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Economic Impact Assessment of Flood Disasters Using Population Mobility Data

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Industrial sectors are increasingly exposed to the risks posed by flood disasters, which threaten business continuity and result in significant losses. The current practice of resilience analysis in industrial sectors mainly relies on surveys and statistical data, which brings about challenges regarding the time and cost involved in data collection, and difficulties in quantifying the impact of floods on industrial sectors. In light of this, this research proposes a method to assess the impact of flooding to industrial sectors by leveraging large-scale, high spatial-temporal resolution mesh Origin-Destination mobility data that are real time and aggregated to 500 m grid scale. Specifically, this research utilizes the mobility data to identify the home and work location of population in the flood affected area, and further quantify the changes of number of visitors and labor supply in various types of industrial sectors under flood disaster. The effectiveness of the proposed approach is validated through a case study of the 2018 Heavy Rain Event in Japan. By enabling multiple data sources for impact assessment in industrial sectors, this research provides decision-makers with timely empirical evidence to develop effective post-disaster recovery strategies.

1 Introduction

Industrial sectors are exposed to increasing risks of flood disasters that threaten the business continuity and cause losses. Therefore, rapidly and accurately loss assessment due to flood disasters are urgently needed for disaster prevention and mitigation. Currently, dataset collected through the questionnaire surveys have been commonly used to estimate the indirect damage caused by disasters, particularly for estimating business interruption losses and human well-being losses. While utilizing questionnaires for post-disaster data collection is valuable, but it presents several challenges. First, conducting surveys immediately after disasters is challenging, as untimely surveys may introduce bias into the collected data. Second, surveys are time-consuming and costly. Third, there may be insufficient responses, leading to inadequate information for analysis or generalization, and disasters can heighten the risk of survey bias. Therefore, this research proposes a methodology using mesh mobility data to estimate the impact of floods on industrial sectors. The methodology allows for the quantitative measurement of changes in commuting and visitors in industries due to disasters and is applied into the case studies of the 2018 Heavy Rain Event in Japan.

2 Study area and data

2.1 The Heavy Rain Event of July 2018

From June 28 to July 8, 2018, Japan experienced an exceptionally intense period of rainfall, officially termed the “Heavy Rain Event of July 2018” affecting extensive regions. The agricultural, forestry, and fishery industries suffered damages amounting to ¥629 billion, while public infrastructure, including levees, railways, and roads, incurred losses totaling ¥465 billion. Hiroshima, Okayama, and Ehime bore the brunt of the calamity, experiencing a substantial economic setback equivalent to 23–30% of their GDP.

2.2 The population mobility data

This research employs population mobility data to evaluate the impact of the Heavy Rain event on industries in Hiroshima prefecture. The data encompasses the trajectories of 26,473 users in Hiroshima prefecture from June 24 to July 23, 2018. As depicted in Figure 1, an individual user's trajectory (u)

is represented as a temporally ordered sequence of tuples: $T_u = \{(l_1, t_1), (l_2, t_2), \dots, (l_3, t_3)\}$

Where $l_1 = (lon_i, lat_i)$ is a location, lon_i and lat_i the latitude and longitude coordinates of the location, and t_i is the corresponding timestamp (YY/MM/DD).

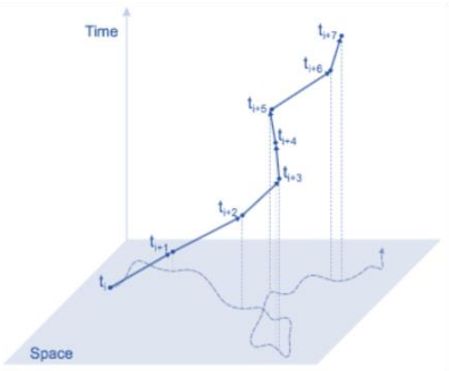

Fig.1. Illustration of recorded daily individual trajectories in the mobility data

3 Methodology

The methodology employed in this research involves a multi-step processes. Firstly, home and work locations are identified and validated at both the city and 500m mesh levels. Subsequently, Origin-Destination (OD) flow, commuting flow, and commute time are derived. Lastly, the analysis extends to estimating the number of visits for each types of industrial sectors through Point of Interest (POI) analysis.

4 Preliminary results

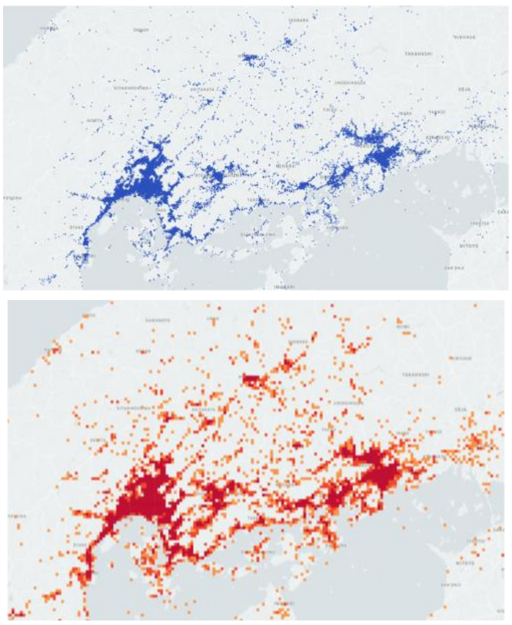

Fig.2. Spatial distribution of identified home locations (above) and work locations (below).

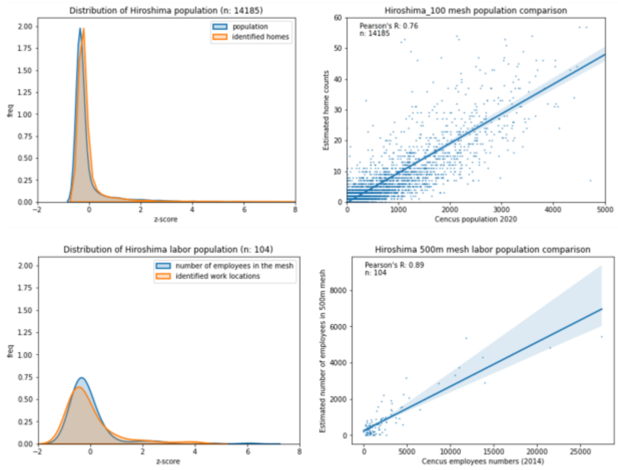

Fig.3. Validation of identified home and work locations

Fig.4. Number of daily visitors by industry sectors

5 Discussion and concluding remarks

Understanding and reducing the impacts of flooding on the industrial sector is crucial for minimizing disaster losses and risks. The proposed methodology aims to monitor industrial recovery in real time, offering timely evidence for industries and the government to shape effective post-disaster recovery strategies.

Reference:

Yabe Takahiro, et al., 2022. "Toward Data-Driven, Dynamical Complex Systems Approaches to Disaster Resilience." *Proceedings of the National Academy of Sciences of the United States of America* 119 (8): 1–7.

Acknowledgement

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