THE METAVERSE AND REGIONAL CHALLENGES IN JAPAN

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Abstract

Disaster Risk Reduction (DRR) has become increasingly relevant to all spheres of human life. This article focuses on the application of the Metaverse in Japan to enhance disaster preparedness among people. While disaster drills have become a part of school education in Japan, challenges remain in establishing industry-academia linkage to accelerate the dissemination of knowledge and experiences with necessary disruptive technologies. The authors explain the current hurdles of the wider application of the Metaverse and examine policy directions, paying attention to remedial measures. Seeking the active participation of small and medium enterprises (SMEs) as a vital part of the DRR framework is crucial. The various factors affecting SMEs and making them vulnerable are explained. Nurturing cohorts of SMEs towards effective DRR could enhance their resilience and disaster preparedness. SME resilience will bring coherency to the national policy of disaster management.

Keywords: The Metaverse, Disaster Risk Reduction, Disaster Preparedness, SME, Resilience

Disaster Risk Reduction Beyond Digital Divide

New information and the digital era have witnessed a drastic change in data management concepts as well as information sharing, urging us to opt for a demand-driven innovation beyond the digital divide, to serve the most vulnerable with the benefits of technologies (Shaw 2020). While approximately 96% of the world's Official Development Assistance (ODA) allocated to disaster-related activities is for post-disaster recovery, only 4% is for disaster risk reduction (World Economic Forum, 2022).

This article deals with Japan's significant move towards the Metaverse application to adapt immersive learning in disaster risk reduction.

The Metaverse and Disaster Risk Reduction among the Public

Metaverse is a coined word consisting of "*meta* (transcendent)" and "*universe* (world)", expressing a three-dimensional virtual space where people are connected through avatars using AR (augmented reality) and VR (virtual reality) technology on the Internet.

Avatars, a virtual self, can communicate and move through virtual space on the Internet. The world of the Metaverse (1) enhances communications and (2) facilitates movement via the presence of the avatars. The primary usage of the Metaverse in DRR is to make it possible to experience disasters through the presence of avatars as the virtual self that represents an individual.

The application of the Metaverse creates an immersive learning process for the participants to understand the impact of disasters and survival strategies. Thus, creating an opportunity to access virtual realities amounts to enhanced disaster mitigation.

Mitigating Disaster Risks

Disaster Drills for Disaster Preparedness among the Public

In public and private spaces of Japanese society, physical disaster drills have been a vital part of compulsory education in the schooling system throughout the country. Understanding disaster risks requires knowing the space you live in. The Metaverse has enabled people to virtually experience potential risks and threats that would turn out to be detrimental to human lives. Thus, the simulation of disaster situations by the Metaverse helps us increase our chances of survival.

The Focus of The Government

The focus of the Government of Japan is to enhance Metaverse-based engagement that will define the future of Japanese society. It is anticipated that the Metaverse will further define the way of living and working better in Japan. The frequency and severity of floods and landslides have increased and the significance of countermeasures and accurate assessment of damages caused by landslide disasters has become crucial; thus, evacuation plans need to be refined (Ministry of Land, Infrastructure, Transport and Tourism 2023b).

The Earthquake Early Warning System

Since 2007 smartphones have been installed with an earthquake early-warning application in Japan, which sounds an alarm immediately before an earthquake strikes. Such an alert comes with initial small tremors before a large earthquake,

urging people to get themselves ready for evacuation. It uses seismometers and seismic intensity meters for measuring the tremors by the Japan Meteorological Agency, which has approximately 690 locations nationwide and a seismographic observation network from the National Research Institute for Earth Science and Disaster Prevention in approximately 1,000 locations nationwide. Smartphones in Japan can access a Disaster Message Board Service, and various emergency response apps of different network providers, including information-sharing apps for foreign visitors to receive emergency updates free of charge (Ministry of Foreign Affairs, 2021).

Evacuation Plans and Beyond

The Government of Japan consolidates digital infrastructure by collaborating with Architectural BIM, PLATEAU, and Real Estate ID to promote "Architecture/Urban DX" integration. By linking these data, we can calculate casualty insurance premiums, facilitate payments in the event of a disaster, and develop disaster victim ledgers in local government. This will make disaster prevention measures sophisticated (Ministry of Land, Infrastructure, Transport and Tourism, 2023b).

Project PLATEAU

Methods, Data, Technology, and Equipment

Project PLATEAU has created 3D city models. It is a web system functioning as a damaged housing visualization system. It automatically detects buildings damaged by landslides and other disasters. A smartphone application visualizes the results at the disaster site with an AR application. The damaged dwelling visualization system was developed by adding functions to Symmetry Digital Twin Cloud (SDTC).

SDTC is a GIS data integration and visualization system developed by Symmetry Dimensions Inc. based on CesiumJS. It functions as a web application that integrates and visualizes various data of a city, building a digital twin. It uploads point cloud data obtained from drones. It performs spatial analysis of point cloud data acquired by drones and 3D city models to detect buildings damaged by sediment runoff.

Project PLATEAU and Disaster Risk Reduction

Linking the basic resident register needs to be agreed upon before implementation. Overall, it was found that the detection of damaged houses by comparing point cloud data taken by drones with 3D city models could enhance effectiveness in grasping the status of damages. Minimizing casualties by natural disasters could be possible through such rapid and accurate assessment of the situation and the need for rescue operations.

Applications of the Open City Models

The open city models provided by Project PLATEAU can be seamlessly integrated with the building model precisely. It enables VR-based fire evacuation training, covering the inside and outside areas of a high-rise building in Tokyo, for example.

However, all the municipalities in Japan have not been covered yet. Since processing load in visualizing a virtual world based on Project PLATEAU requires a huge amount of data, some means of optimizing the visualization are required (Mitsuhara and Shishibori, 2022).

Social Engagement

Industrial DX aims at "Realizing the development of entire industries by utilizing a wide range of industrial knowledge and DX functions to connect industries, companies, and communities and solving social issues through the fusion of real and digital technologies" (Fujitsu Limited, 2023). Disaster mitigation and emergency rescue operation could be potential sources of business opportunities for private entities.

Practical Applications of The Metaverse

Before Disasters: Enhancing Disaster Preparedness

The application of the Metaverse carries significant meaning for reduced disaster risks if applied before disasters. There are some examples of applications for DDR related to disaster preparedness.

3D Cities: In 2020, the Ministry of Land Infrastructure, Transport and Tourism, Government of Japan, initiated a project called Project PLATEAU. It builds and utilizes 3D city models for disaster-resistant city development. As many as 48 cities all over Japan have superimposed maps indicating simulated structural inundation areas on 3D city models, allowing the public to anticipate what is to come at the time of a disaster and simulate the possible ways and means of disaster mitigation (Metaverse Souken, 2023).

Digital Twins: Tokio-Marine & Nichido Fire Insurance Co., Ltd. has utilized digital twins to predict large-scale disasters.

DX Disaster Drills and Experiential Learning: Meiji Yasuda Life has been using VR to convert disaster drills into DX. NTT has conducted participatory flood control training on the Metaverse. Tokio Marine & Nichido Fire Insurance Co., Ltd. has developed an AR app that enables disaster experience.

Evacuation Drills: The evacuation drills, such as virtual Tsunamis approaching on digital maps, allow the participants to experience pseudo-evacuation, which urges them to sprint towards a shelter in the real world. This could supplement or enhance real-world evacuation training (Mitsuhara and Shishibori 2022).

During Disasters: Structural Damage Assessment

Structural damage assessment is the first step toward recovery for a community hit by a disaster. It differentiates safe structures from unsafe ones.

A rapid scientific damage assessment carried out by a scanner drone equipped with an image processing algorithm makes it possible to compare the state of affected structures before and after the disaster. A much closer damage assessment for inter-story drift ratio and the degree of inaccuracy and uncertainty could be figured out through handheld AR. The intelligent algorithm that uses

VGGNet Convolutional Neural Network has recorded 89.39% accuracy in assessing structural damage. Swift damage assessment has been possible through a point-cloud-based algorithm and using slave drones (Khanal et al., 2022).

Post Disasters: Enhanced Possibilities of Reducing Vulnerability

The Metaverse enables the participants to digitally experience virtually created disasters. Post-disaster areas which can be visually assessed with accuracy enable an accurate assessment of the degree of damages before reaching the affected areas.

Project PLATEAU uses a web system that automatically detects buildings damaged by landslides and other disasters, also measuring the degree of the damage. The post-disaster application is on a simulation basis, tested and verified by a study team conducted by Symmetry Dimensions Inc. and Pasco Co. Ltd at Kakegawa-city of Shizuoka Prefecture from April 2022 to March 2023.

Hurdles Felt by SMEs and Recommended DRR Policy Framework

The role of SMEs in DRR needs to be increased with the necessary support from academia and local governments. The paucity of funds for disaster management, the lack of digitalization of the SMEs, and the lack of Business Continuity Planning (BCP) are the major sources of concern for SME owners. However, while the growth and sustainability of SMEs are focused on, disaster preparedness is not discussed (METI, 2022).

Industry-Academia Collaboration in DRR

By engaging educational institutions from primary schools to high schools in disaster drills, DRR education has incorporated community participation, administered by local governments, with the cooperation/participation of local industries. The role of industry in DRR has been viewed as that of a benevolent collaborator for academia, when considering big corporates. However, equal attention is not paid to SMEs.

Industry: Japan Metaverse Economic Zone

The field of the Metaverse has been constantly evolving in Japan. On 16 February 2023, an agreement on the "Japan Metaverse Economic Zone" was signed to create "an Open Metaverse Infrastructure from a Role-Playing Game Perspective (Fujitsu, 2023)" as an industrial DX initiative utilizing gaming technology.

Academia: Higher Education and DRR

Corporate investments supporting such Metaverse construction involve major players in the Japanese economy, educational institutions, as well as municipalities in Japan. One such example of a Metaverse application for disaster management is taken up by the Metaverse School of Engineering of the University of Tokyo working in collaboration with 16 business entities in Japan (Metaverse School of Engineering, 2023; Kyoiku Katei Shinbun, 2023).

Keeping SMEs in the Loop of Industry-Academia Collaborations

Through educational interactions, such as lectures, by the concerned industries, and opening internships and industry visits for the students, the promotion of basic research through industry-academia collaborations could be possible. Disaster risk reduction needs to have a wider reach. For this, the authors propose the following four points to be considered.

1) Regional, location-specific application of the Metaverse

2) Introducing the Metaverse in imparting DRR education

3) SMEs adapting the Metaverse given the Business Continuity Plan (BCP)

4) Nurturing DX human resources to serve location-specific disaster management needs

Business Continuity Plan (BCP) is a plan for companies to protect their employees and minimize disruption of business in the event of disasters such as earthquakes and heavy rains, terrorism, and epidemics of infectious diseases, and to support recovery and reconstruction in the event of a disaster. Overall, it contributes to the local economy (NHK, 2023). Society 5.0 propagates safe evacuation, prompt rescue, and optimum delivery aiming for a reduction of damage and early recovery post-disasters (Cabinet Office, 2023b).

Enhancing BCP of SMEs

In a recent survey held in Hiroshima in May 2023, 267 companies were asked to indicate their commitment to BCP. 46.8% replied that they have an intention to formulate BCP, including "Formulated BCP," "Currently formulating," and "Considering formulating" (NHK, 2023). Five years after the torrential rains hit western Japan in July 2018, such state of disaster preparedness is alarming.

Nurturing DX Human Resources

Disaster mitigation and emergency rescue operation could be potential sources of business opportunities for private entities. However, the authors would like to propose that in the current scenario where SMEs have not fully adopted BCP to enhance their disaster preparedness, it is vital to consider the process of nurturing DX human resources familiar with DRR, who could undertake internship or training sessions at SMEs where BCP is not in place. This is yet another level of industry-academia collaboration for enhancing further research and development vis-a-vis the on-site application of the Metaverse. Introducing Metaverse at higher educational institutions for imparting DRR education can be implemented outside of the campus, too. It is in this field that SMEs can be grouped into different cohorts where such trained students/professionals can be invited to establish the training modules for the existing employees and the management of an enterprise.

SMEs for DRR through BCP

As a user-friendly ready-to-use BCP format, Kariya-city of Aichi Prefecture offers its own BCP sample format on the official

website of the municipality (Kariya-city, 2021). However, such an endeavor is not always happening in all municipalities in Japan.

In disaster management, we tend to forget that people are at work too, and not always at home or in school. Also, the decision-making at the workplace often rests with the management, while infrastructural set-up, as well as assigned responsibilities, restrict the movement as well as decision-making processes of the employees. The stakeholders in the private domain, especially SMEs, have been left out of disaster management in Japan. To save precious lives, it is high time to pay attention to enable the active participation of SMEs in DRR education and BCP formulation to make the country's disaster management policy consistent and comprehensive.

Conclusion

It is noted that the accuracy of the Metaverse is appreciated, but affordability challenges are to be tackled. Predefined disasters such as a fire can be virtually experienced. Thus, the Metaverse application helps with the customization of disaster drills and prioritization of rescue operations by linking the 3D cities. Simulating the simultaneous evacuation of many people can be enhanced with the application of the Metaverse. Rapid on-site decision-making in disaster situations could be enhanced. There are three major benefits listed below.

Improved Accuracy

The more the simulations become close to real situations, the better and easier the planning against disasters. Enhanced simulations make the participants more responsive and engage in active learning. Instead of creating physical structures or not-so-real drills, the Metaverse enables the participants to experience close-to-reality situations.

Planning for Structural Safety and Safe Evacuation

Resilient cities are the key to a resilient society that can pursue the DRR principles.

Climate change and increased risks of large-scale disasters have made preparatory education more meaningful and crucial to ensure the survival of human lives. Using 3D models in virtual space such as digital twins for design simulation of cities and buildings will allow educational institutions to participate in scientific planning of disaster mitigation. It is realistic simulated evacuation experiences that lead to saving human lives. Evacuation training with decision-making experiences and trials enhance the decision-making ability to opt for a safe route as rapidly as feasible (Mitsuhara and Shishibori, 2022).

Enabling Experiential Learning

The Metaverse enables us to have an extensive virtual experience through immersive experiences that are perceived as real, and appeal to our senses. It makes us ready to face real disasters in a more calculated affordable manner. Participants' evacuation behavior, the visual impact of avatars, utterances, and associated emotions should be understood.

Enhancing Disaster Preparedness

In conclusion, the Metaverse has enabled simulations to become more accurate and cost-effective, while enabling us to anticipate what is to come. The Metaverse, by entering a pseudo-real world, can collect more personal information in comparison to conventional IT services. It could be difficult for users to correctly recognize the risks. User security features need to be provided beforehand with a full understanding of security risks in specifications and services provided through the Metaverse (Nomura Research Institute, 2022).

Priority Consent and Security Risk

Priority consent is recognized in three phases: education for disaster risk reduction before the disaster; evacuation and emergency rescue operations during and, then, post-disaster. The individuals' rights and privacy need to be protected, especially when multiple agencies could

be allowed to have access to the personal details of the residents.

Acknowledgment

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