefecture’s Takata Line in parallel with the Ofunato Line BRT, going through Hosoura and connecting Ofunato and Rikuzentakata, were reduced to one round-trip per day, limiting the ability of the service to handle the demand for visits to the Prefectural Ofunato Hospital. BRT differs from ordinary bus services in the number of stops; thus, a new challenge is how to ensure the potential for dividing functionality between the two and handle transport from BRT station to destination.
4. LOCAL PUBLIC TRANSPORT RECOVERY PROCESS IN MINAMISOMA

(1) Outlines of Minamisoma

Minamisoma City is located on the coast of Fukushima Prefecture, about 10-40 km north of the Fukushima Daiichi Nuclear Power Station. It is made up of three main wards, Odaka, Kashima and Haramachi (see Fig.6). The population of the city at the time of the disaster was 71,651, making it the largest municipality included within the “restricted areas” designated after the accident.

In addition to the damage from the earthquake and tsunami, Minamisoma was also severely affected by the nuclear accident. Even as of August 2016 — five years and five months after the disaster — around 13% of the population (9,437 individuals) remained in evacuation outside the city, while only approximately half of the population (34,327 individuals) had returned to their former homes. Moreover, while the number of residents who have opted to move away from the city has increased, evacuees from areas closer to the nuclear power plant (such as Okuma and Namie towns) have moved into Minamisoma. Since part of Minamisoma had been designated evacuation orders, overnight stays within those areas had been prohibited. Accordingly, approximately 6,800 citizens are living in emergency temporary housing and government-subsidized rental units in the city. Some evacuation orders in Minamisoma were lifted in July 12, 2016, but it is impossible to predict how many citizens will return to their former homes and neighborhoods. Therefore, there will be great difficulty for local transport operation and planning. To explore these challenges further we need to consider the specific effects of the disaster on local public transport, and how public transport has been used to respond to the changing phases and circumstances of the disaster.

(2) Restoring bus services in Minamisoma

Before the disaster, transport networks in Minamisoma consisted of the JR Joban Line (5 stations in the city), scheduled bus service on 24 routes operated by three bus companies, and DRT in Odaka Ward. However, all such public transport was suspended immediately after the disaster.

As of April 22, 2011, more than 1 month after the nuclear accident, the directive to remain indoors was lifted for the area between 20 and 30 km in radius from the Fukushima Daiichi Nuclear Power Station. Elementary and junior high schools started again to use their own school buildings or used temporary facilities in Kashima Ward, which is more than 30 km in radius away. Following the school reopening, public transport in Minamisoma was gradually restored.

On September 30, 2011, the designation of Evacuation Standby Area for most of Haramachi Ward was lifted. The temporary public housing had been built in and around Kashima Ward, and the provision of public transport for such housing had progressed to secure evacuees’ access to medical care and retail shops. Residents began to return to their homes in Haramachi Ward. The ward is in the center of the city, and it is where the city hall is located. Additionally, it was at this time that new intercity bus services were inaugurated to/from Sendai and Fukushima. Haramachi Travel, Ltd. (currently Tohoku Access Co., Ltd.) inaugurated the Sendai-Minamisoma intercity bus service on November 17, 2011, and Fukushima Kotsu Co., Ltd. inaugurated the Fukushima-Minamisoma intercity bus service on December 15, 2011. To respond to the strong requests for commuting transport for high school students, service was restored on the JR Joban Line for the section between Soma and Haranomachi on December 21, 2011.

The temporal extension and spatial dispersion of evacuation should be noted when considering the mobility in the nuclear disaster-affected areas. Municipalities that were unaffected by the nuclear disaster tend to have temporary housing within the municipality. However, in Fukushima Prefecture, there are many cases where the temporary housing is
not in the municipality where the evacuees were living. In some cases, even the municipal government headquarters moved out of the municipality. In the case of Minamisoma, the municipal government is in its original location but residents live in temporary housing outside the municipality. These residents cannot participate in the reconstruction of their community. Thus, their potential contributions to reconstruction are squandered. Therefore, wide-area mobility beyond municipal borders needs to be secured more than in normal times.

On April 16, 2012, the designation of “Restricted Area” in the city was lifted, but the evacuation order had already been in effect. Therefore, transport needs came up for brief visits to homes to clean and repair them, and to visit and take care of graves and Buddhist altars ahead of returning to live there. However, there is no public transport service from the temporary public housing to Odaka Ward, and the evacuees who often make brief visits to the area are mostly elderly people. To meet this need, Minamisoma City and Fukushima University together started the “Project to Support Brief Home Visits” on October 30, 2012. The two taxi companies in Odaka Ward were commissioned to operate minibus taxis called “Jumbo Taxi” (see Fig.7).

Most of the public transport in Minamisoma that was provided after the nuclear disaster were funded by national and prefectural subsidies. Such services were designated as free, or only low fares were set. There will be great difficulty in continuing such services when the financial assistance is terminated.

Another issue is the lack of public transport staff and operators — the critical human resources supporting local public transport networks. The number of individuals holding “large-sized motor vehicle second-class licenses” — special licenses for operating buses that are a key human resource component for a public transport network — is decreasing and those holding these special licenses are aging, as evidenced by the fact that the average age of these holders is over 60. Many holders of special licenses opt to drive trucks, which are in high demand for reconstruction, and the lack of bus drivers will remain a serious issue in coming years.

5. CHANGES IN RESIDENTS’ AND EVACUEES’ ACTIVITIES AFTER THE NUCLEAR ACCIDENT

(1) Outlines of the questionnaire survey

Here we introduce the results of our survey of residents and evacuees on the status of their activities and access to grocery stores. The aim is to make clear the impact of the limitation of residents’ and evacuees’ mobility on their quality of life in the Recovery Phase after the cascading disaster.

A questionnaire survey was made on the individual level among people residing in or evacuated to the city of Minamisoma. The questionnaire was distributed on July 23, 2015 to 3,072 housing units. Two copies of the questionnaire were delivered to each household, for a total of 6,144 questionnaires distributed. The questionnaire was delivered and collected by mail to each housing unit. The collection day was August 12, 2015. The total number of responses was 1,599. The attributes of the respondents are summarized as follows: 50.5% of the respondents were female and 71.6% were over the age of 60. Of 1,561 valid respondents, 310 are evacuees living in...
Minamisoma. Of these 310 evacuees, 188 are living in temporary houses, and 66 are in rented houses.

Fig. 8 shows the share of respondents who have driver’s licenses by sex and age group. Around 90% of male respondents up to age 84 have driver’s licenses. There is a gradual decrease in the ratio of female respondents age 65 or over who have driver’s licenses. Therefore, elderly females tend to be driven by elderly males in cases of elderly couples living alone.

(2) Changes in residents’ and evacuees’ activities after the nuclear accident

In the questionnaire survey, we included a question for changing status in going out after the nuclear accident, and we found many respondents answered “Decreasing number of places where I want to go” after the nuclear accident whether they had driver’s licenses or not. Although the indoor sheltering order in most of Haramachi Ward was lifted on April 22, 2011, the supermarket located near Haranomachi Station in Minamisoma remain closed as of September 2016 (see Fig. 9). The slow recovery of retail businesses can be attributed to a decline in the number of shoppers, shortage of part-time workers, and the fact that suppliers are out of operation. The average ratio of job offers to seekers has increased since the disaster particularly in Minamisoma and surrounding municipalities. The ratio stood at 2.00 as of the end of July 2016, and this is up 1.49 points from six years ago. This situation, in turn, has further decreased accessibility for residents.

Table 4 summarizes changes in the situation of going out after the nuclear accident. The share of respondents without a driver’s license who answered “Decrease in travel frequency” after the nuclear accident is 59.2%, which is higher than that of respondents with a driver’s license (33.5%). In addition, the share of respondents without a driver’s license who answered “Becoming troublesome to go out” after the nuclear accident is 44.1%, which is also higher than that of respondents with a driver’s license (25.8%). In contrast, the share of respondents with a driver’s license who answered “Increase in travel frequency” is 19.5%, which is higher than that of respondents without a driver’s license. These results show significant differences by the test of independence (p<0.01), and indicate that the gap in mobility after the nuclear accident tended to increase between two groups: residents or evacuees with, and residents and evacuees without a driver’s license.

Table 4 Changes in the situation of going out after the nuclear accident.

| Changes in the situation of going out after the nuclear accident | Do you have a driver’s license? | p-value |
|---------------------------------------------------------------|--------------------------------|--------|
| 1) Decrease in travel frequency                               | Yes: 35.5%                      | 0.00 **|
|                                                              | No: 59.2%                       |        |
| 2) Increase in travel frequency                                | Yes: 19.5%                      | 0.00 **|
|                                                              | No: 4.5%                        |        |
| 3) Became unable to drive a car                                | Yes: 2.1%                       | 0.00 **|
|                                                              | No: 8.6%                        |        |
| 4) Became able to drive a car                                  | Yes: 16.7%                      | 0.00 **|
|                                                              | No: 0.4%                        |        |
| 5) Became unable to be taken to a destination by someone       | Yes: 2.0%                       | 0.00 **|
|                                                              | No: 8.2%                        |        |
| 6) Became able to be taken to a destination by someone         | Yes: 3.5%                       | 0.00 **|
|                                                              | No: 38.0%                       |        |
| 7) Decreasing number of places where I want to go              | Yes: 40.0%                      | 0.54   |
|                                                              | No: 38.0%                       |        |
| 8) Increasing number of places where I want to go              | Yes: 6.6%                       | 0.01 * |
|                                                              | No: 2.4%                        |        |
| 9) Decrease in monthly travel costs                           | Yes: 3.9%                       | 0.62   |
|                                                              | No: 3.3%                        |        |
| 10) Increase in monthly travel costs                          | Yes: 22.5%                      | 0.01 **|
|                                                              | No: 15.1%                       |        |
| 11) Becoming troublesome to go out                             | Yes: 25.8%                      | 0.00 **|
|                                                              | No: 44.1%                       |        |
| 12) Want to go out more                                       | Yes: 7.6%                       | 0.03 * |
|                                                              | No: 3.7%                        |        |
| 13) Stay unchanged                                            | Yes: 22.0%                      | 0.03 * |
|                                                              | No: 15.9%                       |        |

Number of respondents: 1,224 (Minamisoma), 245 (Yamagata)

* p<0.05, ** p<0.01

Table 5 Changes in the situation of going out in Minamisoma and Yamagata.

| age group | Decreasing number of places where I want to go | Became able to drive a car | Becoming troublesome to go out | Decrease in travel frequency |
|-----------|-----------------------------------------------|---------------------------|--------------------------------|------------------------------|
| 35-44     | Minamisoma: 40.9%                             | Yamagata: 5.3%             | Minamisoma: 11.8%              | Yamagata: 13.3%              |
|          | Minamisoma: 12.9%                             | Yamagata: 8.0%             | Minamisoma: 8.0%               | Yamagata: 18.3%              |
|          | Minamisoma: 10.7%                             | Yamagata: 26.9%            | Minamisoma: 34.2%              | Yamagata: 22.6%              |
| 45-54     | Minamisoma: 41.1%                             | Yamagata: 25.8%            | Minamisoma: 10.3%              | Yamagata: 10.8%              |
|          | Minamisoma: 24.0%                             | Yamagata: 22.6%            | Minamisoma: 22.6%              | Yamagata: 34.2%              |
|          | Minamisoma: 26.9%                             | Yamagata: 22.6%            | Minamisoma: 34.2%              | Yamagata: 22.6%              |
| 55-64     | Minamisoma: 38.5%                             | Yamagata: 11.1%            | Minamisoma: 15.7%              | Yamagata: 7.7%               |
|          | Minamisoma: 28.0%                             | Yamagata: 16.2%            | Minamisoma: 28.0%              | Yamagata: 16.2%              |
|          | Minamisoma: 33.0%                             | Yamagata: 41.3%            | Minamisoma: 41.3%              | Yamagata: 30.0%              |
| 65-74     | Minamisoma: 41.1%                             | Yamagata: 16.2%            | Minamisoma: 14.6%              | Yamagata: 9.2%               |
|          | Minamisoma: 28.0%                             | Yamagata: 16.2%            | Minamisoma: 28.0%              | Yamagata: 16.2%              |
|          | Minamisoma: 41.3%                             | Yamagata: 30.0%            | Minamisoma: 41.3%              | Yamagata: 30.0%              |
| 75-       | Minamisoma: 41.0%                             | Yamagata: 26.1%            | Minamisoma: 12.8%              | Yamagata: 3.5%               |
|          | Minamisoma: 41.7%                             | Yamagata: 30.4%            | Minamisoma: 41.7%              | Yamagata: 30.4%              |
|          | Minamisoma: 54.3%                             | Yamagata: 48.7%            | Minamisoma: 54.3%              | Yamagata: 48.7%              |

n=1,473 n=530 n=1,473 n=530 n=1,473 n=530 n=1,473 n=530

**p<0.01, *p<0.05**

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Note: The above tables and data are based on the survey results and do not reflect current conditions or future predictions.
In order to find the unique characteristics of changes in activities after the nuclear accident, we conducted another questionnaire survey in Yamagata City (617 respondents), which was less affected by the damage caused by radiation, and compared the results between the two cities.

Table 5 summarizes changes in the situation of going out from five years ago, a year before the nuclear accident, by age group both in Minamisoma and Yamagata cities. Those who answered “Decreasing number of places where I want to go” from five years before in Minamisoma numbered higher than those in Yamagata in each of the age groups. Additionally, respondents aged 45 or over who answered “Becoming troublesome to go out” in Minamisoma number more than those in Yamagata. These results show significant differences by the test of independence (p<0.05). They indicate that the opportunity to go out decreased after the disaster in Minamisoma, and it is the unique characteristic of the nuclear accident. In contrast, the share of respondents who answered “Became able to drive a car” after the nuclear accident is almost the same in all age groups in Minamisoma. Not a few destinations for each activity in Minamisoma had not reopened since the nuclear accident, which we consider to be why many respondents answered “Decreasing number of places where I want to go” after the disaster in every age group. Not a few middle-aged and elderly people in Minamisoma have no other choice but to drive a car in order to obtain basic necessities. In contrast their motivation for going out will become diminished because there has not been enough inner-city public transport services in Minamisoma.

These features should be recognized not only as the unique characteristics in the regions afflicted by the nuclear accident, but also as the differences in commercial accumulation between the two cities. However, not a few middle-aged and elderly people in other municipalities included within the “Re-
stricted Area” designated after the nuclear accident will also have decreased opportunities for interaction with others, because Minamisoma was the most populous municipality included within the “Restricted Area.”

Meanwhile, looking again at the results for Minamisoma, we found that there are differences in the change in activities depending on the type of living place after the nuclear accident. Table 6 shows changing situations in going out after the nuclear accident according to the type of living place by adopting residual analysis. The proportion of those who lived in the same place as before the nuclear accident and had decreased travel frequency due to fewer destinations is significantly higher than that of people under continued evacuation or who changed their residence (p=0.00). Conversely, the proportion of those under continued evacuation who answered “Becoming troublesome to go out” but whose travel frequency had not decreased is significantly higher than that of people living in the same place or who changed their residence (p=0.04). In the near future, it is thought that more citizens will be able to live in their previous place as the evacuation order will be lifted in Minamisoma, but there are concerns that opportunities to go out will decrease due to fewer destinations and it will become troublesome to go out. These analyses are only for respondents with a driver’s license, so those without a license will have further decreased opportunities for going out.

(4) Analysis of grocery shopping

Table 7 summarizes changes in the situation of grocery shopping after the nuclear accident in Minamisoma. Each share of respondents without a driver’s license who answered “Decrease in grocery shopping frequency”, “Increase in frequency of someone else buying groceries for him/her”, “Becoming unable to go to the stores where I want to go”, and “Increase in frequency of going grocery shopping with someone” after the nuclear accident is higher than that of respondents with a driver’s license. These results show significant differences by the test of independence (p=0.00) and indicate that the opportunity to go grocery shopping has decreased after the disaster in Minamisoma.

Following Inoi et al.10 in the present research, the respondents were asked to report their status on going out to shop for groceries, as follows: “I can do it by myself without any problems”, “I can manage it by myself”, “I can manage it with some help” or “I can’t do it at all”. Table 8 summarizes changes in the situations of grocery shopping after the nuclear accident of the respondents with a driver’s license versus those without a driver’s license, according to the type of statuses of going out by adopting residual analysis. The proportion of those who answered “I can’t do it at all” for going grocery shopping without a driver’s license (Type L) and had increased use of delivery services to buy groceries is significantly higher than that of the other types of people (p=0.04). In addition, the proportions of those who answered “I can’t do it at all,” or “I can manage it with some help” for going grocery shopping (Type O, P, R, S) and had increased frequency of someone else buy groceries for him/her are significantly higher than that of the other types of people (p=0.00). Therefore, alternative mobility services are helpful for those with some difficulties going out, but more people without a driver’s license tend to rely on someone else to buy groceries for them. The proportion of those who answered “I can do it by myself without any problems,” or “I can manage to do it by myself” for going grocery shopping without a driver’s license (Type Z) and had increased frequency of going grocery shopping with someone is significantly higher than that of those a with driver’s license (p=0.00). There are not enough

| Table 8 | Summary of changes in the situations of grocery shopping. |
|---------|----------------------------------------------------------|
| Holder of | Status of going shopping for groceries | Type | Increasing use of delivery services |
| driver’s license | | | |
| yes | unable | I (n=14) | 7.1% |
| medium | J (n=25) | 8.0% |
| independent | K (n=1,062) | 6.9% (+) |
| no | unable | L (n=36) | 16.7% (+)* |
| medium | M (n=51) | 11.8% |
| independent | N (n=125) | 10.4% |
| Holder of | Status of going shopping for groceries | Type | Increase in frequency of someone else buying groceries for him/her |
| driver’s license | | | |
| yes | unable | O (n=14) | 35.7% (+)** |
| medium | P (n=25) | 28.0% (+)** |
| independent | Q (n=1,062) | 3.2% (-)** |
| no | unable | R (n=36) | 66.7% (+)** |
| medium | S (n=51) | 29.4% (+)** |
| independent | T (n=125) | 12.0% |
| Holder of | Status of going shopping for groceries | Type | Increase in frequency of going grocery shopping with someone |
| driver’s license | | | |
| yes | unable | U (n=14) | 21.4% |
| medium | V (n=25) | 40.0% (+)** |
| independent | W (n=1,062) | 12.6% (+)** |
| no | unable | X (n=36) | 16.7% |
| medium | Y (n=51) | 35.3% (+)** |
| independent | Z (n=125) | 25.6% (+)** |

** p<0.01 * p<0.05
(-) significantly low (+) significantly high
unable: those answered “I can’t do it at all.”
medium: those answered “I can manage it with a help.”
independent: those answered “I can do it by myself without any problems,” or “I can manage to do it by myself.”
public transport services to secure access to goods, services and activities indispensable for life in regions afflicted by the nuclear accident, so we need to consider residents’ access to destinations of each activity not only from temporary housing but also from public restoration housing, in order to improve their accessibility to groceries in the transition or the recovery period in the afflicted area.

6. CONCLUSION

This research focused on some cities in the areas afflicted by the Great East Japan Earthquake Disaster of March 11, 2011 and by the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Co., Inc., and demonstrates that some of the post-disaster responses and challenges regarding local public transport stem from the peculiar nature of a combination of tsunamis and a nuclear accident.

We considered the responses by bus operators immediately after the disaster through case studies of Hachinohe, Ofunato, and Minamisoma, which experienced different levels of damage from the disaster. The timeline for the restoration of bus services, as well as the processes whereby these services were restored, varied greatly according to the amount of damage experienced in local areas. However, there are similarities between all three municipalities. One similarity is that in all three cities local bus routes within the city were only restored well after express bus services had been restored. What the above fact begins to suggest is that the early restart of the express buses and the opening of new lines was partially spurred by responsive measures adopted by the Ministry of Land, Infrastructure and Transport (MLIT). This system has proved effective for securing intercity transport after the disaster, and is a policy that should be considered again in the case of another large-scale disaster.

The restoration process of local public transport services after the emergency phase, from immediately after the disaster to the beginning of April 2011, were considered through case studies of Ofunato and Minamisoma. In the Recovery Phase, when many people moved from emergency shelters to temporary housing, free bus service was provided to areas with temporary housing in order to secure evacuees’ access to medical care and retail shops. The mobility of the afflicted regions was secured and maintained through a variety of “flexible” responses conditioned to a large extent by transformations in the living conditions of evacuees. However, non-permanent sources of funds were used, resulting in more expenses being allocated to local public transport compared to before the disaster. For that reason, there is a need for a strategy to reasonably ensure accessibility to groceries and other goods, to medical care and to other services and activities indispensable for life. There is thus great importance in drawing up a master transport network plan, and many of the perspectives and techniques demanded by ordinary public transport plans also apply to the afflicted municipalities. Additionally, in the case of Ofunato, the local transport network plan gives Bus Rapid Transit (BRT), which is the alternative transport system of JR Ofunato Line, as the main corridor in Ofunato. BRT differs from ordinary bus services in the number of stops; thus, a new challenge is how to ensure the potential for dividing functionality between the two and handle transport from BRT station to destination.

The questionnaire survey for residents and evacuees on the status of their activities and access to groceries was analyzed, and it had the aim of making clear the impact of the limitation of residents’ and evacuees’ mobility on their quality of life in the Recovery Phase after the cascading disaster in Minamisoma. One of the defining features of the evacuation of Minamisoma is that evacuees are living at great distances from their former homes, often beyond the city and beyond the prefecture. Therefore, providing mobility that covers a wide area is more important than in normal times, in view of regional restoration. In Minamisoma, the graying of the population has progressed rapidly since the disaster. The number of households consisting exclusively of elderly people has been increasing. In addition, shopping, medical care and other destinations in the city have not reopened, lowering the residents’ access to goods, services and activities indispensable for life. In contrast, bus and other public transport services were at a low level — with few routes and infrequent buses — even before the earthquake in Minamisoma, and residents were highly dependent on private cars. Therefore, not a few people started to drive a car after the nuclear accident, and it is the unique characteristic of the nuclear accident.

Local public transport in the Emergency Phase responded to different transportation needs from those in normal times. Bus operators in the areas afflicted by the Great East Japan Earthquake restored their operations in a few days from the disaster, transported overseas rescuers, and transported refugees between the shelters and the bathing facilities. In addition, they provided intercity service to/from the prefectural capital and a regional core city (e.g., Sendai, Miyagi Prefecture) immediately after the disaster. These operations were smoothly implemented because the MLIT made flexible responses toward the early restoration of bus services, and
provided fiscal budget assistance for bus operations in afflicted municipalities. However, there was no agreement on these policies in advance. Accordingly, it is necessary to establish a plan for emergency responses of local public transport with the ministry or municipalities and transport operators before the event of future wide-scale disasters.

Toward the Restoration Phase, schools and commercial facilities restored operations. Both cities need to address mobility needs to commute to school, to go shopping, or to go to medical facilities from the public temporary housing, which are similar mobility needs to normal times. In the afflicted municipalities along the coast of the Tohoku Region, there are many cases where frameworks for strategically planning to secure, maintain and improve the local public transport network are not in place. Without further consideration of public transport, even when public reconstruction housing and higher ground relocation housing is constructed and evacuees return to permanent housing, it is highly likely that for people without their own personal automobiles or without someone to offer them a ride, essential tasks of daily life will be significantly constrained. Accordingly, it is necessary to develop policy guidelines for local public transport and to conceptualize a transport network from the initial phase of reconstruction planning. In the case of the disaster-afflicted municipalities along the coast, bus and other public transport services were at a low level even before the earthquake, and residents were highly dependent on personal automobiles. If an environment that enables citizens to freely move about is not created, those without driver’s licenses will lose their opportunities for going out. Therefore, it is necessary to establish a plan for securing residents’ daily mobility in the Restoration Phase of wide-scale disasters.

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APPENDIX

(1) Source: From the interview with the bus operator in August 2011.
(2) Source: MLIT presentation materials on May 16, 2011.
(3) Source: From “Master Plan for Revitalization of Public Transport in Regions Along the Sanriku Railway” and the annual report from FY 2010 to FY 2014.

REFERENCES
1) Chang, S. E. and Nojima, N. : Measuring post-disaster transportation system performance: the 1995 Kobe earthquake in comparative perspective, *Transportation Research Part A: Policy and Practice*, Vol. 35, No. 6, pp. 475-494, 2001.
2) Chang, S. E. : Transportation planning for disasters: an accessibility approach, *Environment and Planning A*, Vol. 35, pp. 1051-1072, 2003.
3) Nitta, Y. and Matsumura, N. : Characteristics of Alternative Buses as Complementary Transportation System to Railway after the Great Hanshin-Awaji Earthquake, Research Articles of the Great Hanshin-Awaji Earthquake, pp. 363-370, 1997. (in Japanese)
4) Litman, T. : Lessons from Katrina and Rita: What major disasters can teach transportation planners, *Journal of Transportation Engineering*, Vol. 132, No. 1, pp. 11-18, 2006.
5) Kato, H. and Fukumoto, M. : A survey of action of local bus, *Transport Science*, Vol. 43, No. 1, pp. 4-10, 2012. (in Japanese)
6) MLIT (Ministry of Land, Infrastructure, Transport and Tourism) : The Brains of the Securing of Local Mobility, 2012. (in Japanese)
7) Yoshida, I. : Changing situations and the issues of mobility in disaster areas of Japan, *Proceedings from the International Conference on Mobility and Transport for Elderly and Disabled Persons*, No. 14, pp. B93-B108, 2015.
8) Yoshida, I. : The restoration process and policies of local public transport in the afflicted regions, *Housing ("Jutaku")*, No. 716, pp. 72-81, 2016. (in Japanese)
9) Yoshida, I. : Transport issues after cascading disasters in Fukushima, *Proceedings of World Conference on Transport Research*, Vol. 14, ID=1130, 2016.
10) Inoi, H., Nitta, Y. and Nakamura, Y. : Evaluation of the effect by the community bus considering Capability Approach, *Journal of Infrastructure Planning and Management, Japan Society of Civil Engineers*, Vol. 21, No. 1, pp. 167-174, 2004. (in Japanese)

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