

Transition and Characteristics of Road Clearance Based on Government Announcements During Multiple Disasters in the Noto Peninsula in Japan

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Abstract:

This study analyzes the road damage and clearance status during the heavy rain disaster that occurred in September 2024 on the Noto Peninsula, based on materials released by the disaster response headquarters and converted into GIS data.

The analysis revealed that significant fluctuations in the situation occurred during the first three days following the disaster, with smaller changes observed thereafter. Additionally, the study highlighted the instability of the information during the immediate aftermath, as indicated by the frequent changes in the reported information, and identified areas where the full extent of the damage had not yet been assessed.

Using these findings, the study also discusses the challenges associated with the integration and dissemination of information using GIS during complex disaster events in Japan.

Keywords: multiple disaster, heavy rain, road closure, road clearance, Noto peninsula

1. Introduction

1.1 Background

Japan is a country prone to frequent natural disasters, including earthquakes, floods, tsunamis, and landslides. In recent years, the impact of global warming has exacerbated flood-related damages nationwide.

On January 1, 2024, a magnitude 7.6 earthquake struck the Noto Peninsula region, located in central Japan. This event resulted in numerous casualties and caused widespread road closures due to landslides and other secondary disasters.

Subsequently, starting on September 21, 2024, the same region experienced heavy rainfall that led to significant damage. This situation presented a compound disaster scenario, with the heavy rain occurring during the recovery process following the earthquake. In addition to roads that

were already impassable due to the earthquake, the damage caused by the heavy rain led to further road closures, isolating many communities.

Monitoring road conditions during disasters is crucial for understanding the extent of damage, transporting the injured, and delivering relief supplies.

This marks the first case in Japan of a compound disaster involving both earthquake and flood impacts. Therefore, it is essential to analyze the temporal progression and patterns of road closures during this event.

1.2 Positioning of This Study in Related Research

The following studies serve as concrete examples of assessing road conditions and network status during disasters. Michal et al. (2015) conducted research based on a case study in the Czech Republic. Regarding the

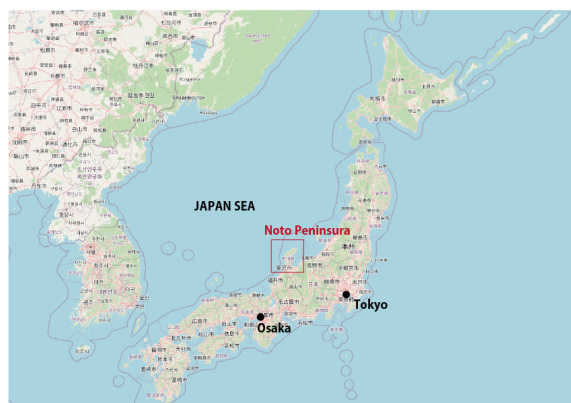


Figure 1. Location of the Noto Peninsula Region (from OpenStreetMap”).



Figure 2. Locations of Cities and Towns and Overall Overview of the Noto Peninsula Region (from OpenStreetMap)

utilization of GIS information for situational awareness during disasters, notable case studies include Abbas, S.H. et al. (2009) in India and Zêzere, J.L. et al. (2014) in Portugal.

In Japan, studies such as those by Yasuo Asakura et al. (1998), focusing on the functional hierarchy of national and prefectural roads, and Takeshi Kamatani et al. (2019), evaluating road networks during large-scale disasters, provide valuable references. Building on these works, this research observes, evaluates, and analyzes the state of road clearance during specific compound disasters.

1.3 Purpose

This study aims to analyze the transitions and characteristics of road conditions during a compound disaster in the Noto Peninsula region based on observations visualized using GIS. Additionally, it seeks to identify challenges related to the use of GIS for road information management in future compound disaster scenarios.

2. Characteristics of the Noto Peninsula Region and Multiple Disasters

2.1 Location and Features of the Noto Peninsula Region

The Noto Peninsula is located in central Japan, facing the Sea of Japan. The peninsula is surrounded by national highways, with Wajima City in the northern part and Suzu City in the western part serving as key urban centers. At the southern base of the peninsula lies Nanao City, while Anamizu Town and Noto Town are located in between. (Figure 2)

Outside these urban areas, small settlements are scattered across the region, connected by coastal roads and mountain passes. The entire peninsula is one of the most rapidly depopulating regions in Japan and is also experiencing significant population aging.

2.2 Characteristics of Multiple Disasters

2.2.1 Noto Peninsula Earthquake on January 1, 2024

A magnitude 7.6 earthquake struck the region, resulting in nearly 500 fatalities. The earthquake triggered tsunamis and landslides, causing widespread damage. Additionally, road infrastructure was severely impacted by tsunamis, landslides, liquefaction, and surface uplift caused by fault movements.

2.2.2 Noto Peninsula Torrential Rain on September 20, 2024

Between the night of September 20 and the early morning of September 21, the Noto Peninsula experienced an intense torrential rain event. In Wajima City, hourly rainfall peaked at 121 mm, with a three-hour total of 222 mm. Given that the average monthly rainfall in Wajima City is 214 mm, this rainfall exceeded the monthly average within just three hours. Record-breaking rainfall levels were observed across the peninsula.

The areas already affected by the January earthquake suffered additional damage, including landslides and flooding. In some cases, temporary housing for residents displaced by the earthquake was also inundated.

3. Method

3.1 Creation of GIS Data for Analysis

Information on the damage status and clearance progress of roads was collected and organized with a focus on major national and prefectural roads. At the time, investigations into the damage status were conducted by municipal governments and other relevant authorities. The results of these investigations were compiled by the Ishikawa Prefecture Disaster Response Headquarters and published as PDF materials on their official website. Based on these published materials, this study mapped road closures and clearance progress as GIS data for analysis using QGIS (Figures 4.1–4.10). Mapping was conducted for a total of 10 time points: daily from September 22nd to September 29th, 2024, as well as on October 1st, October 4th and October 9th.

For the base map data, publicly available data from Japan's National Land Numerical Information system were utilized. (Table.1)

Data	Source
Regional Boundary Data	Digital National Land Information
Road Data (National Highway and Prefectural Roads)	
City and Town Halls	Meeting Materials by the Ishikawa Prefecture Disaster Response Headquarters (PDF data)
Disaster Damage Reports	

Table 1. Margin settings for A4 size paper

3.2 Observation of GIS Data for Analysis

A temporal analysis of the created GIS data for analysis on road damage and clearance progress was conducted to examine changes over time. The analysis period was divided into three phases: the period during and immediately following the heavy rainfall (September 22–24), the first week after the disaster (September 25–28), and the subsequent period (September 29, October 1, and October 4). Observations were made to identify the characteristics of each phase.

4. Results of Observational Analysis

4.1 Road Conditions During the First Three Days After the Heavy Rain Disaster

The title Figures 4.1 to 4.3 illustrate the road conditions immediately after the heavy rain disaster and on the 3rd day following the event. It can be observed that road closures occurred in areas such as central Wajima City, the southwestern part of Wajima City, and along the coastal roads in the northern part of the peninsula.

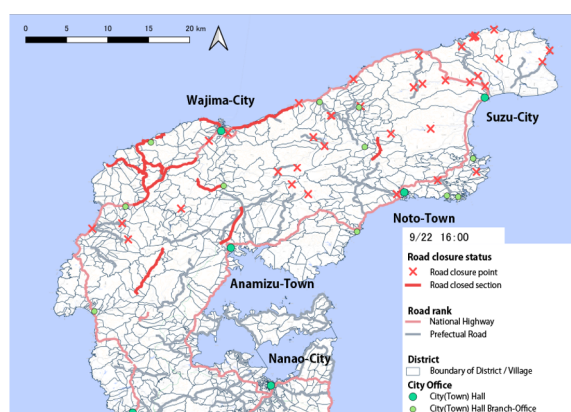


Figure 4.1. Road closure status as of September 22nd, 2024

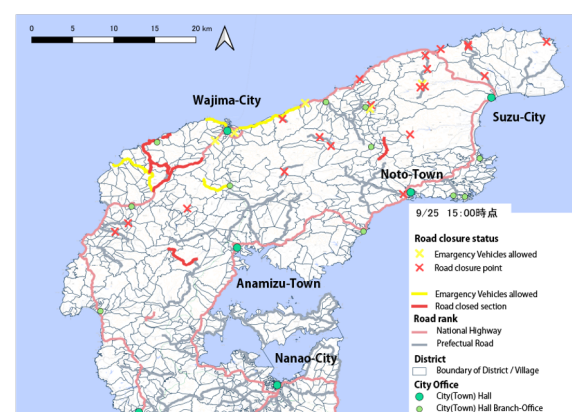


Figure 4.4. Road closure status as of September 25th, 2024

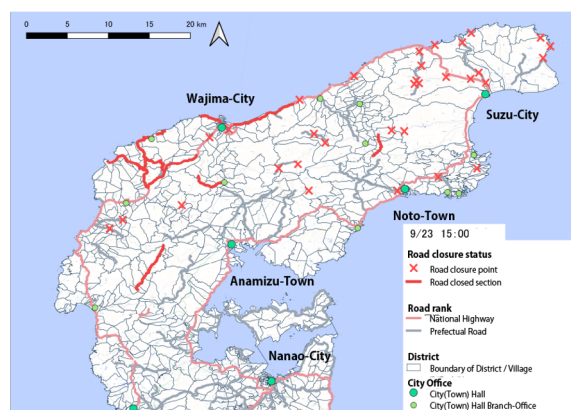


Figure 4.2. Road closure status as of September 23rd, 2024.

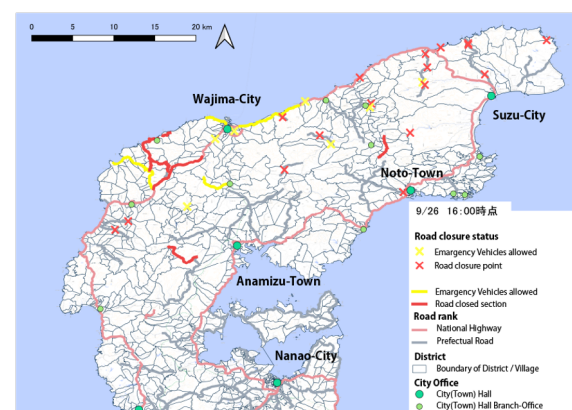


Figure 4.5. Road closure status as of September 26th, 2024

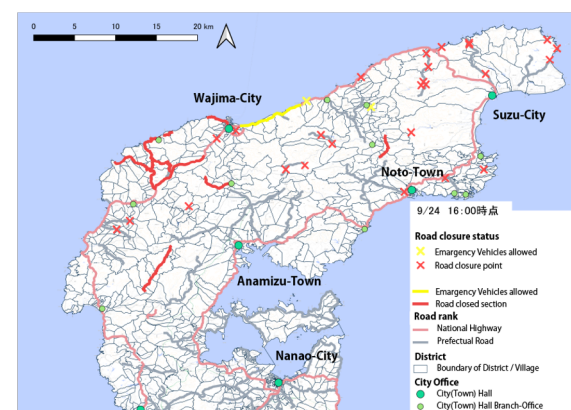


Figure 4.3. Road closure status as of September 24th, 2024

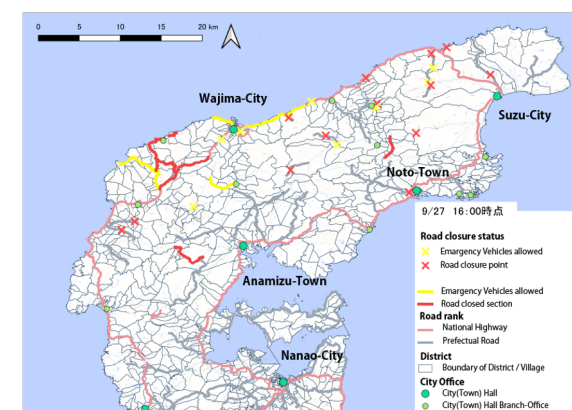


Figure 4.6. Road closure status as of September 27th, 2024.

From September 22nd to September 23rd, the main road connecting Anamizu Town to Wajima City was closed but was quickly reopened. Additionally, information regarding road closures and affected sections was updated several times. This suggests that information was unstable immediately after the disaster due to the scale of the event and highlights the prioritization of road transport to Wajima City.

By September 24th, information regarding roads

accessible only to emergency vehicles began to be shared. Emergency vehicle access to the branch office of the city hall was made possible via the coastal road extending eastward from Wajima City.

Between September 24th and September 25th, the number of sections accessible only to emergency vehicles increased. Emergency vehicles were also able to access the severely affected southwestern part of Wajima City via the western coastal roads of the peninsula. Some road closures were revised, potentially reflecting improved understanding of the actual conditions in previously unassessed areas.

4.2 Road Conditions from Four to Seven Days After the Heavy Rain Disaster

After September 26th, there were few changes in the road clearance status. It is presumed that distinctions were made between sections that could be temporarily managed for disaster response and those that could not. Efforts were made to ensure emergency vehicle access to isolated communities and regions, while road closures continued in areas that suffered extensive damage.

4.3 Road Conditions One Week After the Heavy Rain Disaster

Even one week after the disaster, there was little change in the road clearance status. While some sections in

northern Suzu City and around Noto Town became accessible to emergency vehicles, the overall progress in road clearance remained limited, indicating a period of relative stagnation.

4.4 . Summary

Regarding the progression of road damage and clearance, significant changes were observed during the first three days following the heavy rain disaster. However, after this period, no major developments were noted.

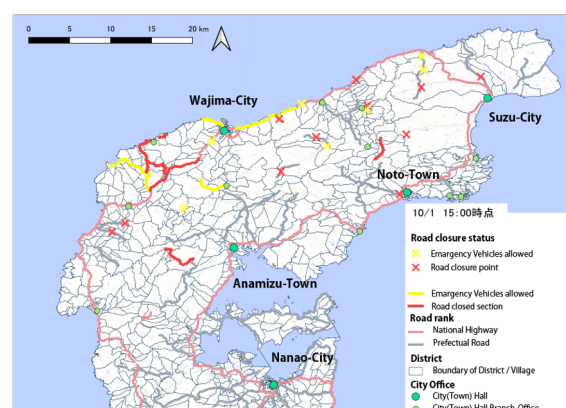


Figure 4.9. Road closure status as of October 1st, 2024

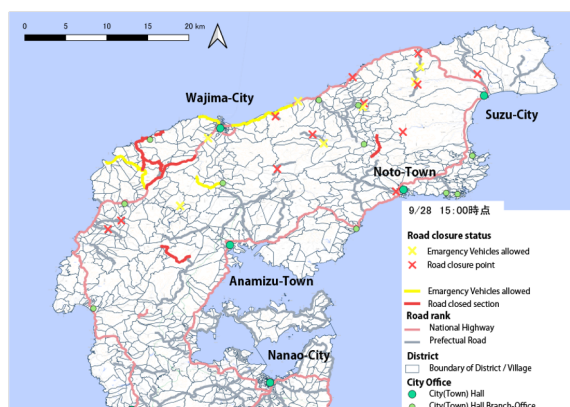


Figure 4.7. Road closure status as of September 28th, 2024

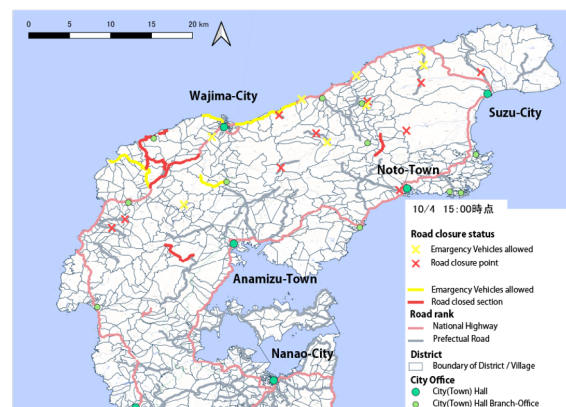


Figure 4.10. Road closure status as of October 4th, 2024

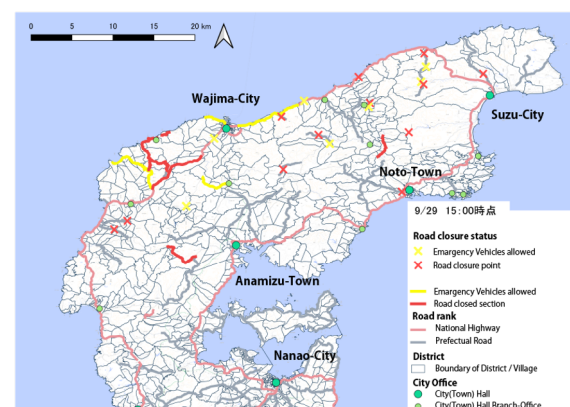


Figure 4.8. Road closure status as of September 29th, 2024.

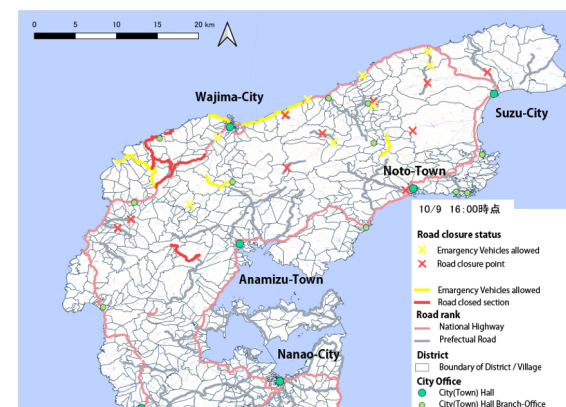


Figure 4.11. Road closure status as of October 9th, 2024

In the immediate aftermath, the focus was on clearing roads connecting urban areas. However, due to the large-scale nature of the disaster, information was unstable, and road closures frequently changed in terms of location and affected sections.

5. Insights from the Response to This Multiple Disaster - Application and Development of GIS Technology During Large-Scale Multiple Disasters in Japan-

5.1 The Necessity of an Integrated Information System Immediately After Disasters

As demonstrated in the analysis in the previous chapter, road conditions during the first three days after the disaster were somewhat unstable. The first three days following a disaster are critical for understanding the extent of damage, conducting life-saving operations, and initiating early response efforts. Information about road closures and clearance statuses is vital not only for the passage of emergency and disaster response vehicles but also for the transportation of supplies.

The data used in this study were public information consolidated by the disaster response headquarters, primarily derived from PDF files published online. It is essential to integrate road information with other damage-related data using GIS technology, make such data publicly available, and ensure accessibility for citizens and stakeholders. Developing a GIS-based system to address these needs is a desirable future direction.

5.2 Utilization of Tools Like the “Passable Roads Map”

In Japan, efforts have been made to share information on road conditions during disasters. One such initiative is the “Passable Roads Map,” a tool developed by automobile manufacturers that visualizes road accessibility data from car navigation systems.

This map is highly reliable as it is based on actual travel data. In the context of this study, it is recommended that such tools be utilized not immediately after a disaster but after a few days, when the situation has stabilized, to support general citizens and logistics operations.

However, a challenge arises in the immediate aftermath of a disaster when fewer vehicles are on the roads, leading to less stable data. To address this, advancements in technology and system development are required to accelerate the collection and analysis of disaster-related information.

5.3 Understanding Situations for Public Information Dissemination During Complex Disasters

In this heavy rain disaster, compounded by the impacts of a major earthquake, several areas experienced prolonged road closures. During complex disasters, using GIS to understand the types and extents of damages can be effective for predicting the scope of impacts at the onset of such events.

In the case of this complex disaster, public information

dissemination was divided between earthquake-related and heavy rain-related damages. However, road conditions, including the extent of damage and clearance progress, must be considered holistically, accounting for the combined effects of earthquakes and heavy rain.

During complex disasters, it is necessary to leverage GIS technology to provide information that is both categorized by disaster type and integrated across multiple disasters, enabling seamless dissemination of comprehensive information.

The restoration work on roads damaged by multiple disasters has been consolidated into a GIS-based portal site managed primarily by the Ministry of Land, Infrastructure, Transport and Tourism (Figure 5.2). However, such initiatives remain largely unknown to many citizens. Therefore, it is essential to continue utilizing GIS data for the integration and dissemination of information in the future.

6. Conclusion

This study observed and analyzed the road closures and clearance status associated with the heavy rain disaster that occurred on the Noto Peninsula, based on data released by the disaster response headquarters and organized using GIS technology.

The analysis revealed that during the first three days after the disaster, significant fluctuations in the situation were observed, and information about the damage was unstable. However, it was also found that after this period, changes in the situation became less frequent.

Furthermore, through this investigation of the Noto Peninsula heavy rain disaster, issues related to the integration and dissemination of disaster information and road conditions using GIS were identified and organized. The ongoing initiatives related to these efforts were also summarized.

As global warming progresses, it is expected that large-scale natural disasters will occur simultaneously in multiple regions. Based on the findings of this study, it is desirable to engage in discussions about how government officials, residents, and private companies can integrate and disseminate information using GIS in response to such challenges.

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